CHAPTER 3. Global Scenarios

3.6 Global Energy Scenarios 2020

Written in 2006 based on studies conducted in 2005–06

1. INTRODUCTION

The Global Energy Scenarios 2020 study has produced four global energy scenarios. These scenarios give detailed cause and effect relationship about potential developments that might influence the global energy situation from now to the 2020. The study was conducted at the initiative and with financial support from Kuwait Petroleum Corporation and Dar Almashora Consulting.

The study was structured in three-phases:

- **Phase 1:** Identification of significant energy scenarios and relate research reports (see Volume II: Annotated Bibliography of Global Energy Scenarios) and the selection of four axes for the scenarios: Technological breakthroughs; Environmental Movement Impacts; Economic Growth; and Geo-Politics and War/Peace/Terrorism. Each could be high, low, and moderate (for vacillating). The scenario team selected the combination of conditions of axes that might produce the most interesting and plausible scenarios for further discussion in the energy policy process.

  The four scenarios are:

  1. **Business as Usual – The Skeptic**
     Moderate growth in technological breakthroughs
     Moderate environmental movement impacts
     Moderate economic growth
     Moderate changes in geo-politics and war/peace/terrorism
  2. **Environmental Backlash**
     Moderate growth in technological breakthroughs
     High environmental movement impacts
     Moderate economic growth
     Moderate changes in geo-politics and war/peace/terrorism
  3. **High Tech Economy – Technology Pushes off Limits**
     High growth in technological breakthroughs
     Low environmental movement impacts
     High economic growth
     Few changes in geo-politics and war/peace/terrorism
  4. **Political Turmoil**
     Moderate growth in technological breakthroughs
     Low environmental movement impacts
     Moderate/low economic growth
     Major changes in geo-politics and war/peace/terrorism

- **Phase 2:** Two-Round Delphi to collect judgments from experts in the energy and related domains.
    - The first round rated key elements drawn form the global scenarios and related research studied identified in the first phase.
    - The second round collected comments on draft scenarios constructed from the results of the first round of the Delphi.

- **Phase 3**: The results of both rounds were used to construct the final scenarios.

The four scenarios considered are:

1. Business as usual. This scenario assumes that the global dynamics of change continue without great surprises or much change in energy sources and consumption patterns, other than those that might be expected as a result of the change dynamics and trends already in place.

2. Environmental backlash. This scenario assumes that the international environmental movement becomes much more organized; some lobbying for legal actions and new regulations and suing in courts, while others become violent and attack fossil energy industries.

3. High tech economy. This scenario assumes that technological innovations accelerate beyond current expectations, and have impacts in the energy supply mix and consumption patterns, to a similar magnitude as the Internet initiated in the 1990s.

4. Political turmoil. This scenario assumes increasing conflicts, wars, and several countries collapsing into failed states, leading to increasing migrations and political instabilities around the world.

The methodology and results from all phases of this research are presented after the full text of the scenarios.

2. Four Global Energy Scenarios

Scenario 1: Business as Usual––The Skeptic

Moderate growth in technological breakthroughs
Moderate environmental movement impacts
Moderate economic growth
Moderate changes in geopolitics and war/peace/terrorism

A Caldron of Contradictions

The world of 2020 is a caldron of contradictions. It is a good time for some and a bad one for others, both promising and disappointing, full of apparent opportunities and broken promises, a world of both hope and despair. There have been only moderate technological breakthroughs in energy and other fields. Environmental impacts, while not benign, at least have not yet been catastrophic. Economic growth has been cyclical; geopolitics and terrorism have been brutal sometimes and quiet at other times. In short, with some exceptions, most past trends have continued to our time. The shifts that have occurred seem to have a random quality and are applauded or despised largely on the basis of politics, ethnicity, or nationality. One trend, however—continuing energy demand growth—has reached a crescendo, and most people in the world are now feeling its consequences.

Many historians have written about bad decisions made by governments—from the Trojan horse to the war in Vietnam. In 1984, historian Barbara Tuchman wrote *The March of Folly*, a book describing huge government mistakes that were often not subtle, that anyone even partially informed should have known in advance could be catastrophic. Good data were available. Alternate solutions had been proposed. But despite the high stakes, the future for those decisionmakers turned out badly. Why? Governments sometimes lie (the Gulf of Tonkin and U-2 incidents) or, to be generous, are misinformed. It is often easier for officials to go with the flow than to take risks (although some of the bad decisions were risky indeed). Political Pollyannaism, a blind faith in beneficial but low-probability outcomes rather than the more rational high-probability catastrophes, clouded decisions. Bad judgment, bad luck, holding self-interests above societal interests, amorality, timidity, and xenophobia: all trumped over rationality. These myriad forces have shaped civilization over the past 50,000 years and they shape our time as well. It is indeed business as usual.

Life Goes On

The best example of today's folly is our energy mess. The world's current energy situation and the bad decisions that got us here certainly qualify as a colossal, global blunder, as important as any in history. The data on energy reserves, prices, and alternatives have been largely known for decades, apparent alternative solutions were on the table, the outcome of doing little or nothing was relatively easy to forecast, and yet forces were in play that led to the failure to act decisively. Economic growth has been thwarted, poverty abounds, the bad guys call the shots, and moral foreign policy decisions have been compromised in the interest of satisfying the world's need for oil and other energy sources.

Should the countries of the world have known that oil-consuming countries would be held hostage to the suppliers? You bet. There were many signs: the anti-US tirades of Hugo Chavez in Venezuela, bombastic governments in Iran, political instability in Nigeria, the massive and growing energy demands of China and India, and the alliances between China and suppliers such as Saudi Arabia and particularly with African countries such as Libya, Sudan, and Angola. Back in the first decade of the new century, Iranian leaders spelled it out directly and forcefully: they said they would use oil supply as a weapon to avoid sanctions designed to force them to put aside plans to develop nuclear weapons. So if the price of gasoline in the United States could be $3 per gallon without a discernable effect on economic development or consumer behavior, why not $4 or $5? According to the US Energy Information Agency, today—in 2020—industrial countries import three-quarters of their oil from the Middle East Gulf region.

People began to ask, "Who is getting all of that money?" There seemed to be only a very loose connection between the price of oil and the gas price at the pump. The tax policies of the members of the European Union were taking the lion's share of the overall economic rent from oil in Europe, larger than the share going to OPEC members. So there was a clamor to cut taxes and even a murmur that the oil taxes being paid to EU governments should instead go to poorer OPEC members.

There were some inspired moments. In 2006, President George W. Bush announced an energy plan that was to have greatly lowered US dependence on imported oil by 2025, just five years from now. One might have guessed that OPEC members would react badly, since their source of income and political bargaining chip was being challenged. But they needn't have worried; it didn't happen. Why? Because the industrial countries' commitment to oil was too strong. Because no one was convinced, really convinced, that the world had reached "peak oil"—that point in time when petroleum reserves grow more slowly than production—and because the oil-producing countries and petroleum companies did their best to convince the world that there was more economic oil to be found. In fact, many people are still not convinced.

A public opinion survey taken the other day asked people what they thought about our present situation and outlook. The pollsters found that about 37% of those sampled said they thought they were better off today than in 2005, and almost 40% said they thought that in 2040, 20 years from now, things would be much better than today, a modest growth at best.

Another massive plan was jointly proposed in 2009 by another US President and by the British, German, and Japanese Prime Ministers. They announced a program patterned after the Apollo space program but with renewable energy as the focus. (See Box 2–1.) It was a world plan, however, not just a plan for the United States. They called the program "The New Fire." This time it struck a spark; it excited nations, science laboratories, industrialists—even those in the petroleum business—because many people had come to believe that the time of peak oil was probably close at hand and, more important, that the plan was serious. There were skeptics, of course. Some other factors helped convince people this time: high energy prices were going even higher, inflation was everywhere, and reserves were diminishing. It was clearly past the time for action despite limited funding, the selfish interests of certain industries, and bickering over appropriate directions within the program.

Box 2–1. The New Fire

A Joint Proposal of the United States, Germany, the United Kingdom, and Japan

Governments make tough decisions. Most big decisions are tough because they have uncertain outcomes, because once made they cannot be withdrawn. Uncertainty and the risk of damaging peoples' lives keep decisionmakers awake at night wondering about the right path. For a few decisions on the horizon, however, risks seem very low and the potential benefits far outweigh the downside potential. For these decisions, we wonder, "Why not?"

Moving boldly ahead in energy research is one such decision. We have reached peak production of oil throughout the world. The attempts to meet the challenges of this event have been much too timid.

We propose a 10-year global goal of developing energy sources and systems that will reduce the world's rate of consumption of petroleum by half without increasing pollution, a goal that is easily measurable. The program is vast and involves many industries and nations. Over its 10-year span it will devise new energy sources and infrastructures. It will create non-exportable jobs in the United States and in all countries that are part of the program. It will stimulate our economy and the economies of cooperating nations. It will improve economic development of poor countries that contribute to its goals. It will improve general technology—not only the technology of energy production and use, but technology in many fields, spinning off inventions affecting health and education. It may even help reduce the threat of terrorism as we distance ourselves from the perception that thirst for oil motivates our Middle East policies. Some people have argued that a sound energy policy is our best anti-terrorism move.

Measured in today's dollars, the Apollo program of the 1960s cost $100 billion over 10 years. Let's say this new energy program will also cost $100 billion. Where will the money come from? From savings in military expenditures, from the economic stimulation that the program itself will create, from matching funds that other nations will contribute to the effort, and from reduced expenditures for imported oil.

Industries around the world will benefit from the program. Expedited R&D will test new energy concepts and will design—experimentally at first and then on a large scale—the infrastructure to deliver the new forms of energy to consumers. The answers may not rest in a single epiphany or scientific discovery but in a network of reinforcing policies and practices that build robust systems capable of reducing operating uncertainties and making risks tolerable. Engineering and science education will be invigorated; new careers will be created.

What of consumers? They are ready. We already have incentives in place to encourage the use of mass transit. These will be strengthened. The program will result in improvements in the environment—cleaner air and water. The line for hybrid cars is getting longer. Many consumers look at the price of gasoline and wonder how long it will be before people everywhere are paying $5 per gallon or more at the pump. Consumers understand that to control their economic future they must move to limit their countries' dependency on the decisions of suppliers.

Box 2–1. The New Fire (continued)

What of the oil-producing countries of the Middle East? How will they react to a plan designed to decrease their sales? The rational decision for them would be to increase production and lower oil prices so that we might lose heart and go back to the oil addiction we have learned to love. Like any addict, we have to resist. Sure, we ought to fill up our reserves when the price drops, but we must remain committed to the program. Once our resolve is apparent, the best strategy of the oil producers, if they think clearly, will be to join the parade and help search for whatever comes next. Old buggy whip manufacturers went out of business when the buggy gave way to the automobile. If the whip people had entered the car business, the world, for them at least, would have been a lot different. So it is with the oil-producing countries. When the next energy wave appears on the horizon, they ought to see that it is better to ride it that to be drowned by it. In at least one plausible scenario, some of the forward-thinking oil-producing countries could help fund the global effort to find the replacement for oil.
Consider China. That nation will enjoy the falling petroleum prices that the oil-producing countries use to bait the West; this will be a windfall that furthers China's economic development. People there may even see themselves as the emerging "last consumer" enjoying the new abundance of oil as the old consumers switch to new sources. But such opportunism carries the seeds of its own defeat as new energy systems come on-line and replace obsolete engines of consumption.

From the start, developing countries will have important research to perform, thus promoting their indigenous scientific capacity, reducing their "brain drain," and providing new goals and incentives for education. With the fruits of this program, these countries can follow more-efficient economic development; they can jump-start toward an economy that avoids the energy pitfalls that others have discovered.

These actions will benefit the world and will hurt only those who gloat over our pain: terrorists and those who make unconscionable profits from manipulating energy prices. We are going to ask all people who support this program to practice conservation and all nations that cooperate to initiate incentive programs that will encourage the wise use of fuel.

In September 1962, President Kennedy said, "We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win…" This is a great model for our time. We choose to solve the looming energy crisis not because it is easy but because to go on as we are will deny the world of our children the best the future has to offer, will keep the world on a path of depletion, a path promising riches for some and poverty for many. We choose to solve the energy question for the long term and not accept short-term patches. We choose to create our future and not simply let it happen.

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The New Fire is Cooling

Nevertheless, the excitement kindled by the New Fire program did not result in a globally unified effort as had been hoped but rather piecemeal projects that added up to less than the sum of their parts. Special interests prevailed. What a wasted opportunity! There were vigorous attempts to entice all countries to subscribe to post-Kyoto agreements that would reduce greenhouse gas emissions to 1990 levels (the attempts failed), strengthened energy-efficiency standards, carbon trading plans, taxation schemes on fuel use (in place in many countries), education to raise energy awareness (sounds good, but putting into practice is difficult), readjustment of budgets for related basic scientific research (but mainly research that was scheduled anyway).

One lobby was pushing for an advanced fission nuclear reactor generation program, but the safe storage of nuclear materials still stymied the engineers. Some projects were imaginative, such as seawater agriculture along the desert coastlines of the world—planting salt-loving plants on beaches of areas like Somalia in order to make biofuels competitive, provide additional carbon sinks, and stabilize coastal erosion. Solar-derived space energy, or space solar power, was generally seen as pie in the sky and way too expensive in any event; even the experts now predict that is still two or three decades in the future. Terrestrial solar cells have been improving in efficiency but are not yet nearly efficient or cheap enough to be in wide use.

Now the world is a decade into the New Fire program, and the countries that could have developed alternatives to oil have not. There have been only "Band-Aid" quick fixes and timid projects that pander to special interests, not the unified and massive programs that could have been justified. The technological development programs have been largely left to the free markets, and the marketplace believed that instability in energy prices should limit the levels of "prudent" investments. When people today wonder how the world has developed as it has, most often they point to many culprits: corruption, greed, irresponsible environmental extremism, short-term profit-taking and policymaking, the oil companies, life-style excesses, failure of imagination, and a lack of understanding that resources are, after all, finite.

The oil-producing countries were pleased with this situation. They controlled supply, and supply largely set prices. They were also the countries that thought they had the most to lose if technological developments produced viable alternatives to oil. Thus when it appeared that high oil prices might justify large-scale investment in alternative energy systems, the price of oil dropped, supply tended to expand, and the economic justifications of new programs evaporated. Away from the glare of media, OPEC threatened repeatedly to denominate oil price in euros, a move that could have favored Europe and proved costly to the United States. The threat was enough to cause tension among industrial countries.

India and China decided to extend their cooperative energy agreements, strengthening their earlier "Memorandum for Enhancing Cooperation in the Field of Oil and Natural Gas," which outlined comprehensive cooperation in hydrocarbon trading and joint bidding, exploration, and production. This move sounded ominous to other countries.

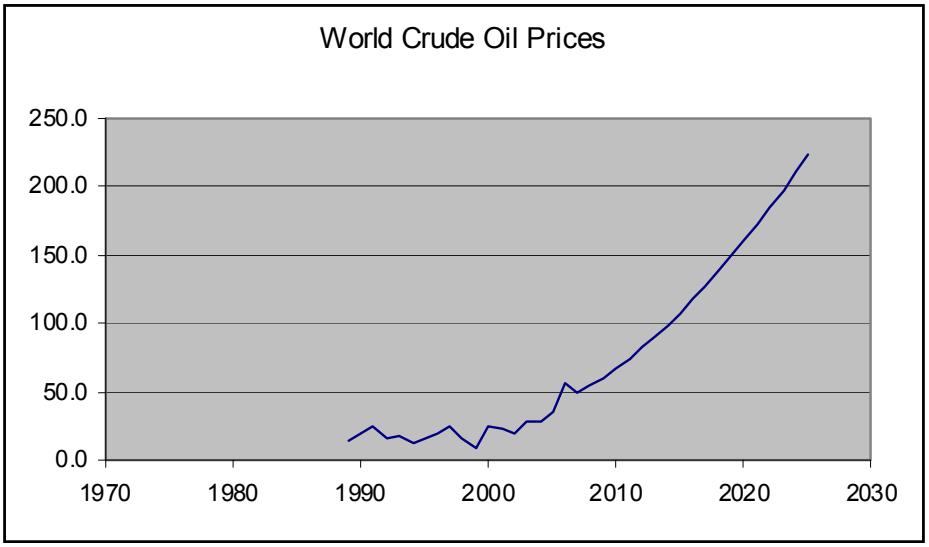
There were other signals, well above the horizon, that the big energy-consuming countries were being manipulated by the producers and that there was trouble ahead. The western consuming countries, in particular, could have seen the obvious and anticipated the outcome. Consequently, they, and to a greater or lesser degree all oil consumers, are hostages now. If you asked presidents of oil-exporting countries why things have turned out as they have, they often say, "It's your own fault. You have consumed beyond your means. We don't make you take the oil—we sell you what you demand, and your failure to develop alternatives underscores your addiction to easy energy and your unwillingness to take the future into consideration in your policies."

On the other hand, oil company presidents say, "We're doing the best we can; our hands are tied. The shareholders demand a return so we must proceed as we have in the past. There has been no national strategy that would have allowed us to devote enough resources to research energy alternatives." And some still say, "We have many decades of supply left, so let us move slowly and wisely."

The Cost of "Addiction"

The major driver of economies around the world has been the price of oil. Today, in 2020, crude oil costs over $160 per barrel ($90 per barrel in 2005 currency), up by a factor of three in the last 20 years (see Figure 2–1). And the price could be over $200 per barrel by 2025.

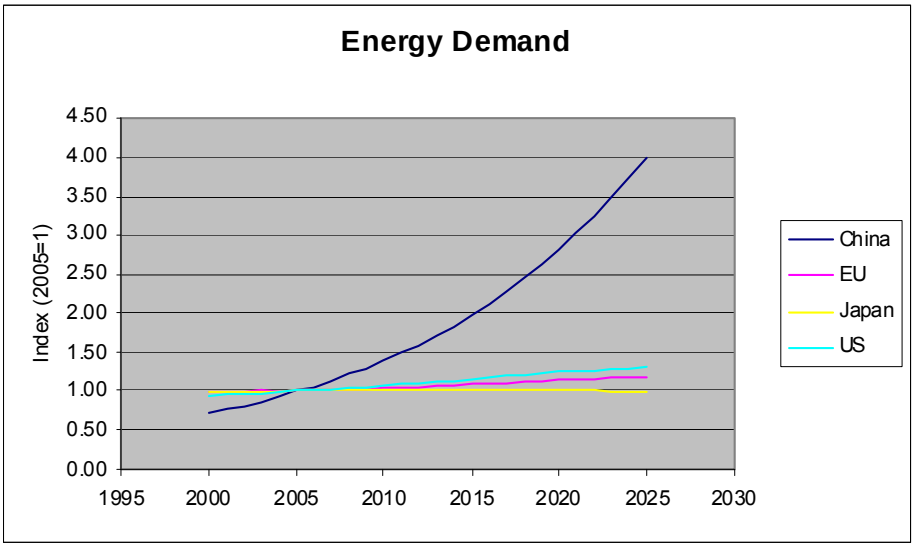
Figure 2–1. World Oil Prices, 1988–2025 (in current $)



Source: The Millennium Project based on EIA data.

Despite the higher oil prices, demand has just kept rising. Figure 2–2 shows the history and a projection of growth of energy demand in four countries or regions over the last two decades.

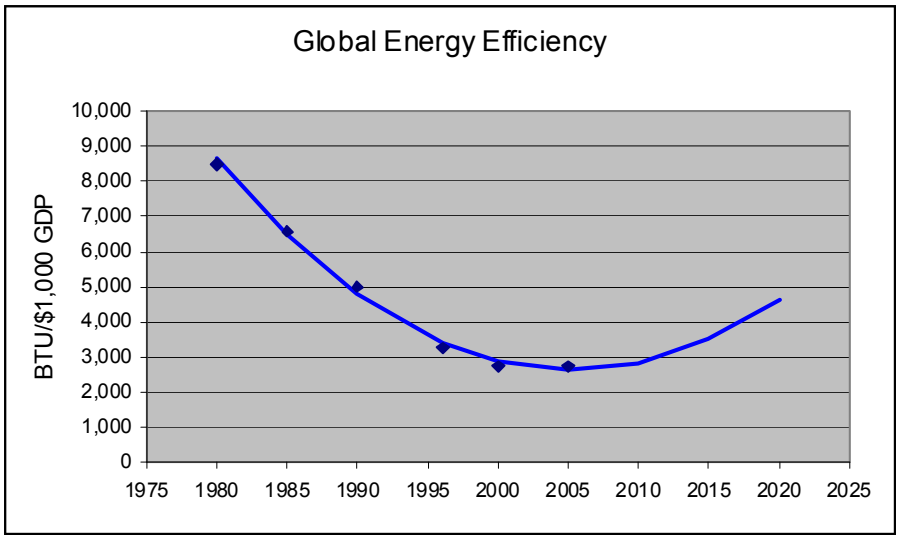
Figure 2–2. Total Energy Demand Growth, 2000–25



Source: The Millennium Project based on data from the International Futures model of the University of Denver.

Increasing demand has resulted in even higher prices in a tight feedback loop. Higher prices have encouraged changes in the fuel mix and improved energy conservation and efficiency. Figure 2–3 shows how much global energy was required to produce $1,000 in global GDP over the last 50 years. As can be seen, the world was doing pretty well until about 2005, when efficiency was at its peak The easy conservation targets were being harvested—automobile speed limits, incentives for smaller cars and for home insulation, taxes on sport utility vehicles, incentives to replace antiquated and inefficient energy consumption by industry, and improvements to mass transit. The curve started rising again, and now it is on a par with 1990 or so. Why should that be? It took awhile to see that improvements had ended. Now economists say that around 2010 the higher energy prices led the world to squeeze out all of the easy efficiency changes that were available—improving efficiency was too costly from then on.

Figure 2–3. Global Energy Efficiency



Source: The Millennium Project based on the US DOE EIA

The environmentalists had their say—at least to a small degree. They focused on legislation and international treaties while the pollution continued merrily along. Oh, a few policies were changed. Carbon trading became a game, with loads of experts and their computer models leading the way. The Corporate Average Fuel Economy standard was beefed up almost everywhere. Other policy changes included subsidizing renewable sources while taxing fossil sources, stiffer efficiency regulations, support for "tele-work," elimination of import tariffs for ethanol and other biofuels, and charging automobile owners for access to city centers.

Further, the markets were relied on to encourage development of renewable fuels, but the effects that are now all too obvious were minor, like pouring a glass of water in the ocean. (And speaking about oceans, their levels are now clearly on the rise.)

It was also surprising to many economists that economic growth continued at first, despite high oil prices. In 2015, however, there came a time when the higher oil pices had an effect, when oil prices went above $100 per barrel and when the rate of discovery of new reserves was continuing to fall behind production rates. At that point, the old complacency was eroded. People drove less, bought less, worried more, and were cold in the winter. Water problems plagued many countries in the world. Jobs were lost and rhetoric could not hide the fact that most consuming countries were hostage. Further, inflation rose and even soared in some nations. A few new industries emerged in response to these new pressures (see Box 2–2), but the net effect was a gradual erosion of optimism.

Countries that had non-conventional energy raw materials, such as Canada, saw the scene as shifting in their favor. The tar sands of Alberta drew massive investments, and a major extraction, processing, and export industry grew up there. This served to expand the reserves and curb enthusiasm for the development of nonrenewable sources. Now tar sands supply almost 3% of the world's energy. Once Canada had an exportable product, it was in their interest to maintain high prices. Similarly, Brazil, a large exporter of ethanol, also set pricing policies that gave them the highest return. What the US and Europe saw as an escape from the price tyranny of OPEC proved a chimera.

The world used to think that inflation was conquered, that somehow the US Federal Reserve Board and other European and Asian central banks had found the magic control knob to tailor inflation and more generally economic growth to whatever rate seemed appropriate. Now it is clear that the beast has come to bite us again. In the US and the EU, in 2015, the rate topped 9% (see Figure 2–4 for the history and short forecast of one measure of inflation); in other countries double-digit inflation was the norm, with some countries reaching near-panic stages.

Box 2–2. We Love Our Golf Carts

A new form of transportation has emerged. Some of these cars look like small Rolls Royces, others like Ferraris. Since 2010, in many countries there has been a small industry making specialized golf carts; their users, mostly elderly people, love them. Many towns have created a special infrastructure for these vehicles, expanded bicycle paths in effect, that allow the carts to travel from the outlying residential centers to the town in safety. Certainly, they are slow, 40 mph peak, but they are very efficient since most run on batteries. A few of the carts are powered by small internal combustion engines that only sip fuel. Their use began in communities where the affluent elderly tended to concentrate. They provided reliable, short-distance transportation.

The vehicles abound in the suburbs of sufficiently affluent cities, particularly where the towns have provided special roads and paths. If we count the number of people over 65 who have incomes above $100,000 as our market segment, we find that there are 10 of these cars per 100 people, a very significant slice. They take many forms: replicas of classic cars (car companies sell intellectual property rights to the shapes), modernistic and fantastic varieties, and rolling jokes like the Titanic version complete with smoke stacks. People buy them complete or go to small businesses that customize the factory platforms.

Three significant catalysts aided the growth of this mini-industry:

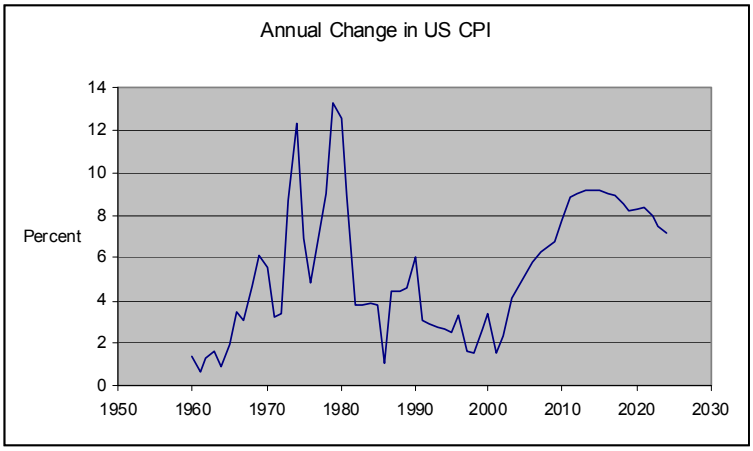
1 Provision by towns and private communities of roads reserved for such vehicles. These are not roads in the ordinary sense; they bear lower weights and hence are much less expensive; they can be shared with bicycles, roller blades, and horses, and, most important, they can be beautiful, wooded, and park-like.

2 Granting of special licenses for use of these new roads. In the old days, children of elderly parents had to tell them, at some point, that they were no longer capable of driving conventional cars safely—a traumatic experience since this was a sentence for a life-style change from independent mobility to dependence. Departments of Motor Vehicles found it no easier to tell elderly applicants that they no longer had the acuity necessary to drive conventional vehicles. Solution: the new golf carts provided an alternative: encroaching decrepitude no longer means immobility. The new licenses have restrictions, of course.

3 Encouragement by organizations like AARP and insurance companies for the elderly to drive vehicles that are safer than conventional automobiles. For the insurance companies, it was a matter of economics; for organizations of elderly persons, this opened new domains of experience for their clients.

Not only did the market grow, but unexpected by-products appeared. To list a few: there are golf cart races at Daytona and Indianapolis, the kids hop them up, there are gymkhanas and rallies, and there are distance and duration competitions. Teen-agers are advocating a new pre-licensing class for their age group. This new vehicle category did not cannibalize the conventional car market; it layered on a new dimension.

Figure 2–4. US Inflation Trends, 1960–2025



Source: *S. Easson and T. Gordon,* A Study of the Use of the Delphi Method, A Futures Research Technique, for Forecasting Selected US Economic Variables and Determining Rationales for Judgments, *Prepared for the Society of Actuaries, October 6, 2005*

Why? The number of baby boomers born in 1960 was at a peak. In 2015 they were 55 years old, and thus the retirement rate was at its peak and demand for services—particularly health care—also peaked. Because of the numbers of people demanding care but also because health care was expensive, corporate retirement plans were failing and many plans required government rescue. It is true that population growth rate has slowed around the world, and in 2020 the world has just shy of 7.5 billion people or so, up by about 25% since 2000. Nonetheless, government spending for weapons, wars, rebuilding countries in which they warred, and subsequent peacekeeping bled national treasuries and deficits soared. Anti-terrorism vigilance has also been very expensive. Mother Nature didn't help either. For whatever reason—some say it's climate change—earthquakes, hurricanes, and pandemic scares seemed all too frequent.

The Cascade of Consequences

The price of energy was the primary reason for the growth of inflation, however, and it turned out that the oil-producing countries had more control than the regulatory agencies. Trade deficits grew in energy-importing nations. Since the price of imported oil was so high, many of the importers had to increase their money supply to help reduce their trade deficits. Many countries called their international loans. Action: print more money. Result: inflation. Many economists think it is lucky that inflation stayed as low as it did. The only reason inflation began to ease in many countries after 2015 was recession in most places and a depression in some. When that happened, some saw a "great depression" looming. But the dip lasted only five years and now recovery is becoming apparent, although it's a different and difficult world.

The economic crisis was a special problem for Middle Eastern countries that had a rich elite and an ever-growing multitude of young, poorly educated, unemployed youths. As happened in France in 2006, demonstrations by young people full of anger, losing hope for a better future, called their governments to task; people everywhere protested their poverty. When global inflation spread to these countries, the political pressures became intense and resulted in challenges to elitist regimes in Egypt, Saudi Arabia, the Arab Emirates, and elsewhere. Where these challenges were successful in Middle Eastern countries, political control and control of oil supply shifted to fundamentalist governments. Like dominos, these changes led to bidding wars and confrontations between the West and China and India for oil supplies. Some people suspect that the fundamentalist regimes designed their oil policies to pit China and India against the West. But more on that in another essay.

Chinese Cars for the World

China's demand for oil now, in 2020, exceeds that of the US and the EU; in fact, it accounts for 30% of the growth in oil demand since 2000. China, by 2010, was the world's largest consumer of many commodities: aluminum, copper, steel, and coal. What fueled this huge increase in oil demand? High economic growth was responsible, to be sure, but more important the primary mode of Chinese private transportation changed from bicycle to automobile. In 2000, the country had only 10 motor vehicles per 1,000 people, compared with 765 in the US. By 2020, that figure

was 200 motor vehicles per 1,000 people in China, and most industry analysts forecast more growth to come.

As important as the Chinese domestic market was to the country, it was their export market that changed the face of the world and the world's energy situation. China's economic policies favored the development of the automobile industry. In 2000, Chinese automobile manufacturers produced more than 2 million vehicles; sales volume was up by 14%; automobile manufacturing was the path to the future. Feng Fei, vice minister of the State Council of China's R&D Center, said in 2004, "The auto manufacturing industry has stepped onto a stage for large-scale production in China." He predicted that China would be able to export sedan-chair cars on a great scale, and they did. (See Box 2–3.)

Box 2–3. Sedan Chairs

Sedan chairs? Ah, there's the clue.

When China entered the World Trade Organization, automobile manufacturers around the world saw this country as a great potential market for their products, and the export of cars to China became an important marketing target in Detroit, Stuttgart, and Tokyo. It was easy to multiply the projected population of China by the number of cars per person in the US, Germany, or Japan to get staggering figures about the potential of the Chinese automobile market. Furthermore, with China in the WTO, import tariffs would be limited.

However, there were impediments to this dream of Cadillacs in Beijing and BMWs in Shanghai. China was not about to give the market away to foreign companies, particularly in view of the petroleum consumption, overcrowding, and pollution it implied. Thus a development plan was initiated in Beijing to nurture the young domestic automobile industry, to encourage the design of a car compatible with Chinese needs, and to find ways in the interim to use imported vehicles to fill the gap between domestic production and demand.

The foreign car manufacturers saw the blip in demand as a hopeful sign and built overcapacity based on this expectation. Bad decision.

The Chinese car evolved from the boxy, three-wheeled motorcycle sedan car that became popular in Chinese urban centers early in the century. The new sedan car that was designed for domestic use was very light, had a small engine capable of running on pure ethanol or gasoline, was available in three- or four-wheel configurations, and—best of all—had a sleek plastic body, mostly recyclable. An early gimmick was that if the car failed it could be turned in for a new one. The pricing was initially subsidized by the government; but when sufficient volume built up, the cars were profitable at half the price of the imports. International competition withered.

Then the exports began in earnest. There was a bit of customization for foreign markets, primarily added electronic systems. Imagine a car that looked great, carried four people, got 75 mpg at a peak speed of 75 mph (this became known as the 75 squared spec), with a range of 400 miles at a price of under $10,000. In the electric version, the mpg was basically infinite. The world's auto manufacturers continued to build their products, but fewer than they had hoped, focused on niches and image, and became suppliers of parts and aftermarket add-on to the Chinese cars. Many failed, many merged.

By now, in 2020, the Chinese sedan car design has evolved to a true all-electric vehicle. This year, China produced over half a million units; all other countries together produced another half-million. Electric cars made great sense in China; the technology was well understood and it was seen as a way that the country's coal could be used (via generation of baseload electricity) to

provide mobility and minimize pollution in urban centers. Most large cities banned entry of vehicles that burned gasoline or diesel fuels, so the move to electric propulsion was welcomed around the world. Many countries gave tax credits to purchasers of electric vehicles. The export market was waiting for the Chinese electric cars. Consequence: despite their attempts to survive by introducing new engines (for example, Stirling engines), old-line automobile companies failed, and oil companies consolidated.

The World Energy Supply

The net consequences of these developments on world energy supply are summarized in the Table 2–1. As might have been guessed, the demand for oil and conventional coal have increased considerably since 2006, but demand for natural gas has grown by almost 50%. Despite the scientific interest in fusion energy, including important research by the Chinese, the process is still seen to be a very long way off.

Table 2–1. Evolution of the World Energy Mix (Business as Usual Scenario)

Consumption	***2005 Consumption (mill TOE)***	***2020 Consumption (mill TOE)***	***Gain or Loss (mill TOE)***	***Percent Change***
TOTAL (sum of components below)	*11,409*	***15,544***	*4,135*	36.2
Oil	3678	**4,300**	622	16.9
Natural gas	2420	**3,600**	1,180	48.8
Coal (conventional)	2778	**3193**	415	14.9
Traditional biomass and waste	793	**1400**	607	76.5
Nuclear fission	624	**790**	166	26.6
Hydro	634	**750**	116	18.3
Other biomass Methanol Ethanol	370	**388**	18	4.9
Unconventional oil from tar sands and shale	88	**350**	262	297.7
Coal processes total from liquefaction, oxygenation, gasification	-	**500**	-	!
Solar (photovoltaics, solar power towers, solar thermal, and space solar)	11	**100**	89	809.1

Wind	8.5	**100**	92	1076.5
Nuclear fusion	0	**0**	0	
Methane gas hydrates	0	**22**	22	
Geothermal	4.8	**50**	45	941.7
Tides	.1	**1**	1	900.0

Source: The Millennium Project based on 2006 energy survey

Overall, global energy use has grown by over 36% since 2005. Conventional oil supply has grown at a much slower pace (17%), so it is losing its market share. However, note that oil from tar sands has grown rapidly and now supplies over 2% of the world's total.

Conventional coal has also grown more slowly than the total (15%) and hence has lost share, although the new coal processes such as liquefaction and gasification have grown rapidly and now make up about 3% of the total. Not only has natural gas grown greatly, but it is now contributing an amount of energy that is of the same magnitude as coal and oil. Nuclear (fission) and hydro continue to supply significant amounts, about 5% of the total. All of the other so-called promising renewables are still waiting in the wings. One spot that is a bit brighter than the rest is terrestrial solar energy. Although space solar projects have foundered, terrestrial solar energy has grown. The questions about space solar resulted from high anticipated costs, uncertainty about the technology, and the unproven net energy balance of the scheme. (There is some suspicion that pro-oil interests have engaged in anti-space power lobbying.) Yet terrestrial solar (photovoltaics, solar thermal, and solar power towers) is now approaching a healthy 1% of the world's energy supply.

Ethanol is a particularly important fuel and fuel additive. Of course, it comes from many sources: waste, cellulose, corn, sugarcane, palm oil, sweet sorghum, saw grass, and so on, so agricultural polices throughout the world were adjusted to encourage this renewable supply. Genetic research into new, higher-alcohol-producing varieties was encouraged. Engine designs were altered to accept fuel blends in which ethanol (and other alcohols) represented a higher and higher percentage. Brazil, which was a prodigious producer of sugarcane-based ethanol, became a major exporter of the fuel, and by 2010 half of its exports were going to Japan. The parade of ethanol exporters grew and, to mention a few, included Argentina, Australia, Central and South American countries (such as El Salvador), Malaysia, Mexico, South Africa, and Poland. As early as 2004, India established programs to encourage ethanol production.

The EU, with its huge agricultural production of sugar and grain, converted a major portion of its surplus into fuels (Germany and France led in the production of bio-fuels). And to boost the possibility of a European biofuels industry, the EU introduced protective tariffs on imported ethanol. The US and other countries cried "protectionism" and created ethanol reserves. Anti-genetic modification attitudes in Europe were deeply ingrained and continued, and production of the crops needed for this embryonic industry were lower than they might have been. The

European countries opposing genetic modification included Austria, France, Portugal, Greece, Denmark, and Luxembourg. With the emphasis on ethanol, world food supply became imbalanced and hunger increased. There were brave experiments that attempted to use marginal lands and brackish water for the production of alcohol crops, but these added only marginally to the acreage. It seemed that the world could not have both adequate food and expanded production of alcohol grains. It was indeed business as usual.

Opportunistic Terrorism

The intersection of these developments with global terrorism deserves special attention. Terrorism is still a major concern. There have already been small attacks during the past two decades, and many people expect that they will grow in scale in the next 20 years, able to disrupt supplies by 5–10% for at least a month. Some analysts think the anti-oil mission of the terrorists is to cause democratic governments and secular economies to fail so that fundamentalist governments can take their place in some oil-producing nations. There may be other reasons as well, such as alienating the moderates from their ineffectual governments, maintaining wealth concentrations in oil-rich countries, and slowing the development of advanced technologies, which they see as irreligious. Some people have even suggested that, through terrorism, the terrorists themselves believe they can become rich by taking over oil resources.

At very least, some analysts think that terrorists want to see a rise in the price of oil (and attacks on supply result on price increases) to enrich Arab countries. They want to reduce the Western presence in "their" countries. They want to undermine democratic governments by pushing them to adopt strict security provisions that move these countries toward police states and truncate what the terrorists consider to be immoral freedoms. Some see terrorism devolving to a protection racket, functionally indistinguishable from organized crime. Clearly, they want withdrawal of Western troops and corporations from Moslem countries to "purify" the Islamic caliphate.

Killing of people over the last 20 years was a strategy designed to illustrate the weakness and fragility of non-fundamentalist countries. With the obvious need for oil, it was apparent that there were other ways to provoke failure and to illustrate, and perhaps intensify, the inherent weakness and fragility of the countries they perceived as decadent. Initially the approach was to attack the oil fields and the institutions and infrastructure of the oil industry. Military presence in oil fields was increased in response to this threat. Ports and pipelines were vulnerable, so new ports and pipelines were built offering parallel paths to the markets. By and large, though, security was spotty and only partially successful.

Terrorists hatched a plan. In great secrecy, in a dozen places, biochemists loyal to their cause were directed to produce self-replicating microorganisms designed to contaminate oil with contagious human pathogens. Bugging the oil, they called it.

This was not the only oil/biotech program under way. Many biomethane projects were being pursued to find more cost-effective ways of converting agricultural crops, and cellulose in general, to fuel. A dozen legitimate laboratories have been attempting to develop strains of

microbes that, in one application, could be injected into depleted wells to digest heavy oil residuals and produce less viscous crude that could be more easily pumped to the surface. In another application, anaerobic microorganisms were designed to convert the residual oil to methane.

The contraband organisms looked much like the legitimate ones, and they were injected into half a dozen wells in the Middle East. When mini-epidemics developed among oil field workers, there were celebrations among the minions of the radical terrorists. They announced their success, and in so doing created a wave of fear about the extraction, processing, and use of oil. This was better and more effective than exploding a bomb under a pipeline. At a considerable cost, the oil companies had to bio-isolate their workers and prove to various environmental protection agencies around the world that refining oil also pasteurized it.

Finally

So, yes, it's easy to be a skeptic. We've heard it all before. What people miss most about the old days is vacations in distant places, freedom to drive what they wanted and where they wanted, having a government they could believe in, that tells the truth—if indeed anyone knows what truth is any more—and stability. Today there is too much pessimistic thinking about energy. Reserves have grown in the past when depletion was forecast, and now many people in the industry say it will happen again. As for developing new energy systems, with effort and fortitude the world powers can solve the problem; they can do anything they want to do. But the World Soccer Games are on TV now, so let's worry about all this tomorrow.

Scenario 2. Environmental Backlash

Moderate growth in technological breakthroughs
High environmental movement impacts
Moderate economic growth
Moderate changes in geopolitics and war/peace/ terrorism

The catastrophic nuclear accident in 2008 that polluted the Indian Ocean with radioactive waste galvanized the brewing environmental movement with a new dynamic force around the world. Pro-environment politicians were elected, and the G8 hammered out an agreement to create and implement the Global-Local Energy-Environment Marshall Plan (GLEEM Plan) with an Apollo-like mandate to fix the energy situation and reduce climate change.

Figure 2-5: Maps of Nuclear Power Reactors: India

Source: INSC, http://www.insc.anl.gov/pwrmaps/map/india.php
(Purple reactor labels show specific reactor locations; some reactor labels may not represent the exact geographic location.)

The environmental backlash had been gathering momentum for years—both from nature and from environmentalists. From the 1970s onward, forecasts of climate change and its impacts have proved to understate what actually occurred. In the last 10 years, major areas of tundra have melted, releasing huge amounts of methane, a gas 22 times more dangerous for the climate than CO_2. Nature's backlash was felt most directly via increasing droughts, flooding, hurricanes, tornadoes, new diseases, fires, sandstorms, falling crop yields, and social unrest among millions of environmental refugees from dying rivers and lakes. During the past 10 years East Africa experienced massive famine, killing 20 million. Many fishing industries around the world are gone. The water tables have fallen dramatically in India and China over the last 20 years, leaving dry wells for hundreds of miles in many locations, forcing millions to flee to already congested cities, where tensions explode into riots.

Increasing demand for meat accelerated the industrialization of livestock production, with its massive concentrations of animals and their wastes, which led to the Pig Flu pandemic of 2010 that killed more than 25 million people. Less dramatic but also quite devastating is the slow-motion march of desertification in Asia, Africa, North and South America, and the Middle East. Hundreds of species of marine life have been exterminated due to increased acidification of the oceans from CO_2 deposition. The changing climate increased drought and fires in some areas and floods in others. It altered insect migrations, which carried mutated viruses that caused new epidemics; it shifted crop yields to more northern and southern latitudes, causing parts of Siberia and Canada to become a viable breadbasket; and it meant glaciers in high mountains disappeared, leading to water problems in major mountain-valley regions around the world.

The nuclear catastrophe caused massive fisheries collapses, first in the Indian Ocean as a result of the accident, causing food shortages in much of south Asia, then subsequently in other fisheries, as pressures to catch fish were redirected. Just as in the Chernobyl nuclear accident, the human mortality will not be fully known for years, but it is expected to be worse than in Chernobyl. Many people fled the area and settled elsewhere with little systematic medical follow-up. There were also some airborne contaminations that caused crop losses and failure in the region. Radiation caused enough loss of plankton in the Indian Ocean that the natural CO_2 absorption capacity was reduced, contributing to record annual increases in atmospheric GHG concentrations. Increased acid rain in the industrial areas further reduced the ability of green cover to absorb CO_2 and increased soil erosion.

The backlash from nature that makes scientists most worried is the beginning submergence of the Gulf Stream in the North Atlantic by freshwater runoff from the Greenland icecap. This will reduce the ability of warm ocean currents to flow along Europe's coasts, giving it the same weather as Canada before its recent climate changes. If Europe cools, its ability to feed itself will also be reduced, increasing food costs around the word.

The environmentalists' backlash cut a broad swath across the array of industrial powers. There were strategic lawsuits, high-profile public confrontations, protocols to environmental treaties that used biosensors and satellite data for better detection of environmental crimes, tougher national regulations (mostly in Europe), inflammatory Internet blogs, and violent attacks on the key offices of fossil fuel industries. Although the horrific 2008 disaster caused the environmental movement and public attention to cross a fundamental threshold, knowing that environmental viability for life support was no longer assured, the world's dependence on fossil fuels continued.

Increasing damage from hurricanes, like those that hit New Orleans in 2005 and Houston in 2007, and drying water sources in India and China added to the intensity of the environmentalists' outrage at the inaction on climate change. Prior to the Indian Ocean nuclear catastrophe, political and corporate leaders gave emotional speeches full of beautiful rhetoric about sustainable development but they acted with little urgency; they congratulated themselves over agreements that were trivial compared with the enormity of the situation and the task to be achieved. This caused a gathering potential firestorm of resentment and anger in the environmental movement that just needed a spark to spread worldwide.

It is ironic that the spark was a nuclear accident, rather than emerging climate changes, that led to environmentalists' greater focus against the global fossil fuel industries. Since the growth in nuclear energy was essentially stopped by the environmental movement by the mid-1970s, and the 2008 catastrophe killed all future plans to build new nuclear power plants, the fossil fuel industry became the next logical target. Their mission was to change the world's energy sources to non-nuclear, non-fossil fuels for baseload electricity and transportation power. Self-organized groups set out to destroy any obstacle blocking this change. Although the nuclear disaster got it going, it was the continuing evidence of climate change that sustained the movement. Today the Gulf Stream has shifted enough that it brings less heat north, making Europe colder[1]. It was difficult to believe—climate change made Europe slowly warmer, and then made it cooler, bankrupting farmers, increasing heating costs, and depressing not only some economies but also the spirits of many Europeans who now expect to eventually have a climate more similar to Canada's.

Environmentalists have endorsed nonviolent civil disobedience since early-twentieth-century protests at the Hoover Dam in the United States, but even before the Indian Ocean catastrophe increasing numbers had begun to talk about more serious sabotage of the fossil fuel industry because people were not taking global warming seriously enough. Even during the 1990s there were attacks on oil company facilities and kidnappings of employees that had been largely kept out of the press, for fear of copycat attacks. These and subsequent scattered attacks on oil companies, automobile manufacturers, and large car dealerships were unable to make much impact on fossil fuel consumption. The potential targets were too numerous and diverse. Should the saboteurs hit drillers, refineries, pipelines, tankers, storage tanks, truckers, gas stations, car manufacturers, consumers, corporate headquarters... what?

The daily reports of new impacts from the radioactive material seeping into the Indian Ocean got so many people enraged that coordinating attacks and setting priorities for targets became irrelevant. The radiation pollution from the accident spread along the populated continent of India and neighboring areas, causing bitter political disputes between the states. Activist groups organized themselves in the U.S., Europe, Asia, and Latin America. They chose the most convenient target at hand that would make national and international news and used cell phone cameras to get dramatic images on Internet blogs that fed the media.

The new environmental movement took many forms. "Green Smart" emerged as a loose network of architects and engineers that became a force in urban planning and alternative communities around the world and made inroads in rural agriculture. "Save Gaia" radicals hit oil pipelines in the Middle East and the United States with assaults that disrupted supply by 5% for a month, and they carried out a series of cyber attacks on oil and car companies' financial systems. In the middle were "moderate radicals" and university students who marched on the United Nations, the World Bank, parliaments, newsrooms, and corporate headquarters of leading energy companies around the world.

The Save Gaia bombers were protesting the way the world was run, the way the wealthy spent their money, and the superficial values spread by the media throughout the world that kept people pursuing irrelevant consumption while the life-support systems of nature were being

[1] http://www.soc.soton.ac.uk/index.php?pagetype=display_news&idx=303

destroyed. These radicals wanted to take the profit motive out of environmental destruction by targeting and causing economic damage to fossil-fuel-related businesses. They spread rumors via the Internet to affect stock prices and got employees of conscience to resign. Save Gaia had many political and economic sympathizers—those opposing globalization, free trade, cartels, imperialism, and the status quo in general—who saw the movement working to their advantage.

The backlash took many forms. In Nigeria, the environmental and economic pillage of many areas of the country by government officials and oil companies had created militant groups that grew in strength every year, kidnapping hundreds of oil company employees and both stealing from and attacking pipelines. The risks to the oil companies seemed to have no end. Finally, they took matters into their own hands. They hired militants, environmentalists, and economic development professionals to create development programs around the oil-producing areas. It was far more cost-effective to get ahead of the problem by working with the militants than to expect the government to provide a safe and reliable working environment.

On the legal front in North America, Friends of the Earth and Greenpeace achieved a precedent-setting victory in the ExxonMobil lawsuit on climate change; like the previous judgments against the tobacco industry, the ExxonMobil verdict shocked the business world. That was the key event that let the fossil fuel industry know that the rules of the game had changed forever.

ExxonMobil was convicted of causing up to 4% of the economic losses due to global warming and had to pay this amount to the Global R&D Fund established by the G8's GLEEM Plan for alternative energy systems. It nearly bankrupted the company, but corporate leaders negotiated payment terms while integrating environmentalists into their diversification planning, and the company may well survive. Business executives in other major oil and automobile companies scrambled to create crash programs to drastically reduce their greenhouse gas emissions and fit into the plan. This paved the way for the post-Kyoto international agreement to reduce greenhouse gas emissions to 1970 levels.

Environmentalists were brought in to work with company engineers to help their businesses become greener. Some diversified into alternative energy sources. Others got into "green agribusiness," such as seawater agriculture, synthetic photosynthesis to produce alcohol fuels, and massive tropical forest growth programs for carbon credits. Still others improved energy efficiency by retrofitting buildings for better use of sunlight for heating and for producing local electricity from nanoplastic photovoltaics.

Environmentalists became extensively involved in training and education to show how to be more energy-efficient and to change cultural attitudes. They also worked with politicians to standardize and internationalize carbon taxes, road taxes, product labeling, and other incentives and taxes to allow the market to adjust to the new conditions.

Some energy executives and environmentalists just could not work together, making their efforts a complete waste of time. Some others who were merely paying lip service to environmental concerns got caught up the excitement of re-educating their markets about clean, more-efficient and more-profitable businesses alternatives. Public education for cultural change is exciting. The burst of corporate innovations encouraged governments to create environmental taxation and

emission trading systems to ensure a level playing field for business. Governments began to expedite the process of getting innovations to market and streamlined the permits within a comprehensive framework. For example, many old abandoned oil and gas fields in high wind areas were converted to wind energy sites as the result of government incentives.

Architects increasingly integrated the concepts of ecology and architecture,[2] creating a range of "arcologies" in new construction projects that reduced heating and cooling costs. Urban systems ecology became a popular major in universities as success stories of matching industries whose waste was an input to the production requirement of others became known.

Backlash Changes Business as Usual

The environmental backlash helped make brainpower, determination, altruism, and honesty more fashionable in the energy industry than the previous mindset of corporate loyalty and short-term bottom-line thinking. Luxury businesses worked with Green Smart and other environmental groups to make top-quality products that were energy-efficient, environmentally friendly, and educationally significant. Even advertising agencies, movie producers, and rock video choreographers began to use more images and concepts that reinforced the honor of environmental stewardship.

New rules mandating stronger fuel flexibility in cars in Brazil also resulted in a large, new biofuels industry gasifying parts of the sugarcane plant previously unused (and other plants) to produce "Fischer-Tropsch" liquids, which allowed Brazil to export most of its ethanol to other nations by 2015 and to become "the new Saudi Arabia" of the Green Era.

Nevertheless, increasing oil prices, the nuclear accident, and a range of environmental backlashes created recessions and depressions around the world. Countries that decided to cut oil dependency avoided many of these economic problems. Sweden moved from being 77% dependent on oil for its energy in 1970 to 32% in 2005 and zero by 2020.[3] Iceland hopes by 2050 to power all its cars and boats with hydrogen made from electricity drawn mostly from its geothermal resources. By 2011 Brazil powered 80% of its transport fleet with ethanol derived mainly from sugarcane and is now nearly free of oil requirements for transportation. Sugarcane is the best cultivated plant for capturing CO_2.

The Eminent Scientists Group appointed by the UN Secretary General created the definitions of terms, standards, and measurements that proved necessary for effective political and economic polices. These common measures helped the establishment and implementation of environmental tax incentives, product labels (such as energy per unit), and international sanctions on violators of a series of UN treaties related to sustainable development. Improved biochemical sensors and their prevalence due in part to counterterrorism efforts have reinforced the use of these scientifically determined definitions and measures. Offenders were more easily spotted and exposed to the press, which helped generate the political will for enforcement. With these

[2] For current examples of archeology see http://www.arcosanti.org/
[3] http://www.sweden.gov.se/sb/d/3212/a/51058;jsessionid=aRO1qHEpCvAg

changes in policy and technology, and with an increasingly informed global market, businesses competed to show their "environmental correctness."

The Green Smart label has become the most sought-after product endorsement due to its strict environmental standards and public relations plan that lists the best to the worst companies and countries in the world. Companies had little choice but to be rated by these standards.[4] Highly energy-efficient companies with excellent environmental impact audits received some tax advantages and attracted more investments and international market access than those that did not get favorable reports. They were also nearly immune from health, safety, and environmental lawsuits, which attracted even more investors to buy their stocks.

Some companies that used environmentally sound production practices created their own green labels to gain a competitive advantage. "Green" producers and consumers united in political movements that changed waste-subsidizing government policies. Utilities began charging for the real costs of water, nuclear energy, and so on. Buying clubs and consumer unions encouraged people to purchase from companies that used more environmentally friendly industrial processes. The merger of many educational activities of the environmental movement and human rights groups, in collaboration with many leading multinational corporations and the global inter-religious discourses, helped to establish reasonably clean air and water and healthy soil on the political agenda as a human basic right rather than just a factor in economic cost/benefit analyses. Environmental stewardship has increasingly been added as a moral responsibility in the preaching of religions. It became almost unthinkable to propose an environmentally dangerous project.

The Wealthy Step In

The successes of George Soros in the development of the transition economies, Ted Turner in the United Nations, and Bill Gates in international health programs laid the foundation for many wealthy individuals to support the GLEEM Plan. For example, CEOs of some of the largest businesses in the world gave each other awards for who had implemented the most change in their own corporations to support the Plan. Vast PR campaigns promoted the awards and their achievements. In China, several new billionaires constructed eco-industrial parks to display green production systems and habitats that become a new alterative to Disneyland. Local charities sprang up to support small- and medium-sized companies to become more green. Larger companies got tax incentives to help smaller ones. Others that contributed to the R&D Fund called for in the Plan received tax credits from their governments. Some even painted their private planes green as a statement that their corporations supported the GLEEM Plan.

Several wealthy scientists endowed Scientists for Global Renewal to promote the best scientific conclusions on how to implement the Plan by giving its own World Energy Science Prize and opposed the activist groups who lobbied for actions with little scientific evidence. Philanthropists, celebrities, and media stars in Europe set up LeapFrog to help poorer countries skip as many of the industrial stages in the transition from subsistence farming to the knowledge

[4] Some less well known rating systems are already in place: http://www.csrwire.com/article.cgi/5008.html

economy as possible, while supporting sustainable energy technology. Major parts of the Congo basin were bought by a club of the 100 richest individuals in China to prevent what happened to Amazonia. The three richest entrepreneurs in India financially leveraged the major water projects in Asia. Some of the wealthiest people in the Middle East have turned around several major desertification areas in the world.

Smaller investors also had a way to participate financially in the environmental backlash by investing in international funds such as the Green Brick (composed of the top 10 Green Smart companies in Brazil, Russia, India, China, and Korea) and GreenMap (composed of the most promising companies, regardless of location, that are producing the technologies within the GLEEM road map).

GLEEM in the World's Eye

The GLEEM Plan had 13 elements:

- Establishment of the World Energy Organization as a unique transinstitution of self-selected governments, corporations (both for profit and not-for-profit), national academies of sciences, and international organizations (such as the International Atomic Energy Agency and what became INSOLSAT, the International Solar Satellite Consortium based on the INTELSAT model).
- Periodic meetings of a council to review the Plan and amend long-term plans as necessary to reduce further energy-environment problems.
- A long-term R&D Energy Fund administered by the WEO to provide a global focus for business, government, university, and individual efforts to invest in energy and sustainable development projects that were scientifically sound, not already being pursued, too distant to attract venture capital, and unable to receive funds by individual governments if acting alone. The resulting products and processes would have lower costs and license fees, applying the principles of how the costs of AIDS medicines were lowered.
- Establishment of a World Energy Prize for proven technology ready for massive investment for international proliferation.
- A trust fund, administered by IAEA, to finance the dismantling of dangerous plants (Chernobyl-type) and the management of nuclear waste.
- Creation of a Meta Internet to make the world's energy-environment knowledge more easily available, including implementation status and road maps for transparent access to the current status and future prospects of the global energy-environment nexus and nearly real-time information from the many centers that analyze risks, benefits, and time-to-impact of various energy and environmental projects in a standard user-friendly format that nonscientists can understand, including politicians.
- Harmonization of environmental treaties leading to a common set of government policies (including local energy management agencies), technological and management standards, measurements of impacts, and incentives (including international agreements on taxation of fuels for international air and water transport and an authoritative unique Global Green Label with a related energy ratings standard for consumer products) to save energy and produce it more safely.

- Designation of the WTO to enforce environmental and energy standards in trade as set by the United Nations Eminent Scientists Group.
- An International Court of Environmental Arbitration and Conciliation created as a complement to the WTO and the International Criminal Court to strengthen enforcement of international agreements and provide a common dispute settlement mechanism with reliance on bio-nanosensors and satellite networks.
- A world education program by UNESCO in cooperation with WEO, UNEP, and the UN University to support the production of Internet events, computer games, music videos, and additions to school curricula to help ensure that the next generation will continue the transition to a more sustainable world.
- A Global Partnership for Development to promote a series of partnerships among high- and low-income peoples, corporations, and civil society groups to improve energy applications and economic development.
- Establishment of a special agency to help the expansion of the U.S. Peace Corps, British Voluntary Service Overseas, UN Volunteers, and various forms of tele-volunteers to help support energy-environmental local initiatives in developing countries, technology transfer, and training and to ease the burden of such country's compliance with the new regulations in coordination with the WEO.
- Launching of a Post-Kyoto Protocol that was beneficial economically and environmentally to both rich and poor countries.

Many science and technology forums sprang up to exchange best energy-environment practices that helped keep media attention on progress and regress on these elements of the Plan. These fed the ongoing assessment of the Plan available to all on the Meta Internet Web site.

The GLEEM Plan's R&D helped further novel technologies that served as non-fossil, non-nuclear fuels or significantly improved the efficiency of their use. The key funding categories were energy for transportation in developing countries; universal access to electricity; carbon capture, separation, storage, and reuse; and the gap between R&D and commercialization. New projects included portable sources, energy storage systems, decommissioning of nuclear power plants, and nuclear waste management. WEO also helped to implement policies—such as the elimination of energy subsidies and tax incentives—that perpetuated the status quo and stifled development of alternative sources.

Government Helps the Plan

The scientific energy measurements and standards defined by the UN Eminent Scientists Group were used to set energy pricing policies to reflect the external and environmental impacts of energy production and use. Governments, in partnership with environmental scientists and the private sector, created carbon taxes ($50 per ton)[5] and fees for the most environmentally damaging activities. All stages of the production process were included (extraction, production, distribution, and consumption). A portion of the revenues subsidized R&D for more environmentally sound technologies and provided incentives for use of such technologies,

[5] All US dollar references are in 2006 value, not forecasted to 2020 value)

goods, and equipment. Governments allocated some of the income to be administered internationally by the WEO long-term R&D Energy Fund.

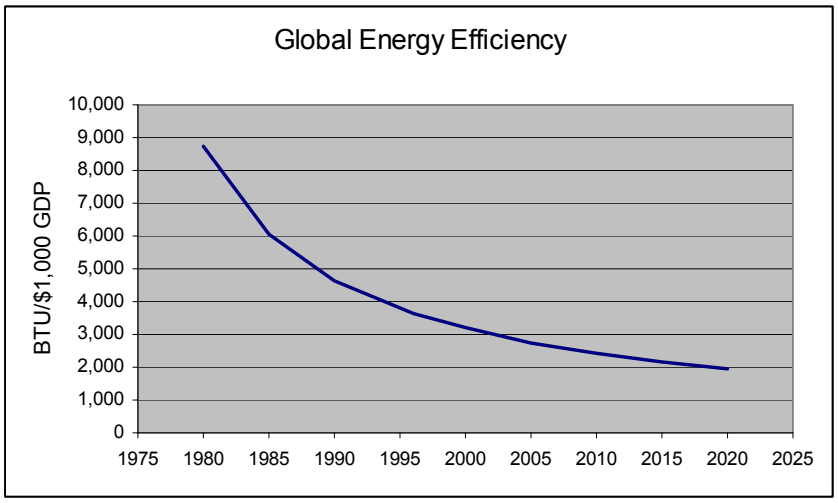
As the cost of adding carbon capture and storage sank below the carbon trading fees, the use of CO_2 sequestration accelerated around the world. Nearly all countries have consumption standards for vehicles (new and old) and some have had to ration energy and water usage. Many parts of China and India still do so today, which is the key limiting factor to their rates of economic growth. These governments supported new solar Stirling technologies that are now used to convert CO_2 streams into useful liquid fuels, based on complex molecules combining nitrogen-based compounds with small amounts of carbon for stability and safety.

Carbon trading has been practiced by the majority of the top 50 emitting countries since 2010; funds from this activity are used both for local environment-energy projects and for the Global R&D fund.

With assistance from UNEP, the World Bank, and the UN regional economic commissions, most governments today have a system of national accounts that includes the economic impacts of the depletion of natural resources. The Sustainable Development Index is now used to help countries set national priorities. Most corporations of any size have used the ISO 14001 Environmental Management System to create their own EMS to continually improve their environmental profile.

These policy changes, plus the continuing technological breakthroughs and some cultural changes, have begun to have some impact on the energy-environment nexus. For example, the energy efficiency of the world economy has continued to improve.[6] (See Figure 2-6)

Figure 2-6: Global Energy Efficiency



Source: The Millennium Project based on IEA data and Round 1 inputs

[6] This curve was derived using CurveExpert. The shape is "saturation growth rate"

What Happened Next?
…If It Ain't Fit, Retrofit

Government incentives helped stimulate retrofits in such green technologies as photovoltaic roofing tiles and walls for buildings, better use of natural light for heating as well as saving electricity, more-efficient windows, and liquid crystal display lighting (solid state lighting that puts the right photon at the right place at the right time in the right color and with the desired intensity) that is 10 times more efficient than conventional lighting. Even shading over parking garages in India and China is being replaced by photovoltaic nanotech sheeting to produce extra income for parking lot owners. Cars and trucks have been retrofitted for different fuels. Rooftops from Egypt to Ecuador are getting solar panels.

However, some of the biggest retrofits that are beginning to alter the energy situation are the additions of CO_2 capture and storage mechanisms in fossil fuel plants and home heating systems and improvements to temperature control in buildings. Improved insulation of existing buildings, heat-controlling paints and surfacings, air conditioning systems, and retrofits to recover and use "waste" heat are reducing energy consumption.

Improved standards for new buildings (insulation, spatial orientation, ratio of windows, efficient heating/cooling systems, and localized energy production) should also improve conditions. The use of low-cost highly efficient energy storage systems that complement solar roofs and other developments are allowing some individuals to go "off-grid."

The development and recycling of non-fossil environmentally friendly materials for repair of roads and highways is beginning to reduce the need for asphalt. First-generation photovoltaics are being replaced with advanced nanomaterials that absorb solar energy more efficiently. Wherever feasible, nanotubes are replacing transmission wire in much of the world to conduct electricity more efficiently. This has had the same effect as producing a new source of energy without greenhouse gases or nuclear waste.

Many cars built since 2015 remove CO_2 from exhaust gases by chemical absorption with solvents. Businesses that retrofit their previously built cars with this new carbon capture equipment are growing around the world—and fast!

Energy storage was dramatically improved by replacing old batteries with those using a range of nanotube applications.[7] These new "nanobatteries" plus the three-dimensional computer chips with nanotubes have drastically cut the computer drain on the electric grids that just 15 years ago accounted for nearly 20% of electric usage in high-tech areas of the world.

The retrofit craze to get tax incentives could have been more effective if more people had conducted pre- and post-analysis on life-cycle financial and ecological cost-effects before installation. Nevertheless, the global infrastructure is being made more efficient.

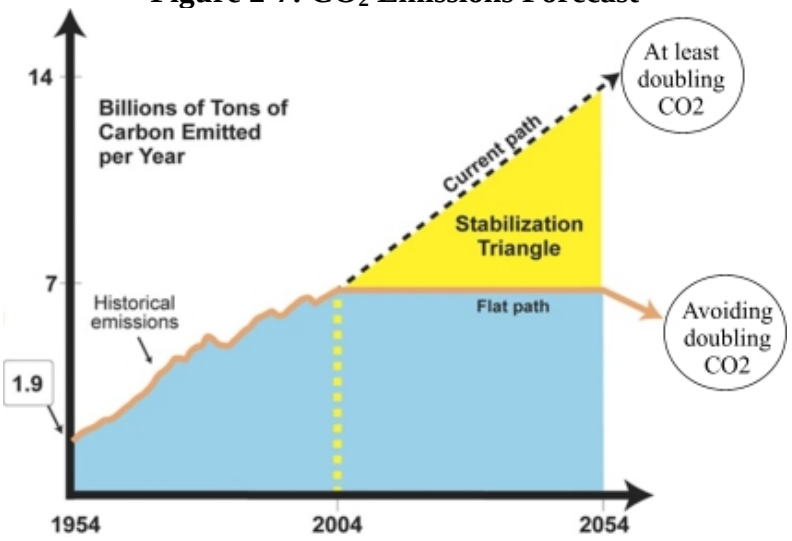
[7] Draft paper by Dennis Bushnell, Chief Scientist, NASA Langley Research Center d.m.bushnell@larc.nasa.gov

Transportation

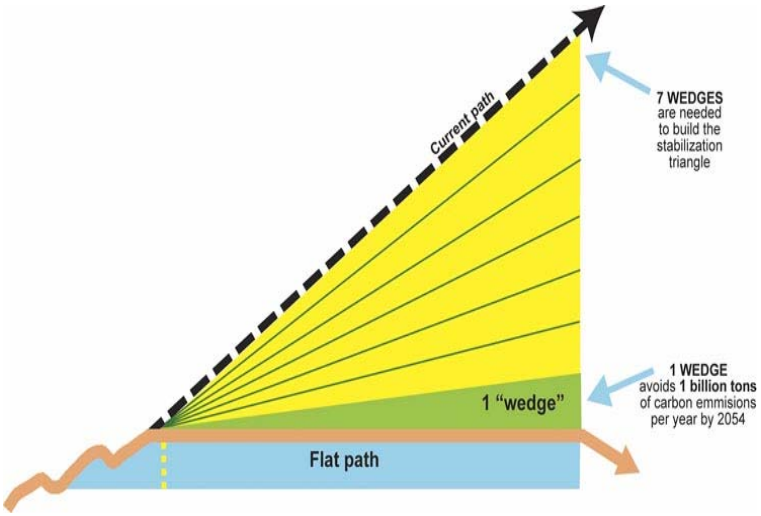
Genetically engineered synthetic life that can create hydrogen and biofuels like ethanol and methanol has been developed.[8] This marked the historic transition from reading genetic code to writing it. Genetic codes were specifically written from data banks of genetic information that produced life forms that now create hydrogen and ethanol in the presence of sunlight in a manner similar to how plants produce oxygen. Bio-hydrogen factories are beginning to produce large enough volumes to begin to be a source of reliable fuel for transportation. Although scaling up has been difficult, this approach could one day be a major source of hydrogen.

In response to the G8's GLEEM Plan, the major oil companies and automobile industry leaders met with environmental leaders and scientists to work out a road map to cut carbon emissions dramatically. (See Figure 2-3) This included bio-hydrogen, electric cars, biofuels, and many ways to improve efficiencies. Even several years before the Plan, BP[9] led the oil industry to the attempt to stabilize carbon dioxide in the atmosphere (back in 2003, the transport sector accounted for about 27%[10] of U.S. GHG emissions). Some in the oil industry tried to find ways for the fossil fuel industries and consumers to reduce the amount of annual emissions of carbon from all sources to 7 billion tons by 2020, while continuing economic growth. Although 9 billion tons of carbon are now emitted, it is much better than the old forecast that there would be 12 billion tons.[11]

Figure 2-7: CO_2 Emissions Forecast



[8] http://www.syntheticgenomics.com/
[9] http://www.bp.com/sectiongenericarticle.do?categoryId=9008205&contentId=7015200
[10] http://www.epa.gov/otaq/climate/420r06003summary.htm
[11] It is 7 billion tons of carbon in 2004, which can be translated into about 25 billion tons of CO_2. http://www.bp.com/genericarticle.do?categoryId=98&contentId=7000452. (see section on Climate Change)



Source for both graphs: Princeton University Press Release[12]

Others did not take this seriously, since it would mean either building 4,900 nuclear plants around the world to replace a sufficient number of fossil-fuel-burning power plants or increasing the use of solar power by an impossibly large amount. Still, three years later, when the nuclear accident took the nuclear solution off the table, the oil industries realized that fundamental changes were necessary.

In this search for fundamental change, some transportation and energy companies followed Brazil's leadership and led the fight for governments to pass regulations mandating flexible fuel vehicles that could use gasoline, ethanol, methanol, or mixtures of these fuels. As early as 2005, over 30% of Brazil's gasoline demand was met by ethanol, while ethanol provided only 2% in the United States. This open standard for fuel competition provided the final incentives to make the less costly fuels more widely available.

When it was realized that less than 6% of the U.S. land mass could produce enough biomass to supply that country with its oil and natural gas needs, it became a national security issue in the U.S. Congress, which passed the biomass energy bill. Granted, there was not the accompanying reliable water necessary to produce all that biomass, but the bill spurred the R&D that helped the world make enough fundamental changes so that today 19% of all new cars use biofuels.

Biofuel production used to rely on fossil energy to convert biological sugars to transportation fuels. Even with the use of fossil energy to make the biofuels, their greenhouse gas emissions were 20–50% lower than those of petroleum fuels. Fossil fuels are now replaced with nanotech solar strips of photovoltaics layered for catching photons of the most efficient wavelengths. This, plus the use of cellulosic ethanol production techniques, now allows biofuels to be considered "greenhouse gas neutral" because the amount of CO_2 plants take from the atmosphere when growing is roughly equal to what they give back when burned as fuel.

Biodiesel fuel production got an early boost when the EU mandated that 5.7% of its diesel fuel

[12] http://www.bp.com/genericarticle.do?categoryId=98&contentId=7000452

be biodiesel by 2010. Biofuel production has now replaced 10% of petroleum usage.[13] This should increase if the terraforming of Earth's coastlines by seawater agriculture continues. Biofuels have become a new form of wealth for previously impoverished rural areas of the world. For example, biofuels from sugarcane helped the Haitian economic recovery, and seawater agriculture helped reduce poverty along the coast of East Africa and Somalia.

Although this prevents further damage, it does not solve the problem of climate change. Additional ways had to be found to sequester the excessive global warming gases. Green Smart engineers have been testing nanotechnology applications to exhaust systems to reduce CO_2 emissions. The use of nanotech on the surface of buildings to strip carbon from the air is a source for future molecular manufacturing applications. Massive tree plantings have helped, but they have only reduced the growth rate of carbon in the atmosphere without turning it around. However, the uses of advanced composites, ceramics, nanotubes, plastics, and lightweight-steel have more than doubled the efficiency of cars and trucks, which has reduced emissions proportionally.[14]

The promise of the hydrogen economy is still just a promise—but an attractive future possibility. There are many alternative production methods and applications for hydrogen, and more than 7% of all new cars are powered by hydrogen today; nevertheless, it has not become the dominant fuel yet. Many would not buy hydrogen cars before sufficient numbers of local gas stations carried hydrogen, and few hydrogen producers and car manufacturers would take the risk of investing in distribution systems and new car designs that might not sell.

The global R&D fund in the GLEEM Plan might have more substantially funded the development of hydrogen by reducing the investment risks, but a new problem was discovered. To achieve a 50% reduction in oil used for transportation (in the United States, for example, in 20 years by using hydrogen fuel cell cars), half the new cars sold within five years would have to be running on hydrogen. Since that seemed unlikely, the hydrogen enthusiasm began to wane, not to mention that the hydrogen production might have to come from water electrolysis using electricity generated by many new nuclear power plants that the environmentalists would protest. Nevertheless, some dedicated truck fleets used a combined system of hydrogen with ammonia.

The use of metal hydrides, which store hydrogen at densities approaching liquid hydrogen, is being developed. Just a little increase in temperature releases the hydrogen. The depleted block of metal hydrides could be replaced at gas stations with a new "charge," just like a battery. However, the process is still very new and it is notyet clear if it will succeed. In 2010, a magnesium alloy with a modified nanostructure was shown to store enough hydrogen to allow a vehicle to drive 500 kilometers, but commercialization has been slow because of very high production costs and technical problems, such as the requirement for operation at 350–400?C, still have not been economically resolved. Hydrogen suppliers have not been able to support the massive level of hydrogen distribution infrastructure needed to entice vehicle manufacturers and drivers to switch. Chemical hydrides and carbon nanostructure materials operating at lower temperatures than metal hydrides are becoming competitive in R&D trials.

[13] http://europe.eu.int/comm/energy/res/sectors/bioenergy_en.htm
[14] http://www.oilendgame.com/ExecutiveSummary.html

Electric cars are more acceptable now that nanomaterial batteries improved the weight-storage ratio. They account for 15.4% of all cars sold in 2020. As a result, China's long-term strategy to be the world's leader in electric cars has paid off, and China now sells over a million cars a year. China accounts for over 50% of all new electric cars sold in the world. Granted, the majority of them are sold within the country, but their success has gone a long way toward changing world opinion about that nation's earlier air and water polluting practices.

Hybrids are still the most popular, accounting for 31.7% of all new cars sold in 2020. Their owners can now plug them in at night to get the previously unused power in the electric grids to recharge their cars. Hence, electric plug-in hybrid cars with flexible fuels acquired the "Green Smart" image along with the Chinese electric cars. Pure electric cars were exempt from road taxes, congestion charges, and other similar state fees. Some cities—Paris, São Paulo, Tokyo, and Mexico City—have been offering free parking for electric cars for several years now, while most major cities have significant areas that are closed to private vehicle traffic. Where this is being done, the picture of urban-cloaking congestion is beginning to fade.

The use of natural gas in cars has not grown significantly because such vehicles do not address the issue of CO_2 production in a manner that is significantly better than gasoline-powered cars. And, like oil, natural gas would also run out one day.

New uses of nanotubes, ceramics, and plastics reduced the weight of cars and trucks, which in turn lowered the amount of carbon emissions per mile traveled. Fuel cell cars with methanol in the tank, electric cars, and advanced Stirling engines are expected to reduce this even further.

Gasoline vehicles still account for 26.5% of all those sold around the world in 2020. Although some expected the power of OPEC to become nearly hegemonic as non-OPEC countries passed their peak oil production in 2010, Canada has become an energy powerhouse. When the United States finally realized that the Canadian oil sands could actually replace Middle Eastern oil, investments poured into western Canada, like the California gold rush. There was no political risk and no exploration costs, since Alberta was covered in the black muck. Worried by the Save Gaia attacks, the oil managers had a series of high-profile meetings with moderate environmentalists to make less damaging extraction and production plans. When the political risks subsided in Venezuela, it too received major investments into tar sands and heavy oil production around the Orinoco basin, estimated to hold 1.3 trillion barrels of oil equivalent, and became an important factor in world energy. Despite these new sources, gasoline was a dying fuel and the replacements all were seen to have finite lifetimes.

Electricity

The need for new electric production has grown dramatically due to increasing population and wealth, more electric cars, new desalination plants, and the closing of nuclear power plants (over 300 of the 443 nuclear power plants and the 25 under construction around the world in 2005 have been decommissioned by 2020). Even with the 20.7% improvement in total energy efficiency over the past 15 years, the demand cannot be fully met. Electricity is rationed in

China, India, and intermittently in many other countries. There are 1.2 billion people without reliable access to electricity today.

Coal and natural gas still produce the majority of our electricity today, but the alternatives in solar, wind, and biomass are catching up. The environmental movement has affected some fossil fuel demand, but not enough to stop climate change. The greatest growth in kilowatt-hours of electricity from solar between 2010 and 2020 was due to new technology, government policies, public education, and the increasing prices of fossil fuels. Solar concentrators, mass production of thin plastic film photovoltaics with better use of nanotechnology, and solar paints lowered costs and increased efficiencies. The GLEEM plan and the WEO promoted these technologies around the globe.

With these advances in solar energy technology, governments began to make installation of solar electricity and water heating systems mandatory in all new government and some commercial buildings. They also subsidized some forms of production and gave tax incentives to buyers. Energy historians credit the "California Solar Initiative" back in 2006 as the key event in solar electric's growth that uses $2.3 billion to accelerate solar electric production.

Farmers around the world added extra income from wind energy, which had little negative effect on agricultural output. Nearly half of Denmark's electricity comes from wind. Offshore wind supplies a growing proportion of the rest of Europe's electricity. Even the United States gets much of its electricity from the winds of North Dakota, Kansas, and Texas. Five years ago the construction of great ocean wind farms began in earnest; these farms are expected to account for at least 5% of world electric production by 2030. Some of this will be wirelessly transmitted via satellite to the electric grids around the world and some will produce hydrogen to be transported by sea.

The joint report of the EU-China nZEC (Near Zero Emissions Coal) project and the FutureGen project of the U.S. released in early 2019 demonstrated the engineering feasibility of coal gasification with carbon capture and storage, while producing hydrogen. Its commercial viability is yet to be determined, however, but even when it is, it will take another 20 years—until 2040, at least—to build enough new plants and retrofit existing ones to have much effect on climate change.

Also coming into question is the growing world dependence on natural gas. Although its supply would last longer than oil, it too would be gone one day and its use also emits greenhouse gases. So some asked why not use the peak oil frenzy and climate change issues to try and fix the energy problems with truly long-term solutions. As a result, further development of natural gas supplies seems short-term, and additional investment has diminished recently.

Additional Innovations

As the world has moved to ubiquitous computing and communications, the need for local and portable energy has grown dramatically. Mini methanol-fueled fuel cells now power most wearable and portable electronic and photonic appliances. There are also fashionable nano-solar

accessories added to clothing and bags.

On a larger scale, and as the International Space Station neared completion, the consortium of countries that built the ISS plus China, Brazil, India, and Korea have begun to throw their weight behind space solar power.[15] When the environmental movement finally realized that space solar power had a better chance of success than any other approach to non-fossil, non-nuclear energy to supply the world's needs indefinitely at costs comparable to or less than today's electricity prices, many began to support the establishment of INSOLSAT. This triggered massive international funding for space solar power. The first commercial orbital solar electric satellite and receiving antenna on Earth feeding electricity to the terrestrial grids is expected to go online by 2030. Income potential should be enormous, and private industries want to participate with government investments. An agreement was reached. Today governments account for 50% of the investments in INSOLSAT, while the oil industries have 25%, automobile industries 15%, electric utilities 5%, and private investors the last 5%.

At first, the concept of space solar electric power had no natural allies. Initially the environmental movement opposed it, as being big science, centralized technology, and environmentally dangerous. Some governments and the nuclear industries saw it as a long-term competitor for providing baseload electricity without CO_2 emissions and tried to co-opt environmentalists to oppose it. Ground solar and other alternative renewable energy players saw it as competition for R&D funds and associated it with Star Wars fantasy hightech. NASA saw it as cutting into their International Space Station priorities, arguing that they could get only one major project funded at a time. So when the ISS was essentially complete in 2011, NASA began to openly support space solar electric power.

Surprising support for the idea of wireless energy transmission via satellite came from African countries of the Sahel. They had little invested in energy plants and lobbied the World Energy Organization members to invest in wireless energy transmission from their desert solar photovoltaics to satellite relay systems. Tele-robotic assembly in Earth orbit has begun; the initial test of a solar satellite in orbit is scheduled for next year. The design objective is for 90% efficiency in the wireless energy transmission from orbit to Earth. Japan has announced that if the consortium breaks down, it is prepared to continue building orbital solar power satellites on its own for commercial operations by 2040, potentially making it a major suppler for electric grids around the world.

In the meantime, coal is still the main energy source for electric power generation today, and much important work to reduce its pollution and emissions has been done and is continuing. Nevertheless, the global momentum is now irreversibly moving toward non-fossil renewable power generation sources, completing the more-efficient electric grids around the world, and getting inexpensive electricity to the billion people who still do not have access. There is also an evolving decentralized network for energy, which provides local energy for increasing numbers of people.

[15] Space Solar Power research program see http://space-power.grc.nasa.gov/ppo/publications/sctm/ for background see http://www.spaceref.com/directory/future_technology/solar_power_satellites/

Work Smart—at Home—from Mumbai to Mexico City

Tele-work, work-at-home, and flexible time have finally become acceptable for many information and knowledge workers around the world, saving energy, increasing productivity, and allowing families to raise their children more easily. Although some expected problems of social disintegration, children got more attention from their parents, and previously isolated neighbors had more time together.

The initial successes of China's sustainable communities and Finland's Information Society Initiative for international development (which put small computer transceivers in the hands of millions of poor people around the world by 2012) helped trigger the World Bank-Linux-MIT-Google work smart economic development programs in many developing regions as well as richer megacities. This helped reduce the growing demand on urban public and private transportation systems, which are still congested—but less so—in part due to the price of oil, which still hovers around $123 per barrel in 2020.

The "return to the future" movement was in part caused by intolerable urban congestion. Green Smart engineers and energy-environment NGOs worked with private and public land developers to create high-tech environmentally sustainable communities in different settings around the world. These communities were designed for foot, bicycle, and electric vehicle transportation, reduced material consumerism, increased knowledge and esthetic consumerism, and included sylvan spaces throughout the built environment. Often these communities were built for fewer than 2,000 people.

Seawater Agriculture

Proponents of biomass fuels had difficulty proving that there was enough sustainable water to provide reliable large-scale substitution for petroleum. Then they discovered the value of coastal deserts for seawater agriculture. After a series of meetings among the Food and Agriculture Organization, the International Food Policy Research Institute, NASA, and USAID, the World Summit on the Energy-Food Nexus was held in New Delhi, India, to secure agreements to initiate very large-scale seawater agriculture. Vast desert coastlines like those of Somalia were selected to become salty Gardens of Eden by growing salt-tolerant plants on beaches for biofuels, fertilizers, and food. Large-scale saltwater agriculture also had the effect of raising water tables and absorbing CO_2.

The initial successes of saltwater agriculture in the Persian-Arabian Gulf, China, and some of the coastal deserts in Baja California have begun to "reclaim" or desalinate the land, allowing for new channels to be dug that now bring additional seawater further inland to deserts. Of the 10,000 natural halophyte plants, more than 100 have been used for food or biofuel factories. With genetic modifications, many more—such as rice, tomatoes, wheat, and maize—are now grown in salty conditions. This turned out to be very important, since climate change reduced the yields of these crops in China and India.

Desert sunlight also produced electricity via nanotech plastic—highly efficient photovoltaic strips to run the biofuel plants and support the emerging coastal desert communities.

In the desert interiors like the Sahara, 10-mile-long robotically managed closed-environment agricultural tubes, interspersed with nanotech photovoltaic strips, are beginning to produce sufficient food for Africa and exports to Asia. Surplus energy from the strips is planned to be exported by microwave to Earth orbital relay satellites and on to electric grids on the ground.

Animal Protein without Growing Animals

The price of meat, eggs, and milk began to increase dramatically around 2012 as the amount of land and animal feed required to meet world demand for animal protein could not be met. Simultaneously, the increasing urban demand for meat led to dense concentrations of animal production, and mutating pathogens in their wastes were found to cause a number of new diseases among livestock and humans.

Continual global disease threats were killing consumer confidence and the livestock sector. Alternatives had to be found. Public and private investments in the Netherlands began the new meat revolution. The amount of energy, land, water, fodder, and time to produce meat via animals had been called one of the greatest environmental and energy wastes in civilization. Thanks to the Dutch initiative, stem cells are now taken from the umbilical cord blood of cows, goats, and pigs to grow muscle tissue without the need to grow the entire animal. This has substantially reduced the threats of disease and bioterrorism, as well as the requirements for land, water, and energy. Even some vegetarians see this as a moral alternative to the conventional animal factories.

Educated Consumers

The race to educate the world about being Green Smart consumers began after the World Summit on Cognitive Development in 2010. Then, only about 1.5 billion people were connected to the Internet, compared with 3.5 billion today. Back in 2010, most institutions that had even a peripheral association with education began debating the most equitable and cost-effective ways to make everyone more knowledgeable, virtuous, intelligent, and Green Smart. Educational software was beginning to be imbedded into kitchens, people movers, jewelry, and anything that could hold a computer chip and nanotech transceiver. Now the interconnection of many separate programs into several global systems of education has created a cyberspace through which most people can receive the best education at their own pace, learning style, available time, and even language. Energy and environmental considerations in decisionmaking is a new focus of education, which in turn has significant impact on the number of energy-environmentally destructive purchases.

The Meta Internet is working smoothly, providing energy-environmental data that are married with an integrated global scholarly and scientific knowledge base that is far more user-friendly

today. It has increased the speed of problem-solving in all fields by providing a logically structured framework into which existing and newly acquired knowledge is placed and assimilated for examination, discussion, and extension by scientists and scholars worldwide and for a full range of educational applications and public access. Academic and business interests collaborated to create a sophisticated body of principles and techniques for knowledge visualization and the use of artificial intelligence to make it possible to navigate rapidly around the cumulative knowledge of the world. The speed of feedback from inquiry to intelligent response is so fast today that curiosity is becoming a normal mental state for most adults, which in turn exposes energy-environmentally destructive purchases to the now more educated consumer.

The promise of the information and knowledge economies to reduce the energy requirements for transportation is beginning to be felt around the world. The price of ICT interfaces has become so low by 2020 that many people in poorer regions of the world are now given free connections as part of employment benefits, rights of citizenship, insurance policies, marketing programs, and credit systems. This accelerated the diffusion of access to the Meta Internet within poorer countries. UNICEF, the World Health Organization, UNESCO, and some international development agencies also helped with distribution in poor regions. Speech recognition and synthesis, which is integrated into nearly everything, made technology transfer far more successful than originally deemed possible by the UN Development Programme's Tele-volunteers, who did much to help the poorest regions understand and use the benefits of these new technologies. As a result, many remote villages in the poorest countries have cyberspace access for tele-education, tele-work, tele-medicine, tele-commerce, and tele-nearly-anything. This helped reduce the energy consumed per unit of GDP.

In the past we had universal declarations and local ignorance, but increasingly all these efforts have added up to a more educated public around the world.

Results by 2020 and Foundations Laid for the Future

The sixth World Summit on Sustainable Development, held in 2017, reviewed the status of the GLEEM Plan and implementation of the energy-environment Interlinkage Convention that harmonized the hundreds of environmentally related treaties. The International Court of Environmental Arbitration and Conciliation and WTO have given teeth to these agreements.

Technological breakthroughs, regulatory changes, and increased public awareness of the energy-environment linkages have changed the mix of energy usage. For example, hybrid cars now outsell gasoline-only cars, and biofuel and electric cars are catching up fast. (SeeTable2-2.)

The big promise of nanotechnology to decrease manufacturing unit costs, requiring a smaller volume of materials and energy usage and hence lowering the environmental impact and increasing productivity, is just now on the horizon.[16]

In the meantime, over one-third of our transportation needs are still met by petroleum. The oil

[16] http://www.foresight.org/cms/press_center/128

producers also continue to supply the needs of aviation, plastic, and pharmaceutical industries for the foreseeable future.

Unfortunately, the dynamics set in motion over the past will continue climate change for some years to come. Although great gains have been made in both energy efficiency and the production of energy via non-greenhouse-producing systems, humans still emit about 9 billion tons of carbon per year. Granted, this is less than forecast back in 2005, but it is still too much, since the absorption capacity of carbon by oceans and forests is only about 3 billion tons per year. If we are to avoid the point of inflection for a serious runaway greenhouse effect, we still have to continue improving. We must hope that the new polices, technologies, and cultural patterns will make the impacts less traumatic that they might have been. As a result, those who died as a result of the Indian Ocean nuclear catastrophe will not have died in vain.

Table 2-2: Types of Vehicles Sold in 2020

New vehicles Sold in 2020	Percentage of sales in 2020[17]
Hybrid	31.7
Gasoline	26.5
Biofuels	19.0
Electricity	15.4
Hydrogen	9.5

Source: Millennium Project Global Energy Delphi Round 1

[17] These numbers add up 102.1% instead of 100%, because the individual estimates were averaged from Round 1 participants of the Global Energy Delphi. http://www.acunu.org/millennium/energy-delphi.html Rather than fit them to 100% the results are simple reported with the 2.1% variance.

Scenario 3: High-tech Economy – Technology Pushes Off the Limits

High growth in technological breakthroughs
Low environmental movement impacts
High economic growth
Few changes in geopolitics and war/peace/terrorism

In 2020, population has grown to 7.5 billion people, the global economy is approaching $80 trillion,[18] and the wireless Internet 4.0 is now connecting almost half of humanity. Synergies among nanotechnology, biotechnology, information technology, and cognitive science (commonly known as NBIC technologies)[19] have dramatically improved the human condition by increasing the availability of energy, food, and water and by connecting people and information anywhere, anytime. The positive effects are to increase collective intelligence and to create value and efficiency while lowering costs.

The acceleration of technological development has opened the door to continuous and rapid worldwide economic growth and has in fact allowed the world to achieve energy sustainability using many different energy sources. The NBIC technologies are proving to be the key to a very bright future, in which machines increasingly work so efficiently that the cost of goods continues to plummet and tremendous wealth is created faster and faster for everybody. All basic necessities, as well as intellectual and physical luxuries, can be accessible to even the poorest societies, thanks to a political system that has managed to keep world peace.

Space exploration, artificial intelligence, and robotics are close to a takeoff point that some experts refer to as a technological "singularity."[20] Meanwhile, Moore's Law continues to hold, and computers continuously become faster and more powerful. Quantum computing, 3D circuits, and subatomic particles have given new life to Moore's Law. It is expected that sometime soon the largest computers will have more transistors than humans have neurons in their brains. At that moment, artificial intelligence might overtake human intelligence, as some scientists suggest. That could be the beginning of an incredible scientific development, when humans can be transformed into more advanced life forms: transhumans and posthumans. In fact, already some cyborgs and clones are becoming accepted and normal in some societies, and their numbers are increasing faster than those of the so-called "naturals". Biological evolution, which is slow and erratic, will be overtaken by technological evolution, which is faster and directed. Humans will never be the same, and all thanks to the great new energy mix.

The Proper Energy Mix

It all started late in the twentieth century. In 1992, an official announcement by the World Energy Council (WEC), based in London, stated clearly that the planet was not running out of

[18] All dollars are in 2006 values.
[19] http://www.wtec.org/ConvergingTechnologies
[20] http://www.singularity.com/

energy resources. A few years later, the International Energy Agency (IEA), based in Paris, also confirmed that there was more than enough energy, including oil and gas, to last for many decades, maybe even centuries, thanks to the availability of new technologies.

Such news from two recognized institutions like the WEC and the IEA openly contradicted the pessimistic views of the previous reports of the Club of Rome, which had forecast in 1972 that the world would be running out of resources by the end of last century. The major problems with the Club of Rome's computer models and its *Limits to Growth* report were that they failed to consider technological change, they overlooked new energy sources (all the way from deeper resources within Earth to new energy sources outside the planet), and they did not include resource substitution. Predictably enough, technological change, discovery of new resources, and resource substitution have been the three key energy drivers in the twenty-first century. There may be other drivers playing an important role, like the move toward virtual presence replacing real presence and the demise of irresponsible environmental fanatics, but they have had a smaller effect up to now.

After the oil shocks from the early 1970s to the late 1980s, the price of oil declined in the 1990s and even dipped below $10 per barrel in 1998. During the early 2000s, however, a long period of underinvestment in the oil industry and the long and accelerating rise of China's economy pushed prices over $70 per barrel in 2005. That same year, Hurricane Katrina hit the Gulf of Mexico and destroyed many offshore platforms plus several petroleum installations in Louisiana and Texas. Gasoline prices rose momentarily above $3 per gallon in the US and close to €2 per liter in some European countries. During the 2006 State of the Union address, US President George W. Bush said that his country had an "addiction to oil" and that the US should reduce its dependence on oil from the Middle East by 75% by 2025.

The best way to eliminate the addiction to foreign oil was by accelerating breakthroughs in advanced energy technologies. Since 2001, the US had spent nearly $10 billion to develop cleaner, cheaper, and more reliable alternative energy sources. The plan was to accelerate breakthroughs in how homes and businesses used energy and in how automobiles were powered. There were programs to improve cars, make cleaner coal-burning power plants, convert coal into a gas and store its carbon dioxide emissions underground, and develop more efficient use of wind, solar cells, ethanol, and batteries for hybrid cars, and so on.[21] The new subsidies for coal, wind, solar, nuclear and ethanol were intended to diversify energy sources, first in the US and then in the rest of the planet. Since the US used roughly a quarter of all the energy produced in the world at that time, these programs ultimately had a profound impact on the future of energy around the world.

That was not the first time that a US President had said, "Let's get serious about energy." In the 1970s, in response to the first oil shock, President Jimmy Carter proposed that the country fight a "moral war" to overcome its "oil addiction." But conditions were different then. First, in the 1970s there were fewer environmental concerns and, second, energy technologies were not very advanced. By the 2000s, environmental groups had become more sophisticated and were a major force, but there were also many more potential technological breakthroughs that helped in tackling the energy problems of that time. Carter's dreams of solar power were ahead of his time,

[21] See http://www.whitehouse.gov/news/releases/2006/01/20060131-6.html.

while his support for Colorado oil shales was uneconomical then. The energy returned on energy invested (EROEI) was actually very low, which meant that it took more energy to get the oil out of the shale than was produced when burned. Other initiatives were carried out in major European countries and in Japan during the 1970s, and they substantially increased the energy efficiency in both cars and buildings, reducing oil consumption and conserving energy.

Many years later, a new US President gave the 2020 State of the Union address. The first female president of the U.S., underlined the great progress made in terms of energy independence and energy diversification in the country. Although the promises of neither the hydrogen economy nor nuclear fusion have yet been fulfilled, the US is almost energy-self-sufficient thanks to advances in biotechnology and nanotechnology. In fact, biofuels now account for over 20% of US vehicle combustibles and long-life, automatically rechargeable nanobatteries are all the rage in electric, flexifuel, and hybrid cars. In addition, tailor-made artificial bacteria using photoelectrosynthesis are becoming a surprisingly reliable and novel source of electricity production in new power plants.

Similar advances have been pioneered in other major countries, and Europe particularly emphasized a massive conversion program for old power plants. Japan, on another front, has led the world in energy conservation practices. China, a rising economic power, is now leading the way in car technologies and carbon capture and storage (CCS) in coal-based power plants and in CO_2-free oxygenated coal gasification (clean coal), a source of both electricity and methanol fuel. Even poorer developing countries have become less dependent on imported energy, their industries are now less energy-intensive, and they use energy much more efficiently. On average, the world energy intensity per unit of GDP has steadily decreased, even though our energy consumption is still increasing, and major new technological changes like the extension of new uses of the electrical “vector” on everyday life are still expected. The continuous progress of energy efficiency has been due to the steady accumulation of incremental improvements in energy efficiency throughout the entire economy. It has also been driven by the steady rise in the real price of energy, which has resulted in structural changes in societies, such as denser housing, reduced travel, and manufacturing closer to the point of sale.

The Energy “Waves”

Due to the accelerated growth of many developing nations, led first by China and later by India, global economic growth has increased 4% annually on average during the first two decades of the twenty-first century. From 2000 to 2020, energy demand and supply have grown by 2% annually. This means a growth in the world’s economy of 100% and a growth in energy consumption of almost 50% during the last two decades. This indicates a very healthy expansion of the energy sector and a sustained increase in energy efficiency.

Thanks to the consistent strength and cooperation generated by continuous trade and investment flows, and barring wars and catastrophes, the world economy is also headed for more growth in the next few decades. Such growth will particularly benefit the poorer people who are still without any access to electricity, the number of which has fallen from close to 2 billion in 2000 to just over 1 billion in 2020, and electricity might actually reach everybody in the planet by

2040. World GDP growth of 4%, thanks to the continuous rise of China and India, is spreading to even poorer parts of the world. In addition, there is a continuing decline in energy intensity—that is, the amount of energy required to produce a dollar (or dinar, euro, pound, ruble, rupee, yen, or yuan) of GDP. In other words, energy efficiency is increasing and less energy is needed to produce more, particularly now that so many nations are moving from industrial to post-industrial societies. Furthermore, poorer countries have been growing proportionally faster than richer countries, and their economic stability is paving the way for continuous growth around the world. Of course, this assumes that the forces that could impede this growth are held at bay in the future as they have been in the past.

Fossil fuels still represent over 80% of total energy supplies in the world today, in 2020, but the trend toward new energy sources is clear in the future thanks to new technological developments. Coal production has basically remained stable between 2000 and 2020, which means that the share of coal has been decreasing in the last two decades, mostly due to environmental considerations in the OECD nations, even with the new zero-emissions FutureGen plants (based on the Integrated Sequestration and Hydrogen Research Initiative program). Coal gasification (without hydrogen production or sequestration, IGCC) has also played a big role—especially with natural gas prices going up. China is still the largest producer and consumer of coal and has begun to export it in gaseous form, but forecasts indicate a future decline in coal-fired power plants, regardless of the existing huge coal reserves, which according to some experts could be adequate for almost two centuries.

Oil has maintained an annual growth slightly below 2%, just below the average world energy growth. In fact, there is still plenty of oil yet to be produced: the first trillion barrels of oil were produced by 2000, and the second trillion will be produced before 2030. Nonetheless, there are still close to 4 trillion additional barrels of oil in the earth, including regular conventional oil, deep-water oil, super-deep oil, enhanced oil recovery (EOR), Arctic oil, heavy oil, and oil shales. (See Figure 2–8.) In fact, the reserves can still continue increasing, depending on future prices and technological developments, including better recovery rates and production techniques for the 1.2 trillion barrels of oil equivalent in Canadian tar sands and the 1.3 trillion barrels of oil equivalent in Venezuelan Orinoco bitumen, for example.

Many advances in oil exploration (advanced 3-D and 4-D seismic with sophisticated interpretation), drilling (extended horizontal wells and complex well profiles), offshoring (deepwater drilling and floating production units), reservoir management (digital reservoir simulation and optimized drilling), new field developments (offshore arctic and remote offtake), chemical extraction techniques for oil shells, in-situ upgrading of extra-heavy crudes, and bacterial liquefaction of high viscosity hydrocarbons are continuously increasing the base of economically recoverable conventional and nonconventional oil. However, the price of oil—still below $100 per barrel—is high enough to motivate the search for alternative energy sources. (See Box 2–4.)

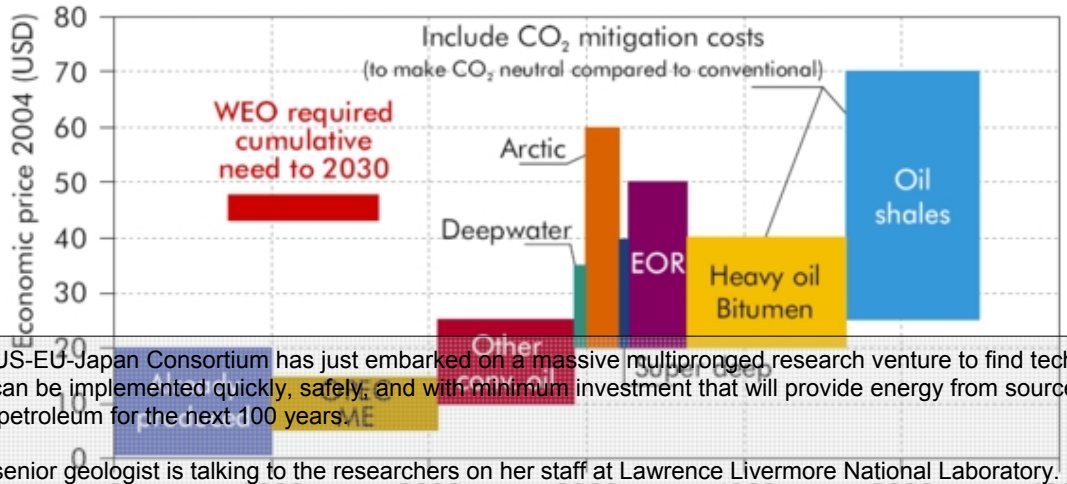
The worldwide best-selling book of 2019 was *Life After Oil* by Daniel Yergin, author of *The Prize* and founder of Cambridge Energy Research Associates (CERA). In his latest book, Yergin wrote about all the new possibilities for energy generation in a world where gas is overtaking oil as the main energy supply, and where new sources of energy will also soon be overtaking gas

and eventually substituting for most fossil fuel production in the planet. However, there will be plenty of energy opportunities for everybody in a continuously globalizing world, including an abundance of solar energy in Africa and the Middle East, bioenergy in the US and India, and space solar power satellites in the US, China, Japan and Russia, for example.

Yergin argued again that the world will never really run out of oil, but that it will be replaced by other cleaner, cheaper, and more abundant energy sources. He reminded us of the five previous times when many "experts" thought that oil was being exhausted: in the 1880s, after the first World War, after the second World War, in the 1970s with the first oil shock, and in the early 2000s with all the talk about an approaching global Hubbert peak (just like a previous Hubbert peak in the US during the 1970s). However, Yergin showed that oil production, and even oil reserves, had continued to grow, if only more slowly, around the world—from the North Pole to the South Pole, and even below the poles. He ended by quoting the famous dictum by Saudi Arabian Sheikh Ahmed Zaki Yamani: "The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil." In fact, in the early 2000s, BP, formerly British Petroleum, rebranded itself as Beyond Petroleum and started working on solar energy and biofuels. That was a clear sign of how oil companies transformed themselves into full energy companies, leaving behind their humble beginnings in the restrictive petroleum fields. Even OPEC countries had to react and begin seriously thinking, for the first time, about *Life After Oil*.

By 2020, gas production has indeed caught up with oil production. The supply of gas doubled between 2000 and 2020, and it overtook coal production in 2016. Now, according to most forecasts, other energy sources will also catch up in the 2030s with gas and oil, which are both declining relatively. Even though there has never been any continuous shortage of coal, oil, or gas, except for small local production problems sometimes caused by political disruptions or weather factors, the era of fossil fuels does seem to be reaching its zenith and might end in the next few decades. Indeed, other energy sources, including some not even considered today, will apparently be the dominant sector in the US by 2040. (See Figure 2–8.) These energy "waves" will also be seen soon in most of the world. They show a clear "decarbonization" trend going from hydrocarbon fuels with more carbon to those with more hydrogen: from wood to coal, oil, gas, and maybe eventually pure hydrogen and solar energy (itself based on hydrogen).

Figure 2–8. Oil Resources According to Production Costs ($ per barrel)



Source: The Millennium Project based on IEA

Box 2-4. Journey to the Center of the Earth

The US-EU-Japan Consortium has just embarked on a massive multipronged research venture to find technologies that can be implemented quickly, safely, and with minimum investment that will provide energy from sources other than petroleum for the next 100 years.

The senior geologist is talking to the researchers on her staff at Lawrence Livermore National Laboratory. "Well, people," she says, "we have the piece of the research pie that's called 'deep drilling.' That includes geothermal and anything more exotic that we can think of… We got this because our nuclear weapons work gave us some familiarity with the intense pressures and temperatures found deep in the earth. We're open for discussion."

A young astrophysicist on the team says, "I seem to remember that back in the 1970s Tom Gold proposed that methane was produced in an inorganic process, deep in the earth, and was not from organic decay as most textbooks say. If so, it seeps upward until it gets trapped in domes and may even be forming now given the right conditions. The Russians said that Gold got the idea from them, but most of the scientific community thought the whole idea was bunk."

Another scientist says, "But I remember that there were experiments at Carnegie Institute or Indiana Center, under Henry Scott, I think, in which granite, water, and iron oxide were crushed in a diamond mill that essentially duplicated temperature and pressure conditions in the deep mantle—12 miles or so—and presto, the water disassociated and the carbon atoms from the rock linked up with the liberated hydrogen to form methane. The iron oxide was a catalyst."[1]

"So," the leader says, "I take it you're suggesting we dig deep, really deep, to find the methane deposits and maybe the points of origin and maybe, just maybe, we'll find that methane production is a continuous process. OK. Good enough for now. Here are the assignments. Pick your favorites.

Team 1, engineering: How can we make drill bits and down hole tubes function at depths of 20 miles, when the rocks around them are hot enough and the pressures are high enough to break down water and granite?

Team 2, experimental geophysics: Can we scale up Scott's experiments so that we can get clear validation and corroboration of his findings at more than milliliter quantities?

Team 3, economics: What's the cost of deep drilling? Can it pay off? And even if we are successful, just how effective will massive increases in the amount of low-cost methane be in changing the energy scene? Do we need a new infrastructure or will it fit in?

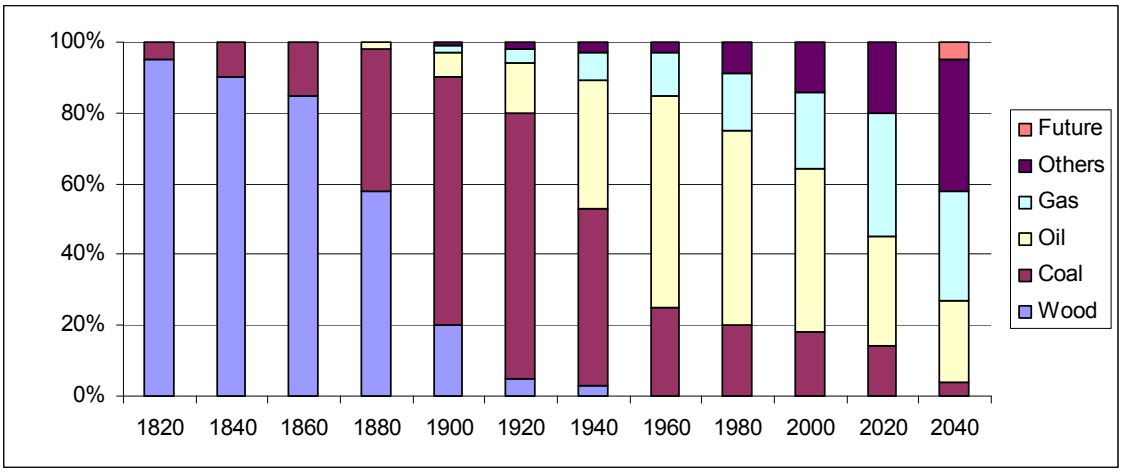
Ten years later: large-scale experiments had confirmed the possibility of continuous generation of methane in deep earth. The engineering team had pushed boldly ahead with drill bits built of nanotech materials that were harder and more heat-resistant than diamonds; high-intensity laser blasting pushed the down holes deeper. The well casings were essentially self-manufactured as the holes progressed. Drilling was taking place at 200 sites that had been identified as high probability locations by the United States and its closest allies. The project was called Journey to the Center of the Earth, after the famous *Journée au Centre de la Terre* by Jules Verne in 1864, or among the thousands of scientists and engineers, and the media, simply "JuiCE."

At 20 miles they struck pay dirt, or rather pay gas:[1] massive quantities of gas, at high pressure, contaminated only by the oxygen liberated by the reaction (which made it somewhat dangerous).

The infrastructure team was ready. Processes for converting the methane to methanol were known and methanol could be use as a liquid fuel. Since the combustion of methane is highly exothermic, it could serve as a fine heating fuel and as a source for generation of electric power. Most exciting of all, however, is the possibility of catalytic decomposition of methane into hydrogen (the start of the hydrogen economy?) and carbon nanofibers that can be extracted for other applications.[1]

The team had produced the technology, found the resources, and identified the geophysical processes by which methane was being continuously produced. The price of oil fell from its peak of close to $200 per barrel to $50. Governments of nations dependent on income from oil exports either collapsed and fell into chaos or quickly allied with the new "energy nations."

Figure 2–9. Energy "Waves" in the United States



Source: The Millennium Project based on US Department of Energy

Outside fossil fuels, nuclear energy has increased marginally, and its share in the total generation of electricity has dropped by almost half, even though the third-generation fission plants might eventually regain some terrain. Several nuclear reactors have been decommissioned in Europe, and new nuclear plants have been concentrated in very few countries. Many plants became obsolete and were closed without substitution, mostly in Europe, while new plants were opened in a few countries, mainly in Asia: first China, followed by India, Japan, and South Korea. China has constructed 25 nuclear reactors in the last two decades, increasing its electrical capacity by 20 GW. Russia, similarly, built 30 reactors and brought up its share of nuclear energy to 25% of total electricity production, which allowed Russia to keep exporting more oil and gas. Otherwise, most other countries have not experimented much with nuclear energy because of its safety and environmental problems.

Furthermore, nuclear fusion has not yet been successful. The ITER tokamak fusion reactor built in southern France by an international consortium (founded by China, Europe, India, Japan, South Korea, Russia, and the US) carried out its first plasma operations in 2018, with a budget overrun of 80% and two years behind schedule. But it is estimated that much more research in plasma physics is needed before electricity-producing fusion power plants might become fully operational in a decade or two. This will be an important step, since nuclear fusion is much more efficient than the chemical reactions using standard fossil fuels, and it is substantially safer than nuclear fission (nuclear fusion is the energy process of the stars and it combines two hydrogen isotopes, deuterium and tritium, to create helium). However, the technical issues to sustain a controlled plasma interaction will still need a lot of future research and might well be overtaken and rendered obsolete by "space energy" beamed from satellites.

The Energy "Internet"

Traditionally, the other main source of electricity generation has been hydropower. By 2020,

however, most major dam projects have already been finished, particularly after the inauguration of the Three Gorges Dam in the Yangtze River in China. The Chinese dam was finally completed in 2010, almost two decades after the start of its construction and with a total cost of $75 billion, making it the most expensive single project in human history. Its 26 generators have a combined capacity of 18 GW, which is almost equivalent to the total nuclear power of China. Even though hydropower cannot keep increasing worldwide because of the lack of prospective sites, it still represents about 15% of total electricity generation and a bit less than 5% of total energy production around the world.

Besides hydropower, other renewable sources have been growing steadily up to 2020. Solar thermal energy has many industrial, agricultural, and home applications. Some solar thermal baseload plants—for instance, the tower of power—have become useful in certain areas: sunlight falls on mirrors, focusing on a boiler, which warms a fluid in a heat exchanger, and then steam turns conventional turbines. Silicon solar photovoltaics has also grown but it is still almost twice as expensive as other conventional sources, and it depends so much on weather conditions that it is extensively used only in isolated or remote locations where there is plenty of sunlight. However, continuous development of new plastic "nanosolar" electrical cells is about to reach break-even point.[22] Geothermal and tidal energy have also improved a lot, but they are equally restricted to places that have the required special geological conditions. By 2020, solar power has reached 10% of total electricity capacity in Algeria, and geothermal power is 15% in El Salvador. Deep geothermal energy, sometimes called "hot rock energy," is finally being considered in many countries, starting with Australia about a decade ago.[23]

There are still huge differences in electricity generation from region to region, going from 90% fossil fuels in the Middle East, mostly oil and gas, to over 70% renewables in Latin America, mostly hydropower and biomass. In France, close to 80% of the electricity is produced by nuclear energy, which the country also exports to neighboring Belgium and Germany. On the other hand, countries like Brazil, Uruguay, Paraguay, Norway, and Venezuela depend on hydropower for over 80% of their electricity. Use of hydropower depends on local conditions and regional geography, and the same can be said about wind, solar, geothermal, and tidal power. In some places they are very important, but in others they are not possible at all—for example, hydropower supplies over 90% of the electricity in Norway but close to zero in the Saharan countries, and wind provides the bulk of Denmark's electricity but nothing in Singapore. Thus each energy source is specifically important in its own region but not everywhere, and large countries like China, India, and the US rely on a variety of multiple sources of energy, which are normally connected through multiple grids.

Worldwide averages, despite the enormous regional disparities, are over 20% electricity generation from renewable sources: hydroelectricity, wind energy, and solar power each with close to 5%, followed with less than 1% by geothermal and tidal power. The rest is now provided by new biofuel sources, both natural and artificial. Renewables have been and will be the sector growing the fastest, led by new sources like biofuels. Traditional biomass consumption will fall with development and urbanization, but it will be replaced by other renewables, which will

[22] See http://news.nationalgeographic.com/news/2005/01/0114_050114_solarplastic.html and http://www.nanosolar.com/
[23] See http://hotrock.anu.edu.au/index.html

supply new urban energy needs. In addition, biofuels have had an enormous growth from close to 0% of total consumption in 2000 to almost 5% worldwide in 2020. Fortunately, thanks to the spread of local, national, regional, and global electrical grids, there is a growing balance and compensation in energy capacities around the world. Electrification has continued aggressively, and the "powerless" regions, mostly concentrated in Africa and South Asia, are shrinking. In a high-tech world, spreading grid electricity will not be the most often chosen way for isolated communities, since off-grid, decentralized energy systems are beginning to flourish, especially in regions with low population density.

In 2018, Rahul Gandhi, the heir of the Nehru-Gandhi political dynasty, became Prime Minister of India and proposed the creation of the Indo-European Electrical Network (IEEN). This was partly motivated by his dream of connecting his own two worlds, the Indian subcontinent of his father Rajiv and the Italian birthplace of his mother Sonia. Rahul Gandhi signed the agreement with Angela Merkel, President of the European Union, and construction of the missing links in this energy grid started immediately. The year 2019 saw the completion of the southern route that connected India to Europe through the Middle East, which basically followed the ancient paths of the Silk Road. This southern route also relied on the Gulf Cooperation Council Grid finished in 2012 and the Mediterranean Ring completed on 2015. The northern route, from India to Europe through Russia, was still under construction in 2020, but it should officially open in early 2021.

The success of the IEEN has been so great that other countries quickly want to join now, all the way from Africa to East Asia, including Australia and New Zealand, and these connections are planned for 2022. The complete redundancy and spare capacity of the IEEN are fundamental to its functioning; every part of its decentralized and automatically redistributed electrical mesh has backups and multiple alternatives. Just as the Internet did earlier for telecommunications, the IEEN has enabled continuous and reliable electrical interconnections among peoples and nations. In fact, the new electrical grids are becoming something like an energy Internet. The differences in peak-load time from East to West and from North to South have helped to increase efficiency and redundancy to these global electric networks. This has been particularly important in order to reduce political threats and increase the electrical surplus.

The Americas had been connected since 2015, when the Pan-American Electrical Grid (PAEG) was completed. In fact, the PAEG was an outgrowth of the Pueblo-Panama Plan (PPP), started by Mexican President Vicente Fox in 2006 and connecting Mexico to Panama in 2010. The final electrical links between Mexico and the US were also completed in 2011, and Brazil eventually got connected to all its neighbors by 2015. First the PAEG and now the expanded IEEN will achieve the dream of connecting all humanity when the electrical grid is finally closed between Siberia and Alaska in 2023. This will be a major advance for the whole planet and will bring reliable electricity to every corner of every continent.

The ideas of visionary thinker Buckminster Fuller and his Global Energy Network (www.geni.org) will soon be realized, and this will bring more contacts and more exchanges between all nations, while reducing and almost eliminating the fear of conflicts in a totally interconnected and interdependent world. In fact, Buckminster Fuller spoke of playing not "war games" but "world games" to bring peace and prosperity to every nation on Earth. Electrification

has brought development to the poorest parts of the world and the continuous acceleration of growth to a globalized world. This created a virtuous cycle of energy increase and economic development. Furthermore, new technologies and better materials also improve transmission line efficiencies and reduce the cost of connecting renewable energy sources to the grid. Radically new automated grid management systems combining new chips, new sensors, actuators, and communications, and new algorithms make it possible to juggle the supply and demand for electricity more effectively across time, which is essential to getting full use from renewable energy sources, intelligent appliances, and car batteries.

From Fossil Fuels to Bioenergy

Another major piece of news in the energy industry has been the impressive growth of many forms of bioenergy, which originally started with bioalcohols in the 1970s and biodiesels in the 1990s. Bioalcohol, commonly just called ethanol for its main chemical component, has grown from almost nothing in 1980 to 20 billion liters in 2000 and almost 200 billion liters in 2020—that is, close to 20% of the total car gasoline market in the world today. Similarly, biodiesel has grown from about zero in 1990 to 1 billion liters in 2000 and around 30 billion liters in 2020, which is almost 2% of the total diesel consumption in the world.

The bioalcohol or ethanol industry started in Brazil after the oil shock in the 1970s. It had a first successful phase during the 1980s with the introduction of the first ethanol engines, but it slowly decayed in the 1990s with the decrease of oil prices. However, it had a major revival in the early 2000s with the appearance of the first flexible fuel cars. The flexifuel engines could use gasoline, ethanol, or any mixture of the two. In addition, by the time the first flexifuel cars appeared all gasoline sold in Brazil contained 20–25% alcohol, and it had an equivalent price to gasoline per mileage driven. Ethanol and flexifuel cars allowed Brazil to stop importing gasoline and start exporting bioalcohols in 2005. By 2010, all new cars sold in Brazil had flexifuel engines, and ethanol became one of the major Brazilian exports, mostly to Japan and other Asian countries. Brazil produces ethanol from sugarcane, and it has substantially increased its yield from 300 cubic meters per kilometer in 1980 to 550 in 2000 and 900 in 2020, thanks to biotechnology that has now made ethanol 20% cheaper than oil. Brazil has been so successful with bioalcohol that it is now producing ethanol-powered aircraft engines. Furthermore, some Brazilian companies are starting to replace petrochemicals with bio-alternatives. This wise business choice leaves Brazil less vulnerable to price spikes than competitors who still rely exclusively on oil and gas.

The US started a similar program in the 1990s but one based on corn, first in Minnesota and other Corn Belt midwestern states. Minnesota had 10% ethanol in all its gasoline and 20% was required by law beginning in 2013. Soon other states followed. In Europe, E85 fuel (a mixture of 85% ethanol and 15% gasoline by volume, also sometimes called bioalcohol BA85) was doing well in Sweden and quickly spread through much of Europe. However, higher costs in Europe and the unavailability of more land have impeded any faster replacement of gasoline. Biodiesel started in Europe where there was an important fleet of diesel vehicles and it could be produced from a variety of sources—from soybeans to rapeseed to algae.

India started a very successful pilot plan in 2006 to produce 10 million liters of biodiesel on

8,000 hectares of marginal wasteland with *Jatropha curcas*, a nonedible oil crop that is drought-resistant. The experiment was so successful that BP and the New Delhi–based Tata Energy Research Institute (TERI) started commercial production in 2016 after increasing the yield per hectare by 400% thanks to biotechnology. The biodiesel fuel program started as a cheap alternative fuel to the typical Indian three-wheeled diesel motor rickshaw, and the fuel now is beginning to be exported. There is a limit to such exports, however, since India has little marginal land and it needs its arable land for food production. Biofuels based on cellulosic ethanol, which is made of more abundant and less expensive biomass using a variety of bacteria, yeast, and enzymatic processes, is now proving very successful in many countries.

Transportation (by land, air, or sea) still consumes about 20% of the total energy supplied worldwide and about 60% of the oil produced. That is why the advance of biofuels has been so important, particularly with car ownership rising tremendously around the world. For example, in China personal transportation was mostly by means of bicycles in 1980, but there were 10 million private cars in 2000 and almost 80 million in 2020. There is still much room for expansion, since this represents only 6 cars per 100 people in China versus 80 in the US (for a total of 260 million cars in the US). The Chinese growth in car use has been incredible, however, and it will soon be replicated by other countries moving up the economic development ladder.

Thanks to its rapid growth, China has positioned itself as the most efficient producer of the most efficient cars on the planet. China now produces over 10 million cars per year, almost as many as Europe, Japan or the US. Nonetheless, the Chinese ones are the most energy-efficient with miles per gallon ratings of over 100. China copied the flexifuel cars from Brazil and combined them with the hybrid cars from Japan (gasoline-electric vehicles, which use gasoline and electric batteries to power internal-combustion engines and the electric motors) to create hybrid flexifuel cars that also run on electrical energy with nanobatteries.

The US passed Corporate Average Fuel Economy (CAFE) regulations in 1975 and slowly increased the standards for normal engines to achieve 25 mpg by 2000, when the first Japanese hybrid cars by Toyota reached 50 mpg (and all Toyota cars sold after 2012 were hybrid, getting 60 mpg or more). Brazilian cars of the early 2000s added the possibility of combining different fuels in variable mixtures, since the engines had internal control mechanisms to adjust their functioning to changing fuel conditions, while the first European commercial electric cars transformed chemical energy stored on the vehicle in batteries. In 2015, the Chinese created the first sophisticated electrical engines with nanobatteries for hybrid cars with flexifuel engines. These “electric-flex-hybrid” cars have now become a major export from China, and GM (Guangzhou Motors, the main manufacturer in Guangdong province) expects to keep developing better batteries, thanks to the continuous breakthroughs in nanotechnology, to reach 120 mpg by 2022. (And some experts also plan to incorporate fuel cells into these cars once their costs come down enough.) The new cars are not only cheaper but also run on any possible combination of biofuels and electricity. This reduces fuel emissions substantially since the cars can also be plugged in anywhere along the energy Internet, and they are readily and cheaply reparable (for example, construction is modular so that items such as batteries can be fully recycled as well as reused in other of vehicles). The new Chinese electric-flex-hybrids are revolutionizing the world in the 2020s even more than the Ford Model T changed the US in the 1910s.

The Cells of Life

The present energy and transportation revolutions also include creating biofuels directly from living cells—not from long-dead fossil fuels or from recently harvested sugarcane or palm oil, but from real living cells. In fact, generating and using energy is what life is all about. Every child today knows that plants transform carbon dioxide and water into carbohydrates and oxygen. Indeed, that is simply called photosynthesis and its chemical expression is:

$CO_2 + 2\ H_2O + \text{light} \rightarrow (CH_2O) + O_2 + H_2O$

Thus, plants use light and some simple chemical molecules to create carbohydrates, which are really nothing more than hydrocarbons plus oxygen. In addition, about 114 kilocalories of free energy are stored in plant biomass for every mole of CO_2 fixed during photosynthesis. Solar radiation striking Earth on an annual basis is equivalent to 174,000 terawatts (which is several thousand times the current global energy consumption), and only part of this light is used for photosynthetic energy capture. Approximately two-thirds of the net global photosynthetic production is terrestrial (land-based), while the remainder is produced mainly by phytoplankton (microalgae) in the oceans, which cover approximately 70% of the total surface area of Earth. Since biomass originates from plant and algal photosynthesis, both terrestrial plants and water microalgae are appropriate targets for increasing biomass energy production.

Plants do it, most algae do it too, and even some very simple bacteria can fix carbon dioxide and water to produce carbohydrates and oxygen under the influence of light. In fact, many simple cells can do photosynthesis and similar biochemical processes. Making hydrocarbons is one of the simplest biological processes, as a famous report by the UN Food and Agriculture Organization (FAO) explained late last century.[24] Hydrocarbons are not complicated molecules with thousands of atoms and a number of elements, like proteins and enzymes; they are just small molecules with two of the most common elements on Earth: hydrogen and carbon. Surprisingly, it took many scientists and many years to artificially create the first commercial hydrocarbons from living carbohydrates and not from fossil fuels.

Craig Venter, one of the biologists who sequenced the human genome in 2000, later founded a company whose purpose was precisely to create life. In fact, Venter famously said that he spent 20 years of his life trying to "read" life and that he would expend another 20 to "write" life. His company, Synthetic Genomics, was one of the pioneers dedicated to using modified microorganisms to biologically produce alternative fuels like ethanol and hydrogen.[25] In fact, many other such enterprises followed soon, and the first artificial life forms, virus and bacteria, were created in 2003 and 2005. In 2018, one of Venter's research associates, Mohan Kapoor from India, was the first who managed to create artificial bacteria to economically produce hydrocarbons. He had been working since 2015 with *Clostridium acetobutylicum* and other bacteria until he managed to tailor-make a new hybrid organism that efficiently produced hydrocarbons from carbon dioxide and water under controlled lighting.

[24] See http://www.fao.org/docrep/w7241e/w7241e00.htm . This is an excellent FAO report led by some prominent Japanese scientists about renewable biological systems for alternative sustainable energy production.
[25] See http://www.syntheticgenomics.com/.

C. acetobutylicum is a commercially valuable bacterium, sometimes called the Weizmann Organism after Chaim Weizmann, who in 1916 helped discover how *C. acetobutylicum* cultures could be used to produce acetone, butanol, and ethanol from starch using the ABE (Acetone, Butanol, Ethanol) process to satisfy such industrial purposes as gunpowder and TNT production. The ABE process was an industry standard until the 1950s, when low oil costs drove production to more efficient methods based on hydrocarbon cracking and petroleum distillation techniques. *C. acetobutylicum* also produces acetic acid (vinegar), butyric acid (a vomitous smelling substance), carbon dioxide, and hydrogen. These technologies are proving so successful that they are now being used to start factories that use cellular processes to create efficient organisms to digest heavy oil and get more of the residuals. Other planned energy projects involving these new biotechnological developments include producing ethanol from bark using microbes and genetically modified salt-resistant rice and extracting shale oil and tar sands with bacteria.

Mohan Kapoor called his new bacterium *Petroleum artificiali* and started a marketing test in November 2019. It is expected that his bacterium that "eats" carbon dioxide and "drinks" water under light, 24 hours a day, in order to "excrete" hydrocarbons will truly revolutionize the world. Not only will it produce hydrocarbons continuously, but it will also capture carbon dioxide and generate free oxygen and energy. If there are no major problems, production of new fuel excreted by *P. artificiali* will become financially viable in 2021 and will take care of the carbon sequestration problem. Other scientists are now working on more specific bacteria to generate ethanol, methanol, and pure hydrogen. This will eventually allow us to artificially produce all kinds of biofuels according to specific needs, trying to get the best fuel value or relative energy density (that is, the quantity of potential energy in fuel, food, or other substance; see Table 2–3).

Table 2–3. Relative Energy Density of Different Fuels

Fuel type	Energy content (MJ/kg)
Pumped stored water at 100 m dam height	0.001
Bagasse	10
Wood	15
Sugar	17
Methanol	22
Coal (anthracite, lignite, etc.)	23–29
Ethanol (bioalcohol)	30
LPG (liquefied petroleum gas)	34
Butanol	36
Biodiesel	38
Oil (medium petroleum average)	42
Gasohol or E10 (90% gasoline and 10% alcohol mix)	44
Gasoline	45
Diesel	48
Methane (gaseous fuel, compression-dependent)	55
Hydrogen (gaseous fuel, compression-dependent)	120
Nuclear fission (Uranium, U-235)	90,000
Nuclear fusion (Hydrogen, H)	300,000
Binding energy of helium (He)	675,000

Mass-energy equivalence (Einstein's equation)	89,880,000
Antimatter as fuel (estimated according to $E = mc2$)	180,000,000

Source: The Millennium Project based on IEA and US Department of Energy

Some fundamentalist ecologists have started to complain that a full environmental impact analysis has to be performed on such artificial organisms, since they could destroy the delicate balance on Earth. They argue that the processes may work in the laboratory but may have large impacts when scaled up to achieve meaningful production quantities. They worry about escaping molecules and about interfering with natural evolutionary processes. There are even objections from religious fundamentalists of all sects. However, the public is realizing that this is nothing more than a new scientific breakthrough, like the Green Revolution that increased agricultural yields and avoided the starvation deaths of millions of Indians in the 1970s.

More recently, the new bacteria can be compared with the biologically engineered Chinese chicken wings grown directly from chicken stem cells in 2014 without the need to actually reproduce a whole chicken to be killed later for its wings and other body parts or with the Japanese Kobe beef produced genetically from premium cow cells in 2015 without having to grow cattle to be later slaughtered. The "chickenless" Chinese chicken wings and the "cowless" Japanese Kobe beef are also over 10 times cheaper to produce and totally avoid any risks of animal problems, including avian flu or mad cow disease, and they eliminate the methane production and waste streams from beef production. Both of these products have been massively and successfully produced by GM2 (Guangzhou Meats & Meals, the main "meat creator" in Guangdong province), for worldwide exports since 2016. In fact, even McDonald's advertises its new "cowless" hamburgers based on ethical grounds, since they don't butcher any animals and the hamburgers are much cheaper and nutritious than the non-genetically produced ones. People in some African and European countries are still opposed to these genetic foods, however.

Space and the Future

The other important cells for current energy production are the fuel cells that convert biofuels into electrical energy. Fuel cells were first industrialized during the 1960s by NASA in order to generate electricity for the Apollo missions, and they were later used in the space shuttle and the International Space Station. Fuel cells have very high efficiencies in converting chemical energy to electrical energy, since they not constrained by the maximum Carnot cycle efficiency, as combustion engines are. A combustible fuel reacts with oxygen in a fuel cell to transform chemical energy into electricity with efficiencies of more than 60% today, as compared with only 40% at the start of the century.

Fuel cells are being used almost everywhere, in homes, industries, cars, and even rockets. They can also use many types of fuels, from pure hydrogen to landfill waste gas, in order to produce electricity. If pure hydrogen is "burnt" with oxygen, then water is the only emission. If hydrocarbons are used, then carbon dioxide is also produced; and the more carbonated the hydrocarbons are, the more carbon dioxide will be emitted. The main problem with fuel cells is their high cost, which has been reduced but it is still elevated in 2020, even with high-temperature and catalysis breakthroughs. Nanotechnology is currently being used to try to lower

the manufacturing costs of fuel cells, just as was done with nanobatteries after 2015.[26]

In addition, the vehicular cost of using hydrogen with fuel cells has come down from 8¢ per mile in 2000 to 3¢ per mile in 2020, but that is still 50% more than the cost of fuel for hybrid flexi-fuel internal combustion engines. Compared with other hydrocarbon fuels, the costs of using fuel cells and ICEs are similar, which is why the Chinese electric-flex-hybrids do not use pure hydrogen as fuel. However, the cost of the fuel cell itself is still elevated, and disposing of them is dangerous since they are highly contaminating, but fuel cells convert energy with over 60% efficiency versus 20% for ICEs. Ethanol is an excellent combustible, since hydrogen-rich fuels like methanol or ethanol (methane hydrate, natural gas, gasoline, diesel, and even gasified coal), just produce heat and water, plus some carbon dioxide depending on the hydrocarbon molecular weight.

Hydrogen is the most abundant element on Earth. It is the basic component of water, not to mention virtually every fuel ever used by humankind—wood, oil, coal, and natural gas—all of which are made of hydrocarbons. Pure hydrogen, however, does not occur naturally: hydrogen must be harvested using electrical or chemical processes, which have their own hidden environmental consequences; hydrogen is only an energy carrier and it has to be produced from water or hydrocarbons. Obviously, using renewable resources to power those processes could vastly reduce the environmental footprint of hydrogen production; at present, however, producing hydrogen for fuel costs several times more than conventional fuels do.

Since the start of this century, Iceland has made a major effort to become the first "hydrogen economy" in the world, and its advances by 2020 are notable. Nonetheless, this is the special case of a country with overabundant and readily available hydroelectric and geothermal energy that can be used to produce hydrogen as a carrier or storage of energy for later use. The hydrogen produced in Iceland is mostly for transportation, since for other activities it is more convenient to create electricity directly, without intermediaries (just like making Japanese Kobe beef without the intermediate step of the cow). The hydrogen for cars is later used by the fuel cell to transform its chemical energy into electric and mechanical energy to drive the car. Iceland, a country with excess energy, has chosen to electrolyze water and began exporting the hydrogen contained in high-pressure tanks, and in the form of metal hydrides, since hydrogen is released from the hydrides with just a bit of heat.

Hydrogen has not yet become the main energy commodity, as dreamed of by many in the early 2000s, because it is still costly to produce, dangerous to store safely, difficult to transport, and tricky to distribute, and its volumetric energy density is much lower than that of other liquid fuels like ethanol or gasoline (although not in the form of metal hydrides). Safety would be another problem and a major worry; it would take many years to accomplish the logistics and infrastructure changes required to move from standard liquid fuels to hydrogen. The best idea here seems to be the "hydrogen battery," a block of metal hydride storing hydrogen at densities higher than liquid hydrogen. When a hydrogen powered car needs a fill-up, the "gas stations" of the hydrogen era would simply exchange the hydrogen batteries, probably automatically.

Continuous research is being carried out to increase the efficiency and reduce the costs of the so-

[26] See http://www.foresight.org/challenges/energy.html.

called hydrogen economy. Even the use of advanced fission nuclear plants is still considered to electrolyze water and produce hydrogen. Likewise, R&D on high-temperature solar dissociation of water to make hydrogen has progressed, but awaits solution of other difficulties. The theoretical potential of hydrogen as a clean energy carrier is certainly incredible, but it is not economically competitive since it is not freely available. Hydrogen is, after all is said and done, only an intermediate energy medium and an ill-conceived fantasy according to many. It is an energy carrier, not an energy source. Electricity is also a carrier—and a much better one in many ways. An efficient world energy economy would certainly continue to use more and more electricity as one of its carriers, particularly for use in industry and large buildings. For cars, the sustainable economy of the future may well use some mix of electric batteries, heat batteries, and methanol, instead of hydrogen, as primary energy carriers (at least for as long as it costs more to produce than to use hydrogen).

The new space race has also had some very important consequences for the energy sector. The Chinese landed on the moon in 2015, as promised, and the Russians followed one year later, after resurrecting their rocket technologies of the 1950s and 1960s. A combined European, Japanese, and US manned mission landed there in 2017. A moon base called *Luna 1* was started in 2019, and Nikolai Sevastyanov, Honorary President of RKK Energiya, just announced plans to begin mining the moon to bring helium 3 (He 3) to Earth in the Russian Kliper spacecraft. According to Sevastyanov, there is enough helium in the Moon to power all human needs for at least a century.[27] Indeed, the binding energy of helium is much higher than nuclear fission and even than hydrogen nuclear fusion. However, the space race has opened new and easier sources like space solar power satellites.

The Japanese have been experimentally using robotic "spiders" to build large-scale structures in space for over 10 years. The tiny mechanical spiders inch their way across large nets of fabric in space, performing small tasks or lining up to create an antenna or some other structure. The concept is known as a Furoshiki satellite after the Japanese word for a cloth used to wrap up possessions.[28] It has recently been revolutionizing satellite-based applications such as telecommunications, navigation, and Earth observation using radar by providing cost-effective large antennas in space that can be launched on relatively small rockets. More important, the Furoshiki spacecraft could be a viable way to create large space solar power satellites to then beam energy to Earth. In fact, the amount of energy received from the sun in Earth's atmosphere is enough to power 1,000 civilizations like ours. That kind of energy is what was called a Type I civilization in the energy scale devised by Russian astronomer Nikolai Kardashev in 1964. (See Table 2–4.) The famous English-American physicist and mathematician Freeman Dyson had similar ideas about more advanced civilizations building spheres around their suns in order to capture all the radiated energy. He even proposed searching for indications of such spheres having already being built by other civilizations.[29]

A Type I civilization is one that is able to harness all the power available on a single planet (in our case, Earth has an available power of 174×10^{15} W). A Type II civilization is one that is capable of harnessing all the power available from a single star (approximately 386×10^{24} W for

[27] See http://www.space.com/news/ap_060126_russia_moon.html
[28] See http://www.esa.int/esaCP/SEMHVXVLWFE_index_0.html.
[29] See http://www.nada.kth.se/~asa/dysonFAQ.html#WHAT

our sun), while a Type III civilization would be able to harness all the power available from a single galaxy (approximately 5×10^{36} W for the Milky Way, but this figure is extremely variable since galaxies vary widely in size). A Type IV civilization will have control of the energy output of a galactic supercluster (approximately 10^{46} W), and a Type V civilization will control the energy of the entire universe (approximately 10^{56} W). However, such a civilization approaches or surpasses the limits of speculation based on current scientific understanding and may not be possible. Frank J. Tipler's "Omega point" would presumably occupy this level.[30] Finally, some science fiction writers talk about a Type VI civilization that will control the energy over multiple universes (a power level that is technically infinite) and a Type VII civilization that will have the hypothetical status of a deity (able to create universes at will, using them as an energy source). Table 2–4 shows the power in watts produced by various different sources of energy, listed by increasing order of magnitude.

Table 2-4. Energy scale and Kardashev civilization types

Example	Power	Scientific notation
Power of Galileo space probe's radio signal from Jupiter	10 zW	10×10^{-21} watt
Minimum discernable signal at an FM antenna terminal	2.5 fW	2.5×10^{-15} watt
Average power consumption of a human cell	1 pW	1×10^{-12} watt
Approximate consumption of a quartz wristwatch	1 μW	1×10^{-6} watt
Laser in a CD-ROM drive	5 mW	5×10^{-3} watt
Approximate power consumption of the human brain	30 W	30×10^{0} watt
Power of the typical household light bulb	60 W	60×10^{0} watt
Average power used by the human body	100 W	100×10^{0} watt
Approximately 1000 BTU/hour	290 W	2.9×10^{0} watt
Power received from the sun at Earth's orbit by m^2	1.4 kW	1.4×10^{3} watt
Photosynthetic power output per km^2 in ocean	3.3 - 6.6 kW	$3.3 - 6.6 \times 10^{3}$ watt
Photosynthetic power output per km^2 in land	16 - 32 kW	$16 - 32 \times 10^{3}$ watt
Range of power output of typical automobiles	40 - 200 kW	$40 - 200 \times 10^{3}$ watt
Mechanical power output of a diesel locomotive	3 MW	3×10^{6} watt
Peak power output of largest class aircraft carrier	190 MW	190×10^{6} watt
Power received from the sun at Earth's orbit by km^2	1.4 GW	1.4×10^{9} watt
Peak power generation of the largest nuclear reactor	3 GW	3×10^{9} watt
Electrical generation of the Three Gorges Dam in China	18 GW	18×10^{9} watt
Electrical power consumption of the US in 2001	424 GW	424×10^{9} watt
Electrical power consumption of the world in 2001	1.7 TW	1.7×10^{12} watt
Total power consumption of the US in 2001	3.3 TW	3.3×10^{12} watt
Global photosynthetic energy production	3.6 - 7.2 TW	$3.6 - 7.2 \times 10^{12}$ watt
Total power consumption of the world in 2001	13.5 TW	13.5×10^{12} watt
Average total heat flux from earth's interior	44 TW	44×10^{12} watt
Heat energy released by a hurricane	50 - 200 TW	$50 - 200 \times 10^{12}$ watt
Estimated heat flux transported by the Gulf Stream	1.4 PW	1.4×10^{15} watt
Total power received by Earth from the sun (Type I)	174 PW	174×10^{15} watt
Luminosity of the sun (Type II)	386 YW	386×10^{24} watt
Approximate luminosity of the Milky Way galaxy (Type III)	5×10^{36} W	5×10^{36} watt
Approximate luminosity of a Gamma Ray burst	1×10^{45} W	1×10^{45} watt
Energy output of a galactic supercluster (Type IV)	1×10^{46} W	1×10^{46} watt

[30] See http://www.aleph.se/Trans/Global/Omega/.

Example	Power	Scientific notation
Energy control over the entire universe (Type V civilization)	1×10^{56} W	1×10^{56} watt

Source: The Millennium Project based on Wikipedia.[31]

According to Kardashev, our civilization is still at Type 0, but it might reach Type I in the twenty-second century. In the year 2020, we know that we still have available a variety of resources to create a diversified energy matrix depending not on one single energy source but on a mixture of alternatives, at least during this critical transition period.

Earth, the sun, the galaxy, and the universe have more than enough energy resources to power our civilization for the next decades, centuries, and millennia. With the proper technology, it is basically a matter of costs and priorities. Converting the energy resources into available supplies can be done, but it will certainly take massive investments and lots of imagination, creativity, science, and engineering. All resources are obviously finite, but some are almost potentially inexhaustible even with an accelerating growth and rapid technological change. Methane hydrate mining, hydrogen and helium, nuclear fusion, solar energy capture, mass-energy conversion, and antimatter fuel generation are all eventually possible. Our civilization is still in its infancy, and barring any wild cards, geopolitical crises, environmental disasters, or extraterrestrial contacts, technology will keep pushing off the limits to growth.

Scenario 4. Political Turmoil

Moderate growth in technological breakthroughs
Low environmental movement impacts
Moderate/low economic growth
Major changes in geopolitics and war/peace/terrorism

The failure of nation-states and international organizations to make serious decisions is making them irrelevant. Political conflicts over oil are increasing. Transnational organized crime syndicates—with nearly three times more money than that of all the 2020 military budgets combined—play out their power struggles through governments, corporations, and even NGOs. Systems of all kinds—from medical records to financial transfers—have become so complex that individuals are bewildered and even "experts" are lost. Media empires have unwittingly countered much of the moral underpinnings of society with an "anything the market wants" attitude. The health and retirement costs of the aging populations around the world have forced many governments to cut benefits for all ages, which has led to increasing protests and general strikes. Selfish individualism seems to be replacing communal values, making international law meaningless. Global climate change continues. Terrorism has increased because too many see the governing systems as unjust, and international cooperation is breaking down. Migrations of the poor to the rich areas spark riots and expose the horrific income gaps. There is a real fear that the world is slowly being taken over by high-tech warlords, as growing numbers of economic and environmental refugees roam Earth.

The most dramatic of the recent migrations are the Afro-Indo-China water migrations into

[31] See http://en.wikipedia.org/wiki/Orders_of_magnitude_%28power%29.

Europe and North America, which have triggered a series of ethnic and racial conflicts with no end in sight. The EU and NATO create political stability in Europe only for short periods of time until the next eruption occurs. The U.S. economy was so weakened by the costs of wars in Iraq, Afghanistan, and generally against terrorism that it was difficult for it to play a role in reducing conflicts around the world. The EU was not able to reach agreements on strategies to replace the U.S. roles. UN peacekeeping forces were overstretched and underfunded. Conflicts in Saudi Arabia, China, Iraq, Angola, the Caucasus, China, and Nigeria over the past two decades have made oil supply irregular and kept oil prices above $150 per barrel[32] for the past several years. As a result the world seems to be in a perpetual state of stagflation.

Terror Version 2.0

Prior to the multiweapon world attack on September 11, 2011, terrorists used only one medium at a time. The combination of conventional explosives, dirty bombs, and bioweapons changed the world forever. This was a well-planned, fully coordinated, and expertly executed simultaneous attack on oil systems, airports, and cities. The world is still stunned and bewildered by the events and consequences of Terror2, as it came to be known. Three twinned dirty bombs were detonated, one each in Europe, Asia, and North America. Twenty-six of the world's major oil extraction sites, 13 refineries, 100 supply depots, and three shipping lane choke-points were hit with conventional explosives within several minutes of each other around the world. This reduced oil supplies by 20% for almost a year. On the same day, 19 terrorist-martyrs, who had previously ingested individual disease packages, infected passengers in the busiest airports of Europe, Asia, and North America. The price of gasoline quintupled overnight, spot prices were never more volatile, long-term contracts for oil were abrogated, trading in carbon rights was suspended, electricity and gas disruptions multiplied, many banks closed, and transportation-dependent supplies were missing, closing factories and causing food shortages around the world, which was now in the grip of fear and suspicion.

Terror2 brought many of the world's airlines, medical systems, and tourist industries to their knees and the global economy to a depression, from which we have now recovered—but only to a series of recessions and periods of hyper-inflation. Economies have turned inward, politics have become more nationalistic, and religion less ecumenical. Ad hoc demonstrations against incompetent governments erupted around the world, which went into the depression with increased poverty. Within six months the increased inflation caused some banking systems to collapse, unemployment rates to double, and businesses to migrate from emerging markets to advanced countries. Many who were accustomed to relatively high standards of living had suddenly to return to the conditions they had only heard about from their grandparents or seen in movies of poorer countries.

There could be no mistake about the sophistication of the planning behind this shocking multicontinent, multiweapon set of attacks. The failure to distinguish between modernization and westernization kept militants unwilling to seek alternatives to wiping out the "forces of cultural hegemony." Rumors persist that an alliance of political Islamist militants, environmental terrorists, and several organized crime groups made it happen. With the manipulation of media

[32] All US dollars references are in 2006 values

by many players for many purposes, people did not know whom to trust about these events and they have increasingly withdrawn to more local identities and loyalties. There is an unsettled feeling among some people that some governments must have known in advance about such a large set of attacks. Transnational organized crime and terrorist groups could not have grown to have such sophistication and coordination by 2011 without several major governments becoming aware. Or is it that the organized crime groups and enough government personnel and computer systems are so interlinked that it was indeed possible?

In any case, the disruption of the Pan European pipeline that delivered oil to Europe from the Caspian Sea area and Russia placed Europe in a very tight supply situation for about six months. During this time gasoline rationing was instituted. There were frequent electricity brownouts across Europe as a result of the shutdown of the natural gas pipeline that ran from Turkmenistan to Europe through Azerbaijan, Georgia, and Turkey. The Baku-Tbilisi-Ceyhan pipeline[33] was designed to make Europe independent of Russian oil supply and the threat of a Russian oil monopoly, but cutting this pipeline made Europe once again reliant on Russia's oil. Russia would have been glad to fill the gap, but its oil and natural gas production was also disrupted.

The major OPEC countries were having troubles of their own. The Red Sea export port of Yanbu in western Saudi Arabia was closed as a result of an effectively placed bomb, and in Iraq, Basra's oil terminal suffered huge damage from a waterborne attack by suicide bombers.[34] In Canada, bombs shut down the Alberta production of oil from tar sands and oil exports to the U.S. from Canada essentially stopped. Oil rigs in the Gulf of Mexico also came under waterborne suicide attacks, and 15 of them were shut down. In Iran, the North Sea, and Alaska the story was the same. Other targets were the Chunnel that connects the UK and France; Saudi Arabian export facilities at Ras Tanura, Abqaiq, and Jubail; and several nuclear power plants, although these suffered no damage due to their heavy reinforcement.

The situation was incredibly difficult because of the simultaneous need for repair crews, firefighting equipment, replacement pipeline sections, and—most of all—energy, which was now in short supply, to make repairs on the damaged facilities. Many industries shut down completely, countries were paralyzed, economies faltered, travel came to a virtual halt, and security intensified. But of course the new security measures guarded against the last, not the next, threat. What really needed to be done was to restore a certain minimum of social order in the short term and to have a serious and worldwide reflection on the root causes. Previous efforts to do so did not work.

A worldwide social contract was signed, which brought into being the emergency international and transinstitutional plan to respond to collapses due to future Terror2-type attacks, which included ubiquitous sensors, computers, satellites, and a massive worldwide intelligence campaign to determine intentions, at the individual level, to enable preemption. NGOs, universities, and religious organizations tried to improve civility by reinforcing the familiar vows, training teachers in teaching tolerance, and producing media campaigns that highlighted

[33] Built at a cost of $3.6 billion and capable of pumping 1 million barrels a day; see http://www.rferl.org/featuresarticle/2005/05/206868a6-60ca-4f9a-81f0-dea2f7fbc501.html
[34] Such an attack was attempted in June, 2004. See: http://www.globalexchange.org/countries/mideast/iraq/2046.html

the common values that underlie peace in all cultures and religions. However, the root causes are still not addressed seriously enough to this day to make the world better than before Terror2.

The world seems to have been in a daze for the past nine years. Even before Terror2, however, world leaders knew there was increasing political alienation, widening income gaps, a growing number of failed states, falling water tables, spreading new diseases, rationing of commodities, and skyrocketing energy prices. Yet they failed to act to make a difference. In energy, for example, there were many early wake-up calls about impending political turmoil: the fluctuating price of oil since the beginning of the twenty-first century, the reduced discovery rate of new reserves, the pleas for rejecting the world's addiction to oil, the wars in the Middle Eastern oil-rich countries, the growing concern that the world had passed "peak oil," and the sharp increases in energy demand in China and India, to mention just a few of the signals that were well above the horizon long before 2011.

Oil Problems Created Political Flash Points

Oil-related political hot spots occurred in the Caucasus, China, Japan, the Arctic, Nigeria, the Persian/Arab Gulf, Russia, Venezuela, and Antarctica, where demand had finally shattered any semblance of accord on preserving the natural heritage. Here's a brief overview on what happened in some of these areas.

The Caucasus

Following years of tensions between the Russian Federation and the Republic of Georgia, the situation finally came to a head in 2009 (two years before Terror2) over domestic terrorism and irredentism. This was a preview of the turmoil to come. An undeclared war erupted, causing interruption of the flow of oil and gas in the Baku-Tbilisi-Ceyhan Pipeline and the South Caucasus Pipeline. As a result, Azerbaijan's economy collapsed under the strain and civil unrest erupted. Armenia took advantage of the civil war by igniting a conflict over the Armenian ethnic enclave in Nagorno-Karabakh in Azerbaijan. Armenia annexed the enclave as well as vast portions of western Azerbaijan, including sections that contained important portions of the two pipelines. Turkey's economy suffered due to problems with the energy flow, and the formerly moderate ruling party of Turkey, the Islamic Justice and Development Party, began to lean further right in order to deal with an angry constituency and to avoid defections to more religious parties.

Figure 2-10: The Caucasus Region

Source: BBC

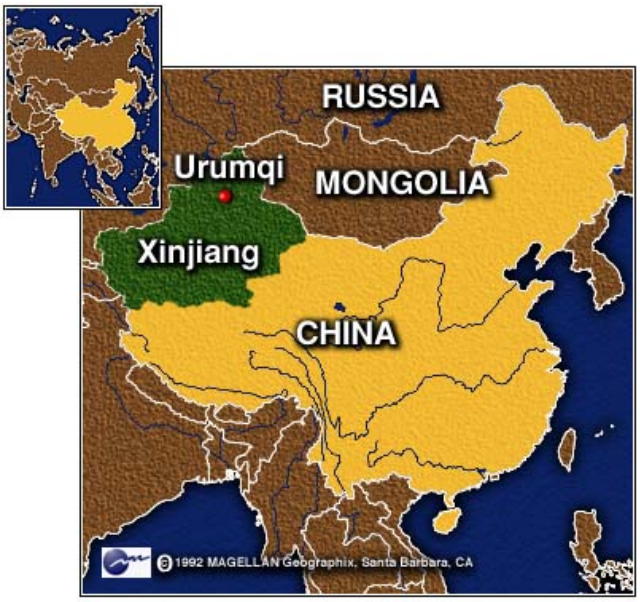
This in turn caused stress between the Turkish government and the Kurdistan Workers Party, which declared autonomy in the southeast. The Turkish government, assisted by the Shi'a factions of the new Iraqi government, who were afraid of strengthening the Kurdish parties in the Iraqi government, sent troops, effectively ending a five-year truce with the Workers Party.

The EU froze Turkey's accession talks, which pushed Turkey further into the Middle Eastern orbit. Iran's power and influence grew in the region, and its overt support for the Shi'ites in Iraq effectively ended the tenuous Iraqi national cohesion. Tensions and undeclared wars increased, while alliances formed among terrorist groups of Iran and Iraq and the variety of warlords across the region that we see today.

The largest oil reserves in China are in Xinjiang in northwest China, where a pan-Islamic or pan-Turkic separatist movement has been growing for years among the Uighur people. Conflicts between the Xinjiang Liberation Organization/Uighur Liberation Organization and police have increased support from the Uighur diaspora and widespread sympathy from the Uighur population, including the induction of new recruits who were trained in guerrilla tactics. The Xinjiang-Shanghai Pipeline was a key target for several separatists' attacks, making the delivery of oil and gas to the Chinese coastal cities no longer reliable. These cities were important to success of the Chinese Communist Party,[35] and people began to lose faith in the government's ability to manage the energy price fluctuations. Anti-government demonstrations began. Nothing changed. The government blamed the ULO for fluctuations in energy prices.

Figure 2-11: China

[35] Ewing, Dan, "China's New Energy Strategy and the Specter of Inflation," located at NixonCenter.org, http://www.nixoncenter.org/publications/2001articles/Dan%20Ewing/China%20Energy%20and%20Inflation.htm



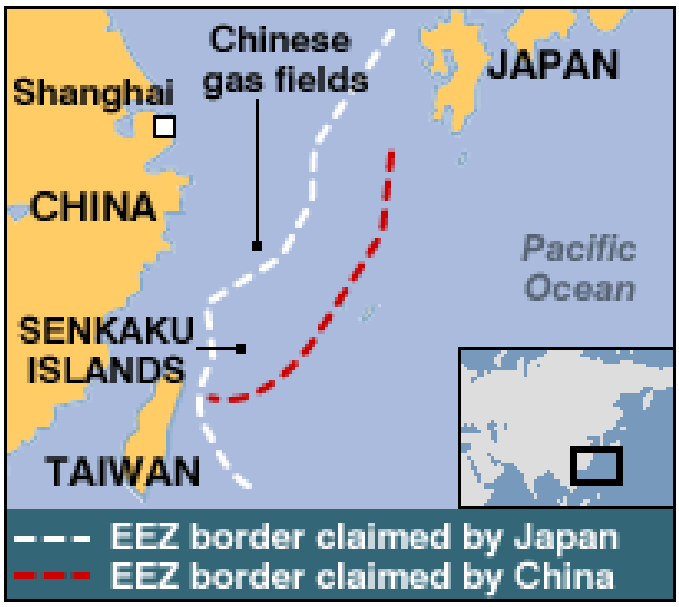
Source: BBC

In counter-demonstrations in the richer cities in the coastal regions, people expressed anger toward the Muslim Uighur. There were racial and anti-Islamic overtones. A new wave of protests by the Uighur broke out in Xinjiang, which in turn were met by police violence. Most in China supported the crackdown on the Uighur and the imposition of martial law in areas of Xinjiang where ULO activities were the strongest. This incited the more moderate Uighurs, who called on the Islamic insurgents fromthe Central Asian republics and the Middle East to assist their new pan-Islamic Uighur state. This led to the current state of civil war in northwestern China and quickly reduced China's oil production, further accelerating its efforts for increased international oil access beyond the 8 million barrels of oil per day it was consuming.

China was able to leverage its vast holdings of U.S. debt to prevent U.S. criticism of its civil wars and tactics. As a result, the uprisings were suppressed with a very heavy hand in an effort not to lose territorial coherence. When the U.S. complained, China switched from the dollar to the euro as its international monetary standard and began to foreclose on some of the U.S. debt. China's increasing power within the UN Security Council prevented any discussion of Chinese internal actions. Nevertheless, the separatist groups were strong enough that oil from Western China was no longer reliable, forcing China to increase pipeline access to Russian oil. It did, however, stimulate Chinese alternative energy efforts in solar-powered fuel cell technology, biofuels from the coastal seawater agriculture regions, and wind energy, while increasing its import of Australian liquid natural gas.

Tensions between China and Japan had been growing for two decades over the control of oil and gas fields in the East China Sea. They flared up when Japan accused China of siphoning oil from the Japanese exclusive economic zone. China and Japan began to draw from the same reserves as rapidly as possible.

Figure 2-12: East China Sea



Source: BBC

Japan accelerated its effort when Russia agreed to provide its oil pipeline access to China instead of Japan.[36] This made it politically impossible for Japan to make any compromise on the gas fields in the East China Sea. Further complications were conflicting treaties. Japan claimed the area under the UN Convention on the Law of the Sea that allows coastal countries to claim an economic zone extending up to 370 kilometers from their shorelines. Both Japan and China are parties to this agreement. China claims the area under the 1958 Geneva Convention on the Continental Shelf that allows coastal countries to extend their borders to the edges of their undersea continental shelves.[37]

Although weakened politically and economically by the costs of past wars and the current need for energy, the U.S. was able to send its Seventh Fleet on naval maneuvers near the disputed area, and then China and Japan agreed to take the issue to the World Court in The Hague. Tensions still remain high while the oil and gas pumps are on hold, and Japan increased its competition with China for Australia's liquid natural gas, while playing different elements in China against each other and accelerating its efforts to extract ocean-bed methane hydrates, for which environmentally safe technologies do not yet exist.

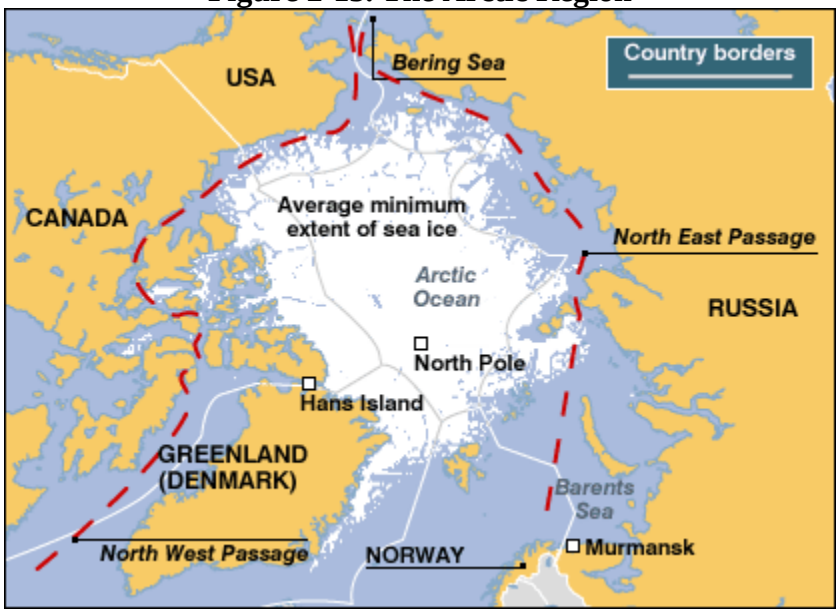
The Arctic

Climate change continues to melt the polar ice. Huge resources have become more and more accessible in the Arctic, where a quarter of the world's undiscovered oil and gas are estimated to reside. Norway, Denmark (through Greenland), Russia, Canada, and the United States are competing for access.[38] The dispute revolves around the different methods of determining

[36] http://news.bbc.co.uk/2/hi/asia-pacific/4831624.stm#pipelinebox
[37] The Chunxiao/Shirakaba and Duanqiao/Kusunoki fields have been confirmed to be connected at the subterranean level to a gas field that lies within what Japan says is its EEZ. The Tianwaitian/Kashi gas field is also suspected to be directly connected to deposits on the Japanese side.
[38] http://www.russiaprofile.org/international/2006/1/11/3022.wbp, http://news.bbc.co.uk/2/hi/business/4354036.stm,

maritime frontiers. The median line method, supported by Canada and Denmark, would divide the Arctic Sea between countries according to their length of nearest coastline. This would give Denmark the Pole itself but Canada would gain as well. The sector method would take the North Pole as the center and draw lines south along longitudes. This would penalize Canada, but Norway and, to a lesser extent, Russia would gain.

Figure 2-13. The Arctic Region



Source: BBC

The United States and Canada argue over rights in the Northwest Passage, Norway and Russia disagree over the Barents Sea, Canada and Denmark are competing over a small island off Greenland, the Russian parliament is refusing to ratify an agreement with the United States over the Bering Sea, and Denmark is seeking to trump everyone by claiming the North Pole for itself. The United States has yet to sign the UN Convention of the Law of the Sea. If the World Court does not resolve these issues or takes a long time, or if one or more parties do not accept its ruling, then private capital insured by governments and backed by gunboats will invest in hopes of gaining oil and gas, while preparing to pay retroactive penalties. To keep this from becoming a hot spot for confrontation between former allies, quiet face-saving deals are in preparation to pay royalties to those who cede access.

Nigeria

Nigeria should and could be a key player in the development of Africa and new sources of oil, but political turmoil keeps preventing sufficient investments to achieve that potential. Rightly or wrongly, oil companies operating there have been severely criticized because of their environmentally unfriendly extraction practices and their failure to condemn human rights violations. Pipeline vandalism has long been a problem in Nigeria. Pipeline fires, dynamiting of

http://www.timesonline.co.uk/article/0,,13509-2034643,00.html

Shell's pipeline in the Opobo Channel, attacks made on the Forcados terminal, attacks on the Escravos pipeline, kidnappings of expatriate oil workers in the Niger Delta region: all of these prove the depth of the resentment felt by the Ijaw people who live on the river Niger.[39]

Ijaw leaders have been associated with the Niger Delta People's Volunteer Force. In recent decades the resentment among the Ijaws has grown since they have seen little of the rich returns from the oil resources in their region.

Organizational cohesion and arms procurement of the NDPVF rose significantly with funds extracted from the widespread sale of stolen oil and from support of the Ijaw diaspora in the United States and elsewhere. Over time, the NDPVF became a serious threat to government security forces. Contrary to its original guerrilla hit-and-run tactics, for the first time militiamen seized and held oil-sensitive territory and a refinery. Most likely they were players in the September 11, 2011, actions in Nigeria. When diplomatic negotiations failed and Nigeria labeled the NDPVF a terrorist organization, heavy arms became available to the militiamen in the occupied territory. The NDPVF has become a serious threat to the Nigerian federal authorities, with the group spearheading a secessionist movement that keeps Nigeria in a state of instability. Although it still has one vote in the United Nations, Nigeria is really broken along religious and ethnic lines, with organized crime controlling oil exports, which remain too low for it to be a key player in oil supply.

The Persian/Arab Gulf

As a result of these conflicts and falling reserves around the world, the importance of the Gulf Region has increased. As oil supplies dried up around the world, small Gulf States have become increasingly nervous about big power conflicts. There is an old African saying, "When great bulls fight, only the grass underneath gets hurt." The Gulf States did not want to get trampled by the competitions among China, India, and the United States.

Saudi Arabia had been modernizing and beginning to hold democratic elections when Terror2 hit the world in 2011. It empowered the extremists within the political Islamist movements to claim their time was at hand. Religious campaigns in the streets, political sermons in mosques, and scathing articles in newspapers condemned corruption and advocated the need for change. The extremists surprised the world and won the first national election, selecting their Prime Minister for Saudi Arabia. However, the victory was short-lived. With about 3,500 princes and countless informal deals with power brokers around the world for several generations, the royal family was strong and deeply embedded in all aspects of Saudi government and society. Old debts were called in from governments, corporations, and individuals. Civil war broke out between different factions within the country, resulting in Saudi Arabia being broken into several parts, with an uneasy truce holding today.

[39] These attacks occurred in 2005-2006 and are reported in http://www.eia.doe.gov/emeu/cabs/Nigeria/Oil.html

Figure 2-14. The Middle East

Source: BBC

The future of Saudi Arabia and the Gulf Region seems to depend, more than ever, on western powers to protect sea lanes and pipelines while the region develops democratic forms of government under an Islamic framework, making distinctions between modernization and westernization.

Other Factors Making the World More Unstable

The daily struggle of 30 million AIDS orphans without love or mercy turned so many in Africa to crime networks that roving gangs eventually made political stability impossible in many countries. Water shortages across much of India and China had induced migrations of people in unsettled conditions, and migrations of the poor to the richer areas have caused civil strife around the world, which continued the political turmoil.

Meanwhile, Russia, Europe, and New Nuclear Plants

Russia had no fuel supply concerns that would have led it to use nuclear rather than fossil power plants. As possessor of a huge nuclear arsenal, Russia had no need for a commercial nuclear sector to disguise weapons work. Yet the government decided to pursue the nuclear route for domestic electricity and to export its fossil fuels. Absent the regulations and litigious NGOs of the West, this strategy allows it to export the hydrocarbons that it would otherwise use internally.[40]

[40] See: http://www.news24.com/News24/World/News/0,,2-10-1462_1873545,00.html

Russia built dozens of nuclear reactors for several reasons. By building these plants, the country further developed a technology that it thought might someday be exportable. In addition, excess electricity production would allow Russia to supply nations previously in the Soviet Union, bringing them further into Russia's economic orbit. The Russian plan, now largely accomplished, was to build about 40 new nuclear reactors in order to increase the share of nuclear energy in the nation's energy balance to 25%. Although many experts forecast that a means for safe storage of nuclear waste is likely by 2030, the increasing opportunities to hijack radioactive waste during transport are still a worry. It was during transport that such radioactive wastes found their way into the "dirty bombs" of September 11, 2011. Nevertheless, the designs for the new Russian nuclear plants were a step forward. They were specifically designed to be secure from terrorist attacks and, based on the Chernobyl experience, to be as free as possible from human or mechanical malfunction.

One of Russia's most important energy exports was and still is natural gas. In a series of power moves between 2005 and 2008, private ownership of energy resources was replaced again by state ownership, clearly a step back toward the old days. This shift was evident when the Yukos natural gas venture was terminated and Gazprom (the state-owned company) became the natural gas monopoly. Natural gas is delivered from Russia to Europe in a 1,200-kilometer, $5-billion pipeline along the Baltic seabed. It was almost destroyed in the 2011 attacks but now is repaired. It provides Gazprom with a direct route to the European markets and bypasses Poland and the Baltic states.[41]

Europe still relies heavily on the exported Russian gas and hence has a interest in trying to keep Russia politically stable, which may not be possible. Therefore, the EU sought to diversify its energy supply by developing coal gasification technology, wind, solar, and other forms of renewable energy sources. Nevertheless, the importance of the Russian gas led the EU to political compromises in the UN and in trade agreements that might not have been necessary in other circumstances. Europe is still trying to formulate a common energy policy that will help assure continuing and stable supply.

Unstable Oil Supply Forces the U.S. and Canada Closer Together

Canada has joined the ranks of major energy exporters with its development of tar sands, bitumen, and heavy oils. As a result, its relationship with the United States has become much closer, since it is now a supplier of a strategic energy commodity. Canada has the luxury of selling part of its energy resources to maintain good relations with China and India. To make sure that enough of Canada's energy resources flowed south rather that west, the US fostered many joint endeavors with Canada to develop technological breakthroughs for stretching the amount of oil extracted from any one well, conservation techniques that improve efficiency, cleaner uses of coal, and conversion of bitumen to synthetic crude oil with measures for carbon dioxide capture and storage. With an all but dead environmental movement, even the development of shale oil is now pursued.

[41] See: Jan 5th 2006, *The Economist* print edition

North American R&D funding has tripled and some progress has been made in the development of solar cells, water-energy efficient agriculture, and new organisms that use life processes to produce crops that can be converted to fuels. There is also some experimentation with "synthetic" organisms that will permit the extraction of residual petroleum from wells previously thought to be depleted. The development of large-scale portable generators by the U.S. military has led to an acceleration of diffusion of points of generation. Military technology also provided new kinds of batteries for a range of battery-powered devices, including the electric car. These batteries have now become a major North American export.

Other investments focused on high-efficiency water purification processes, in the hope that the region might at some future time export water in trade deals for oil. The R&D program also concentrated on the development of new catalysts to lower the energy requirements of electrolysis, a step toward a hydrogen economy. Some Arab countries have also been investing in similar water technologies, taking advantage of their oil profits and worrying about the future of their own water supplies.

Brazil and much of Latin America have become primary exporters of ethanol, and researchers in North America are attempting to design a crop and process that will improve the output of alcohol. If this work is successful, not only will these countries have a new fuel or fuel additive, but these investors are hoping that they may be able to export some of this product in competition with Brazil. India followed China in entering this biotechnology race for new energy sources. European environmentalists have blocked the use of genetically modified organisms that can create new energy supplies, arguing about the consequences if the synthetic organisms escape and evolve in nature. Nevertheless, the long-term future stability of energy supply could well come from the merger of natural and artificial systems.

* * * *

Efforts to create serious international governance structures that require compromise and give-and-take negotiations have largely failed over the past 20 years. Ethnic groups and countries are looking out for their own interests. The global economy has not yet grown back to its pre-2011 size. Many have turned inward, focusing more on local affairs and with increasing reliance on religion for security. Some believe humanity is in a time of religious revival. It is unfortunate that the international community ignored for so long the grievances of radical Muslims living in regions of oil supply.

An electronic iron curtain has come down between the knowledge-able and the knowledge-less. The decay of family and social values, corruption, and transnational crime seem to have become the governing elements in the system. Many people have withdrawn into the personal, private, cyberspace world. Not enough seem to care about the environment or their neighbors. One wonders if the world has entered a new kind of World War III.

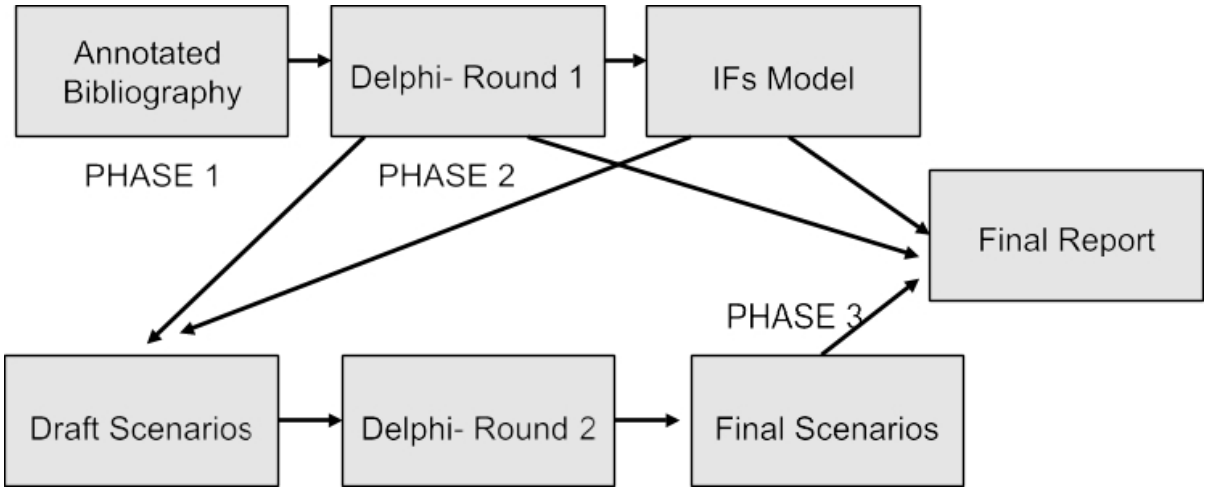
Analysis of the 2006 Energy Survey

3. Study Flow and Demography of Responses

The Global Energy Scenarios 2020 study had three phases:

- construction of an Annotated Bibliography of Global Energy Scenarios—which depicted the most important global energy scenarios already written
- survey of energy experts for identifying important changes and timing of changes concerning the energy industry
- based on the responses collected through the survey, four global energy scenarios were drafted and circulated to experts for comments, suggestions, additions

Millennium Project Global Energy Scenarios Study Flow



The first phase, the construction of an annotated bibliography of global energy scenarios and related reports, was used for inputs to the surveys questionnaires.

The survey of energy experts was conducted to identify important events concerning the future global energy situation and collect judgments about the timing of critical future developments and the contribution of various energy sources to the total mix in 2020.

Two survey modes were used to collect these judgments: an on line questionnaire form and an MS Word based form that could be completed and submitted online or by fax or mail. The format was roughly similar to a single round Delphi; the questionnaires are available at http://www.acunu.org/millennium/energy-delphi.html and an example is also included in Appendix C. The MS Word form of this questionnaire was available in English, Russian, Portuguese, and Spanish. A third experimental approach was also employed: RT Delphi, a new means for conducting a Delphi study that employs only a single round with a built-in means for feeding back the responding group's judgments; this one is detailed in Appendix C.

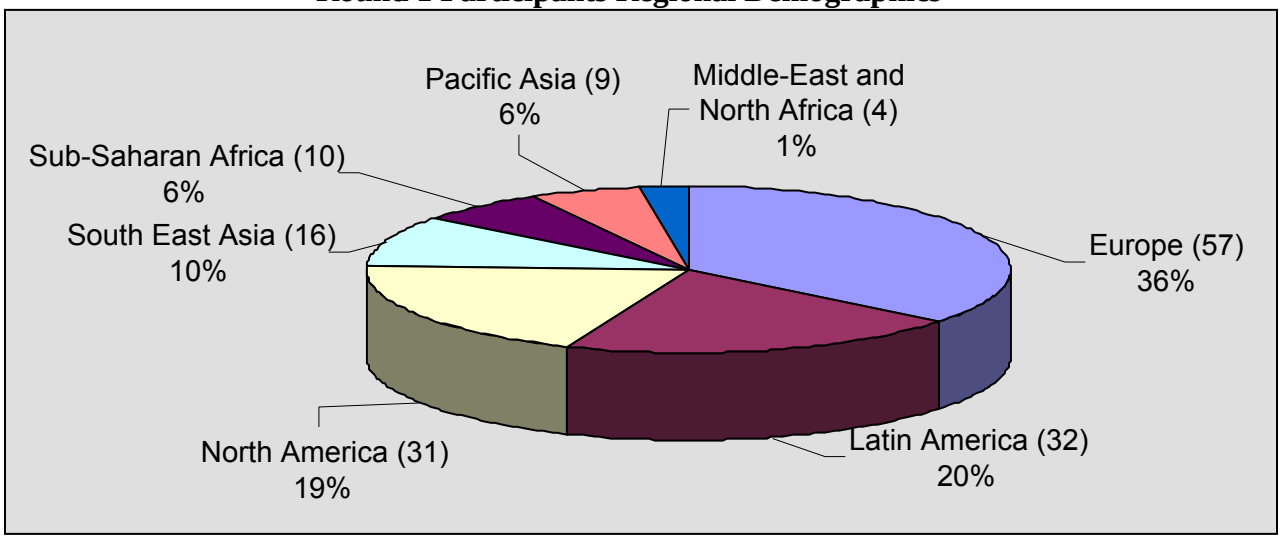
The results of these surveys were used to construct draft scenarios, which were circulated for

comments in the third and final phase.

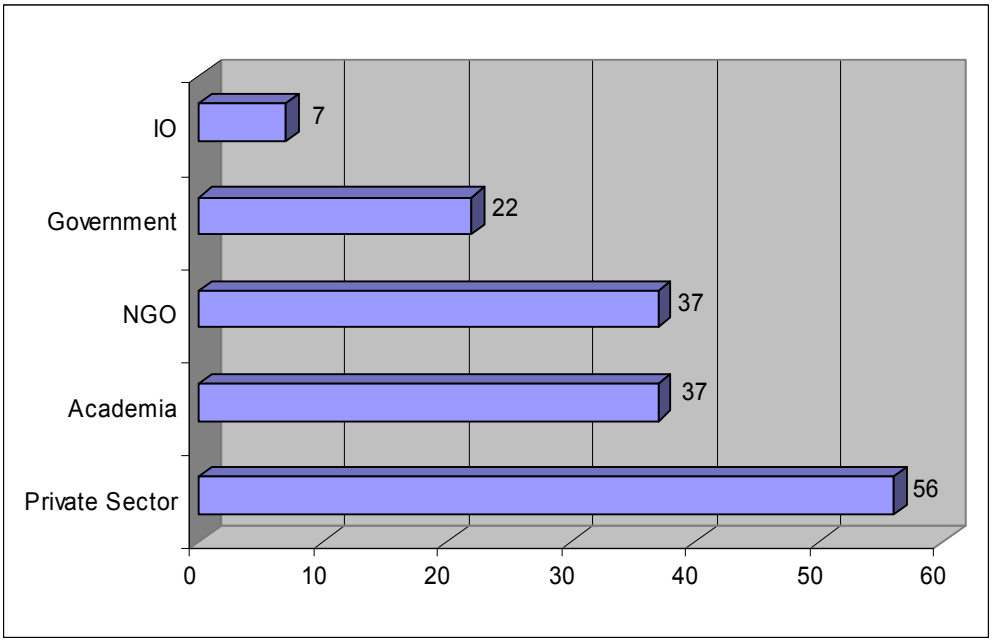
Demography of Responses

Round 1: The full Delphi produced over 159 responses (not including another about 30 participants in the RT Delphi[42])

Round 1 Participants Regional Demographics



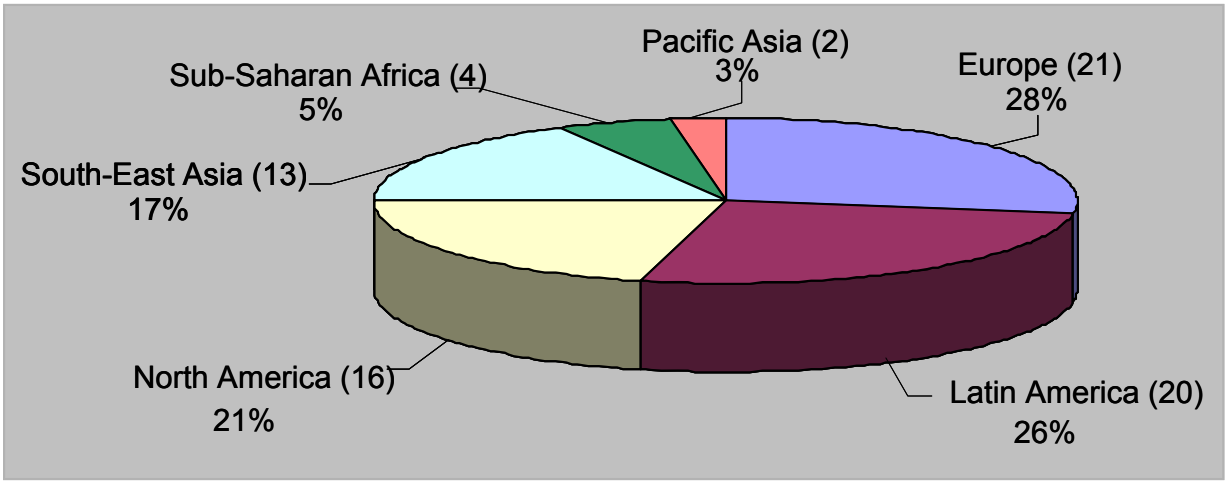
Round 1 Participants Sectoral Demographics



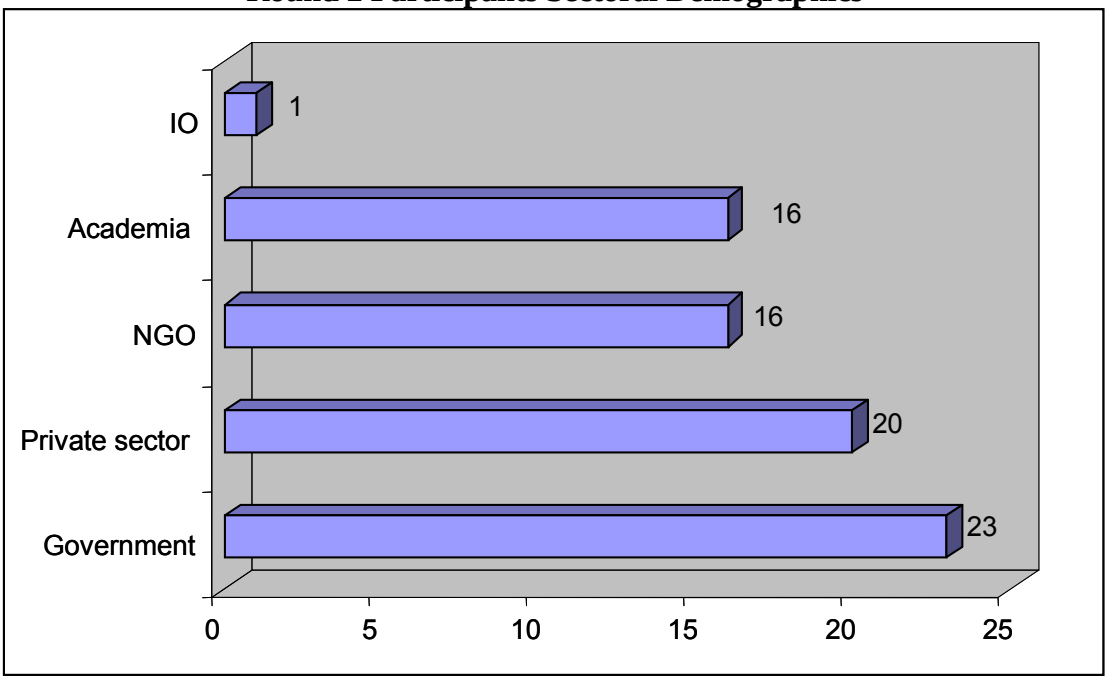
[42] In total, there were 89 registration in the RT Delphi; the greatest number of responses for any single question was 19. Most of these answers were early in the sequence indicating either that boredom set in or that the early questions served to illustrate the process.

Round 2: combined, there were received over 115 responses to the four scenarios from 76 participants. The demographics of the participants are:

Round 2 Participants Regional Demographics



Round 2 Participants Sectoral Demographics



4. Forecast of Future Developments

All three forms of the survey presented a series of 18 future developments thought to be important to the evolution of the global energy picture and participants were asked to supply judgments about the date at which they thought the development would occur assuming the context of the four scenarios. The table below summarizes their median responses. In this survey we offered respondents the opportunity to make comments and in many instances the respondents entered comments such as "never" rather than numerical estimates. Had we just averaged the numerical estimates as is often done in analyses of this sort, the "never" opinions would have been ignored. Therefore we chose to use median estimates, assigning the value of the year 2200 to the "never" responses. The lower quartile, median, and upper quartiles of the responses are shown in the table below in the four columns labeled "Survey Results." Three numbers appear in each cell: the lower quartile is the top number; the median, the center; and the upper quartile, the final number. All respondents' comments appear in Section 6 and Appendix C.

The shaded columns on the right represent the answers from the RT Delphi which because of the smaller sample size are probably less reliable. About 70 persons answered in each cell of the survey; about 10, in the RT Delphi. Ranges for the RT Delphi are shown because the respondents used pull down menus that offered ranges of answers.

Table 5. Developments Estimated Time Occurrence

(lower, median, and upper quartiles for the survey responses, and time-range for the RT Delphi responses)

	SURVEY RESULTS				*RT DELPHI RESULTS*			
	Business as Usual	Environ-mental Backlash	High Tech	Political Turmoil	Business as Usual	Environ-mental Backlash	High Tech	Political Turmoil
1.16 Terrorist attack on oil production and/or delivery systems disrupts supply by 5-10% for at least 1 month	2010 2010 2020	2010 2010 2020	2010 2015 2020	2010 2010 2015	2010- 2015	2010- 2015	2015- 2020	2010- 2015
1.13 The geopolitics of gas becomes as central to energy growth as the geopolitics of oil was in the last 30 years of the previous century	2010 2020 2020	2010 2015 2020	2015 2020 2025	2010 2015 2020	2015- 2020	2015- 2020	2020- 2025	2015- 2020
1.14 Carbon trading practiced by 30 of top 50 emitting countries	2012 2020 2025	2010 2015 2020	2010 2015 2020	2020 2030 2050	2015- 2020	2010- 2015	2020- 2025	2020- 2025
1.11 Industry consolidation continues, resulting in only a few large oil companies in the world	2015 2020 2025	2015 2025 2030	2015 2020 2030	2015 2025 2030	2015- 2020	2015- 2020	2015- 2020	2025- 2030
1.1 Hubbert Peak when half the conventional oil is gone (but conventional may one day in the future include deep drilling, tar sands, and shale)	2015 2020 2030	2024 2030 2040	2020 2040 2050	2015 2015 2020	2020- 2025	2015- 2020	2025- 2030	2015- 2020
1.5 One million electric cars per year are produced, plurality manufactured in China	2015 2020 2030	2015 2020 2025	2015 2020 2020	2020 2025 2038	2020- 2025	2020- 2025	2015- 2020	2025- 2030

	Business as Usual	Environ-mental Backlash	High Tech	Political Turmoil	Business as Usual	Environ-mental Backlash	High Tech	Political Turmoil
1.9 Significant portions of urban centers in most major cities are closed to private vehicle traffic, or have a system of tolls for entry by cars.	2015 2020 2030	2010 2015 2025	2015 2020 2030	2020 2030 2040	2015-2020	2015-2020	2015-2020	2025-2030
1.12 Water problems destabilize India and China, lowering economic growth, and causing coal and oil demands to fall.	2015 2020 2030	2015 2022 2035	2015 2025 2050	2013 2017 2030	2015-2020	2015-2020	2020-2025	2015-2020
1.15 Carbon taxes in one form or another in more than 50 countries	2015 2020 2030	2010 2015 2024	2013 2020 2025	2015 2030 2050	2020-2025	2015-2020	2020-2025	2025-2030
1.17 Majority of major new buildings in developing countries are designed for low energy consumption	2015 2020 2030	2012 2017 2030	2012 2020 2025	2020 2038 2050	2025-2030	2015-2020	2020-2025	2025-2030
1.18 Most countries have policies to achieve significant shifts in fuel mix, including removal of subsidies on coal and other fossil fuels	2015 2020 2030	2010 2015 2020	2012 2015 2020	2020 2030 2040	2020-2025	2015-2020	2015-2020	2020-2025
1.7 High efficiency engines power 25% of new cars; e.g. using Stirling engines	2020 2025 2030	2015 2020 2030	2015 2020 2025	2020 2025 2040	2025-2030	2020-2025	2020-2025	2025-2030
1.10 The amount of energy consumed per dollar of GDP worldwide drops 25% from today's value	2020 2025 2030	2018 2020 2030	2015 2020 2028	2030 2030 2040	>2030	2020-2025	2020-2025	2025-2030
1.2 Affordable photovoltaic cells with >50% efficiency are available	2020 2030 2040	2020 2025 2035	2015 2020 2030	2020 2030 2050	omitted	omitted	omitted	Omitted
1.4 A solution is found for long-term safe storage or destruction of radioactive waste	2020 2030 2050	2020 2030 2050	2015 2025 2050	2020 2035 2065	2025-2030	2020-2025	2020-2025	2025-2030
1.6 New credible fission technologies are developed to solve problems of nuclear generation; improved security, reduced risk of malfunction	2020 2030 2050	2020 2040 2050	2015 2025 2040	2030 2040 2050	2025-2030	2020-2025	2025-2030	2025-2030
1.8 30% of electrical power is generated at the point of use	2020 2030 2050	2020 2025 2040	2015 2025 2040	2020 2030 2060	>2030	2020-2025	2020-2025	2025-2030
1.3 First demonstration of cost-effective generation and delivery of base load electricity from solar earth orbital satellites	2030 2050 2070	2030 2040 2050	2020 2030 2050	2035 2050 2100	2025-2030	2025-2030	2020-2025	2025-2030

A comparison of the data from the two sources shows that the RT Delphi ranges contained the median value of the survey responses in about 80% of the cases.

5. Forecasts of Energy Consumption by Sources

Section 3 of the survey and RT Delphi requested an estimate of the total energy consumption in 2020 and the distribution of that value among various energy sources. The table below shows the median expectation of the amount of energy consumed by each energy source in 2005 (given) and 2020, from the survey:

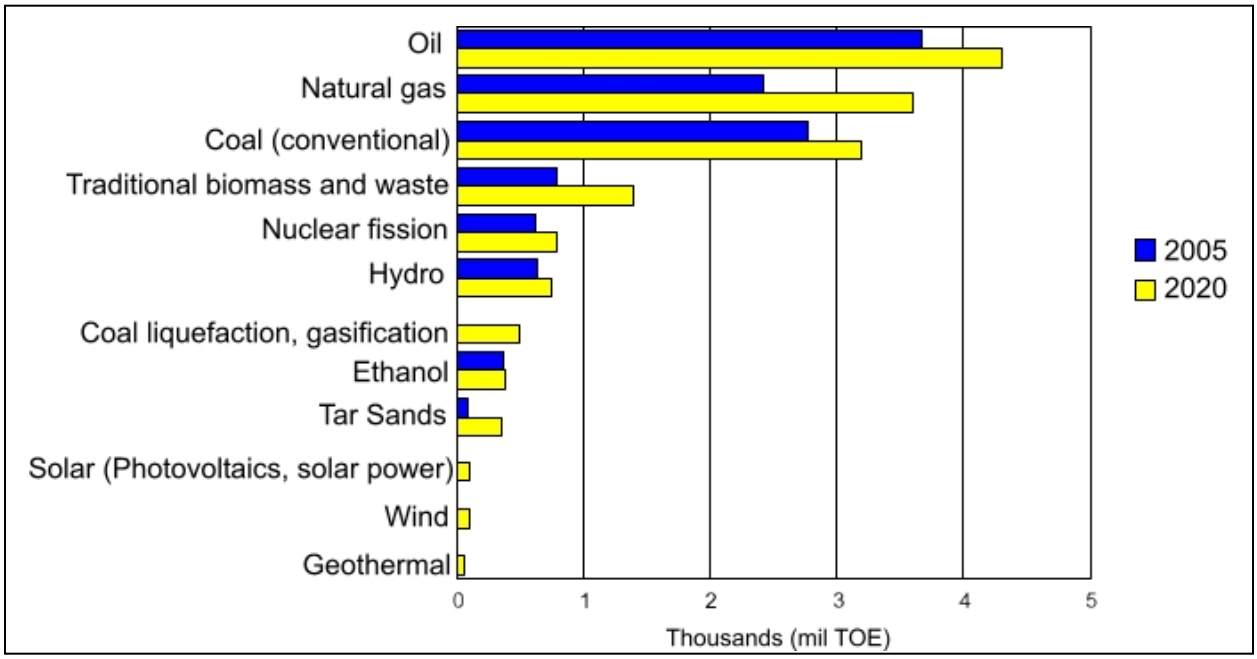
Table 6. Energy Consumption by Sources—Comparison 2020 vs. 2005

Consumption	*Amount 2005 Consumption (mil TOE)*	*Estimate of 2020 Consumption (mil TOE)*	*Gain (Loss (mil TOE)*	*Percent Change*
TOTAL (direct estimate)	11,411	**16,830**	5,419	47.5
TOTAL (sum of components below)	*11,409*	***15,544***	*4,135*	36.2
Oil	3678	**4,300**	622	16.9
Natural gas	2420	**3,600**	1,180	48.8
Coal (conventional)	2778	**3193**	415	14.9
Traditional biomass and waste	793	**1400**	607	76.5
Nuclear fission	624	**790**	166	26.6
Hydro	634	**750**	116	18.3
Other biomass Methanol Ethanol	370	**388**	18	4.9
Unconventional oil from tar sands and shale	88	**350**	262	297.7
Coal processes total from liquefaction, oxygenation, gasification	-	**500**	-	!
Solar (Photovoltaics, solar power towers, solar thermal, and space solar)	11	**100**	89	809.1
Wind	8.5	**100**	92	1076.5
Nuclear fusion	0	**0**	0	
Methane gas hydrates	0	**22**	22	
Geothermal	4.8	**50**	45	941.7
Tides	.1	**1**	1	900.0

These estimates are somewhat inconsistent. If the contributions of the individual sources are summed, they do not equal the direct forecast of the anticipated total in 2020. The sum of the source estimates (italicized) is 15,544 mil TOE rather than the direct forecast of 16,830 mil TOE, a discrepancy of 1,286 mil TOE or about 8%. Perhaps this is within the range of expected accuracy of the survey.

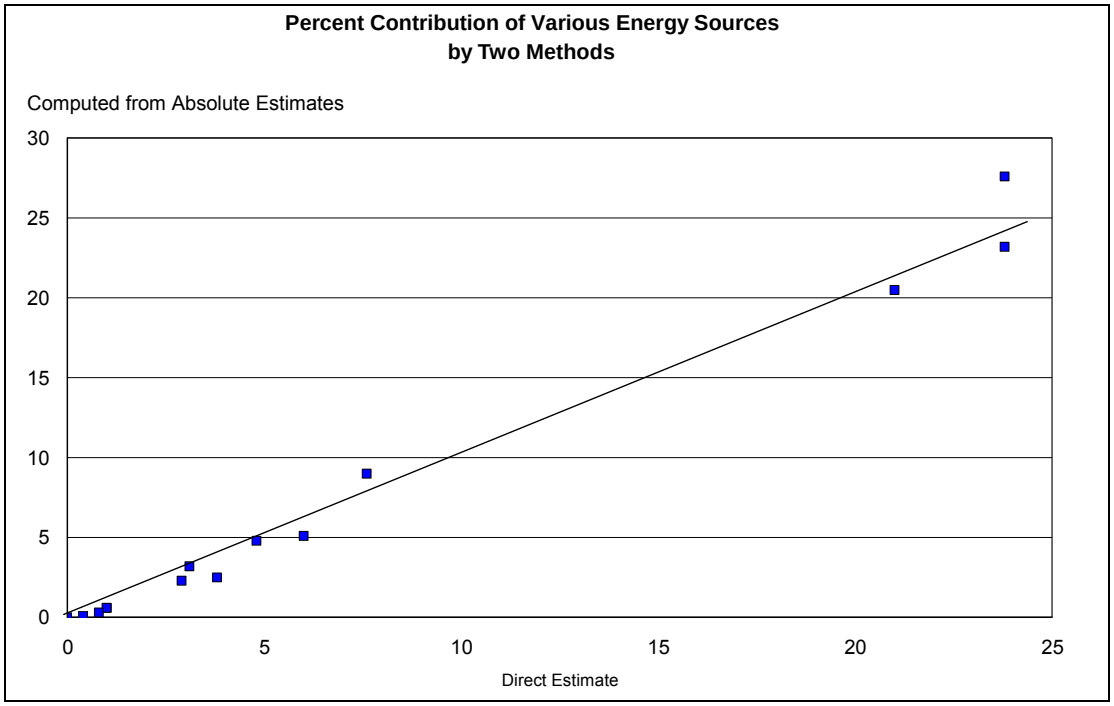
The largest growth occurs in natural gas use, followed by oil, traditional biomass, and coal. Unconventional oil from tar sands also shows remarkable growth of 262 mil TOE.

Figure 19. Energy Consumption by Sources—Comparison 2020 vs. 2005



Since the survey questionnaire asked for both absolute values contributed by each energy source and the percentage energy that each source represented, it was possible to compute percentage (e.g. percentage = estimate for the energy source in 2020 / total energy demand in 2020). The graph below shows the normalized values for each estimation method. The comparison is very good.

Figure 20. Energy Consumption by Sources—Comparison of computation by absolute estimates vs. percentage



The anticipated percentage of the contribution of oil represents the largest discrepancy (29% computed, 24% direct estimate).

The table below shows the median estimates of the survey participants.

Table 7. Percent of Energy Consumption by Sources—Survey results

Percent of Total Consumption	*Percent of Total 2005 Consumption*	*Percent of Total 2020 Consumption Direct Survey Estimate (normalized)*	*Percent of Total 2020 Computed from Estimates of mil TOE for each source*
TOTAL	100	100	100
Oil	32.7	23.8	27.6
Natural gas	21.5	23.8	23.2
Coal (conventional)	24.5	21.0	20.5

Percent of Total Consumption	***Percent of Total 2005 Consumption***	***Percent of Total 2020 Consumption Direct Survey Estimate (normalized)***	***Percent of Total 2020 Computed from Estimates of mil TOE for each source***
Traditional biomass and waste	7.1	7.6	9.0
Nuclear fission	5.6	6.0	5.1
Hydro	5.7	4.8	4.8
Other biomass Methanol Ethanol	2.6	3.8	2.5
Unconventional oil from tar sands and shale	0.1	2.9	2.3
Coal processes total from liquefaction, oxygenation, gasification	0.0	3.1	3.2
Solar (Photovoltaics, solar power towers, solar thermal, and space solar)	0.1	1.0	0.6
Wind	0.1	1.0	0.6
Nuclear fusion	0.0	0.0	0.0
Methane gas hydrates	0.0	0.4	0.1
Geothermal	0.1	0.8	0.3
Tides	0.1	0.1	0.0

The RT Delphi requested similar judgments of the participants: the total amount of energy consumed in 2020 and the percentage of that amount supplied by each source. The respondents were offered pull down menus from which ranges of responses could be chosen. Each "Business as Usual" cell received about 5 responses. The total amount of energy was judged to lie between 12,000 and 13,000 mil TOE; average RT Delphi responses to the question about percent distribution are shown in the table below. The shaded column on the far right repeats the direct estimate of the survey from the table above, for comparison:

Table 8. Percent of Energy Consumption by Sources—RT Delphi responses

Percent of Total Consumption	*Percent of Total 2005 Consumption*	*Percent of Total 2020 Consumption RT Delphi*	*Percent of Total 2020 Consumption Survey Direct Estimate (normalized)*
TOTAL	100	100	100

Percent of Total Consumption	*Percent of Total 2005 Consumption*	*Percent of Total 2020 Consumption RT Delphi*	*Percent of Total 2020 Consumption Survey Direct Estimate (normalized)*
Oil	32.7	10-20	23.8
Natural gas	21.5	20-30	23.8
Coal (conventional)	24.5	20-30	21.0
Traditional biomass and waste	7.1	5-10	7.6
Nuclear fission	5.6	5-10	6.0
Hydro	5.7	1-5	4.8
Other biomass Methanol Ethanol	2.6	1-5	3.8
Unconventional oil from tar sands and shale	0.1	< 1	2.9
Coal processes total from liquefaction, oxygenation, gasification	0.0	1-5	3.1
Solar (Photovoltaics, solar power towers, solar thermal, and space solar)	0.1	1-5	1.0
Wind	0.1	<1	1.0
Nuclear fusion	0.0	<1	0.0
Methane gas hydrates	0.0	< 1	0.4
Geothermal	0.1	<1	0.8
Tides	0.1	<1	0.1

6. SUMMARY OF RESPONDENTS COMMENTS

About 3,000 separate comments were received from the participants. As Appendix C shows, the participants held views that were quite varied and often at odds, perhaps more than has been seen in recent studies of this sort. There were many areas in which the differences of opinion were sharp and well defined, more than would have been expected had there been a common wisdom about the future of energy. For example, in commenting on the likelihood of terrorist attacks on oil production resulting in the disruption of supply by 5-10% for at least a month, in the Business as Usual scenario, the comments ranged from "Now or any day" to "Never."

In the past, such disagreement has been traced to different interpretations by the respondents to the given question, but here there seems to be little chance of that. The disagreements of this sort are found in responses to most of the sets of comments.

It is difficult to generalize about the themes that the comments covered, but in general, there are a few that stand out. The comments listed here are a very small sample of the total set (see Appendix C) and they are taken out of the scenario context in which they were suggested, but they give the flavor of the mind set of the group. This summary section includes examples of comments and these have been edited and compressed.

Diversification of energy sources is inevitable

- Free markets determine fuel mix according to wholesale price.
- Gas reserves are no match for non-conventional oil reserves and gas extraction is expected to peak about 30 years behind the oil peak. So the "gas era" will be shorter-lived than the oil era.
- (Future potential breakthroughs include) energy from space, Stirling solar farms, better batteries, true brain-like intelligence managing power grids, maybe Stirling vehicles, maybe carbon-tolerant alkaline fuel cells or truly solid truly proton-exchanging electrolyte fuel cells, plug-in hybrids
- Nanoscale energy storage in ultracapacitors or advanced batteries
- …Oil, fission nuclear, and gas will reach their peak production phase in turn and in a short interval from 2020 to 2040 causing a resultant a rift of energy supply from these sources without sufficient substitution sources available at the time of rift.

Actions of governments will continue to determine the outcome of the energy situation

- …US government intervention in India-Pakistan-Iran gas pipeline
- A possibility (of) energy use per capita rationing
- Why can't politicians see we need a cohesive energy program, NOW
- …Major third world significant oil producers will hardly move towards the category of failed states, event under this scenario, since emerging economic-military powers like China and India, and even the G8 will first invade them and take them over, in order to maintain market supply stability.

Future energy problems can lead to conflict and create and intensify other nascent problems

- War over oil will be between the Big Powers and oil countries…

- Global warming will have alarming impact on the water situation, requiring greater use of fuel not to meet conventional energy needs but also in transportation of water
- The global economy seems to be getting less sensitive to oil prices. So instead of several recessions and depressions over the next 10 years, maybe we will build up to a monster crash around 2015
- China enters serious recession due to high oil prices and their low economic output per gallon. Liquidates US treasuries, sending US into serious inflationary cycle. Global economy destabilized
- The price of oil will eventually go so high that a repeat of the inflation/recession phenomena will occur to reduce demand and lower prices again
- Occasional technological collapses (grid failures, unexpected environmental consequences such as massive algal blooms or toxic waste excursions) because everything is very tightly managed

Energy supply, prices, and availability intertwine with the economy

- I don't see this extraordinary role of the oil prices; the great recession we face will be due to developments on the financial markets
- Oil intensity to economic growth is on the decline. The oil prices are also not expected to go up all the time as other viable and economic energy sources may become available by 2020.
- New tech stimulates the economy. Lots of possibilities here. An Apollo energy program. Unexpected breakthroughs like: Deep Earth Continuous Gas Generation, Cold Fusion, Solar Harvesting in the Sahara, Really Cheap Electrolysis, Simple Albedo Modification, Space Elevators
- Cheap solar makes energy negligibly expensive

Distrust of energy industries and energy industry/government alliances will grow

- How well can we trust the reserve estimates from the energy industry?
- …subversion by oil companies and governments
- Giant corporations increase their political power
- Political turmoil will allow companies to form old fashioned cartels again.
- Risk aversion by monopoly national oil companies causing oil production to be flat.
- OPEC members and Russia may just control all their internal production, and slow down new developments
- Misinformation blitzes when it suits 1st world and multinational interests.
- The giant corporations act by means of governments of the USA, United Kingdom and Russia

Cynicism current thinking about energy is rampant

- There is a lot of inertia in the system even with most effective action which we are far from doing.
- Hype culture results in several “false (energy technologies) breakthroughs” being promoted – come back to haunt movement later.

Geopolitics will change the geography of energy

- Canada will never challenge Saudi Arabia. Russia and Saudi Arabia’s control of oil.
- Russia, Iran, and Qatar control natural gas.
- Orinoco heavy oils!
- Venezuela and Canada (given their large proven XHO reserves, western hemisphere positioning and growing links with Asia) will play a bigger role.

- Middle East increases its role in world affairs. US-Japan-China increase energy dependence; …OPEC will decrease it role
- Brazil becomes exporter of ethanol.
- Oil sands will erode Saudi dominance, then oil shale (when economic) will result in global reshuffling.
- Developed countries become key energy holders with the technology available, who then create a "New Energy OPEC" and retake power from Middle East in terms of energy geopolitics.
- Conflicts in Saudi Arabia, China, Nigeria, and Venezuela could benefit Russia's role.
- What consequences (the establishment) of a fundamentalist government in Saudi Arabia?

More research is needed soon; some specific projects were mentioned

- (The required) research would entail financial resources of the magnitude that no country would be ready to spend at the moment.
- Other means of increasing the current energy production – Intensive research on fuel cells, nano-batteries and exploiting the other non-conventional energy sources should be considered
- …the timelines to critical marker-points in development and deployment are remarkably different than previous times….this is primarily because of the synergistic interrelationship of various technical and scientific domains, such as materials science, biotechnology, chemistry, solid state physics, computing, systems engineering, and various other related domains which currently converge.
- Applied nanotechnology (will prove extremely important to the future of energy)
    - solid state batteries (replacing current lead/acid batteries)
    - low cost organic semiconductor solar and thermal voltaic materials
    - high efficiency LED lighting – home, business, industrial
    - "smart" building materials, dynamic and passive, including solar and thermal voltaics and integrated sensing and monitoring, "energy efficient" design
    - solid state hydrogen storage cells
    - catalysts used for liquefied coal synthetic fuels
    - hydrogen derived from genetically enhanced micro-organisms
    - optimized thin films, membranes, and Nanomaterials for low cost fuel cells
    - next generation wind systems, in energy generation, distribution and storage
    - high efficiency / "near" superconductive materials
    - space borne orbiting solar collectors, using a modernized sealed system, high pressure steam turbine to electrical conversion mechanism, beamed to the ground in the form of low density, easily convertible micro-wave energy
- Human energy is insufficiently studied. For example, the encyclopedia of energy efficiency cites a kind of psychic energy that is insufficiently investigated. Take the information spread around the globe about a woman who lifted the wall that fell on her child. After letting the child free ten men could not lift the wall.
- International joint scientific energy research should necessarily be coupled with environmental protection and economic studies.
- An all-out "Apollo Moon Project" style of program to achieve alternative / renewable resource enabled energy independence within a specific definable timeline, say 10 years, in which specific milestones can be defined as marker-points.

There is skepticism about solar satellites and nuclear power

- Solar from orbit:
    - Complete idiocy and hopefully will never occur
    - Difficult to achieve
    - I hope never: too dangerous

  - Too expensive compared to nuclear, transmission problem
  - Won't happen
  - Damages of the electromagnetic fields and space waste
  - Dispute over the space domain among huge technically based countries
  - … "defense" satellites will be developed to eliminate these new sources of power (solar satellites in orbit to send power to earth)
- Nuclear
  - Security against terrorists will never be so much better than now.
  - Quality science and transparency show a truly safe solution stays just beyond reach – though not impossible
  - Send it into the sun via rockets
  - … Who can guarantee something over a period of several hundred of thousand to10 million years?
  - The solution already exists; the problem is socio-political
  - Safe storage is relative. It's impossible to prove it ahead of the outcome. Perhaps the most unpredictable factor is the stability of the society safeguarding the repository. Historic precedent is dismal in that respect.
  - R&D people who worked (on nuclear power plant design) during the low cost energy period retire, then it will be too late
  - Huge Capital expense and public fear means successful prototypes not scaled up for 50 more years.

Automobile propulsion is a key factor and China plays a key role

- One of the most promising existing trends (electric autos), due to China's superior manufacturing base and tech in this area
- A very well understood old technology (electric cars), facilitated by modern battery technologies! Highly practical in urban areas and economically attractive in countries that have cheap coal and dependent on World oil markets with escalating prices. Aided by very low vehicle maintenance costs.
- The number of these cars is insignificant in relation to the global economy and greenhouse
- The necessity of reducing pollution allows new laws and politics discouraging the use of cars
- Hybrids rule

The comments included many wild cards; some of these are listed below:

- Cold fusion
- Seawater agriculture along the desert coastlines of the world (begin by planning salt-loving plants on beaches of areas like Somalia) could make biofuels competitive at today's oil prices.
- Direct conversion of the nuclear energy to mechanical and electrical energy
- Perhaps first promising nuclear fusion plant
- Hurricane control with warlike aims
- Major environmental disaster caused by global terrorist movements.
- Archebacteria
- Climate change begins to affect coastlines, (i.e. major cities) species, (food production)
- Potential massive environmental changes - e.g. Shutdown of Gulf Stream

7. SCENARIOS FEATURES

There were a number of questions posed to the participants that requested quantitative responses. Approximately 35–50 responses were received for each question; the averages of these responses are summarized below.

Quantitative Average for Some Developments

	Business as Usual	Environmental Backlash	High Tech	Political Turmoil
2.7 Possible price of oil in 2020 (in today US$ dollars/barrel)	90	123	63	144
2.10 Amount of carbon emissions in metric tonnes	19	9	7	27
2.15 Percentage of all new vehicles powered by hydrogen in 2020	5.0	9.5	13.3	1.4
2.16 Percentage of all new vehicles powered by biofuels in 2020	3.1	19.0	20.6	4.3
2.17 Percentage of all new vehicles powered by electricity in 2020	6.9	15.4	11.3	4.1
2.18 Percentage of all new vehicles that are hybrid in 2020	21.6	31.7	25.9	10.5
2.19 Percentage of all new vehicles powered by gasoline in 2020	55.6	26.5	23.9	71.9
2.20 Total energy efficiency gains 2006 to 2020	18.7	20.7	34.9	11.7
2.28 Number lacking electricity in 2020 (today it is 2.3 billion)	1.4	1.2	0.7	2.5

The following table summarizes the percentage of answering respondents who agreed with statements given in the original questionnaire: The original statements are shown in italics and the agreeing percentage below the statements. It can be assumed that a large number of participants who did not write in "Agree" did agree, but did not feel in necessary to write that in; hence, the actual percentage of agreement is likely to be higher. Nevertheless, the following table does give a good view of the relative agreement among developments.

Percentage of Agreement on Some Developments

Potential elements, to be considered for each scenario	**Business as Usual**	**Environ-mental Backlash**	**High Tech**	**Political Turmoil**
2.1. Economic Growth Global GDP World depressions? Recessions? Growth spurts/accelerations?	*Moderate to high economic growth until oil prices go so high they cause recessions, and depressions* *66.3%*	*Moderate to low economic growth, oil price fluctuates with environmental actions, supply disruptions* *60.9%*	*New tech and great efficiencies prevent oil peak prior to 2050* *61.9%*	*Low economic growth, recessions/ Depressions* *58.4%*

Potential elements, to be considered for each scenario	Business as Usual	Environ-mental Backlash	High Tech	Political Turmoil
2.2 Demand - per region and/or economic grouping	*China and India continue to drive prices and supply of oil* *56.0%*	*Environmental action reduces demand mostly in Europe and US* *46.8%*	*Technology advances affect mostly First World demand and usage* *50.6%*	*Wars consume energy resources and prevent development of new sources* *48.7*
2.3 Economies successfully adapt to factor of 50% increase in energy prices without undue inflation.	*Not initially, but adjustments by 2015* *59.7%*	*Inflation occurs but adjustments by 2020* *53.7%*	*Prices moved lower by 2020 not requiring adjustment* *53.6%t*	*Inflation occurs as the result of both energy cost and conflicts* *64.9%*
2.4 Changes in human values, wealth and expression of status	Moderate to low 52.1%	Moderate to high Conservation 59.7%	Moderate 54.8%	Little to none 60.0%
2.5 Motivations, social purposes	*Economic and social status focus, expansion of Corporate Social Responsibility (CSR)* *58.8%*	*Sustainable development energy conservation, environ-mentalist development paradigm* *69.7%*	*Positive high tech meme epidemics* *52.5%*	*Survival, security* *74.5%*
2.8 Environmental Movement Impacts	*Some impact. Irregular focusing on legislation and treaties* *72.8%*	*Larger impact on regulations and treaties. International coordination of strikes on fossil fuel key points* *65.7%*	*Full range of cooperation with high-tech and environmental movement to various forms of resistance* *71.4%*	*Focus on environmental security issues* *51.7%*
2.9 Key environmental events/developments	*Many environmentalist accept nuclear power as counter global warming alternative* *38.2%*	*Nuclear power plant accident in India pollutes Indian Ocean* *18.6%*	*Environmental-High Tech Summit* *66.2%*	*Pipelines and refineries attacked during political problems in Saudi Arabia and Nigeria* *51.6%*
2.11 Status of carbon sequestration, capture, storage, science, policy	*Some moderate progress* *62.7%*	*Very aggressively pursued. Carbon trading cost exceeding CO_2 capture/ sequestration costs increase the latter* *70.7%*	*Aggressively pursued* *66.7%*	*Little* *69.8%*
2.12 Key Technological Breakthroughs	*NextGen Coal Plant, Nuclear* *Ocean and land wind farms, solar towers* *47.8%*	*Ocean wind cities (nanotech 3-layer sheets change photovoltaic efficiencies)* *44.6%*	*Wireless energy transmission.* *If coal can be burned with low CO_2 emissions, then US, China, Russia, Nigeria benefit* *48.3%*	*Military portable energy production, storage and transmission systems* *44.6%*
2.13 Artificial bacteria and other micro-organisms are created to produce fuels and chemicals by 2020.	*Likely* *52.5%*	*Some cases. Environmentalist split on the issues* *67.3%*	*Very likely* *74.1%*	*Not likely* *63.8%*
2.14 Main transportation energy sources	*Gasoline, dual fuels (gasoline and ethanol), and hybrids* *71.0%*	*Mix of gasoline, electric, natural gas, biofuels, hydrogen* *69.9%*	*Electric vs. hydrogen, new hybrids* *66.2%*	*Gasoline and hybrids* *64.9%*

Potential elements, to be considered for each scenario	Business as Usual	Environ-mental Backlash	High Tech	Political Turmoil
2.21 Conservation gains From base 2005	*Moderately pursued* *74.1%*	*Very aggressively pursued and forms of rationing and regulation* *72.9%*	*Not pursued, but realized by more elegant techno-logical design* *58.5%*	*Not pursued* *58.3%*
2.22 Energy Transmission	*Electric grids become more efficient, some nanotech batteries, little hydrogen* *74.1%*	*Electric grids more efficient, many innovations in batteries, some wireless energy transmission, little hydrogen* *64.3%*	*Greater efficiencies in electric grids, new kinds of batteries, wireless energy transmission begins, some hydrogen cars* *72.4%*	*Electric Grids moderately improved, military spin-offs for new kinds of batteries* *69.8%*
2.23 Geopolitics of war, peace, terrorism and changes emerging power dynamics	*OPEC increases political power due to dramatic drop in non-OPEC supply by 2015* *54.7%*	*Green parties dominate European politics, increasing regulatory power* *56.0%*	*Political Transhumanists and technological optimists increase in power.* *62.1%*	*Military industrial complexes, semi-regional trading blocs* *81.1%*
2.24 Conflicts and terrorism	*Increasing diversity of groups and methods Regional war over oil, pipeline sabotage* *67.9%*	*Some coordination between eco- and political-terrorism hits fossil fuel systems* *39.6%*	*Dramatically increased surveillance and sensor systems reduce terrorist events and conflicts* *43.6%*	*Several national wars over energy and water. New failed states, more terrorism. Water problems destabilize India and China, lowering economic growth, coal and oil demands fall.* *56.7%*
2.25 Oil and gas pipeline construction factors	*Russia to Japan implications for China both tapping and investing in Siberia (Putin's offer) Also Sakhalin Island off Russia's Pacific coast. US$7 billion Japanese offer for Taishet-Nakhodka pipeline. Canada to US pipeline with Alaskan oil as well* *60.5%*	*Targets for environmental terrorists* *47.6%*	*Wireless energy transmission. Hydrogen transportation* *52.4%*	*Political/conflict implication of pipeline deals. New pipelines through Palestine and Israel as sources of both conflicts and potential peace settlements* *60.0%*
2.26 Key Global/National Policies	*Carbon trading, renewable portfolio standards, enhanced CAFÉ* *71.7%*	*Carbon taxes (US$50/ton?) Product labeling, Tri-car fuels, legally binding renewable goals with subsidies and incentives for cleaner cars, stock market strategies, Alt. S&T Fund, global warming lawsuits begin with Greenpeace on Exxon* *75.0%*	*International Solar Satellite Consortium, ISTO, S&T Fund* *44.9%*	*International systems lack support* *82.1%*

Potential elements, to be considered for each scenario	Business as Usual	Environ-mental Backlash	High Tech	Political Turmoil
2.27 Major energy players (e.g. Will Saudi Arabia keep its dominance or will Canada challenge its position with the sand oil, and by what year?	*Middle East increases its role in world affairs. US-Japan-China increase energy dependence* *54.9%*	*Middle East decreases role with increasing roles from alterative energy tech from Europe-US-Japan* *58.0%*	*US – Japan on nanotech, Space Solar Power, Hydrogen suppliers* *52.0%*	*Conflicts in Saudi Arabia, China, Nigeria, Venezuela could benefit Russia's role.* *62.5%*

A review of this chart shows that the statements about which more than 2/3 of the respondents agreed were:

Developments with Highest Rate of Agreement—Business as Usual

Area	*Statement*	Percent Agreeing
2.21 Conservation gains from base 2005	*Moderately pursued*	74.1
2.22 Energy Transmission	*Electric grids become more efficient, some nanotech batteries, little hydrogen*	74.1
2.8 Environmental Movement Impacts	*Some impact. Irregular focusing on legislation and treaties*	72.8
2.26 Key Global/National Policies	*Carbon trading, renewable portfolio standards, enhanced CAFÉ*	71.7
2.14 Main transportation energy sources	*Gasoline, dual fuels (gasoline and ethanol), and hybrids*	71.0
2.24 Conflicts and terrorism	*Increasing diversity of groups and methods Regional war over oil, pipeline sabotage*	67.9

Developments with Highest Rate of Agreement—Environmental Backlash

Area	*Statement*	Percent Agreeing
2.26 Key Global/National Policies	*Carbon taxes (US$50/ton?) Product labeling, Tri-car fuels, legally binding renewable goals with subsidies and incentives for cleaner cars, stock market strategies, Alt. S&T Fund, global warming lawsuits begin with Greenpeace on Exxon*	75.0
2.21 Conservation gains From base 2005	*Very aggressively pursued and forms of rationing and regulation*	72.9
2.11 Status of carbon sequestration, capture, storage, science, policy	*Very aggressively pursued. Carbon trading cost exceeding CO_2 capture/ sequestration costs increase the latter*	70.7
2.14 Main transportation energy sources	*Mix of gasoline, electric, natural gas, biofuels, hydrogen*	69.9
2.5 Motivations, social purposes	*Sustainable development energy conservation, environ-mentalist development paradigm*	69.7

2.13 Artificial bacteria and other micro-organisms are created to produce fuels and chemicals by 2020.	*Some cases. Environmentalist split on the issues*	67.3

Developments with Highest Rate of Agreement—High Tech

Area	*Statement*	Percent Agreeing
2.13 Artificial bacteria and other micro-organisms are created to produce fuels and chemicals by 2020.	*Very likely*	74.1
2.22 Energy Transmission	*Greater efficiencies in electric grids, new kinds of batteries, wireless energy transmission begins, some hydrogen cars*	72.4
2.8 Environmental Movement Impacts	*Full range of cooperation with high-tech and environmental movement to various forms of resistance*	71.4
2.11 Status of carbon sequestration, capture, storage, science, policy	*Aggressively pursued.*	66.7

Developments with Highest Rate of Agreement—Political Turmoil

Area	*Statement*	Percent Agreeing
2.26 Key Global/National Policies	*International systems lack support*	82.1
2.23 Geopolitics of war, peace, terrorism and changes emerging power dynamics	*Military industrial complexes, semi-regional trading blocs*	81.1
2.5 Motivations, social purposes	*Survival, security*	74.6
2.22 Energy Transmission	*Electric Grids moderately improved, military spin-offs for new kinds of batteries*	69.8
2.11 Status of carbon sequestration, capture, storage, science, policy	*Little*	69.2

8. Assessment of the RT Delphi Results

The RT Delphi method is a new approach to performing a Delphi study that does not involve the use of sequential "rounds" and as a result, greatly improves the efficiency of the process and shortens the time to perform such studies. In January 2006 this method was applied experimentally to the collection of judgments about the future of energy, paralleling the survey described earlier; the objective was to collect additional judgments and to test the method. Appendix C describes the process in more detail; the substantive results from this work have been reported in earlier sections of this report.

Eighty-two people signed-in during the two week period that the study was in progress; people signing in were primarily from Europe, North and South America. The greatest number of responses for any single question was 19. Most of these answers were early in the sequence

indicating either that boredom set in or that the early questions served to illustrate the process.

The substantive results of the RT Delphi are compared to the survey results in Sections 4 and 5 of this report. Differences in the presentation of the questions prevent exact comparison, but in a general sense, the comparison is good. Further the comments offered by the RT Delphi respondents are of the same nature, length, and usefulness. Our conclusion is that the method performed as intended and indeed makes feedback possible in a much shorter time than a standard Delphi study.

Several respondents offered suggestions for improvements. For example, one said:

> I tried it Thursday night but had no luck. I got a "server error" every time I hit the "save" button. Today it seemed to work--mostly. In several cases when I hit the "Comment" button, the pages that showed up with or without previous comments by other participants lacked an entry field, so all I could do was return to the matrix. For the majority of responses, however, the comment feature worked properly.
>
> This type of round-less Delphi is a great idea. Of course, it would be more effective with a larger number of participants.
>
> I was on a relatively slow (128 kbps) ISDN connection, so going to the comments pages and then redisplaying the matrix was tedious and time-consuming. And because the question was not repeated on the Comment page, I had to go back and forth some additional times. It would be nicer if the Comments interface would use a separate window so that toggling back to the matrix would be instantaneous and not require scrolling down to relocate the last position.
>
> Also, individual comments should be set apart more noticeably and include a time stamp so it will be easier to find new additions. And, it would be much nicer if the matrix would indicate the number of comments for each cell plus the date of the latest comment. The icing on the cake would be if cells that have received new comments since the last visit could be highlighted with a color background on return visits.
>
> The fact that the description of the scenarios was on an earlier page required some additional paging back and forth for reference. Perhaps a summary could be included at the top of every page.
>
> Overall, I think it's on the right track.

In the sense that this was a test of a complex system, such comments were expected and quite useful. All will be considered in the design for the next application.

We believe design of almost any multi-round Delphi study could be changed to utilize the RT Delphi approach outlined here. Of particular importance are the applications involving a matrix format. In a conventional questionnaire, the questions would be asked sequentially; a 10 by 10 matrix would thus require a tedious and numbing sequence of 100 questions. With the matrix arrangement, the whole set could be presented on one page. The matrix format suggests use of RT Delphi to produce an input/output matrix in which the coefficients in the cells are provided by the judgment of experts rather than the more usual, but complex, econometric regressions.[43]. Similarly, a cross impact problem can be handled much more simply in this way. In this

[43] The use of Delphi in collecting judgments for an input/output matrix was suggested by Jon Landeta in a paper titled "Current Validity of the Delphi Method in the Social Sciences, in review for publication by*Technological Forecasting and Social Change*, scheduled for 2006.

application the experts would provide the conditional probabilities in the cells and the probability computation could be accomplished at the end of the process or even during its use.

9. ROUND 2 DESIGN AND RESULTS

The second round was built on the results of the first by greatly extending the scenario descriptions synopsized in Round 1, utilizing the answers provided by respondents to questions posed in Round 1. The "fill in the blanks" questionnaire is a Millennium Project innovation. It is used to allow the participants to extend the given scenarios by inserting their own perceptions, at appropriate points in the narrative. A final question asks how each of the scenarios can be improved. Appendix C presents the full array of responses to the "fill in the blanks" questions of Round 2. There were about 11 questions posed in each scenario and more about 25 responses were received for each. This section presents only a few of the questions and answers of Round 2 for purposes of illustration. While we have included selected questions and responses here that seemed imaginative and helpful to us, this list is by no means complete and the interested reader should refer to Appendix C.

Scenario 1: "The Skeptic" (a Business as Usual Scenario)

1.1 There was a public opinion survey taken the other day to see what people thought about our present situation and outlook. The pollsters found that the percent of the people they sampled said they thought they were better off in 2005:

- Average: 36.8

1.2 and the percent of the people who said they thought that in 2040, 20 years from now, things would be much better than today:

- Average: 38.6

1.4 When people today wonder how the world has developed as it has, most often they point to_____as being responsible.

- Corrupt politicians and "the best Congress money can buy"
- Developed countries
- Oil companies
- Irresponsible, counterproductive environmental extremism
- Unfettered global capitalism.

1.10 Some analysts think the anti-oil mission of the terrorists is to cause democratic governments and secular economies to fail so that fundamentalist governments can take their place in some oil-producing nations. There may be another reason:

- Terrorists, mostly from Arab or Muslims countries, would like to see the rise of the price of the barrel of oil in order to enrich many Middle East countries.

- To disrupt the well being of western societies
- Terrorism has increasingly become a protection racket, functionally indistinguishable from organized crime
- They want the industrial countries to butt out of their domestic politics and stop supporting dictatorships to keep their oil flowing.

1.12 What would make this scenario more plausible and useful?

- The economic crisis intensifying in Moslem areas – a rich elite and an ever-growing multitude of young, poorly educated, unemployed youths. Result: overthrow of elitist regimes in Egypt, Saudi Arabia, Arab emirates, etc. to shift control of oil suppliers to Moslem extremist groups; introduction of military actions to secure oil supplies; confrontation between China/India and the West to control oil supplies, manipulation by Moslem regimes to pit China/India against West..
- The impacts of India (consumption and technical genius), Brazil (strong national policy of energy independence and a nation-building pioneer spirit), and Russia (vast resources and resurgence of totalitarianism with corrupt capitalism) should probably be added. Brazil could become a model of energy commonsense
- Taking it out of an USA context and making it more global
- … At present .. only Kuwait and some of the small Gulf states …are rich in oil and can be seen as liberal. Who else is liberal – Saudi Arabia, Iran, Iraq? In my opinion this part of the scenario is misconceived.
  The scenario is very detailed but it is missing the political impact of the possible energy shortages. For example, an interesting question is …whether potential energy shortages will stimulate international cooperation, or on contrary…an epoch of conflicts for resources.

Scenario 2: "Environmental Backlash"

2.1 Other backlashes from nature included:

- Fresh and saltwater bodies experienced massive blooms of noxious or useless vegetation as a result of rising temperatures and increased nutrients from waste discharges.
- Acidification of the oceans from CO2 deposition resulted in the extermination of hundreds of species of marine life.
- Rapid spread in malaria, including previously clear areas in Europe and North America -- which turned out to be due to the elimination of DDT and other insecticides demanded by environmentalists.
- Submergence of Gulf Stream in North Atlantic by fresh water runoff from Greenland icecap - Europe goes cold, rising water levels - MANY coastal regions [where most people live] inundated.
- Sub-Saharan Africa experiences massive famine killing 20 million people due to severe droughts in ……..
- Increase in global insect driven plagues.

2.4 Other elements of the GLEEM Plan included

- Establishment of a World Environment Organization to serve as an umbrella for the major multilateral environment agreements and a framework for harmonizing them, providing a common

dispute settlement mechanism, and technical assistance to ease the burden of compliance on developing countries

- A authoritative unique Global Green Label accepted by all countries and a series of technological and management standards be set
- A key role was given to scientists for Global Renewal -anti-irrationalism association. It decides who gets the World Energy Prize.
- Adoption of a triple bottom line model as a basis for international financial assistance through the World Bank and UN Development Program whereby social, environmental and economic pressures are balanced with due regard and priority to all three.

2.8 In the meantime, what is important to understand about electric production and transmission today in 2020 is

- Coal will likely be the biggest source of electricity.
- Grids have to a large extent been re-designed to handle rising shares of distributed generation
- There is an evolving decentralized network for energy, whereby the consumer is generating much of the energy needed in the home and for transport via renewable energy and efficiency improvements, decreasing the need for electric energy transportation
- That the cost of electricity has increased dramatically, as it has become clear that all the "green" alternatives have much lower "energy amplification" than the old coal & nuclear plants, i.e. they provide much less energy output per unit energy input. In addition, the "green" sources are less reliable -- patients have died in hospital operating rooms when the wind driving their turbines died at an inopportune moment.
- A black market has sprung up in making & selling (illegal) gasoline-powered generators for domestic & small business use. Rather similar to Prohibition in the US in the 1920s, laws to require the use of "green" energy have resulted in many opportunities for corruption as people seek to salvage some of the life they once knew.
- Efficiency gains since 2000 have exceeded population growth leading to a reduction in absolute consumption.

2.9 What would make this scenario more plausible and useful?

- (That)….massive economic recession would result during the transition to these alternatives and that most of them will be completely useless otherwise we would already be using them.
- Frankly, this scenario is entirely implausible. … It completely ignores human nature, and largely ignores the immutable laws of physics. If it were to be more useful, it should include a more realistic appraisal of the motives & actions of the environmentalists, and of the consequences of their behavior. Are hard-line environmentalists going to accept the massive land-use changes involved in growing biofuels (where? in National Parks?), or in turning desert coastlines into factory-farmed monocultures? Are environmentalists who are concerned about invisible nuclear radiation going to accept the massive use of invisible microwave energy transmission to & from satellites, with birds dropping out the sky?
- There is a clear danger of the kind of terrorist environmental movement so admiringly described in this scenario degenerating into mere criminal gangs. (It has already happened with political terrorist groups like the Irish Republican Army).There is also a clear danger of civil strife, even up to civil war, between citizens concerned about their declining standard of living and the environmental extremists they hold responsible.

- Are the bureaucrats in the postulated WEO going to be as corrupt and ineffective as the current crowd at the UN who deny DDT to African countries while children die needlessly of malaria?
- Rather than this pointlessly Pollyanna-ish scenario, it would be more useful to have a realistic version … If we could have a world in which energy was plentiful, reliable, cheap and green -- we would all choose it. The fundamental issue with this scenario is that if we want energy to be "green", we are going to have to give up one or more of "plentiful, reliable, cheap". The scenario should explore in a physically realistic way which we give up, and what the consequences will be for ordinary people.
- … The current discussion in climate policy circles is trying to agree cuts of the order of 60-80% in emissions by 2050. Therefore the cut detailed (in this scenario) should be much more drastic…
- The change towards environmentally oriented way of living seems to be mainly based on technological development and innovation, which doesn't give the scenario much diversity. The transformation of human behavior is rather underplayed, however the change of human behavior seems to be crucial for many of the changes portrayed to take place.

Scenario 3. Technology Pushes Off the Limits to Growth

3.3 China, a rising economic power is now leading the way in car technologies and

- Oil made of coal, underground coal gasification, ultra clean and ultra fine coal water slurry
- ….in the development of modular nuclear power plants -- which are very resistant to weapons proliferation and extremely safe….. China used to lose hundreds of coal miners each year along with uncounted people from coal-caused air pollution. China has exported their nuclear power plants aggressively to developing countries, which underpinned their tremendous economic growth. Before the eclipse of environmentalism in the early 21st Century, western environmentalists used to whine about the Chinese export of nuclear technology. But their complaints had zero effect on Chinese policy, and the passage of time simply showed how wrong the western environmentalists had been.
- Carbon capture and storage in coal-based power plants.
- New technologies are being developed in transportation that will lead to TransNet, an integrated transportation system, that will include all systems, road, railroad, pipelines, utilities, parcel , cargo and others in a single system , being physically separated from the natural ecosystem, will occupy only about 0,3% of land area , compared to traditional systems, and will be capable of generating its power locally from renewable …
- CO2-free oxygenated coal gasification (clean coal), source of both electricity and methanol fuel. China will remove the CO2 from these plants, not because of the Kyoto Treaty, but because they can make money using solar energy, CO2 and water to make methanol fuel.

3.4 On average, the world energy intensity per unit of GDP has steadily decreased, even though our energy consumption is still increasing thanks to major new technological breakthroughs like

- Long dreamed of "boutique" enzyme and catalyst chemistry for food creation and processing, container and structural material (primarily plastics) manufacture and, of course, fuel production from previously inefficient or useless sources …
- Ocean thermal energy conversion, domestic micro-generation systems, the new 'ultra-lights' vehicles and cooperative 'super-grid' links between Europe, the U.S., Africa and Asia; meanwhile some technologies have increased energy consumption such as entertainment technologies, e.g. the 'Dream Catcher,' an energy intensive virtual experience.

- Actually, the decreasing energy intensity has not been due to any major technological breakthroughs. It has been due to the steady accumulation of incremental improvements in energy efficiency throughout the entire economy. It has also been driven by the steady rise in the real price of energy, which has resulted in structural changes in societies -- denser housing, reduced travel, manufacturing closer to the point of sale.
- Reduced power for computing/electronics enabled by carbon nano tube electronics, saline/seawater AG biomass/biofuels including distributed/inexpensive/small scale bioreactors and Nano-Plastic Inexpensive PV.

3.9 Other planned energy projects involving these new biotechnological developments include

- Making relatively rapid acting bacteria, lichens and fungi that will remove airborne CO2, attack rocky constituents of poor soils (particularly tropical laterite soils) to release nutrient elements and produce organic matter to create productive soils.
- Shale oil and tar sands extraction; using bacteria to produce fuels from various wastes
- Ethanol derived from cellulosic biomass
- Making of ethanol from bark using microbes and using genetically modified salt-resistant rice.
- The Sahara Ocean project, whose main scope is to change and make livable a deserted area while directing all excess water coming from the Poles melting in order to avoid that the rise of the ocean water could destroy costal cities and a big part of the land territory. In such a project, large algae growing lagoons will provide raw material for the production of biomass fuel.

3.11 What would make this scenario more plausible and useful?

- The scenario is more an inspiring and very informative vision rather than a scenario.
- Not plausible. “The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil.” The reason the stone age ended, was because there was bronze. Bronze is a better material. It did take technology to use it, but it is inherently a better material to use. …It is clear that oil is one of the best energy resources because it has better characteristics than any other. That is why we are in the oil age. To leave the oil age you have to have an inherently better energy resource, and none exist. …. To make this more plausible, you have to simply say that human kind must endure a collapse, and start to live in smaller homes, consume less, travel less, work more in farming, and that the population will probably decline.
- Introducing social factors that will seriously affect the technological scenario depicted here. This scenario is typical of technological optimism –“ if it can be done it will be done.” But that is not the real world. …
- The scenario is quite strong on creativity and this would be a very strong feature if the scenario had a centennial or millennial timescale, but on a 14 year timescale it is a significant weakness as it systematically becomes implausible through overestimating change for the applicable timescale.
- The Scenario is too ‘Americocentric’ (and also ‘Sinocentric’ in terms of industry) particularly where it describes how US policy drove world developments. The US is not likely to be the sole driver of world policy for the foreseeable future as it has been slipping behind in recent years. A parallel discussion of European or Asian policy would be more relevant here.
- The discussion of the bacterial process and how it can ‘take care’ of the carbon sequestration problem is scientifically erroneous and implausible. The amount of land or sea area required to physically support the apparatus that would allow a sufficient bacteria complex to absorb direct sunlight would have to cover an enormous area incompatible with current land uses. The

sequestered carbon would then have to be stored indefinitely (and not combusted) to prevent the carbon escaping back to the atmosphere.

- …. I am skeptic about how scenarios like this can make an impact, because who will be able to take in, even read through, so much detail? I would wish for much more "easy to take in" and "easy to compare" kind of elements, and more structure. For example, for all energy scenarios, you could have a short version of the key elements of the scenario at the beginning (not longer than one and a half pages) plus tables or boxes that recur with different content for all scenarios, giving info on the percentage of energy sources, main technology breakthroughs, etc. Apart from the perspective of communicating results and concentrating on clear messages, I also find it difficult to ask any leading energy expert to contribute to a scenario that has 18 pages and he is asked to read and take in all this and then fill in some few blanks …
- There are of course lots of risks with different new energy sources. I think that a global critical network of scientists or a global "virtual assessment network" with basically positive attitude towards innovations would promote the scenario.
- On the R&D side, the most urgent need is to prove out the key uncertain but promising technologies to allow energy from space to substantially beat coal and fission on cost for 24-hour power. There are two (complementary) ways it could be done -- by using lunar materials (now in US plans) or by performing D-D pellet fusion in space. For the latter, we especially need to prove we can design the laser, and we need to show how adaptive smart antenna technology can be used to reduce the cost of beaming power to earth all the way to the grid to 2-3 cents per delivered kwh. …

Scenario 4. Political Turmoil

4.1 The price of gasoline quintupled overnight, spot prices were never more volatile, long-term contracts for oil were abrogated, trading in carbon rights was suspended, electricity and gas disruptions multiplied, many banks closed and

- Led to an aggressive mood of panic, fear and suspicion…., a nearly complete end to immigration, ……and rising nationalist and racist political parties in Europe and other countries.
- Rich oligarchs and lesser survivalists began retreating into their respective prepared sanctuaries
- The costs of the transport (rose and caused) shortages of supplies of foods and products of first necessity, creating inflation and originating the paralysis ….of factories at world-wide level…..
- Social unrest and ad hoc demonstrations for proper action or against inactivity of governments spread out, people started to move to country side if they only had any places or relatives there in order to sustain some living conditions or to prepare for even worse, militia groups arouse and fights between groups occurred; Russian government saw the situation offering room for new intentions and Russian politics on Baltic countries and Northern countries especially on Finland, were re-negotiated in order to guarantee free operations to the Baltic see, and to enhance advanced technology cooperation and St. Petersburg electricity supply from Finland and Northern countries network. ….

4.4 Oil-related political hot spots occurred in the Caucasus, China, Japan, the Arctic, Nigeria, the Persian/Arab Gulf, Russia and

- Libya
- Antarctica, where demand had finally shattered any semblance of accord on preserving the natural heritage.
- Mexico and Venezuela

- Baltic area (potentially)
- Venezuela
- The North-Sea (debate between England/Denmark/Norway on which country was entitled to new deep-sea deposits in international waters, burdening EU consensus…
- Europe, South America, and the Caribbean.
- Ukraine, and Belarus

4.6 China was able to leverage its vast holdings of US debt to prevent US criticism of its civil wars and tactics. As a result

- China began to exercise subtle leadership of the UN Security Council, supplanting the US.
- The world decided to switch from the dollar to the Euro as the world Monetary standard and the world foreclosed on the Massive U.S. International Debt. The U.S. Economy "tanked."
- China reverted to its historical pattern of provinces breaking away from the central government. The Beijing government hastened the process by attacking Taiwan after 2011, seeking to unify the restive Chinese people behind them. All those Chinese leaders succeeded in doing was provoking (a strong military response).
- Chinese President Xing directed additional financial and scientific resources into China's renewable energy programs. Already world leaders in solar-powered fuel cell technology, China rapidly assumed a superior position in bio-fuels, wind and wave power. These renewables, supplemented by the seemingly unlimited supply of gas from the Australian LNG contract, enabled China to become the first super-nation to break its dependance on oil…

4.12 What would make this scenario more plausible and useful?

- This is a really depressing scenario that brings together all fears about the future – which is also its problem. People tend to react to this kind of scenario with something like "Oh, these Future Pessimists again. It can't become this bad. So maybe making it more a patchwork of "Mostly bad, but also some good aspects" might help….
- …(This scenario) is more plausible than the others….In addition there will be a lot of economic problems….massive unemployment, the stock market downturns, and the bankruptcies…..people will have a hard time keeping their houses, …they will end up with borders in their houses to pay for heat, and people will make do on less money. It will be a great depression scenario.
- ….. The scenario could only be plausible if the international community ignores the grievances of radical Muslims living in regions of oil supply, intensification of the greediness of Western Nations, lack of renewable energy, political instability in regions of oil and gas supply, tensions among Western Nations, the uncontrolled rise of China in the world arena….
- The time required for reconstruction will be much longer than expected here…
- For all the misuse of the concept -- we cannot afford to ignore the very real dangers related to WMD in these kinds of scenarios. It is precisely the escalation to the first use of truly large-scale WMD (most likely nuclear weapons in the hands of a subnational group or political faction) which puts the human race into a path (paths) from which extinction is more likely than survival.
- The scenario should pay more attention to the political ramifications of the major changes subsequent to 2011 -- the end of the UN, probable civil wars in North America, Europe, Russia, & China. ….Poorer countries could no longer afford the vast social safety nets they built in richer times. This might trigger significant social changes -- possibly a religious revival, certainly a much greater focus on individual responsibility. It would also be likely that there would be a lot more "localism" -- Brazil might flourish while Germany collapsed; locally-generated nuclear power

would be adopted in a number of countries, replacing imported oil & gas; some countries might resort to military rule; the basics of ensuring food supplies would loom much more important; with the decline of international trade, many jobs would be created in western countries; poor nations that were already closer to subsistence levels might recover from the effects of 2011 faster and outpace developed nations. Humanity would survive!

- It is a brilliant and well worthwhile essay. However, it seems to be heavily from US perspectives. More input from Chinese, Japanese and Indian perspectives would be helpful.

10. Analysis and Comparison of the 4 Scenarios

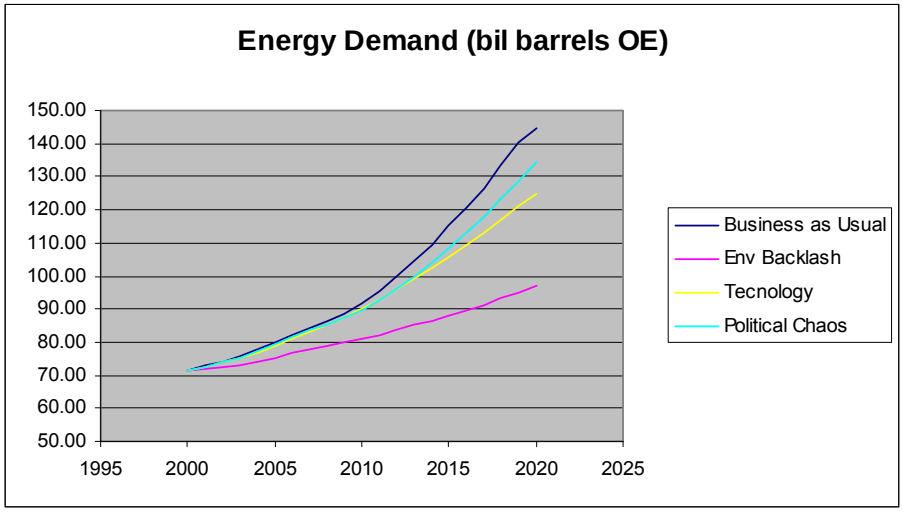
The International Futures, University of Denver[44], was for additional quantitative scenario data. The models were produced for UNEP GEO Project and for the National Intelligence Council, 2020 Project.

Characteristics of the MP scenarios were used to estimate exogenous energy efficiency. Existing IFs scenarios were used where possible. The models were run computing five output variables:

- Annual emissions from fossil fuels- billion tons
- Energy demand- bill barrels OE
- Energy price: index, base 100 in 2000
- GDP per capita in PPP 95 dollars- thousand dollars
- Annual water usage- cubic km

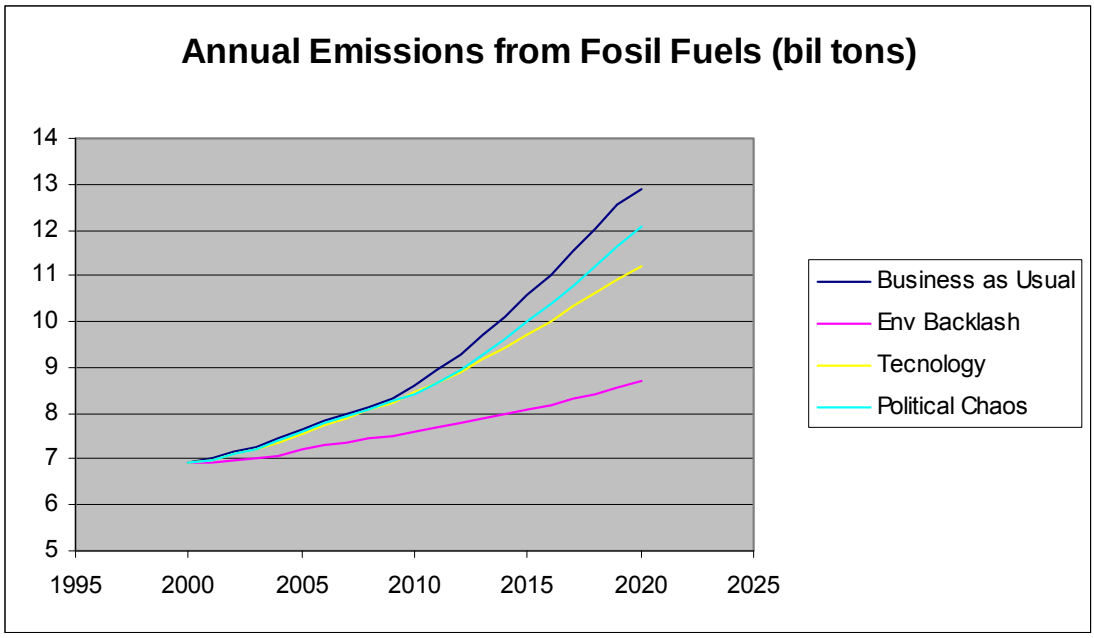
The following graphs illustrate the comparison between the four Global Energy Scenarios 2020 using the IF Model.

Energy Demand
Comparison between the Four Global Energy Scenarios 2020

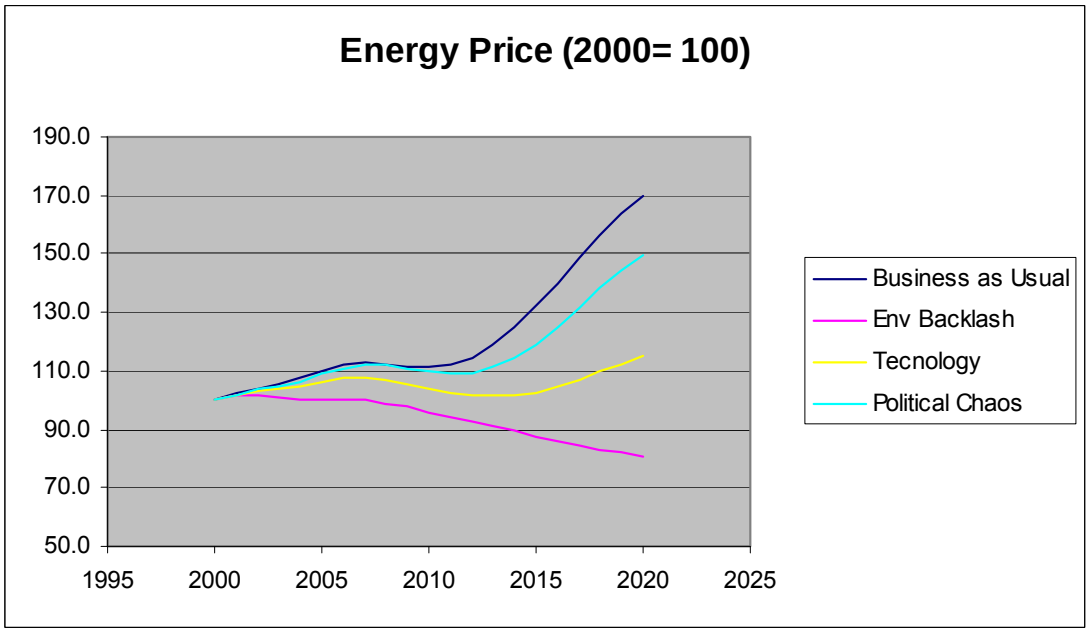


[44] Model developed by Barry Hughes, University of Denver. http://www.ifs.du.edu

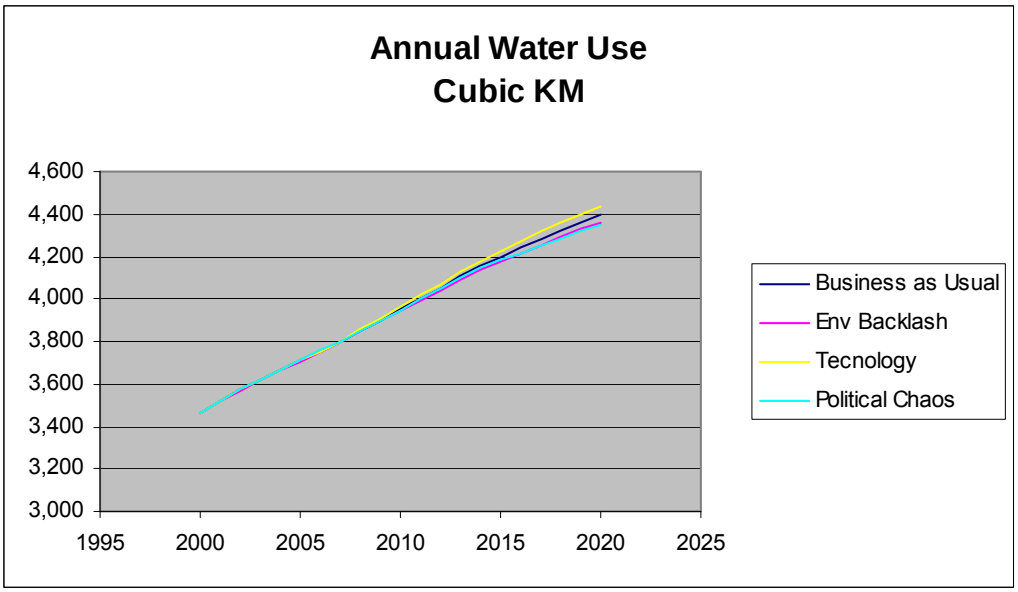
Annual Emissions from Fossil Fuels
Comparison between the Four Global Energy Scenarios 2020



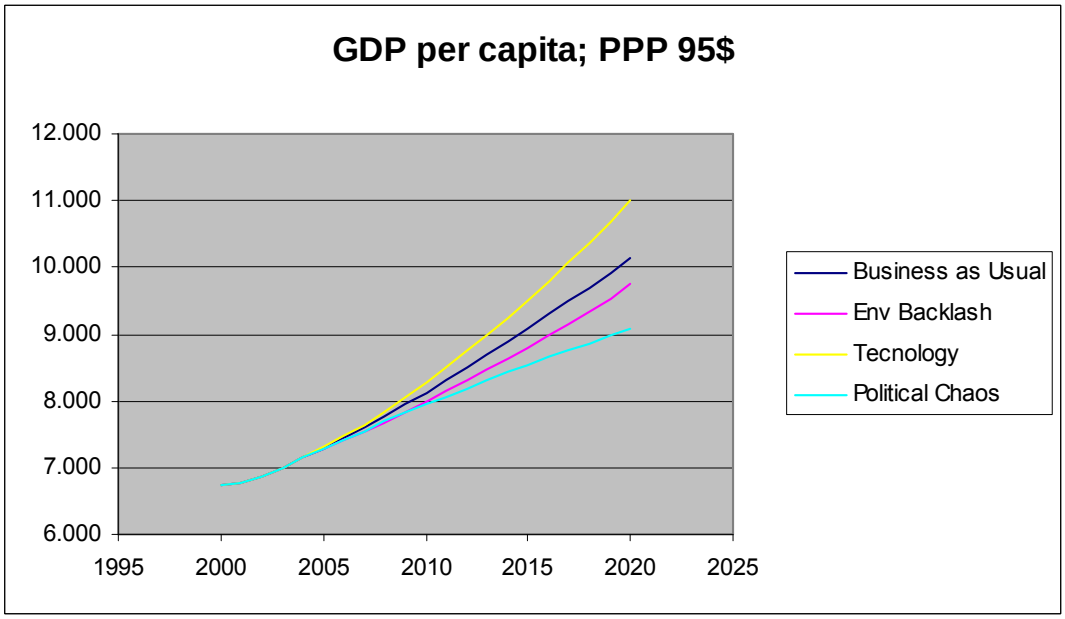
Energy Prices
Comparison between the Four Global Energy Scenarios 2020



Annual Water Use
Comparison between the Four Global Energy Scenarios 2020



GDP per Capita
Comparison between the Four Global Energy Scenarios 2020



11. CONCLUSIONS

In the judgment of the participants, the amount of energy consumed globally in 2020 will have grown from its current value of 11,411 mil TOE to 16,830 mil TOE. The respondents projected the following distribution of energy sources in 2020 (2005 is shown for comparison)

Share of Energy Sources in 2020

Percent of Total Consumption	*Percent of Total 2005 Consumption*	*Percent of Total 2020 Consumption Direct Survey Estimate (normalized)*
TOTAL	100	100
Oil	32.7	23.8
Natural gas	21.5	23.8
Coal (conventional)	24.5	21.0
Traditional biomass and waste	7.1	7.6
Nuclear fission	5.6	6.0
Hydro	5.7	4.8
Other biomass Methanol Ethanol	2.6	3.8
Unconventional oil from tar sands and shale	0.1	2.9
Coal processes total from liquefaction, oxygenation, gasification	0.0	3.1
Solar (Photovoltaics, solar power towers, solar thermal, and space solar)	0.1	1.0
Wind	0.1	1.0

Among the events reviewed in the survey, the following were judged likely to occur during the next 20 years:

- 1.16 Terrorist attack on oil production and/or delivery systems disrupts supply by 5-10% for at least 1 month

- 1.13 The geopolitics of gas becomes as central to energy growth as the geopolitics of oil was in the last 30 years of the previous century
- 1.14 Carbon trading practiced by 30 of top 50 emitting countries
- 1.11 Industry consolidation continues, resulting in only a few large oil companies in the world
- Hubbert Peak when half the conventional oil is gone (but conventional may one day in the future include deep drilling, tar sands, and shale)
- 1.5 One million electric cars per year are produced, plurality manufactured in China
- 1.9 Significant portions of urban centers in most major cities are closed to private vehicle traffic, or have a system of tolls for entry by cars.
- 1.12 Water problems destabilize India and China, lowering economic growth, and causing coal and oil demands to fall.
- 1.15 Carbon taxes in one form or another in more than 50 countries
- 1.17 Majority of major new buildings in developing countries are designed for low energy consumption
- 1.18 Most countries have policies to achieve significant shifts in fuel mix, including removal of subsidies on coal and other fossil fuels
- 1.7 High efficiency engines power 25% of new cars; e.g. using Stirling engines

The development which was seen as last among those considered was:

- 1.3 First demonstration of cost-effective generation and delivery of base load electricity from solar earth orbital satellites

The Round 1 survey asked respondents to consider a set of statements that might be included in the four scenarios. The respondents were asked to agree or disagree with the given statements in the context of the world depicted by the scenarios. Despite the diversity of opinions expressed in the comments, there were a few suggested statements about which 2/3 of the participants agreed; these should certainly be reflected in the final scenarios.

Statements with at least 2/3 Agreement—Business as Usual

2.21 Conservation gains from base 2005	*Moderately pursued*
2.22 Energy Transmission	*Electric grids become more efficient, some nanotech batteries, little hydrogen*
2.8 Environmental Movement Impacts	*Some impact. Irregular focusing on legislation and treaties*
2.26 Key Global/National Policies	*Carbon trading, renewable portfolio standards, enhanced CAFÉ*
2.14 Main transportation energy sources	*Gasoline, dual fuels (gasoline and ethanol), and hybrids*
2.24 Conflicts and terrorism	*Increasing diversity of groups and methods Regional war over oil, pipeline sabotage*

Statements with at least 2/3 Agreement—Environmental Backlash

2.26 Key Global/National Policies	*Carbon taxes (US$50/ton?) Product labeling, Tri-car fuels, legally binding renewable goals with subsidies and incentives for cleaner cars, stock market strategies, Alt. S&T Fund, global warming lawsuits begin with Greenpeace on Exxon*
2.21 Conservation gains From base 2005	*Very aggressively pursued and forms of rationing and regulation*
2.11 Status of carbon sequestration, capture, storage, science, policy	*Very aggressively pursued. Carbon trading cost exceeding CO_2 capture/ sequestration costs increase the latter*
2.14 Main transportation energy sources	*Mix of gasoline, electric, natural gas, biofuels, hydrogen*
2.5 Motivations, social purposes	*Sustainable development energy conservation, environ-mentalist development paradigm*
2.13 Artificial bacteria and other micro-organisms are created to produce fuels and chemicals by 2020.	*Some cases. Environmentalist split on the issues*

Statements with at least 2/3 Agreement—High Tech

2.13 Artificial bacteria and other micro-organisms are created to produce fuels and chemicals by 2020.	*Very likely*
2.22 Energy Transmission	*Greater efficiencies in electric grids, new kinds of batteries, wireless energy transmission begins, some hydrogen cars*
2.8 Environmental Movement Impacts	*Full range of cooperation with high-tech and environmental movement to various forms of resistance*
2.11 Status of carbon sequestration, capture, storage, science, policy	*Aggressively pursued.*

Statements with at least 2/3 Agreement—Political Turmoil

2.26 Key Global/National Policies	*International systems lack support*
2.23Geopolitics of war, peace, terrorism and changes emerging power dynamics	*Military industrial complexes, semi-regional trading blocs*
2.5 Motivations, social purposes	*Survival, security*
2.22 Energy Transmission	*Electric Grids moderately improved, military spin-offs for new kinds of batteries*
2.11 Status of carbon sequestration, capture, storage, science, policy	*Little*

An appreciable number of people sampled the RT Delphi format (82). Many fewer participated by providing answers (the most responding to a single question was 19) Most of these answers

were early in the sequence indicating either that boredom set in or that the early questions served to illustrate the process.

The substantive results of the RT Delphi are comparable to the survey results; however, differences in the presentation of the questions prevent an exact comparison, but in a general sense, the comparison is good. Further, the comments offered by the RT Delphi respondents are of the same nature, length, and usefulness. Our conclusion is that the method performed as intended and indeed makes feedback possible in a much shorter time than a standard Delphi study.

There are revisions to be made in the next application of RT Delphi and this test has been an important source of information about what needs to be done. That having been said, the results seem useful. A greater participation rate would have been beneficial but the late start of this format probably lowered the turn out.

Did the comments offered by the participants display a shared view of the energy future, that is, was a "common wisdom" displayed? No, there were great differences in opinion. For example (and of great importance), we may or may not be close to Hubbert's Peak. But it seems there was implicit agreement on about a number of assumptions, including the (not revolutionary observation that): energy and economic conditions are significantly meshed and that our current sources of energy will continue to be the major fuels at least over the next 20 years. But there seems to be no commonly held view about the future of energy mix, or likely or effective energy policies. In fact, the opinions were so widely different and at odds that they may represent the most scattered in any recent Millennium Project study of this sort.

Yet by reading the 3,000 or so comments it is apparent that there are shared themes among the participants. These are:

- Diversification of energy sources is inevitable
- Actions of governments will continue to determine the outcome of the energy situation
- Future energy problems can lead to conflict and create and intensify other nascent problems
- Energy supply, prices, and availability intertwine with the economy
- Distrust of energy industries and energy industry/government alliances will grow
- Cynicism is rampant
- Geopolitics will change the geography of energy
- More research is needed soon; some specific projects were mentioned
- Skepticism about solar satellites and nuclear power solutions
- Automobile propulsion is a key factor and China plays a key role
- Energy driven political instability, terrorism, recession, and depression seem plausible
- The insatiable thirst for oil of developed countries has produced the current mess, and they themselves responsible for the hostility from the oil producing countries.
- Bio-energy seems to have little downside.
- Regimes will change and may shift toward extremism

- Countries, in emerging from their energy addiction will establish their own niches and specialties.
- A new international organization (GLEEM) could add a new dimension to the evolution of world energy
- China and India hold many keys to the future of energy
- There is no single technological or political “Band Aid” that promises to solve the multiple dimensions of the world’s energy problems.

The comments of the respondents included many wild cards that should be considered for the scenarios; some of these are:

- Seawater agriculture along the desert coastlines of the world (begin by planning salt-loving plants on beaches of areas like Somalia) could make biofuels competitive at today's oil prices.
- Direct conversion of the nuclear energy to mechanical and electrical energy
- Perhaps first promising nuclear fusion plant
- Terrorism becoming a protection racket, functionally indistinguishable from organized crime
- Hurricane control with warlike aims
- Major environmental disaster caused by global terrorist movements.
- Archebacteria
- Climate change begins to affect coastlines, (i.e. major cities) species, (food production)
- Potential massive environmental changes - e.g. Shutdown of Gulf Stream
- The Sahara Ocean project, whose main scope is to change and make livable a deserted area while directing all excess water coming from melting at the poles

Appendices

See also the Appendix on Annotated Bibliography of Global Energy Scenarios

Appendix 1. Delphi Round 1

Millennium Project
2020 Global Energy Delphi

On behalf of the Millennium Project of the American Council for the United Nations University, we have the honor to invite you to participate in an international study to construct alternative global energy scenarios to the year 2020.

The study has three phases. During the first phase, the Millennium Project's staff produced an annotated bibliography of global energy scenarios and related reports. This was used to design the attached Delphi questionnaire for Phase 2. Your judgments are sought about potential developments that might affect the future of the global energy situation. The results of this survey will be shared with the participants and used to construct draft scenarios which will be circulated to you for comments in the third and final phase.

The Millennium Project is a global participatory system that collects, synthesizes, and feeds back judgments on an ongoing basis about prospects for the human condition. Its annual ***State of the Future, Futures Research Methodology***, and other special reports are used by decision-makers and educators around the world to add focus to important issues and clarify choices.

You are invited to use a new "real-time" (or "roundless") approach to the Delphi method in this study at http://RTDelphi.Energy.org. This method allows you to provide and revise your judgments about potential future energy developments until the study is completed on January 11, 2006. The new approach allows you to return to the questionnaire as many times as you like to view other participants' comments during this same period (no attributions will be made). You may revise your comments as often as you wish up to the deadline. If for any reason you do not want to use this approach, or stop in the middle of using it, a more standard questionnaire is attached to this invitation and is available at: http://www.acunu.org/millennium/energy-delphi.html, which can be also filled out online or downloaded to be filled out at your leisure and returned as an attached file prior to the deadline.

The results of all three phases of this international study will be published in the *2006 State of the Future*. Complimentary copies will be sent to those who respond to this questionnaire. **No attributions will be made**, but respondents will be listed as participants.

Please return your responses by January 11, 2006. We look forward to including your views in the construction of alternative global energy scenarios.

Jerome C. Glenn, Director, AC/UNU Millennium Project
Theodore J. Gordon, Senior Fellow, AC/UNU Millennium Project

2020 Global Energy Delphi
Introduction

A series of new global energy scenarios will be written on the basis of responses to this questionnaire. You are invited to provide judgments about statements that will help construct those scenario, such as:

- Estimates of when certain developments may occur.
- Narrative suggestions about elements that should be considered for the scenarios
- Expectations about the contribution of various energy sources
- Recommendations for energy policies.

Your answers will remain anonymous although your name will be listed in the final report as a participant. Please answer only those questions about which you are expert or feel comfortable. Leaving sections blank is a very acceptable answer.

This questionnaire refers to four scenario themes:

1. Business as usual. This scenario assumes that the global dynamics of change continue without great surprises or much change in energy sources and consumption patterns, other than those that might be expected as a result of the change dynamics and trends already in place.

2. Environmental backlash. This scenario assumes that the international environmental movement becomes much more organized; some lobbying for legal actions and new regulations and suing in courts, while others become violent and attack fossil energy industries.

3. High tech economy. This scenario assumes that technological innovations accelerate beyond current expectations, and have impacts in the energy supply mix and consumption patterns, to a similar magnitude as the Internet initiated in the 1990s.

4. Political turmoil. This scenario assumes increasing conflicts, wars, and several countries collapsing into failed states, leading to increasing migrations and political instabilities around the world.

Some factors are common to all scenarios, although they may differ in importance and magnitude. You are invited to judge how they differ. So that we may send you the results and or demographic analysis please enter:

Name:_____
Address:_____
Country: _____

Primary employment:
__ Government __ Business __ University __ Non-profit organization (NGO)
__ International Organisation (OECD, UN, etc.) __ Private Consultant, author
__ Female __ Male

Section 1. Developments that might affect future energy conditions

Please provide your judgments about the year you think the following developments might occur in each scenario. In the same space, you are invited to make any comments about your estimate that you wish. An example is provided in the first development. You are welcome to change that.

The last row of the matrix invites your additional suggestions of other developments that you think should be considered in constructing the scenarios. You may enter as many new developments as you like.

Four Alternative Global Energy Scenarios for the year 2020

When might these developments occur in each scenario	Scenario 1. Business-as-Usual	Scenario 2. Environmental Backlash	Scenario 3. High Tech Economy	Scenario 4. Political Turmoil
1.1 Hubbert Peak when half the conventional oil is gone (but conventional may one day in the future include deep drilling, tar sands, and shale)	2020	2030	2050 advanced tech changes definition of reserves, and different sources, and efficiencies	2015 conflicts use oil and destroy oil
1.2 Affordable photovoltaic cells with >50% efficiency are available				
1.3 First demonstration of cost-effective generation and delivery of base load electricity from solar earth orbital satellites				
1.4 A solution is found for long-term safe storage or destruction of radioactive waste				
1.5 One million electric cars per year are produced, plurality manufactured in China				
1.6 New credible fission technologies are developed to solve problems of nuclear generation; improved				

security, reduced risk of malfunction				
1.7 High efficiency engines power 25% of new cars; e.g. using Stirling engines				
1.8 30% of electrical power is generated at the point of use				
1.9 Significant portions of urban centers in most major cities are closed to private vehicle traffic, or have a system of tolls for entry by cars.				
1.10 The amount of energy consumed per dollar of GDP worldwide drops 25% from today's value				
1.11 Industry consolidation continues, resulting in only a few large oil companies in the world				
1.12 Water problems destabilize India and China, lowering economic growth, and causing coal and oil demands to fall.				
1.13 The geopolitics of gas becomes as central to energy growth as the geopolitics of oil was in the last 30 years of the previous century				
1.14 Carbon trading practiced by 30 of top 50 emitting countries				
1.15 Carbon taxes in one form or another in more than 50 countries				
1.16 Terrorist attack on oil production and/or delivery systems disrupts supply by 5-10% for at least 1 month				

1.17 Majority of major new buildings in developing countries are designed for low energy consumption				
1.18 Most countries have policies to achieve significant shifts in fuel mix, including removal of subsidies on coal and other fossil fuels				
1.19 Please enter additional developments that you believe should be considered in these scenarios:				

Section 2. Global Energy Scenario Elements

The table below suggests four global energy scenarios and elements that should be considered in each of these scenarios. Initial suggestions have been provided in the cells. You are invited to provide your judgments about these initial suggestions in the space provided in the cells below the given suggestion. If you agree with it, please type "agree" or if you want to change it and/or provide a comment, please enter it also just below the given suggestion in the cell. You do not have to fill in all the cells, just those about which you have expertise or feel comfortable providing your judgments.

Potential elements, to be considered for each scenario	Scenario 1. **Business-as-Usual**	Scenario 2. **Environmental Backlash**	Scenario 3. **High Tech Economy**	Scenario 4. **Political Turmoil**
2.1. Economic Growth Global GDP World depressions? Recessions? Growth spurts/accelerations?	Moderate to high economic growth until oil prices go so high they cause recessions, and depressions	Moderate to low economic growth, oil price fluctuates with environmental actions, supply disruptions	New tech and great efficiencies prevent oil peak prior to 2050	Low economic growth, recessions/ depressions

2.2 Demand - per region and/or economic grouping	China and India continue to drive prices and supply of oil	Environmental action reduces demand mostly in Europe and US	Technology advances affect mostly First World demand and usage	Wars consume energy resources and prevent development of new sources
2.3 Economies successfully adapt to factor of 50% increase in energy prices without undue inflation.	Not initially, but adjustments by 2015	Inflation occurs but adjustments by 2020	Prices moved lower by 2020 not requiring adjustment	Inflation occurs as the result of both energy cost and conflicts
2.4 Changes in human values, wealth and expression of status	Moderate to low	Moderate to high conservation	Moderate	Little to none
2.5 Motivations, social purposes	Economic and social status focus, expansion of Corporate Social Responsibility (CSR)	Sustainable development energy conser-vation, environ-mentalist development paradigm	Positive high tech meme epidemics	Survival, security
2.6 Global GDP/Capita				
2.7 Possible price of oil in 2020 (in today US$)	Around US$ 50/barrel	Over US$ 100/barrel	Below US$ 50/barrel	Over US$ 125/barrel

2.8 Environmental Movement Impacts	Some impact. Irregular focusing on legislation and treaties	Larger impact on regulations and treaties. International coordination of strikes on fossil fuel key points	Full range of cooperation with high-tech and environmental movement to various forms of resistance	Focus on environmental security issues
2.9 Key environmental events/developments	Many environmentalist accept nuclear power as counter global warming alternative	Nuclear power plant accident in India pollutes Indian Ocean	Environmental-High Tech Summit	Pipelines and refineries attacked during political problems in Saudi Arabia and Nigeria
2.10 Amount of carbon emissions in metric tonnes	20 billion tonnes	5 billion tonnes	3 billion tonnes	30 billion tonnes
2.11 Status of carbon sequestration, capture, storage, science, policy	Some moderate progress	Very aggressively pursued. Carbon trading cost exceeding CO_2 capture/ sequestration costs increase the latter	Aggressively pursued	Little

2.12 Key Technological Breakthroughs	NextGen Coal Plant, Nuclear Ocean and land wind farms, solar towers	Ocean wind cities (nanotech 3-layer sheets change photovoltaic efficiencies)	Wireless energy transmission. If coal can be burned with low CO_2 emissions, then US, China, Russia, Nigeria benefit	Military portable energy production, storage and transmission systems
2.13 Artificial bacteria and other micro-organisms are created to produce fuels and chemicals by 2020.	Likely	Some cases. Environmentalist split on the issues	Very likely	Not likely
2.14 Main transportation energy sources	Gasoline, dual fuels (gasoline and ethanol), and hybrids	Mix of gasoline, electric, natural gas, biofuels, hydrogen	Electric vs. hydrogen, new hybrids	Gasoline and hybrids
2.15 Percentage of all new vehicles powered by hydrogen in 2020	5%	10%	15%	0%
2.16 Percentage of all new vehicles powered by biofuels in 2020	15%	20%	25%	3%
2.17 Percentage of all new vehicles powered by electricity in 2020	5%	15%	10%	2%
2.18 Percentage of all new vehicles that are hybrid in 2020	20%	30%	30%	10%
2.19 Percentage of all new vehicles powered by gasoline in 2020	60%	25%	30%	85%
2.20 Total energy efficiency gains 2006 to 2020	15%	20%	40%	5%
2.21 Conservation gains From base 2005	Moderately pursued	Very aggressively pursued and forms of rationing and regulation	Not pursued, but realized by more elegant techno-logical design	Not pursued

2.22 Energy Transmission	Electric grids become more efficient, some nanotech batteries, little hydrogen	Electric grids more efficient, many innovations in batteries, some wireless energy transmission, little hydrogen	Greater efficiencies in electric grids, new kinds of batteries, wireless energy transmission begins, some hydrogen cars	Electric Grids moderately improved, military spin-offs for new kinds of batteries
2.23Geopolitics of war, peace, terrorism and changes emerging power dynamics	OPEC increases political power due to dramatic drop in non-OPEC supply by 2015	Green parties dominate European politics, increasing regulatory power	Political Transhumanists and technological optimists increase in power	Military industrial complexes, semi-regional trading blocs
2.24Conflicts and terrorism	Increasing diversity of groups and methods Regional war over oil, pipeline sabotage	Some coordination between eco- and political-terrorism hits fossil fuel systems	Dramatically increased surveillance and sensor systems reduce terrorist events and conflicts	Several national wars over energy and water. New failed states, more terrorism. Water problems destabilize India and China, lowering economic growth, coal and oil demands fall.

2.25 Oil and gas pipeline construction factors	Russia to Japan implications for China both tapping and investing in Siberia (Putin's offer) Also Sakhalin Island off Russia's Pacific coast. US$7 billion Japanese offer for Taishet-Nakhodka pipeline. Canada to US pipeline with Alaskan oil as well	Targets for environmental terrorists	Wireless energy transmission. Hydrogen transportation	Political/conflict implication of pipeline deals. New pipelines through Palestine and Israel as sources of both conflicts and potential peace settlements
2.26 Key Global/National Policies	Carbon trading, renewable portfolio standards, enhanced CAFE	Carbon taxes (US$50/ton?) Product labeling, Tri-car fuels, legally binding renewable goals with subsidies and incentives for cleaner cars, stock market strategies, Alt. S&T Fund, global warming lawsuits begin with Greenpeace on Exxon	International Solar Satellite Consortium, ISTO, S&T Fund	International systems lack support

2.27 Major energy players (e.g. Will Saudi Arabia keep its dominance or will Canada challenge its position with the sand oil, and by what year?	Middle East increases its role in world affairs. US-Japan-China increase energy dependence	Middle East decreases role with increasing roles from alterative energy tech from Europe-US-Japan	US – Japan on nanotech, Space Solar Power, Hydrogen suppliers	Conflicts in Saudi Arabia, China, Nigeria, Venezuela could benefit Russia's role.
2.28 Number lacking electricity in 2020 (today it is 2.3 billion)	1 billion	1 billion	0.5 billion	2.5 billion
2.29 Other economic elements to be considered for each scenario?				
2.30 Other environmental elements to be considered for each scenario?				
2.31 Other technological to be considered for each scenario?				
2.32 Other Geo-Political, War, Peace, Terrorism economic elements to be considered for each scenario?				

Section 3. Global Energy Sources

The current value per energy source is provided in the table below. Please enter your estimates in column 4 and 5 for these sources in the year 2020, assuming the business-as-usual scenario. You do not have to fill in all the blank cells – just those for which you feel comfortable providing your judgments. You may enter your estimate as a total amount in millions of tonnes (metric) of oil equivalent (Mtoe), as a percent of the total world sources by 2020, or both. Please

also add any comments about your estimate you wish. For example, what might increase or decrease your estimate? Even if you did not provide an estimate, you are still most welcome to add comments about the status of that energy source for the 2020.

Energy Sources Total world amount and percent of energy, (not % electricity)	Total amount now (Mtoe)	Percent world now	Total amount 2020 (Mtoe)	Percent world 2020	Comments:
3.1 Total from all sources	11,411				
3.2 Oil (conventional ranges)	3678.4	32			
3.3 Unconventional oil from tar sands and shale	88.0** 0.7**	>0.1 >0.01			
3.4 Natural gas	2420.4	21			
3.5 Methane gas hydrates	0	0			
3.6 Coal (conventional)	2778.2	24			
3.7 Coal processes total from liquefaction, oxygenated, gasification					
3.8 Nuclear fission	624.3	5.5			
3.9 Nuclear fusion	0	0			
3.10 Solar (Photovoltaics on earth, solar power towers, solar thermal, and space solar power)	10.9*	>0.1			
3.11 Wind	8.5*	>0.1			
3.12 Hydro	634.5	5.6			
3.13 Geothermal	4.8*	>0.1			
3.14 Tides	0.08*	>0.01			
3.15 Traditional Biomass and waste	793*	6.9			
3.16 Other biomass Methanol Ethanol	285* 39 45	2.5 >0.5 >0.5			
3.17 Others? ► ►					

Data Source: Unless otherwise specified, the data is based on BP Statistical Review 2005

* 2004 estimates based on the 2002 data and growth rates in World Energy Outlook 2004, International Energy Agency

** Data quoted in Wired News, Why $5 Gas Is Good for America, http://www.wired.com/wired/archive/13.12/gas.html

*** Estimated Methanol and Ethanol consumption in mtoe based on its energy contents.

Section 4. What new policies would make a significant difference for improvement in the global energy condition?

_____

_____

_____

_____

Thank you very much for your participation. Please email this document as an attached file by January 11, 2006 to: acunu@igc.org with copies to jglenn@igc.org and tedjgordon@att.net.

Appendix 2. The RT Delphi Experiment
Application to the Millennium Project's Energy Study[45]

1. Introduction

In September 2004, the Defense Advanced Research Projects Agency (DARPA) awarded a Small Business Innovation Research grant to Articulate Software, Inc. to develop a Delphi-based method for improving the speed and efficiency of collecting judgments in tactical situations where rapid decisions are called for. The grant was based on a decision making problem: a hypothetical decision maker, uncertain about tactics that might be followed in accomplishing a specific objective, calls on a number of experts to provide their judgments about value of the alternative approaches. Delphi was specified in the grant as the method to be employed. The objective was to improve the speed of the process, to real time if possible (hence the name: RT Delphi). The number of participants representing different areas of expertise was assumed to be small, perhaps 10-15 people. The RT Delphi design is particularly applicable in this situation: synchronous participation, a small number of participants, rapid completion required, but can be used when participation is a synchronous, the number of participants is greater, and more time is available.

A second aspect of this grant which will not be described in detail here was to utilize advanced artificial intelligence (AI) and natural language (NL) processing in analyzing the non numerical responses of the Delphi. When incorporated, advanced AI, largely invisible to the user, would improve the process through the use of a formal ontology, to harmonize language and meaning, involve theorem proving, to catch clashes among participants, employ natural language understanding, to get user input to a form the machine can "understand," and introduce automation to allow for larger groups or a faster process, because work is offloaded to the machine. This aspect of the system is currently a research prototype and the subject of future work. Additionally, NL processing will be useful in identifying duplicate inputs when the language used by two respondents is not precisely the same and in clarifying or eliminating logical inconsistencies.

2. Description of the Method

Imagine a Delphi study involving a set of numerical question. When each respondent joins the on-going study, he or she is presented an on-screen form that contains, for each question:

[45] Much of the initial RT Delphi design was performed under the DARPA Small Business Innovation Research project "Group Decision Optimization with Delphi and Ontology" (SB043-041 - D043-041-0152). Articulate Software (Adam Pease) was the prime contractor on this study. T. Gordon contributed the Delphi design and utility matrix concepts to that work, as reported in Gordon and Pease, "An Efficient, "Round-less" Almost Real Time Delphi Method," to be published in *Technological Forecasting and Social Change* in 2006.

1. The average (or median) response of the group so far (and possibly the distribution of responses)
2. The number of responses made so far
3. A button that opens a window showing reasons that others have given for their responses.
4. A button that opens a window that allows the respondent to type in justifications for their own answer.
5. And finally, a space for the new respondent's numerical estimate, answering the question.

The respondent sees, for each question, average (or median) response of the group so far (1) and the number of responses (2) involved in arriving at the average or median. In considering his or her answer to each question the respondent may refer to the reasons others have been given (3) by pressing a button and opening a "reasons window."

Considering this information, the respondent provides an input (5) and instructs the computer to "save" the answer. The group average or median is updated immediately and presented back to the respondent and anyone else who has signed on.

If the respondent's answer to any question is beyond a pre-specified distance from the average or the median, an attention-getting indicator flags the question for the respondent. When the flag is "up" the respondent is asked to give reasons for their response (4) which, when saved, become an entry in the "reasons window" and is seen later when anyone opens that window (3).

There is no explicit second round. When the respondent comes back to the study in a minute or a day, the original input form is presented to him or her. Of course, by then others may have contributed judgments, the averages or medians may have changed and other questions may be flagged since the group response may have changed sufficiently to move the respondent's previous answers outside of the pre-specified distance from the average or the median since the last time the input page was viewed.

In this way the Delphi requirements of anonymity and feedback are met and the process, once underway yields the distribution of the group's responses and reasons for the extreme positions. The process can be synchronous or asynchronous, and if implemented on an Internet site, can involve a world wide panel (as in the Millennium Project's energy study implementation). The administrator can publish a cut off time (an hour, a day, a week, or a month away) and encourage participants to visit the site often before that time. There will be no "stuffing of the ballot box" since each participant has only one form- their original form- that is always brought back when the participant revisits.

If the study is run synchronously (that is, all participants are on line at the same time) all would see their forms change as new answers are received. They would see the group average and interquartile range. If their answers differed by more than a preset number from the group's average, they would be asked for reasons and could see reasons offered by others for their answers. The respondents could change their earlier responses if they wished to do so.

Now consider asynchronous applications (that is, respondents join at times convenient to them). When a respondent signs on to the study at a second, third or any later time, his or her original form would be presented again, showing the original estimate, but with the new group average and interquartile range, as well as the new compilation of reasons for prior answers. . If their answers differed by more than a preset number from the group's average, they would be asked for reasons and could see reasons offered by others for their answers. The respondents could change their earlier responses if they wished to do so.

In either case, after sufficient participants had contributed, the administrator could "freeze" the results and declare the study complete.

Of course, in a real case, many more questions than those shown in the Mars illustration might be included, such as estimates of dates for intermediate steps involved in completing the mission, estimates of funding requirements, and setting priorities of alternate strategies and policies.

In preparing for the study it is necessary to provide a set of "initial conditions" so that the first respondent does not see a null questionnaire. This can be done by using judgmental responses from the beta test panel or using plausible and illustrative entries.

Appendix 3. The RT Delphi Energy Questionnaire

The world wide panel of the Millennium Project and several other list serves were invited to go to the appropriate web site and to participate in the overall study, on line or by down load in filling in the questionnaires. Approximately three weeks after the study began the prospective participants as well as those that has already contributed their judgments via other means were told that the experimental RT Delphi questionnaire was also available and they were asked to view and complete the forms using that mode. They were assured that if they had already answered using another format that their R T Delphi response would still be useful and would not be double accounted. Undoubtedly, the response rate would have been much higher if the RT Delphi form had been available at the start of the exercise.

The introduction read as follows:

REAL-TIME DELPHI

Email address:

Log In | New User

For new users, please log in with the user name of your choosing to begin using RT Delphi. (Please remember this for future visits to the site; it is case sensitive. **For previous users**, please log in with your user name.

RT Delphi allows a group of users to develop a matrix of potential decisions and to test them against a set of criteria to help identify the best decision among those that are being considered.

In the process of completing this assessment you will be asked to:

- Consider alternative decisions to a problem about which your judgment is important.
- Review the list of selection criteria and assess their weights.
- Provide judgments about how each alternative decision meets each criterion, in full consideration of the emerging judgment of the group and justifications that have been provided by others.

Consensus is not a requirement, but users should think carefully when their weights or criteria are very different than that of the group as a whole. If you have questions or comments, please email: acunu@igc.org

After the sign in page, respondents were shown the following:

A series of new global energy scenarios will be written on the basis of responses to this questionnaire. You are invited to provide judgments about statements that will help construct those scenario, such as:

- Estimates of when certain developments may occur.
- Narrative suggestions about elements that should be considered for the scenarios
- Expectations about the contribution of various energy sources
- Recommendations for energy policies.

Please answer only those questions about which you are expert or feel comfortable; "no comment" will be an acceptable answer. Your answers will remain anonymous although your name will be listed in the final report as a participant. Leaving sections blank is a very acceptable answer.

Input to this questionnaire will end on January 21, 2006. Should you wish to use an alternate format for the questionnaire, please go to http://www.acunu.org/millennium/energy-delphi.html .

This questionnaire refers to four scenario themes:

1. Business as usual. This scenario assumes that the global dynamics of change continue without great surprises or much change in energy sources and consumption patterns other than those that might be expected as a result of the change dynamics already in place.
2. Environmental backlash. This scenario assumes that the international environmental movement becomes much more organized; some lobbying for legal actions and new regulations and suing in courts, while others become violent and attack fossil energy industries.
3. High tech economy. This scenario assumes that technological innovations accelerate beyond current expectations, and have impacts in the energy supply mix and consumption patterns, to a similar magnitude as the Internet initiated in the 1990s.
4. Political turmoil. This scenario assumes increasing conflicts, wars, and several countries collapsing into failed states, leading to increasing migrations and political instabilities around the world.

Some factors are common to all scenarios, although they may differ in importance and magnitude. You are invited to judge how they differ.

Questions are presented in the form of matrixes and each cell in these matrixes contains the following information

```
AVG. = the average quantitative response so far
Responses = the number of responses so far
Your input (using a pull down menu)
Reasons = Click here to see reasons others have given for their answers
```

```
          AND TO PROVIDE REASONS OF YOUR OWN.
```
When you see a red cell in a matrix it means your answers differ considerably from the average and your reasons for having a different view are particularly invited.

These instructions could be turned off by the respondents to avoid seeing them repeatedly each time they signed on.

The questions themselves were presented in four sections. In the following presentation, all four sections are illustrated but only the first ten entries are shown.

SECTION 1.

Please provide your judgments about the dates you think the following events might occur in each scenario. Please use the scale that appears on the pull down menus:

```
Never
After 2030
2025- 2030
2020- 2025
2015- 2020
2010- 2015
2005- 2010
Already happened
No comment
```

When you provide your reasons or comments, please keep your comments short while still communicating your judgments; all participants will see the text as you enter it.

NOTE THAT YOU MUST CLICK "SAVE" AT THE BOTTOM OF THE PAGE FOR YOUR INPUT TO BE RECORDED AND BEFORE YOU PROVIDE YOUR REASONS. AFTER YOU HAVE ADDED REASONS, HIT "SAVE" AGAIN

The last row of the matrix invites your additional suggestions. Click on suggestions and a page will open for you to enter other developments that you think should be considered in constructing the scenarios. You may enter as many new developments as you like.

Four Alternative Scenarios for the year 2020

User: tedjgordon

.	Business as usual	Environmental Backlash	High Tech Economy	Political Turmoil
1.01. Hubbert Peak when half the conventional oil is gone (but conventional may one day in the future include deep drilling, tar sands, and shale)	Avg.: 2020- 2025 Responses: 19 Already happened ***Comments***	Avg.: 2025- 2030 Responses: 15 2020- 2025 ***Comments***	Avg.: 2025- 2030 Responses: 16 2025- 2030 ***Comments***	Avg.: 2015- 2020 Responses: 15 2010- 2015 ***Comments***
1.03. First demonstration of cost-effective generation and delivery of base load electricity from	Avg.: 2025- 2030 Responses: 15 After 2030	Avg.: 2025- 2030 Responses: 15 2025- 2030	Avg.: 2020- 2025 Responses: 13 2015- 2020	Avg.: 2025- 2030 Responses: 13 2025- 2030

solar earth orbital satellites	***Comments***	*Comments*	***Comments***	***Comments***
1.04. A solution is found for long-term safe storage or destruction of radioactive waste	Avg.: 2025- 2030 Responses: 16 2025- 2030 ***Comments***	Avg.: 2020- 2025 Responses: 13 2025- 2030 ***Comments***	Avg.: 2020- 2025 Responses: 14 2020- 2025 *Comments*	Avg.: 2025- 2030 Responses: 13 After 2030 *Comments*
1.05. One million electric cars per year are produced, plurality manufactured in China	Avg.: 2020- 2025 Responses: 13 2015- 2020 ***Comments***	Avg.: 2020- 2025 Responses: 10 2015- 2020 *Comments*	Avg.: 2015- 2020 Responses: 12 2015- 2020 *Comments*	Avg.: 2025- 2030 Responses: 10 2015- 2020 ***Comments***
1.06. New credible fission technologies are developed to solve problems of nuclear generation; improved security, reduced risk of malfunction	Avg.: 2025- 2030 Responses: 11 2020- 2025 ***Comments***	Avg.: 2025- 2030 Responses: 8 2020- 2025 *Comments*	Avg.: 2020- 2025 Responses: 9 2015- 2020 *Comments*	Avg.: 2025- 2030 Responses: 8 2020- 2025 *Comments*
1.07. High efficiency engines power 25 percent of new cars; e.g. using Stirling engines	Avg.: 2025- 2030 Responses: 11 Already happened ***Comments***	Avg.: 2020- 2025 Responses: 7 2025- 2030 *Comments*	Avg.: 2020- 2025 Responses: 8 2010- 2015 *Comments*	Avg.: 2025- 2030 Responses: 8 2020- 2025 *Comments*
1.08. 30 percent of electrical power is generated at the point of use	Avg.: After 2030 Responses: 13 2020- 2025 ***Comments***	Avg.: 2025- 2030 Responses: 11 2020- 2025 ***Comments***	Avg.: 2025- 2030 Responses: 13 After 2030 ***Comments***	Avg.: 2025- 2030 Responses: 12 2025- 2030 ***Comments***
1.09. Significant portions of urban centers in most major cities are closed to private vehicle traffic, or have a system of tolls for entry by cars.	Avg.: 2015- 2020 Responses: 14 Already happened ***Comments***	Avg.: 2015- 2020 Responses: 12 Already happened *Comments*	Avg.: 2015- 2020 Responses: 14 2020- 2025 ***Comments***	Avg.: 2025- 2030 Responses: 12 2025- 2030 *Comments*
1.10. The amount of energy consumed per dollar of GDP worldwide drops 25 percent from today's value	Avg.: After 2030 Responses: 11 After 2030 ***Comments***	Avg.: 2020- 2025 Responses: 9 2025- 2030 *Comments*	Avg.: 2020- 2025 Responses: 11 2020- 2025 *Comments*	Avg.: 2025- 2030 Responses: 9 After 2030 ***Comments***

SECTION 2.

Please provide your judgments about some factors that may add important details to the scenarios. In this matrix some initial suggestions are given for your reaction. Please click on suggestions to change the initial entry, add your own, or see the items others have suggested. Feel free to add suggestions that support or argue with the lists that appear. Your opinion is invited about what should be included in the final scenarios.

When you provide your reasons or comments, please keep your comments short while still communicating your judgments; participants will be able to see your text as you enter it.

Note that you must click "save" at the bottom of the page for your input to be recorded.

Four Alternative Scenarios for the year 2020

User: tedjgordon

.	Scenario 1. Business-as-Usual	Scenario 2. Environmental Backlash	Scenario 3. High Tech Economy	Scenario 4. Political Turmoil
2.01 Consider: Global GDP? World depressions? Recessions? Growth spurts? Accelerations?	***Comments***	***Comments***	***Comments***	***Comments***
2.02. Demand - per region and/or economic grouping (qualitative)	***Comments***	*Comments*	*Comments*	*Comments*
2.03. Economies successfully adapt to factor of 50 percent increase in energy prices without undue inflation	***Comments***	*Comments*	*Comments*	*Comments*
2.04. Changes in human values, wealth and expression of status	***Comments***	***Comments***	***Comments***	*Comments*
2.05. Motivations, social purposes	***Comments***	***Comments***	*Comments*	***Comments***
2.06. Global GDP/Capita	*Comments*	***Comments***	***Comments***	*Comments*
2.07. Possible price of oil in 2020 (in today US$)	***Comments***	***Comments***	***Comments***	***Comments***
2.08. Environmental Movement				

Impacts	*Comments*	***Comments***	***Comments***	*Comments*
2.09. Key environmental events/developments	*Comments*	***Comments***	***Comments***	*Comments*
2.10. Amount of carbon emissions (Nature processes 3 or 3.5 billion tons via trees, ocean algae. Today about 7 billion tons are emitted)	*Comments*	***Comments***	***Comments***	*Comments*

SECTION 3.

Please provide your estimates of the energy mix for the year 2020 assuming the "business as usual scenario." If you wish to add estimates for the other scenarios, please use the appropriate columns.

In the top row, using the drop down menu, please provide an estimate of the total amount of energy likely to be provided in 2020 (in million tons of oil equivalents - Mtoe)

Primary energy sources (not electricity) and the percentage that these comprise of the total are listed in the left columns. For each of the given energy sources listed, please provide an estimate of the anticipated percentage in 2020 for each of the scenarios.

You do not have to fill in all the blank cells ? just those for which you feel comfortable proving your judgments. "No comment" is an acceptable answer. Please also add any comments about your estimate if you wish. For example, what might increase or decrease your estimate? Even if you do not provide an estimate, you are still most welcome to add comments about the status of that energy source for the 2020.

As mentioned, the first row requests your estimates of total energy produced in 2020 (in Mtoe). For the remainder of the rows, the drop down menus list the percentages that the energy source represents of that total.

Red cells indicate that your answer differs from the average by more than +/- 10%. Please provide your reasons where appropriate. Note that the last row of the matrix calls for your additions. Click on suggestions in that row and a page will open for you to list other energy sources that you think we should consider for the scenarios. You may enter as many as you like.

User: tedjgordon

.	Scenario 1. Business-as-Usual	Scenario 2. Environmental Backlash	Scenario 3. High Tech Economy	Scenario 4. Political Turmoil

3.01. Total Energy- All sources Current: 11,411 Mtoe	Avg.: 5-10% Responses: 3 5-10% *Comments*	Avg.: 1-5% Responses: 2 1-5% *Comments*	Avg.: 5-10% Responses: 3 10-20% *Comments*	Avg.: 10-20% Responses: 2 10-20% *Comments*
3.02 Oil (conventional ranges) Current: 32 percent	Avg.: 10-20% Responses: 7 20-30% ***Comments***	Avg.: 20-30% Responses: 2 20-30% *Comments*	Avg.: 20-30% Responses: 2 30-40% *Comments*	Avg.: 30-40% Responses: 1 30-40% *Comments*
3.03. Unconventional sources (Tar sands and Shale) Current: greater than .1 percent	Avg.: less than 1% Responses: 5 less than 1% *Comments*	Avg.: less than 1% Responses: 2 less than 1% *Comments*	Avg.: 1-5% Responses: 2 1-5% *Comments*	Avg.: less than 1% Responses: 1 less than 1% *Comments*
3.04. Natural Gas Current: 21 percent	Avg.: 20-30% Responses: 5 20-30% ***Comments***	Avg.: 20-30% Responses: 2 20-30% *Comments*	Avg.: 20-30% Responses: 1 20-30% *Comments*	Avg.: 20-30% Responses: 1 20-30% *Comments*
3.05. Methane gas hydrates Current: 0 percent	Avg.: less than 1% Responses: 5 less than 1% *Comments*	Avg.: less than 1% Responses: 2 less than 1% *Comments*	Avg.: less than 1% Responses: 1 less than 1% *Comments*	Avg.: less than 1% Responses: 1 less than 1% *Comments*
3.06 Coal (conventional) Current: 24 percent	Avg.: 20-30% Responses: 6 20-30% *Comments*	Avg.: 20-30% Responses: 3 20-30% *Comments*	Avg.: 10-20% Responses: 2 20-30% *Comments*	Avg.: 20-30% Responses: 1 20-30% *Comments*
3.07. Coal processes total from liquefaction, oxygenated, gasification	Avg.: 1-5% Responses: 4 1-5% *Comments*	Avg.: 1-5% Responses: 2 1-5% *Comments*	Avg.: 1-5% Responses: 1 1-5% *Comments*	Avg.: 1-5% Responses: 1 1-5% *Comments*
3.08. Nuclear fission Current: 5.5 percent	Avg.: 5-10% Responses: 5 5-10% *Comments*	Avg.: 1-5% Responses: 2 1-5% *Comments*	Avg.: 1-5% Responses: 1 1-5% *Comments*	Avg.: 1-5% Responses: 1 1-5% *Comments*
3.09. Nuclear fusion Current: 0 percent	Avg.: less than 1% Responses: 4 less than 1%	Avg.: less than 1% Responses: 2 less than 1%	Avg.: less than 1% Responses: 2 less than 1%	Avg.: less than 1% Responses: 1 less than 1%

	Comments	Comments	Comments	Comments
3.10 Solar (Photovoltaics on earth, solar power towers, solar thermal, and space solar power)	Avg.: 1-5% Responses: 5 1-5% Comments	Avg.: 5-10% Responses: 2 1-5% Comments	Avg.: 5-10% Responses: 2 5-10% Comments	Avg.: 1-5% Responses: 1 1-5% Comments

SECTION 4.

Now all things considered, what new policies would make a significant difference for improvement in the global energy condition? Please click on suggestions to see the list that is being generated by this Section and please add other ideas that you think are important.
User: tedjgordon

.	Suggestions
new decisions	Comments

When you are satisfied with your inputs in the matrix above, click save below and your input will be added to the group's scoring.

Appendix 4. Respondents Comments to Round 1 (Delphi)

4.1 Section 1

All sections of both the survey and the RT Delphi format invited comments from the participants. These comments are repeated below, edited when necessary but essentially in their original form. The comments from the RT Delphi appear after the comments from the survey and are indicated by the smaller type face.

Section 1 Responses

1.01. Hubbert Peak when half the conventional oil is gone (but conventional may one day in the future include deep drilling, tar sands, and shale)

Scenario 1: Business as Usual

- Comment on the scenarios: We interpret the environmental scenario as a scenario dominated by changes in people's behavior in order to clearly distinguish it from the high-tech scenario. One could also interpret it as being an environmental-high-tech scenario. It is difficult to follow why there will be violent attacks in the environmental scenario.
- Explanation: the expected peak is only defined if restricted to conventional oil. If it is allowed to include functional substitutes, first of all there is no peak until the total amount of coal is finally converted to liquid products;
- How well can we trust the reserve estimates from the energy industry?
- Hubbert Peak when half the conventional oil speculative resources are gone (in my answer conventional may not one day in the future include deep drilling, tar sands, and shale; these are considered technologically too different and separate sources)
- Including Venezuela's soon-to-be-certified-as-proven extra heavy oil (XHO) reserves and Canada's tar sands, both at higher-than-present % Recovery Factors (RF) production (15-30% RF vs. today's 5-10% for XHO).
- Intensifying exploration and recovery techniques
- Intensifying exploration and recovery techniques
- La tendencia histórica ha sido hacia el desplazamiento de este pico hacia mayores valores
- Momentum is too great to expect any sudden changes in the current pace of resource depletion
- New sources found and new extraction methods developed
- Oil prices rise but not enough to curb demand
- Pricing will anticipate this scenario before the peak is realized. Oil era could end before oil actually ends.
- Significant additional deposits likely to be found, even under the business as usual scenario. 2030
- Think its almost certainly happening now
- This definition of conventional oil is like redefining water as hydrogen. It is simply not true of what anybody means by "conventional oil" and facilitates cloudy thinking on a very important topic.
- Unconventional resources are currently economic, and the Hubbert Peak will occur much later, however, the "Business as Usual" scenario is evolving rapidly as we see 15%+ inflation in development costs annually
- We hear about the peak for the last 50 years, although new resources are discovered each day; no foreseeable peak

- When the peat moss is about to hit the fan, which is the present trend -- the motion of the peat moss or the motion of the fan? On the fuel side, Exxon World Energy Outlook now predicts 2010 as peak production time.
- The problem may be that people don't realize the peak is upon them.
- It will depend greatly on demand and hence economic factors. Rapid demand growth from India and China is likely to continue. ASPO recently raised its prediction from 2008 to 2010 taking into account better-than-predicted yields from deep-sea sources. They believe that it will "certainly" happen before 2020. Higher revenue due to competition for a limited resource might accelerate exploration and extraction, but there are many limits to how fast exploration for new oil fields and extraction from tar sands can be stepped up.
- Hubbert Peak: triggers reaction and response (across all spectrum of energy economy) [crises realization point -present E system of production and distribution collectively [collectivelesslly] disunited, unknown]: a. Opportunistic (model -life, self-organized competition) -Response: capital - initially signal to noise high b. Predictive (model) -Response: suggests model(s) of scale and rhythm and justice for/to seek peak(s) and valley(s) in disparate roaming/combing [herd(s) Energy States, trans-nation, meta-national energy-pool resource based economy; operation modeled on Information production, distribution, and consumption (Constituent Confederate Union of energy producer(s) distributor(s) and consumer(s) self organized into republic of united states of energy USofE, / self-assembling democracies] -initially unaffiliated; disassociated; --signal to noise low c. Serendipitous / chance (model - mythic, religious, aesthetic, signal thinking models w/ random pattern matching) -Response: happenstance, right place at the right time -Response: organize under cultural /political leader(s) and ideals.
- All of my time estimates (this, and the next ones in this matrix) are based on my firm belief in the acceleration of changes: 1) the acceleration of (human, scientific) knowledge development 2) the acceleration of the dissemination of knowledge through digital communication 3) the acceleration of the operationalization of knowledge through computer modeling, simulation, COMPUTER AIDED DESIGN, and the like. 4) as a consequence of 1 - 3, the acceleration of social, political and economic changes; changes with the qualities of paradigm shifts.

Scenario 2: Environmental Backlash

- Accelerating clean coal technologies
- Accelerating clean coal technologies
- Alternatives found for power; oil used more for non-fuel applications
- Backlash may force development of more energy efficient use of technology
- Disruptive technologies could totally change the energy landscape by 2050. The question would be: how political equilibria will be designed after the oil age? (We are talking about 2050 scenario!!)
- Environmental movement cannot dramatically curb oil use
- Environmental policy changes are unlikely to have impact on overall consumption of fossil fuels
- Existing, peaking @ 2020 - Tech. exists to define reserves, we know the limits of reserves, but am not making fast choices and interventions, no political support for immediate policy interventions - we knew about the reserve crisis long ago.
- I don't see environmental backlash as a plausible scenario.
- Kyoto style lawyer/political non-tech backlash hurts as much as helps on this variable.
- More likely scenario of the 4 based on the location of many unconventional reserves, politically stable
- Most developments will take time and won't have much effect on the actual peak-oil time.
- Signs are already showing but may not be fully acknowledged before
- Some impressive environmental victories will not change the overall global dynamics
- The peak is so near term in the future that in this scenario not much of a difference would be visible
- The peak is so near term in the future that in this scenario not much of a difference would be visible

- This is highly probable. New high-tech methods will provide much better definition of oil, gas, and tar sands reserves, increasing significantly the proved reserves of hydrocarbons.
- This is highly unlikely. Peak oil is the environmental "backlash" that results from wasteful overuse of a very limited resource
- We hear about the peak for the last 50 years, although new resources are discovered each day; no foreseeable peak
- Will impact on exploration as well as utilization.2020
- Multivalent assaults caused by decomplexification of environmental ecosystems, and decreasing sustainability potential due to monocultural induced imbalances, and synergistic toxicological living media, exert bottom up pressures for uncontaminated resources.

Scenario 3: High Tech

- Advanced tech changes definition of reserves, and different sources, and efficiencies
- Efficiencies through technology
- Even advanced technology changes, definition of reserves, and different sources, and efficiencies may not change much.
- 'ICT and disruptive technologies could improve energy efficiency and allow for a high tech economy
- Immense ability to improve efficiencies and identify alternative energy sources.
- No foreseeable peak in this scenario.
- The advanced technologies change the definition of reserves, of different sources and efficiencies
- The peak is so near term in the future that in this scenario not much of a difference would be visible
- The peak is so near term in the future that in this scenario not much of a difference would be visible
- The technologies developments change the definition of reserves, of different sources and efficiencies
- There is a lot of inertia in the system even with most effective action which we are far from doing.
- This gives a significant possibility of positive impact.
- Use of unavailable reserves and leaps in efficiency
- Using new-to-be- developed more advanced higher efficiency and much higher % RF for XHO production technologies (30-60% RF).
- We don't need "high tech" so much as a new worldview about the good life that is not so cheap energy dependent. The Union of Concerned Scientists for instance has shown how the US could meet its electricity needs basically with current solar technologies
- We hear about the peak for the last 50 years, although new resources are discovered each day;
- High-tech won't make a big dent in the next 20 years because of existing consumption infrastructure and the enormous cost of changing it. So peak will happen regardless of high-tech. However high-tech might substantially change how sharp the peak will be. It might make the depletion slope gentler than the pre-peak slope and thus reduce the economic consequences of peaking.
- Might peak out not because we run out of oil, but because high tech makes alternative fuels more competitive and people use less oil.
- The researches of new technologies to substitute oil will increase exponentially as increases the price of oil. The change of technology doesn't mean necessarily a complete change of infrastructure. The present infrastructure can be adapted.

Scenario 4: Political Turmoil

- Break down of world economy may decrease global use of oil (china)
- Conflicts are terminated by most violent means
- Conflicts decrease consumption - air travel etc

- Conflicts make oil unavailable to some countries - it may not be sold to them or the oil wells may be destroyed
- Conflicts reduce rate of extraction, but not demand
- Conflicts use oil and destroy oil (Many)
- Conflicts use oil and destroy oil – but insignificant compared with global consumption
- Distribution disrupted. Oil available but not supplied.
- However, major third world significant oil producers will hardly move towards the category of failed states, event under this scenario, since emerging economic-military powers like China and India, and even the G8 will first invade them and take them over, in order to maintain market supply stability.
- Iran Conflict
- Likely for two reasons: a) if economic development is path dependent (still based on current patterns), oil will be perceived as a key resource which is not able to accommodate emerging economies' needs. If evolution is disruptive there will be adjustment problems.
- Los conflictos serian más locales que generalizados y no impactarían significativamente respecto escenario
- No foreseeable peak
- Prices rise if conflict soon but not near-term destruction of raw oil in ground
- Quite likely
- Regional conflicts in the Middle East and Black Sea area may change the supply-demand situation not in the distant future.
- Scrambling for technology, equity issues of investing in poor countries? Resources extraction globally - impacts?
- The conflicts use petroleum and destroy petroleum
- The peak will be before 2010 due to Risk Aversion. 50% will happen after the peak
- They already are and BUSINESS AS USUAL will simply worsen the situation
- We hear about the peak for the last 50 years, although new resources are discovered each day;
- Political turmoil discourages investment in otherwise promising oil market such as Nigeria, leading to early peaking.

1.02 Affordable photovoltaic cells with >50% efficiency are available

Scenario 1: Business as Usual

- >50% efficiency seems too optimistic at this juncture
- >50% never, Affordable 2020
- Affordable! The overall efficiency is of no significance if the price is low enough
- At present DOE rates. But what is affordable?
- Does efficiency refer to conversion of incident solar energy or the energy cost ratio of producing and using solar cells? Fossil fuel dinosaurs will seek to avoid or control this resource if there's only a technical change.
- In a competitive price in 2060
- Investments are going to be mainly allocated to other means of energy development.
- It is not clear why the focus is on high-efficiency PV cells; cheaper low-efficiency thin-film cells might come earlier, and are a good alternative for building-integrated PV
- Likely but insufficient
- May not available
- Maybe 2009, due to demand and pricing issues, but technology exists.
- Never (Several)
- Not likely in 15 years, maybe in 50
- The growth entered an exponential period around the 2000
- They will be affordable only because of oil’s cost, but they won’t help the economy from a steep decline

- What will be important is the application and the widespread usage
- Will 50% ever be attained? Is it a sensible goal at all? I'm rather skeptical… But cost-efficiency is another matter.

Scenario 2: Environmental Backlash

- Environmental pressures would help to make this happen by 2050
- Focus on environmentally friendly technology
- If meant negatively, never. Concern about resources needed to manufacture panels - good job creation opportunity; immediate environmental benefit.
- If this technology were widely distributed and controlled, it would make a difference in greenhouse, if we change our "growth is good" worldview, otherwise we're still headed for trouble
- May not available
- Never (Several)
- New legislation increase economic incentives for new technologies
- Political correctness slows science, in past DOE experience.
- Pressure from Environmental. Groups would accelerate it.
- The next generations are more aware of the challenges and focused on them.
- There will be concern about cells material waste

Scenario 3: High Tech

- 50%?
- Affordable but cheap solar cells with low efficiency might be economically viable by 2015
- Function like BUSINESS AS USUAL
- Good possibility
- If not deemed important, 2020 if deemed important
- In all cases, more likely a distributed generation capability that decreases reliance on fossil fuel, but will never be primary source of power
- Increase in the efficiency of the photovoltaic cells
- Innovations will come from highly skilled engineers in developing countries, ex. India.
- May not available
- Never
- New developments on the main elements of cells allows an efficient loaded of energy
- Organic and polymeric photovoltaic cells
- R&D gets good push
- There are already companies developing the technology in Africa
- This will contribute to a high tech economy, but could
- With 35% probability, following up NASA JPL "sandwich" work to utmost and using reflectors.

Scenario 4: Political Turmoil

- Countries need to be independent on oil resources
- May not available
- Never- conflict destroys capacity to move into solar production
- No clear linkage between conflict and invention
- Not affected by political turmoil

- Political turmoil is more related to a sense of injustice and desperation. Any technology can exacerbate this, depending on how it's used
- Possible lunacy in Middle East and US might force intense development in short term
- Prices pressure over Latin America
- R&D is not given enough priority
- Resources redirected towards conflicts
- Solar has substantial military apps and independence apps
- Some focus on energy substitution
- War inhibits such progress.
- Won't happen

1.03. First demonstration of cost-effective generation and delivery of base load electricity from solar earth orbital satellites

Scenario 1: Business as Usual

- >>2100
- 2100+
- After 2050
- Complete idiocy and hopefully will never occur
- Difficult to achieve
- I hope never: too dangerous
- Later than 2075
- Never (Many)
- Never, we've invested our capital in houses, roads, consumer goods etc, debt on these will lower demand for energy and reduce capital available for big projects
- Never. Key enabling technologies are either not being developed or, in the key RLV area, are endangered legacy technologies not easily reinvented
- Not in foreseeable future
- They will be affordable only because of oil's cost, but they won't help the economy from a steep decline
- Too expensive compared to nuclear, transmission problem
- Unlikely
- Very costly and unlikely on all counts
- Won't happen
- But how long after this until it makes a significant contribution?

Scenario 2: Environmental Backlash

- >>2100
- 2100+
- After 2050
- Damages of the electromagnetic fields and space waste
- Environmental impact of MW transmission through the atmosphere cause for concern.
- Hopefully never
- Never (Majority of responses)
- Not to be expected within this scenario (missing support for the associated research and development programs)
- Not used

- Sounds good :-)
- Will be opposed by environmentalists probably
- Won't happen ever - earth based solutions will take precedent

Scenario 3: High Tech

- Advanced industry Airspacial improves its results
- After 2050 (Several)
- Domain of the transportation technology of high watts energy without physical environment
- Extreme capital investment a major obstacle
- Later than 2050
- Never (Many)
- Power generation from other sources will slow down
- Research would entail financial resources of the magnitude that no country would be ready to spend at the moment.
- See the new design configurations in State of the Future CD Rom appendix, and in Beyond the Earth, Krone ed., 2006.
- Small possibility but equally possible that "defense" satellites will be developed to eliminate these new sources of power

Scenario 4: Political Turmoil

- After 2050
- "Who knows"; in case of successful western blocking, maybe in 2050
- >>2100
- 2100+
- Dispute over the space domain among huge technically based countries
- Hardly achievable during worldwide political uncertainty
- Major users turn to other possibilities
- Never (Many)
- Never before stability is back
- Never, but military solar weapons platforms by 2030
- Never: depend on timing and degree of conflict and nature of response.
- Not affected by political turmoil
- Not likely
- Not to be expected within this scenario (solar earth orbital satellites are only conceivable as a result of a huge international effort)
- Not used
- Some western countries can accelerate the speed of research to be independent
- 'Won't happen, too much chaos to produce successfully
- International conflicts for use of orbital space could arise by the perspective of dominate it. It would be more a military than a technology or economic reason.

1.04. A solution is found for long-term safe storage or destruction of radioactive waste

Scenario 1: Business as Usual

- >>2100

- A solution is found for socially acceptable, non-forced long-term safe storage or destruction of radioactive waste on earth, 2020 but social acceptability criterion violated by force
- After 2050
- Although “safe storage and destruction” will remain highly controversial
- Later than 2050
- More a question of public acceptability
- Never (Many)
- Never, see above 1.3, economic growth needed for big projects, stagnant or declining economies will keep avoiding the issue
- Not likely
- Now
- Now or never. Security against terrorists will never be so much better than now.
- Nuclear energy comes to be energetic matrix
- Possible
- Safe storage
- Send it into the sun via rockets
- Temporary solution for storage
- That might be useful but is very doubtful. Who can guarantee something over a period of several hundred of thousand to10 million years?
- The solution already exists; the problem is socio-political
- They will be affordable only because of oil’s cost, but they won’t help the economy from a steep decline
- This scenario is like saying pigs will learn to fly
- Today, it's a political issue
- Under construction today in Finland
- What constitutes a solution? Social acceptance of the risk is the key.
- Safe storage is relative. It's impossible to proof it ahead of the outcome. Perhaps the most unpredictable factor is the stability of the society safeguarding the repository. Historic precedent is dismal in that respect. Maybe a hiatus of policing would not lead to catastrophe, but an apocalyptic scenario cannot be ruled out, e.g. a powerful anarchist group getting control of a repository and using it for dirty-bomb suicide attacks on opponents. The laws of physics make it highly unlikely that an ECONOMICAL way can be found to convert radionuclides to innocuous ones.

Scenario 2: Environmental Backlash

- >>2100
- After 2050
- Current, historically proven disadvantages of unsafe storage
- Environmental pressures would help to make this happen as the primary obstacle is political will and popular support, not technology or cost- see recent report by Dowd swell Commission on disposal of spend nuclear fuel (Canadian)
- Environmental issues will continue
- Never (Many)
- Never, but waste itself might be zeroed out
- Not to be expected within this scenario (associated research would not be supported)
- Now
- One assumes that this is a "publicly acceptable" means of long term storage, but this emotionally charged power source plays into the environmental backlash
- Rather nuclear than more carbons
- Research will be stifled by political expediency. Other partially understood options will be similarly held back.
- Strong confrontations of environmentalist organizations with governments

- The environmentalists restrain the development of the nuclear technology
- They do not accept storage solution
- This scenario is like saying pigs will learn to fly
- Under construction to day in Finland
- To get the environmental movement to embrace nuclear energy as the answer to global warming, finding a solution to the waste problem was key. Also moderate politicians would not increase support until the waste problem was solved; hence, they would support increased R&D to speed up a solution.
- As nuclear is phased out no research into this direction.

Scenario 3: High Tech

- >>2050
- After 2050
- Definitive solution
- Destruction
- Destruction of RW realizes.
- Never (Many)
- Now
- Now or never. Even new technology on earth has unavoidable social/political leaks.
- Nuclear power in a reduced scale at more affordable prices
- Quality science and transparency show a truly safe solution stays just beyond reach – though not impossible
- Tech innovation may accelerate it.
- This scenario is like saying pigs will learn to fly
- Under construction to day in Finland
- Weak linkage

Scenario 4: Political Turmoil

- >>2100
- After 2050
- But social acceptability criterion violated by force
- Conflicts turn aside the priorities towards other areas
- Increase in the risk rates of terrorism attacks
- 'Never
- Not to be expected within this scenario (missing research capacities, missing stability of societies)
- 'Now
- Politically charged issue - technology not the issue.
- Radio-active waste could propel easier construction of WMDs. Nuclear proliferation could be higher.
- Several “safe solutions” go mostly unchallenged given all the other problems
- Sooner here, but improvements would be too late and too little.
- The struggle of power delays this
- Under construction today in Finland
- Wars would cause increasing need for such developments.
- Weak linkage

1.05. One million electric cars per year are produced, plurality manufactured in China

Scenario 1: Business as Usual

- One of the most promising existing trends, due to China's superior manufacturing base and tech in this area
- After 2050
- But more likely resources will be used for electric buses etc first
- Highly likely- this is the most probable direction
- Hybrid, not electric
- Later than 2050
- Manufactured in the world
- No change, producing cars is very energy intensive, and electricity has to be generated from something.
- Possible. But the problem is also congestion. The challenge is going beyond the car concept!
- 'That might be useful, if embedded in a broader concept.
- They will be affordable only because of oil's cost, but they won't help the economy from a steep decline
- A very well understood old technology, facilitated by modern battery technologies! Highly practical in urban areas and economically attractive in countries that have cheap coal and dependent on World oil markets with escalating prices. Aided by very low vehicle maintenance costs.

Scenario 2: Environmental Backlash

- But no advantage if electricity generated from coal
- Current - through pollution and smog in cities - health and global warming impacts of pollution / CO2 release etc. peaking and increasing 2010-2015
- Environmental performance strongly depends on how electricity is produced. Thus rather later than in Baseline
- Hybrid, not electric
- Infrastructure charging, laws, and regulations, investment in public transport, intelligent mobility personal devices will allow shift from private cars based on market incentives
- Many current batteries would be discouraged, but China might try harder.
- No impact
- Not to be expected within this scenario
- Only a change of transport model will make a difference, efficient public transport, and cooperatively owned cars
- People will claim about individual transportation solutions

Scenario 3: High Tech

- Both R&D could be moved faster, especially with new partnerships, greater US, & Japan efforts.
- But they will be hybrid, possibly with electric components.
- Development of accumulators with low weight and high efficiency
- Later than 2030
- New technology could expedite the process
- Not only in China
- Petrol and diesel driven car prices become competitive and new innovations to make them more attractive
- Some linkage but not the main factor (which is the economic development of China and its poor urban air quality impact on health

- Technology developed in demo versions - issues of power output and mass production, market readiness, distance of battery power etc. Reliant on phasing out petrol - logistics of cars on roads and distances...
- Tele-working would reduce the need to travel for business. ICT could improve supply chain for energy efficiency. Personal mobility concepts are revised in a high tech economy! Be creative!!
- The number of these cars is insignificant in relation to the global economy and greenhouse

Scenario 4: Political Turmoil

- Maybe in 2040
- >>2050
- As an result of lack of oil
- But later if China gets dragged into conflicts.
- Doesn't happen
- Hybrid, not electric
- In a world of conflict no advances will be made on more intelligent ways for transport
- Not to be expected within this scenario
- Turmoil would slow development in China
- Uncertainty politics hinders the expansion of alternative sources to the oil
- Vested interests of oil companies; dumping grounds of old vehicles in poor countries, recycling old vehicles...
- Some countries are already investing in the infrastructure of hydrogen solutions like fuel cells. Around 2010 it could start international competition for electric car production.
- It seems to me that if the turmoil occurs outside of China it will accelerate the date; however if the turmoil is in China the date will be later- perhaps much later.

1.06. New credible fission technologies are developed to solve problems of nuclear generation; improved security, reduced risk of malfunction

Scenario 1: Business as Usual

- After 2050
- Continuous process… 2020
- Current rate of development is too slow.
- Developed or operating?
- France is building fourth generation EPA reactor
- Green Peace is against the use of the new technologies
- I do not believe in this.
- Never
- Never
- Never, if you use the word "solve" advisedly, considering realities of global plant construction and fuel cycles and politics.
- New credible fission technologies are commercialized to solve problems of nuclear generation; improved security, reduced risk of malfunction, 2030
- No
- Probably never, utility mindset still in low cost (least cost) mode and will remain in this mode for half a generation i.e. till the Utility managers, R&D people who worked during the low cost energy period retire, then it will be too late
- The ITER project might help in discovering efficient fission technologies
- This scenario is like saying pigs will learn to fly backwards
- Won't happen

- Won't happen
- This is an elusive target, after demonstration will take decades to deploy

Scenario 2: Environmental Backlash

- Decrease of nuclear technology
- Environmental backlash against co2 or radiation?
- Environmental considerations could force nuclear powers to find new solutions early on.
- Environmentalists continue restraining the development of the nuclear technology
- Hopefully never
- 'Likely but linkage not critical to development
- Never
- Never
- Never
- Never
- Never. Improvements now in pipeline would lose funding.
- Not likely
- Opposition of the environmentalists makes the expansion of the nuclear energy impractical
- Probably not actively pursued
- Social segments will be contrary to the use of technology
- This scenario is like saying pigs will learn to fly backwards
- Won't happen

Scenario 3: High Tech

- Development of the many alternatives speeded.
- Fusion
- Highly linked
- Huge Capital expense and public fear means successful prototypes not scaled up for 50 more years.
- If not important, 2050 if important
- LWR technology Developments Continue.
- Never
- New investigations provides confidence around nuclear material by creating programs with major security measures
- New technology may make it possible by the above stated year.
- Possibly 2025, more likely never; "high tech" would have to include improbable increase in global policing and integration.
- Safe nuclear
- This scenario is like saying pigs will learn to fly backwards

Scenario 4: Political Turmoil

- >>2100
- Never
- Nuclear is a difficult option in times of war and terrorism
- The attempt of using nuclear weapons in wars promoted security measures to reduce risks
- This scenario is like saying pigs will learn to fly backwards
- Turmoil would be a positive effect on development
- Won't happen

1.07. High efficiency engines power 25 percent of new cars; e.g. using Stirling engines

Scenario 1: Business as Usual

- Business as usual should assume escalating energy prices, and the demand (by consumers) for energy efficient vehicles, energy efficient homes, etc. will drive technological innovation. Business as usual is likely the same case as #3, High Tech Scenario
- But more because total car numbers will decline
- In progress.2015
- 'It would certainly help. Why isn't it happening yet?
- May not feasible
- Never
- Never, but hybrids by 2010
- Never. Present large funded efforts, public and private, are simply too inept and bureaucratic
- No
- No change, producing cars is very energy intensive, and electricity has to be generated from something.
- Same thing applies as 1.5.
- The momentum is already established for a family of these developments
- They will be affordable only because of oil's cost, but they won't help the economy from a steep decline
- Yes, but this question is about NEW cars! Rising oil prices have rekindled interest in fuel-efficient vehicles. Hybrids are on the upsurge. Research results are promising, using advanced materials, precision manufacturing, continuous computer optimization of the combustion process, etc. And Honda reportedly is close to achieving the goal of a practical, mass-producible ignition-less gasoline engine, which would substantially boost its fuel economy.
- It used to be 15 years to replace the automobile fleet, but cars are lasting longer than they did 15 years ago.

Scenario 2: Environmental Backlash

- Little effect
- May not feasible
- Never
- Never, but hybrids by 2010
- 'Never. By the time they tried, key options would be lost.
- People will claim about individual transportation solutions
- Possible speed-up?
- Small effect
- Triggered by people's demand due to awareness

Scenario 3: High Tech

- Again capital has been very badly invested in low commodity cost era and the debt from this will prevent big science
- Could occur in 2010 through hybrids
- Highly likely
- May not feasible
- Never, but hybrids by 2010
- This is a high tech solution, not a change

- Triggered by cheap technology
- With 50% probability and >3X mpg and fuel flexibility, but only if original inventor of present best Stirling is fully utilized.

Scenario 4: Political Turmoil

- >>2050
- If Straits of Homuz are closed, the number of car miles could drop by 300% and high efficiency cars could make up 25% of remaining
- Little effect
- May not feasible
- Never
- Never (see scenario 1)
- Never, but hybrids by 2010
- Turmoil would slow development
- Unlikely
- War always increase research in certain areas

1.08. 30 percent of electrical power is generated at the point of use

Scenario 1: Business as Usual

- (Power generated at point of use may be dependant on several factors such as economies of scale, proximity to fuel sources, etc.)
- Already over 45% in a few countries, but when people start freezing without Natural gas, heating oil etc, greater emphasis politically on District heating and CHP
- Availability of conventional fuels far from load centers would be the reason for this
- Cleaner power stations increase
- Convenience sake, not energy
- Could be very useful. Would not change BUSINESS AS USUAL which assumes growth is could and would simply move to other means
- Depending on how and at what resource-costs, this would be a very useful solution for many places
- Eskom monopoly in SA - vested interest.
- In Finland 2004 40%
- It will rise to 15% fairly quickly, but then stagnate
- Micro generation is expensive and volatile, unlikely to reach 30%, would imply too much price swing at prompt
- Never (Many)
- Never i.e. including industry otherwise, i.e. households 2025
- Never. Today's PEM fuel cells and diesel aren't close to economic, esp. this scenario. Microturbines don't scale that much, and rooftop photo voltaics not quite 30% strong.
- Small possibility
- They will be affordable only because of oil’s cost, but they won’t help the economy from a steep decline
- Very likely due to improvements in energy generation
- The distributed power generation will cause a revolution not only on energy market but on the whole society. The perspective of the energy customers to be energy suppliers will probably accelerate the fuel cell technology research by private initiatives.
- It seems to me that business as usual will encourage this kind of disbursed distribution- it helps reduce costs for the user, may provide a tax incentive, and may become an architectural meme.

Scenario 2: Environmental Backlash

- As long conventional energy continues to remain cost effective, poorer nations will continue with past practices
- Convenience sake, not energy
- Fiscal measures could encourage shift to local energy production
- Never
- Never, unless they really shut down the world economy. See scenario 1.
- Never; in Finland 2004 40%
- Political pressure leads to mis-investment in this
- Private initiatives.
- Slightly greater possibility
- The environmentalists will love it, I think. If so it will be earlier than the average judgment

Scenario 3: High Tech

- Availability of compact generators 2030
- But in the developing world, especially Africa, Brazil, India, this figure is reached by 2018 due to indigenous technological innovations.
- Cheap alternatives.
- 'Highly likely
- High tech scenarios could provide disruptive technologies for this purpose
- In Finland 2004 40%
- Increased RE technologies for small scale application and especially use of hybrid. Technology developed to use organic substances for power generation at point... Household integration and appliances is crucial...
- Mass scale alternatives to micro generation is used
- Never
- Never
- New fuel cell developments
- New technologies primarily in centralized power production
- Still never. Grid solar beats advanced fuel cells.
- Tech. innovation has to support the answer in previous box.
- Technology development is geared by business as usual
- The growth up to 20% in 20 years in few European countries could be possible by technological advancement
- This would be high tech
- Solar photovoltaics are becoming increasingly competitive. Cogeneration of heat and electricity already makes sense for larger buildings and businesses. Great strides are being made in the reliability and ease of maintenance of cogeneration equipment and the number of utilities is rapidly growing that offer net metering and/or are required by laws to offer attractive purchase terms to small producers. Advances in performance, reliability, and economic production of (noiseless!) fuel cells are likely to make them very attractive to businesses and affluent or poorly-served (by their utility) homeowners for providing base load an emergency power. The market growth in recent years for backup generators is a good indication of the potential for fuel-cell generators to become commodities like refrigerators and AC units. A high-tech economy would only accelerate the development and adoption of fuel-cell technologies.
- Fuel cells in cars used to generate energy for one’s family houses.

Scenario 4: Political Turmoil

- >>2070
- But the amount is lower than in other alternatives
- Huge power stations are easy military targets
- In Finland 2004 40%
- Need to encourage distributed generation and RE options at point (household commercial etc.)
- Need to redesign a world beyond oil era
- Never (Several)
- Never except as part of a pathway to zero GNP and zero life.
- This could reduce people's sense of helplessness, and provide means of living
- Turmoil would slow development
- The energy production, transmission and distribution today is on the hand of few and big companies. A distributed production will change completely the market and the power relations. The big companies will be worried about it.

1.09. Significant portions of urban centers in most major cities are closed to private vehicle traffic, or have a system of tolls for entry by cars.

Scenario 1: Business as Usual

- Already happening. Expanded by 2015
- Could be quite useful in changing urban transport patterns and stimulating local communities
- If it combines with solar-energy-based electrical transport, this would certainly help
- In developing countries may adapt such system by 2015
- In Stockholm to day
- Likely in "mega cities" only (over 5 M)
- Never
- Or toady, depending on what "significant" means. But maybe I visit special cities.
- Prevention of pollution and traffic congestion would lead to this development
- Relatively easy to ménage - for example in London
- Small number of tolls only
- The momentum is already established for a range of such measures
- They will be affordable only because of oil’s cost, but they won’t help the economy from a steep decline
- Urban explosion and related problems of congestion, pollution, etc. necessitate radical action to reduce traffic flows
- Very likely
- When the cities to be unsustainable (pollution and congestion)
- Won’t need to happen post oil peak
- Yes, but London is a megalopolis and has a much better public-transportation system than most other cities. Apart from prestigious shopping streets, most shop owners are vehemently opposed to restrictions that make it less convenient for some of their customers to reach their store. Proposals for city tolls or closing larger areas to regular motorized traffic have been around for decades but have received general popular support in very few places. It also won't have more than a rather limited local impact on fuel consumption!
- London has high tech camera that capture the license plate numbers of cars entering a downtown restricted zone and fines them.

Scenario 2: Environmental Backlash

- A system of tolls for entry by cars prevails

- Both in advanced and developing countries may adapt such systems by 2015
- Environmental pressures are critical to make this happen and it should
- In most urban centers such projects are developed.
- In Stockholm to day
- Never
- Not so hard to do, but benefit is local, not so major.
- Proactive measures taken to incentivise alternative means of movement in and around urban centers
- Regulations allowing market based incentives to shift from private mobility and from car-ownership concept to "just-in-time" leasing
- Same answer as for the previous box, except for the fact that environmental issues could accelerate the pace
- The necessity of reducing pollution allows new laws and politics discouraging the use of cars
- This would reduce greenhouse, if done with other measures, most greenhouse comes from coal burning

Scenario 3: High Tech

- Improved public transportation could accelerate this trend
- In Stockholm to day
- Mass rapid transport systems would be an alternative to facilitate this decision
- May not be closed
- Never
- New transportation systems like “esteiras rolantes
- Same as 1.5
- Small effect but could reduce costs of system to collect tolls or charges
- Will have been technological alternative solutions that made possible to maintain a high traffic of cars
- Might not be necessary as new and environmentally friendly modes of private transportation are being used
- Positive results from other cities will make for additional use

Scenario 4: Political Turmoil

- As a desperate strategy
- In Stockholm to day
- May not be closed
- Never (Many)
- No effect
- Rising oil prices and fewer cars should speed the trend.
- Will not occur

1.10. The amount of energy consumed per dollar of GDP worldwide drops 25 percent from today’s value

Scenario 1: Business as Usual

- (Constant PPP assumed)
- May not drop

- Never (Several)_
- Never. Prices rise faster than conservation (though "amount" assumes a metric).
- Not likely as demand on global scale will grow in all sectors
- Not likely by 2020
- This is pointless as long as there is a growth worldview.
- This will happen only because the price of oil will cause economic decline
- Unlikely, as energy costs will continue to increase as scarcity, relative to demand, continues to increase
- World property bubble will have major impact on GDP which will cause massive drop in energy demand, but which falls faster
- Development process in "third world" will increase energy consumption for more years.

Scenario 2: Environmental Backlash

- Could be accelerated by encouraging a move away from mineral processing.
- May not drop by 2030
- Never, unless world economy goes back to pre-transition times.
- Pressure for energy efficiency
- Small effect
- The earth responds to the amount of greenhouse gas produced, not the GDP ratio

Scenario 3: High Tech

- Highly likely
- Inertia is a problem, but it can be turned around.
- May not drop by 2020
- New architecture projects
- The establishment of a global, equitable knowledge economy will mean that “GDP” becomes a poor unit.

Scenario 4: Political Turmoil

- >>2050
- Extremely varied in different parts of the world… 2045
- May not drop
- Never (Several)
- Never, except as part of a Stone-Age-on-the-way to extinct version.
- No
- Turmoil would slow development
- For leading high tech nations

1.11. Industry consolidation continues resulting in only a few large oil companies in the world

Scenario 1: Business as Usual

- 90% probability for 2030
- About at end of process
- Already the case, small marginal players will always exist for small projects

- Already. 10/20 years out, could be more or less, as nonUS groups assert themselves more and Exxon loses present power base.
- Consolidation may not continue beyond 2010
- Don't want to wager guess
- Globalization creates industrial monopolies around natural resources. Became universal suppliers.
- Likely
- Major oil consuming countries are rapidly trying to acquire oil equity that would lead to consolidation
- Más bien la tendencia es que cada vez haya más stripping companies Para manejar los campos agotados
- Never (A few)
- New companies will always be created
- No change, except bigger incomes for the leftover executives
- Not very likely since new companies also appear as investments in new discoveries grow
- There is already a few numbers of big ones
- This will happen in cycles regardless of time horizon
- True
- Unlikely as new players arise
- Unlikely, small players are more efficient at extracting reserves due to their lower overhead and lower shareholder expectations, second & third tier companies are necessary
- Yes (Several)

Scenario 2: Environmental Backlash

- '50% probability for 2030
- As scenario1
- Ditto
- Doesn't happen
- É necessário maior escala para suprir novos custos ambientais.
- Environmental action would not have great impact on consolidation efforts
- Fight against oligopolies
- Legislation restricts consolidations
- Never (Many)
- Never. Backlash would control big oil more.
- No effect on M&A
- No impact
- Not very likely since new companies also appear as investments as new discoveries grow
- Opposite trend, consolidation reversed
- Probably make things worse
- Small effect
- There are already a few big ones
- True but more slowly
- Yes

Scenario 3: High Tech

- 95% probability for 2030
- Already, but might be more in 2020/2030. Like cable TV -- competition may allow more concentration in sub sectors.
- As scenario 1

- Disruptive industries will increasingly come to the fore questioning the existing
- Diversification of companies for alternative energies.
- Don't know
- Each company would try to develop specific strategic advantages in technology.
- Never (Several)
- No effect, maybe a reversal
- Not very likely since new companies also appear as investments in new discoveries grow
- Small effect
- There are already a few big ones
- True

Scenario 4: Political Turmoil

- 20% probability for 2030
- As scenario 1
- Depends on how they behave themselves in the oil producing countries
- Dispute over the remaining oil reserves
- Don't know
- Lack of vision for a global economy could lead to fragmentation or sense of instability if governance is exclusively left upon global companies. Disruptive discoveries could question global order.
- Never (Several)
- Never
- Never. Multinationals and national governments all get weaker.
- Not at all
- Not very likely since new companies also appear as investments in new discoveries grow
- Political conflict limits consolidation
- Political considerations would be the prime movers for consolidation, as every nation wants to secure its energy needs
- Turmoil would slow development
- Yes
- Political turmoil intertwined with an energy crisis and "failed states" dropping out of meaningful cooperation with the World community would greatly dampen the progress of globalization, and it would most likely not be a short-lived backlash. It might lead to the formation of new blocks trying to outmaneuver each other while favoring their own corporations.
- Political turmoil will allow companies to form old-fashioned cartels again.

1.12. Water problems destabilize India and China, lowering economic growth, and causing coal and oil

Scenario 1: Business as Usual

- Probability of disruption about 50%, (this is only one source of problems)
- Already to some degree-- fall relative to otherwise. China trouble so bad it causes negative trend in China would make global trends worse.
- Bad for the Indians and Chinese, little effect, especially on greenhouse and oil crisis
- Beyond 2100
- Beyond my field of expertise
- Destabilizing true by 2020 but it does not cause fall of energy demand but may be vice versa
- Disregard about environmental issues make these economies as growth centers
- Don't know

- Far fetched
- Global warming will have alarming impact on water situation, requiring greater use of fuel not to meet conventional energy needs but also in transportation of water
- Likely
- Likely soon, but us economy collapse probably sooner
- Never (Several)
- No
- Not likely, tech solutions possible
- Problems in Africa more likely
- Think it is unlikely
- Unlikely in this time frame
- Water problems can destabilize India and China but I do not believe coal and oil demands will in these two countries
- Won't happen. China and India won't slow down. First, an energy driven solution (probably nuclear) to desalinize enough seawater will be found and implemented.

Scenario 2: Environmental Backlash

- Probability of disruption about 40%
- Bad for the Indians and Chinese, little effect, especially on greenhouse and oil crisis
- Beyond 2100
- Beyond my field of expertise
- Bigger regulation on the water usage
- Don't know
- Environmental pressure groups could force to reduced carbon emissions leading to delay the water problems
- Foreseen and prevented
- Increasing and peaking in 2020
- Never (Several)
- Never. Real environmental force would control this.
- No
- Not likely, tech solutions possible
- Small effect
- Sustainability movements grow in Asia
- Sustainable development policy adopted.
- Water and other environmental problems cause destabilizing the societies and fragmentation into local society groups with assumed consequences by 2020
- Won't happen. China and India won't slow down. First, an energy driven solution (probably nuclear) to desalinize enough seawater will be found and implemented.
- Yes
- Yes

Scenario 3: High Tech

- Probability of disruption about 40%
- As in business as usual
- Bad for the Indians and Chinese, little effect, especially on greenhouse and oil crisis
- Beyond 2100
- Beyond my field of expertise
- Don't know
- Foreseen and prevented

- High tech economy in the form of sustainable agriculture options for these countries, water saving and flood control...
- Never (Many)
- Never. Would improve water use and economic growth.
- New equipments for cleaning
- No
- No
- Not likely, tech solutions possible
- Not likely, tech solutions possible
- Problem just solved by different enterprises
- Recycling is the solution
- Small effect
- Won't happen. China and India won't slow down. First, an energy driven solution (probably nuclear) to desalinize enough seawater will be found and implemented.

Scenario 4: Political Turmoil

- Probability of disruption about 50% – could be a reason for the turmoil
- As in second scenario
- Bad for the Indians and Chinese, little effect, especially on greenhouse and oil crisis
- Beyond my field of expertise
- Dispute over clean water in the continent
- Don't know
- If the turmoil is in these regions, the effect could be soon 2020
- Like worst version of scenario 1. Less oil, more death.
- Maybe
- Never (Several)
- New technologies appear to resolve the problem of the water
- Regional conflicts for water cause destabilization on system
- Turmoil would speed destabilization of water
- Won't happen. China and India won't slow down. First, an energy driven solution (probably nuclear) to desalinize enough seawater will be found and implemented.

1.13. The geopolitics of gas becomes as central to energy growth as the geopolitics of oil was in the last 30 years of the previous century

Scenario 1: Business as Usual

- 10 years before the tip of Hubbert
- Absolutely, and within ten years
- Already happening in Russia/Ukraine, Now
- Already here, folks. Anybody notice the brief Russian cutoff of gas to Europe? Or what the cocaine gas folks are already doing in Latin America?
- Already the case USSR/Ukraine but will be more regional
- Don't know
- Gas will be a transitory technology, wind will be more important.
- Gas will peak within 10 years of oil at current rates of use. Probably sooner after peak oil. Will force some changes, but could be simply turmoil if we don't change social model and worldviews based on growth and dominance
- It will never be so central

- LNG will be the new oil
- Mitigation through LNG
- No
- Rather the process has already started with US government intervention in India-Pakistan-Iran gas pipeline
- Russia would be the main target of companies.
- Scenarios very equal to oil. But energy supply diversification still possible from Mediterranean countries
- They are continued discovering new petroleum reserves: gas continues being an alternative fuel

Scenario 2: Environmental Backlash

- Already without end, and worse. Short-term environmental approaches are already responsible for accelerating natural gas use, and folks like Morales.
- The High sensitivity to the ecological situation and reinforcement of an economy based on ecology
- Clean fuel needs would accelerate the process for quest for cleaner energy
- Don’t know
- Exacerbate choice between gas and nuclear
- Gas will peak within 10 years of oil at current rates of use. Probably sooner after peak oil. Will force some changes, but could be simply turmoil if we don't change social model and worldviews based on growth and dominance
- It will never be so central
- Never
- No
- No impact
- Now
- Scenarios very equal to oil. But energy supply diversification still possible from Mediterranean countries
- Small effect
- Two opposing trends: relatively more gas needed to replace coal, but less consumption overall

Scenario 3: High Tech

- Alternatives to gas, oil, and coal prevent this.
- Can be reduced, and the politics of scarcity zeroed out, by really moving faster with large-scale clean electricity sources, alternative to natural gas.
- Don’t know
- Gas will peak within 10 years of oil at current rates of use. Probably sooner after peak oil. Will force some changes, but could be simply turmoil if we don't change social model and worldviews based on growth and dominance.
- Hydrogen and fuel cell technology could further delay the emphasis on hydrocarbon fuels
- It depends much on the type of technological development
- It will never be so central
- Marginalized by renewables
- Mitigation
- Never
- No
- Prior emphasis would be given to the developing countries renewable energy resources.
- Scenarios very equal to oil. But energy supply diversification still possible from Mediterranean countries

- Small effect
- Transcontinental transportation will be improved

Scenario 4: Political Turmoil

- Already starting
- Conflicts over gas and its distribution will arise.
- Could be expected to be even worse
- Dependence on natural gas is increasing because is vital to civilization. Cause of regional conflicts.
- Don’t know
- Gas will peak within 10 years of oil at current rates of use. Probably sooner after peak oil. Will force some changes, but could be simply turmoil if we don't change social model and worldviews based on growth and dominance
- It will never be so central
- Like scenario 1, until economic damage takes hold.
- Never
- Political intervention would hasten the process
- Possible reorientation of wealth in Arab world towards gas producing countries
- Regional conflicts may emerge from disputes over oil reserves and furnishing
- Turmoil would slow development of gas
- Yes (Many)

1.14. Carbon trading practiced by 30 of top 50 emitting countries

Scenario 1: Business as Usual

- Carbon trading is rent skimming by Industrialized Countries: 2020
- I suppose. It's a political trend.
- Largest polluters also being political power have not taken the issue as seriously as it deserves to be taken up
- Likely
- Likely but not sufficient
- Never (Several)
- This simply means that they can go on producing CO2. It might stimulate a few efficiencies and punish waste
- Very soon, 2010 or earlier
- Won’t happen. Property rights will never be defined or negotiated.
- Yes

Scenario 2: Environmental Backlash

- 2010 or earlier
- A better, more sophisticated, and fairer model is developed by 2020
- After Kyoto phase 2
- Highly likely
- It's politically correct.
- Kyoto II takes off
- Never

- Never
- This simply means that they can go on producing CO2. It might stimulate a few efficiencies and punish waste
- Yes (Several)

Scenario 3: High Tech

- 2010 or earlier
- Alternatives to gas, oil, and coal prevent this.
- Development of alternative clean fuels may reduce the pressure on polluters
- I suppose. Not a technology issue.
- Less need for it
- Never
- Never
- New technologies reduce the necessity of trading
- Small effect
- Yes

Scenario 4: Political Turmoil

- Never (Many)
- Doesn't happen
- Impossible in a conflicting scenario
- Lack of political cooperation
- No
- Not likely
- Perhaps never
- This simply means that they can go on producing CO2. It might stimulate a few efficiencies and punish waste
- Turmoil would slow development
- Warfare can be distracting in politics.
- Won't happen

1.15. Carbon taxes in one form or another in more than 50 countries

Scenario 1: Business as Usual

- Carbon taxation is rent skimming by producers of hydrocarbons: it is already established in more than 50 countries
- I suppose this is already a reality with e.g. taxes on gasoline in many countries
- Likely
- More likely general energy taxes
- Never (Several)
- Never. Doesn't look like a trend to me.
- Small possibility
- Very soon
- Yes
- Yes, but it wont change anything

Scenario 2: Environmental Backlash

- A better, more sophisticated and fairer model is developed by 2020
- For sure
- Highly likely
- It's politically correct, what defines this scenario.
- Never
- This would help if the taxes were used to build solar power and change wasteful use patterns and reduce consumption, otherwise little effect
- Very likely
- Very soon
- Yes
- Implementation of carbon taxes requires no new technology and minimal infrastructure. With the failure of Kyoto to achieve the desired results, carbon taxes are probably the next best hope. If most of the World is not quite ready yet for this, an "environmental backlash" would likely be more than enough to change the approach and because it is rapidly implementable it could quickly provide some degree of political relief.

Scenario 3: High Tech

- Never (Several)
- Never. Not a trend and real work can be distracting to politics, if we are capable of it.
- Small effect
- This would help if the taxes were used to build solar power and change wasteful use patterns and reduce consumption, otherwise little effect
- Very likely
- Very soon
- Yes

Scenario 4: Political Turmoil

- Never (Many)
- Doesn’t happen
- Never. Warfare is especially distracting to politics. Political systems are severely constrained in their bit rate in handling information.
- No
- Priority will be given to other measures
- This would help if the taxes were used to build solar power and change wasteful use patterns and reduce consumption, otherwise little effect
- Turmoil would slow development
- Won’t happen

1.16. Terrorist attacks on oil production and/or delivery systems disrupts supply by 5-10 percent for at least 1 month

Scenario 1: Business as Usual

- Almost inevitable in any scenario.

- At any time
- Before 2010
- Can happen any time after 2010
- Could stimulate moderate oil efficiencies, like the oil crisis of 1972-3
- Imminent
- The use of a weapon of massive destruction that is estimated in these years, could trigger an event of this type
- Low probability
- Middle East/ West Asia conflicts could lead to such a situation
- Never (A few)
- Never
- Never is most likely, but this is a nightmare scenario. Well organized terrorists could do much worse than this.
- Never (concentration is not large enough that 1 attack can effect a 5% drop)
- No
- No, look at Iraq. The more the terrorists attack, the more sophisticated mechanisms are put up to stop it.
- NOW/Any day
- Possible in a world that still depends on oil
- Slow cycle
- Yes

Scenario 2: Environmental Backlash

- At any time
- Can happen any time after 2010
- Could stimulate moderate oil efficiencies, like the oil crisis of 1972-3
- Emphasis would be given to sustainable development, including East and West.
- Fast cycle
- Never (Several)
- No
- NOW
- Small effect
- Western greens would not be better at peace making after a few years of settling in to power.
- Yes

Scenario 3: High Tech

- At any time
- Can happen any time after 2010
- Consequences and propagation of the problem would be vastly ameliorated, but it takes time to deeply improve life in poor neighborhoods.
- Could stimulate moderate oil efficiencies, like the oil crisis of 1972-3
- Emphasis would be given to sustainable development, including East and West.
- Fortunately enough
- Never (Several)
- No
- NOW
- Slow cycle
- Small effect
- Yes

Scenario 4: Political Turmoil

- At any time
- Can happen any time after 2010
- Could stimulate moderate oil efficiencies, like the oil crisis of 1972-3
- Eruption of a war in Iran or other oil producing countries could lead to this
- Fast cycle
- Never
- Never
- NOW
- Organized and effective worldwide
- Part of what leads to the kind of devastating conflict I would expect under present trends, short of massive creative thinking.
- Terrorist cells all around the world have means (power capacities) to damage the system
- Very likely
- Very likely
- Very likely within next 20 years
- Yes (Several)
- Politically motivated attacks are at least equally likely as ones motivated by religious belief, particularly pipelines in former Soviet Union and Africa.

1.17. Majority of major new buildings in developing countries are designed for low energy consumption

Scenario 1: Business as Usual

- China already moving fast in this regard so perhaps 2010
- Don't know. Maybe already, if majority are in China and they have sensible building codes.
- In China 2020
- In industrialized terms this has always been true
- Likely
- Never (Several)
- Never
- PLEASE LET IT BE NOW!! 2015
- This would help if others were retrofitted otherwise limited usefulness
- Too soon for this time horizon
- Yes, but it won't change things much

Scenario 2: Environmental Backlash

- If not already. Tight codes are a no-brainer for Nader folks.
- In China 2015
- Led by 1st world imports
- No
- This would help if others were retrofitted otherwise limited usefulness
- Very likely

Scenario 3: High Tech

- Heat exchange technologies, airing and thermal appliances will be improved
- In China 2015
- Industrialization may force developing countries to design high energy consumption building first, so they can go back to traditional buildings
- Led by indigenous designs and technologies
- New cost effective technologies and high energy prices would facilitate this
- No
- See scenario 1. Reasonable support of such codes would be part of a reasonable high-tech strategy, accelerated a little by clear-minded if still-distant leadership.
- This would help if others were retrofitted otherwise limited usefulness
- Very likely
- Very likely
- We have all the knowledge and technology to start making a significant difference now! More developments obviously on the topic of nano-technology round 2010 - 2015 for even more efficient, low-impact buildings.
- Yes
- Yes

Scenario 4: Political Turmoil

- In China 2015
- And increasing - political support & policy interventions needed, especially in RSA, market ready, strict control and policies needed. Demo's done, people sensitized, business-as-usual continuing unabated due to vested interest of construction companies
- Doesn't happen
- Never (Many)
- Never. War is distracting.
- No
- Not likely
- This would help if others were retrofitted otherwise limited usefulness
- Turmoil would slow development
- Unlikely

1.18. Most countries have policies to achieve significant shifts in fuel mix, including removal of subsidies on coal and other fossil fuels

Scenario 1: Business as Usual

- Already happening, free markets determine fuel mix according to wholesale price, EU to liberalize markets very soon
- High energy prices would force governments to consider these options
- Likely
- Maybe
- Never
- Never, most countries requires global cooperation - not likely
- Never. This only happens as part of a transition to one of the other scenarios. Policies are very loud and insignificant for now.
- Small possibility

- Taxes on oil and fossil fuels have always been apart of production, yet they were always the cheapest fuels, and always will be.
- Would stimulate change in energy use and production

Scenario 2: Environmental Backlash

- Likely
- Maybe
- Pressure groups could expedite this process
- Unlikely to speed this up
- Very likely
- Within a few years of a proposed backlash (hard for me to time or to envision), big cutback in subsidies would be expected but not change in mix
- Yes (Several)

Scenario 3: High Tech

- A true hi-tech scenario would need more serious action to change mix by 2010-2015, but subsidies not a major focus + or -
- And methodologies like Causal Layered Analysis, which also takes worldviews, stories of self and society and externals into consideration.
- Would stimulate creation of useful technologies
- Increased
- Never
- No
- Small effect
- Very likely

Scenario 4: Political Turmoil

- Perhaps starting in the times of the turmoil…
- Economic pressure would force fiscal constraint.
- Increased
- Never (Many)
- No
- Not at all
- Reduce social pain
- Today
- Turmoil would slow development
- Unlikely

1.19. Please enter additional developments that you believe should be considered in these scenarios

- 2010, 1.19 Solar energy develop in developing countries
- 2015 Tar sand
- 2015: The Kyoto Protocol for the developed countries including the US is adopted.

- 2025 'Development of high efficiency/high power engines designed to run on vegetable-based fuels favorably compete with oil-based fuels, providing a source of economic growth for third world agrarian economies.
- A significant saving of energy by good social practices is obtained
- Accelerated take-up of fuel-cell cars
- Alcohol becomes an important fuel in the world.
- Biofuels
- Burgeoning middle class in India and China causes sharp increase in world energy demand 2010
- Carbon Capture and Storage,
- Changes in (1) central parameters designed for self orientation of societies as 'GDP'; 'energy consumed'; (2) WHO principles in order no longer to undermine environmental restrictions
- Changes in people's behavior.
- Cheap wind power turbines, mass produced in China and assembled world wide provide >10% of global energy
- Clean coal and carbon sequestration are also in the cards.
- Countries having significant amount of coal reserves will develop more pit head based power plants or plants near by the coastal areas if crude prices are very high.
- Developing countries continue to pursue lifestyle that first world countries enjoy. Labor costs escalate and cheap production stalls across China. Movement of cheap labor markets to the SW pacific.
- Disruptive technologies may come before 2020 making all energy system obsolete
- Energy mix will diversify globally
- Energy Rift Valley (ERV) issue: all three sources oil, fission nuclear, and gas will reach their peak production phase in turn and in a short interval from 2020 to 2040 causing as a resultant a rift of energy supply from these sources without sufficient substitution sources available at the time of rift.
- Fission comes back 2015 in many countries
- Fusion,
- Hydrogen (gas / liquid) is becoming a major energy storage and transportation medium, 2025
- Hydrogen power from a) fossil fuels b) renewable fuels,
- Hydrogen production becomes economical by taking increased taxes on fossil fuels, 2030
- In many 1st world nations, national governments will be shown the way by innovative metropolitan authorities
- Increase in the use of bio-fuel: biodiesel and ethanol
- Laws to order migrations
- LUNAR SOLAR POWER
- Modification or sabotage of world-wide agreements by events of the type of the coalition of Seattle
- Oil resources deplete significantly
- OPEC reserves found to be overstated, governments pursuing aggressive energy efficiency programmers
- Other means of increasing the current energy production – Intensive research on fuel cells, nanobatteries and exploiting the other non-conventional energy sources should be considered
- Renewable fuels make up 10% of traffic energy consumption in industrial countries in 2050
- Renewable sources of energy supplies 30% or more of energy demands in the year...
- Resource "cold war"
- Risk aversion by monopoly national oil companies causing oil production to be flat. OPEC members and Russia may just control all their internal production, and slow down new developments
- Scenarios 1 and 3 will converge and look similar
- Seawater AG/Biomass, 2.H2 from genomic and synthetic Photosynthesis
- Share of renewable energy greater than 10%, 2030
- Small scale energy production, 2015
- Social participation

- The fossil sources reach their peak of production
- The impact of security threats resulting from energy problems on acceleration of development of more efficient energy policy (all aspects – production, transmission, storage, use): Significant plausibility
- The society will become aware of the reality of the radioactive waste, whose storage is not yet guaranteed, as it will become the future of humanity
- Thermal power plant sector competes with domestic, manufacturing in most arid, semi-arid developing countries (not only China and India) by 2015,
- These scenarios consistently assume only external changes in technology, laws etc. There needs to be much more consideration of the effect that changes in personal or social values and worldviews would or could have.
- Water availability, quality, and cost will soon become as critical as energy issue
- Wind energy
- Wind energy will top every thing else, Energy efficient housing great progress
- Wind power (lower wind threshold) and nuclear power (waste disposal) under BUSINESS AS USUAL is possible
- I would like to suggest 2 new subjects / aspects: - a possible energy use per capita rationing - decentralized energy production and supply: could become widespread not only in terms of self-supply new buildings being available in the mass-market, needing no externally produced energy or even producing superfluous energy themselves, but also because of the higher safety after threats or attacks on energy infrastructure or water supply infrastructure.

Appendix 4.2: Respondent Comments to Round 1, Section 2

This appendix presents the comments made by respondents in Section 2 of Round 1 Delphi. As before, the comments from the survey are presented first for each scenario, then in smaller print, the comments from the RT Delphi.

2.01 Consider: Global GDP? World depressions? Recessions? Growth spurts? Accelerations?

Scenario 1: Business as Usual: Moderate to high economic growth until oil prices go so high they cause recessions, and depressions

- Current cycle of strong growth up to 2010, followed of strong depression due to financial crisis and scarcity of oil
- Agree – most likely "linear scenario"
- Likely, but the global economy seems to be getting less sensitive to oil prices. So instead of several recessions and depressions over the next 10 years, maybe we will build up to a monster crash around 2015
- Also greenhouse will make it even worse
- No, economy can work with high prices
- Labor market should also be considered.
- New technologies prevent peak before 2070
- Agree, although earlier recessions may of course be caused by non-energy related events
- Before that happens the countries will shift to natural gas, renewable energy of biofuels.
- Realistically oil prices will grow in response to global economic growth, slowing it rather than causing recessions. Slowdown lasts <5 years after which global oil prices stabilize for the indefinite future with shale oil, synthetic fuels, etc
- Agree except that it goes to scenario 4
- Agree, thought other influences besides oil prices may also spur recessions - e.g. global political unrest
- I don't see this extraordinary role of the oil prices; the great recession we face will be due to developments on the financial markets
- Oil intensity to economic growth is on the decline. The oil prices are also not expected to go up all the time as other viable and economic energy sources may become available by 2020.
- There is some differentiation needed for the world regions, i.e. high growth rates in emerging markets but stagnation in Europe or the like Oil prices will accelerate as more and more people want to use it and the supply dwindles inexorably.
- The price of oil will eventually go so high that a repeat of the inflation/recession phenomena will occur to reduce demand and lower prices again
- If the economy cycles, as it has over the years (business as usual) then a slowdown or growth will result in a slowdown in energy consumption, and a drop in oil prices.

Scenario 2: Environmental Backlash : Moderate to low economic growth, oil price fluctuates with environmental actions, supply disruptions

- And possibly depression
- Oil price could be reduced due to alternatives, lower demand
- Could be same as Business as Usual
- Disagree: the environmental pressure will facilitate the development of efficient technologies which decrease oil dependency, supply disruptions might occur, but will not be large enough to

decrease economic growth, moderate to high economic growth similar to the business as usual case
- Environmental actions will be primarily compensatory (fossil fuels being replace by bio-fuels) and this would not reduce the economic growth
- Larger incentives for higher productivity also benefits economic growth
- No. Moderate and high prices, without interruptions and with smaller flow.
- Moderate or low growth but without interruptions.
- Agree with first half, but unlikely that oil price fluctuates with environmental actions
- I agree to the moderate growth of the economy, but it has minor risk of interruption.
- Disagree – environmentalists will never be able to achieve such a position
- Unlikely for the environmentalists to achieve this level of impact (sadly!). Effective terrorist disruptions will not be due to environmentalists, but fundamentalists.
- Some value, but greenhouse will still cause great problems
- Agree, only if people realize environmental worth and take action in that regard. Necessary curb in demand
- Moderate economic growth, oil price fluctuates with environmental actions and oil peak, oil and gas supply disruptions, accelerated phase-in of renewable energy sources by 2020
- Unlikely that environmental policies will significantly curtail worldwide energy demand.
- New technologies prevent peak before 2060
- Agree - but not just because of "environmental groups getting more organized" but because of increasingly compelling evidence of global warming affecting consumer and corporate behavior
- Possibly increased economic growth due to rationalized taxation, reduced international conflict, and reduced power in the hands of oil companies and car companies hence improved mass transit. Short term Europe gains vs. US
- The environmental issue, pressure not affects the prices and it seems it will not do it.
- True in countries where environmental issues carry weight
- More or less agree unless its the kind of backlash caused by Europe freezing or a Miami Katrina
- Possibility of higher economic growth in leading "sustainability countries", i.e. Finland, which are exporters of new energy saving technologies
- Too much environmental regulation, improperly administered could slow growth and maybe even trigger recession

Scenario 3: High Tech: New tech and great efficiencies prevent oil peak prior to 2050

- Unlikely, oil may peak before 2020 but technologies for smooth transitions will be available
- Moderate to low even if great efficiencies prevent oil peak prior to 2050
- Agree, but oil peak would be reached by 2060.
- Only if they come soon enough.
- Not necessarily, since alternative technologies will be developed that will contribute to restrain the demand and use of petroleum.
- Could be high growth
- As for question 1, peak expected around 2040
- Occasional technological collapses (grid failures, unexpected environmental consequences such as massive algal blooms or toxic waste excursions) because everything is very tightly managed
- Perhaps not; technological innovations may be made elsewhere, not in oil tech.
- Disagree, even with greater efficiencies oil peak will be reached within next decade
- agree, but by then petroleum already would have begun to be irrelevant
- not likely with oil assumption but with alternative forms of energy and use of energy; growth as business as usual scenario
- china and India press this before 2050
- Moderate to high economic growth with recessions caused by disruptive technology shakeouts
- Yes, economic growth still expected to be moderate to high

- Technology does not solve problems: it continues having problems of economic instability and low global growth.
- Agree, although this scenario is not plausible as a separate one. Should be linked with the
- depends on consumption scenario China and India
- OK. However, the economic dynamics will change significantly as blind consumerism is replaced by quality of life as a/the major driver.
- Disagree, too much inertia even if we hurry. But we can survive this.
- New tech stimulates the economy. Lots of possibilities here. An apollo energy program. Unexpected breakthroughs like: Deep Earth Continuous Gas Generation, Cold Fusion, Solar Harvesting in the Sahara, Really Cheap Electrolysis, Simple Albedo Modification, Space Elevators

Scenario 4: Political Turmoil Low economic growth, recessions/ depressions

- Definitely. High oil prices and volatile prices mean economic decline
- Agree + strong oil price volatility
- Disagree, as technology will make up for it.
- unequal growth of countries from high to low and depression; the mean figure not a good measure of the situation quality globally
- Agree – second most plausible scenario
- Unlikely. Many of the major 1st world economies benefit significantly from war and arms build up. Indeed their economies will flourish, hiding the negative impact on the poorest communities.
- Not if political support is directed towards environment - balance in this regard, yes, if directed solely to economic growth
- A given, unfortunately.
- It will depend on the changes done before this happens.
- Likely
- Worse. Nuclear materials to sub national groups, from dissidents to drug salesmen. After one first use... logic does not justify faith this species is immune to extinction.
- Agree , with oil disruptions
- Scientific development not directed at energy issues
- China enters serious recession due to high oil prices and their low economic output per gallon. Liquidates US treasuries, sending US into serious inflationary cycle. Global economy destabilized
- It will depend on the economic feasibility of new technologies. If oil doesn't have a substitute, it will be available in mid west more than in the rest of the world. Then an international political crisis will arise.
- One might question - even if cynically. whether political turmoil leads to recession everywhere, see the phenomenon of war profits, war business etc
- Politics can screw it up. Why can't politicians see we need a cohesive energy program, NOW

2.02. Demand - per region and/or economic grouping (qualitative) Oil intensity to Economic growth is on the decline. The oil prices are also not expected to go up all the time as other viable and economic energy sources may become available by 2020.

Scenario 1: Business as Usual: China and India continue to drive prices and supply of oil

- Yes, Oil demands expected to be high from these countries
- China and India do not lead the petroleum provision, but the demand
- developed countries too
- 2030 Agree
- Disagree. Social gaps need to be reduced
- This is silly. The US and industrial countries do this

- Partly agree- their influence in short term not as great
- China and India continue to drive prices and demand of oil
- At least until 2030
- They will continue to increase consumption
- Sort of. But demand rise is robust, global.
- Very likely
- As oil demand increases, the remaining areas with large reserves will increase in political power, but could also be come threatened by those struggling to gain long term contracts such as US, China, India, and Japan.

Scenario 2: Environmental Backlash Environmental action reduces demand mostly in Europe and US

- Environmental action may not reduce demand mostly in Europe and US
- Environmental action reduces demand mostly in Europe and US
- Niche markets would emerge in Latin America.
- Agree, but overall global demand reduction won't happen as it will be absorbed by new economic powers in Asia and Latin America.
- Also in China and India, because of local environment problem
- Environmental action reduces demand mostly in Europe and US, and slows demand increases elsewhere
- Demand decreases only in Europe
- Agree, prices push the same
- But with spillover effects (technology transfer) to developing countries
- US environmental action will be weak to reduce the increasing demand
- Makes use more effective and supplies more diversified

Scenario 3: High Tech Technology advances affect mostly First World demand and usage

- Technology advances may not affect much First World demand and usage
- Technology advances affect mostly First World demand and usage
- India would be one of these main countries.
- Agree – but there is a chance, that China and India are leapfrogging
- China, India, Japan, Korea, Russia, develop their own technologies for urban use
- No. China is comfortable with new tech. PV, Wind, Solar
- But with spillover effects (technology transfer) to developing countries
- Agree, with reduction
- Not necessarily. High tech developments spread fast today.
- Alternative technologies may penetrate to reduce oil demands stemming from energy security concerns
- Disagree: Carbon capture and PV renewables are important for developing countries.
- Include China
- Plausible, but solely together with the 4th scenario
- OK. They'll reduce dependence on fossil fuels by 1st world economies. But, they'll also stimulate dramatic growth (from low bases) across the developing world.
- What new tech? Demand will far outstrip supply.
- Physically impossible
- Unlikely!!!
- Unlikely
- Disagree to some extent - even with major new tech breakthroughs there will be a point where markets overreact to the evidence that oil reserves are lower than currently publicized
- High economic growth, accelerated phase-in of renewable energy sources by 2020 prevents major recession by oil and gas peak

- Questionable
- Best scenario
- As is the case now

Scenario 4: Political Turmoil Wars consume energy resources and prevent development of new sources

- Agree, except for saving / efficiency measures
- Wars consume energy resources
- Wars consume energy resources and prevent development of new sources
- Disagree. As wars usually and/or always promote economic and technological growth.
- Disagree, war would encourage development of alternative sources
- Not significantly
- Agree, but wars also stimulate technological innovations which would take longer in peace time
- Disagree on development of new sources in Europe and US
- New resources will continue to be developed in spite of wars/conflicts.
- Disagree. War may force the countries to resort to new sources/technologies
- Disagree. Conflicts in the developing countries might stir acceleration of development of new technologies
- Disagree. Wars always foster R & D development
- Maybe, but the impact will be minimal on a global scale.
- Agree. Industry also runs unchecked due to poor capacity to develop and enforce regulation or offer incentives
- True for conventional energy sources, but may spur alternative sources
- War may spur new technology

2.03. Economies successfully adapt to factor of 50 percent increase in energy prices without undue inflation

Scenario 1: Business as Usual Not initially, but adjustments by 2015

- Never happen
- Gradual adjustments by 2020
- Agree. Energy cost has usually never been an obstacle to economic growth
- Happening already
- Adjustments for 2030
- Disagree: adjustment later compared to scenario 2
- Agree, process will be gradual
- Adjustments later, perhaps 2020
- In principal agree with all; but adjustments might be even faster
- Don't agree on inflation
- Seems to be happening “initially”!
- New investments are energy efficient, sunk capital (25 year old + plants) are not as efficient, over time the economies of the globe are becoming more efficient as old capital assets mature and are abandoned. The adaptation will be faster than 2015.
- Slight possibility
- Economy has adapted
- Possible
- Semantic problem. It's been a lot more than 50% in the past 2 years already, economically cost-able but bearable if politics fixed. Trend by 2025 is much more than 50%.
- It's mainly a question of price increases of fossil energies are part of inflation; I don't agree as the

Bank of England does
- Not sustainable unless technology efficiencies
- I don't understand why, but the recent price run up in the US, $3 gasoline had little economic affect.

Scenario 2: Environmental Backlash: Inflation occurs but adjustments by 2020

- Disagree: adjustment occurs earlier compared to scenario 1
- Agree – for developed countries only
- Small inflation
- 2025
- Or latter on
- 2010
- 2010
- There are inflationary regional particularities
- Not plausible scenario
- Disagree – little inflation will occur.
- adjustments faster due to better policy
- difficult to postpone so long
- Like 1, except adjustment to smaller GNP, depending on how scenario interpreted.
- Disruptive

Scenario 3: High Tech Prices moved lower by 2020 not requiring adjustment

- Can adapt by 2015 not requiring adjustment
- optimistic
- No, cost of energy increase may be slowed at best
- low probability
- Stabilized prices but not moving down
- disagree, not by 2020 but may be after by 2050
- Business is business, profits have priorities
- 2010
- 2010
- Prices will not move lower, will continue to rise.
- Not possible due to increasing energy demand
- Disagree – prices will never become lower again
- Suspect the impact of more alternatives will be price stability rather than significantly lower prices.
- Emerging third world can jump ahead by adapting tech advances
- stabilization of demand
- more likely will be seen in developing world
- Technological advances shift demand from non-renewable to renewable energy sources
- No, there will be a kind of leap frogging by DCs
- Agree but it also affects 3rd world
- Not probable. Will also affect emerging countries soon.
- Oil, conventional gas still way up, but lower electricity & alternates compensate, economic leap on Schumpeter scale

Scenario 4: Political Turmoil: Inflation occurs as the result of both energy cost and conflicts

- No inflation as demand drops
- The economies do not adapt, disruptions

- Inflation is a good thing to those economies which benefit from it and a bad thing only to others; energy and conflict may be balancing factors of inflation! But globally I agree.
- 2030 Inflation would increase significantly due to war coupled with higher energy prices
- Agree – second highly plausible scenario
- In affected developing regions, yes. But 1st world economies will profit with little inflation.
- It will depend on the changes done before this happens.
- Very likely
- Prices up, money down, grim reaper visits everyone.

2.04. Changes in human values, wealth and expression of status

Scenario 1: Business as Usual Moderate to low

- Moderate to high conservation
- Medium
- Low
- Low
- Question is vague
- Renewables= wealth, security, health
- Mostly for developed countries
- This is changing in Kenya with higher levels of consumption on non-durables like clothing, holidays, electronics and investment
- Low
- High to selfishness, greediness, and individuality
- Lower
- Little
- Agree. Social gaps keep increasing.
- Chasm between rich and poor widens. Lots more poor people.
- Moderate to high at China and India
- 2010
- Values continue to deteriorate Rich get richer Consumerism defines status
- Extremely important. People consume according to their ideas of what they "have to have." The US with 5% of the world population consumes 30% of resources.
- No. Current values promote quick gratification, Western accumulation of material wealth.
- Low
- Moderate to none
- Low
- Growth declines and reverses as scenario goes to 4
- In business as usual, values are as usual too

Scenario 2: Environmental Backlash Moderate to high conservation

- Yes this will happen because of prices
- Moderate to high conservation
- High
- The values are polarized regionally
- Agree, combined with new technology.
- Considerable change: moderated demand in developed countries
- Chasm between rich and poor widens dramatically
- Yes (definition of status undergoes change- luxury to efficient)
- Agree; disagree with conservation

- Important changes in the human values
- 2020
- Disagree - impossible
- Environmental values grow (at first) – little change in wealth and status dynamics
- Yes, small grouping of people on the planet.
- Not likely for long time despite backlash
- Moderate
- Moderate
- Don't agree
- Depends on how/why. Naderworld could decay into neo-medieval and slow path to scenario 4.
- Moderate

Scenario 3: High Tech Moderate to high conservation

- Technology is key to conservation
- As result of enhanced telecommunications – thus environmental education - world can moderate consumption
- HIGH revalorization of human beings
- High to material welfare
- Depends on type of tech. And help of mass media
- High
- Disagree - impossible
- Significant changes: Quality of life values start to displace consumerism. Global communities collaborate in solving problems (mostly electronically) superseding national and corporate interests.
- Unlikely
- Also possible
- Slight possibility by 2020, greater by 2050
- Likely if technologies allow for adjustments
- Vast increase in income possible, and, more important, reduction in fear, if education as well as energy tech is advanced, paid for
- Some adjustment still needed around 2015

Scenario 4: Political Turmoil Little to none

- Moderate to low conservation
- Perhaps to the worse, human rights threatened everywhere
- No, changes will be moderate to high
- Negative change
- High to straight religion or other fundamental attitudes
- Little
- Human values will become more divided based on political and religious, not necessarily economic factors.
- Values continue to deteriorate Rich get richer Nationalism and Consumerism define status
- Could decrease if countries in turmoil abandon technology
- Worsening
- Little
- Little to none remains.
- Disagree - war/famine etc. Causes people to reevaluate priorities. Look at the effect 9/11 had on the people of New York. A move towards more value on families etc.
- Agree, except for a very few
- Possible xenophobia, delayed horror if wars turn genocidal in backlash against WMD terror

2.05. Motivations, social purposes

Scenario 1: Business as Usual Economic and social status focus, expansion of Corporate Social Responsibility (CSR)

- Like until now i.e. Without change
- Economic and social status focus energy efficiency and conservation
- Global balanced development
- Making money, Stronger cultural identity (negatively manifested)
- Agree, without “expansion…”
- Increasing in Kenya
- In agreement but limited in the industrialized countries
- In agreement but only in the developed countries
- Agree, moreover ethics on the rise.
- Limited social responsibility
- Disagree – what does it mean CSR? Which company claims to be socially irresponsible?
- Agree
- OK. But what about conservation of economic and political inequalities and related control?
- Very small CSR implies voluntary, and these are notoriously: weak on the non PR front
- Agree will happen but will have low impact
- Slight possibility
- Moderate to low
- As a matter of image
- Only superficial changes
- Most of alleged "CSR" really means tighter corporate-government ties and increased corruption
- Very difficult
- When growth reverses, it gets to be more like Spengler or Toynbee on the way to scenario 4.
- Moderate
- Just let me live a good life, in this scenario

Scenario 2: Environmental Backlash Sustainable development energy conservation, environ-mentalist development paradigm

- New economies will emerge but only because high oil prices will force that to happen
- Stronger cultural identity (positively channeled)
- Only 2050
- Motivated also by social tension and disparities within society
- Disagree – impossible at all.
- OK at first. But as movement gains power, changes to political power, moves to hype and hierarchies, and loses credibility (by 2015). Environmentalism goes through “dark age” for 20 years.
- Agree. Its not about being "environ-mentalist," it’s about being a fully alive human being on this planet.
- Some progress
- Sustainable development , energy conservation, environmentalist development paradigm, Economic and social status focus, expansion of Corporate Social Responsibility (CSR)
- Economic depression will be hard on environmentalism
- Potentially increased social stratification from regressive taxation
- Possible
- Again, depends on who/why. Neo-feudalism or segue to 3 or 4 most likely outcomes.

- Their faith is probably unshakable, short of an ice age
- If things get really bad, attitudes can shift- witness the support of environmentalists for fission electricity,

Scenario 3: High Tech Positive high tech meme epidemics

- Low to moderate confidence for high tech development
- Useful memes or mis-usable ones?
- Decrease in cultural identity
- Only if the direction of the markets is modified on the basis of social criteria
- Agree, put so eloquently…
- Developed world gets to transfer `cleaner' technology to developing countries
- Perhaps yes
- No, the process is much more complicated that that
- Agree with first part. Why "meme epidemics?"
- Not likely
- Perhaps, you may call it like that "meme epidemics" but of little probability
- Agree
- Agree. Global communities learn to do what needs to be done despite traditional political and economic institutions – they simply bypass them. They do so because they can and they care, not because of money or status.
- No, changes in this arena could bring about changes towards wealth with less impact on the environment - but usually within the realm of the super rich and those with and interest in conserving resources
- Acceptance of less is more with shortfall made up through tech advance
- Little to none
- High
- This scenario too has variants -- from the lack of fear liberating humans to a more human existence, to robotic sorts of existence.
- Disagree - still a measure of high consumption - gap widens
- Possibly very high, especially with powerful biotech
- High technology increases the unemployment: increase of the social problems

Scenario 4: Political Turmoil Survival, security

- Disagree. Globalization, technology and economic wealth transfer and/or aid will assist in ending most wars, in order to resume equilibrium first and growth later.
- Stronger cultural identity (negatively manifested)
- Security, economic benefit.
- Agree, loyalty to same values
- Peace movements increase
- Loss of motivations and new social purposes appear
- Loss of motivations and new social purposes appear
- Agree – second highly plausible
- OK, but powerful players in 1st world countries (and multinationals) are motivated by increases in their wealth, power and control.
- Agree, plus tendency towards self-reliance (e.g. Home generation, reduced consumption)
- Likely
- A mix of short-term terror and thoughts about the afterlife.
- What consequences if OPEC requires payment for oil in Euros?

2.06. Global GDP/Capita

Scenario 1: Business as Usual

- Increase
- Little to none increase by 2010
- Will increase
- 9000
- Moderate growth
- 2%/year
- Rising
- Slight increase
- Increasing moderately
- Slight increase
- About same as today. Slight increase.
- $10,000
- Maybe 7000$
- Global inequality increases
- Will continue to increase
- GDP/c increases slightly Gap between rich and poor increases
- Continue to rise but at lower rate
- $1,000
- 5,000
- +3-4%/a
- Increase
- Declines
- Increase about 3%/year until about 2012-2018, serious recession, possible major political realignments afterwards make prediction difficult
- +3-4%/a
- +3-4%/a
- Slowing

Scenario 2: Environmental Backlash

- Increase
- Little to none increase by 2010
- Will increase slower
- 7000
- 1,5%/year
- Rising but not as fast as in BUSINESS AS USUAL scenario
- Slight increase
- Increasing moderately and more equal
- Slight increase
- Decrease
- $8,000
- Moderate GDP increase, and reduction in inequality
- Will go down
- GDP/c increases slightly Gap between rich and poor increases
- Starts to level out
- $1,500
- 7,000

- +2%/a
- Sharp decline
- Same as business as usual
- +2%/a
- +2%/a
- Slowing
- Following Kyoto will be costly and probably reduce GDP/cap

Scenario 3: High Tech

- Increase
- Low increase by 2015
- Will increase faster
- 9000
- Potentially fast growth
- 3%/year
- Rising as result of higher productivity
- Moderate increase
- Increasing
- Moderate increase
- Increase
- $12,000
- Investment to the technologies drive the growth, increasing inequality
- Will increase at a much faster rate
- GDP/c? Iqol/c increases by 50% by 2020. Iqol = Individual Qualty of Life
- Ethics debates
- Positive high tech meme epidemics, expansion of Corporate Social Responsibility (CSR)
- I only wish
- See above -- though we become free, ala Maslow, to focus on broader measures of human well-being.
- Singularity religions?
- Tech will accelerate GDP

Scenario 4: Political Turmoil

- Increase
- Down from current level
- Will eventually increase
- Decline
- Minus5%/year
- Falling, especially in developing countries
- Moderate fall
- Decreasing
- Moderate fall
- Decrease
- $7,000
- Decreases due to war, terrorism
- GDP/c increases slightly Gap between rich and poor increases
- Sharp decline
- $500
- 3,500

- Decreasing
- Temporary
- Decrease
- Decreases
- Potentially catastrophic global depression

2.07. Possible price of oil in 2020 (in today US$)

Scenario 1: Business as Usual Around US$ 50/barrel

- But well 100
- Around US$ 80/barrel
- Rather higher
- More of $100
- Disagree: over 50 US$/barrel
- Disagree, at least US$ 100/barrel
- 100
- 80/90
- Higher than above
- $250/bbl
- Disagree $70 /barrel
- Around US$100/barrel
- US $50-80/barrel
- US$90
- Around 90 US $/barrel
- US$ 150/barrel due to increasing demand
- Disagree – around 150
- Higher
- Ridiculous when it's already $60 now
- Disagree -will be higher
- Disagree - expect $75
- US$ 120/barrel
- Unlikely
- Higher
- 180 USD
- 75
- Disagree - higher cost
- $80
- 80
- Change - plus 100
- Around US$ 75/barrel during 5 year transition, then around US$50/barrel
- Possible
- More likely 100
- 150
- $50 is last year! Don't know. $100-$300 is possible. Don't laugh -- $8 a gallon is not so out of sight, prices MUST go up enough to reduce demand.
- 100
- 120, but it is dependent of the amount of rent skimming by user countries via carbon trading fees
- Much higher 100-150
- $75 per barrel

Scenario 2: Environmental Backlash Over US$ 100/barrel

- No. $300 to $700 per barrel
- Over US$ 100/barrel
- Agree
- 60
- Disagree: as long as taxes and emission prices are excluded, oil prices will be similar to scenario 1
- 120
- Higher than above
- Above $50
- 120 - 150
- 200/barrel
- 150
- 150
- Yes, IF carbon taxes are included in that figure
- More
- US$50
- Over 150 US $ per barrel
- Disagree Implausible scenario
- Too low 3x that much by then
- The likely price deck, as current investments are based on long term $45 or $50 oil.
- US$ 300/barrel
- Higher
- 220 usd
- £150
- 150
- Change - plus 100
- Permanent effect
- Probable
- 100
- More like $100. Demand reduction offsets scarcity, again depending on who/why
- Possibly lower
- Below US$ 50/barrel
- 100-150
- $85 per barrel

Scenario 3: High Tech Below US$ 50/barrel

- Over US$ 50/barrel
- Agree
- Disagree. Still over US$ 50/barrel
- Perhaps not much below
- 45
- Don’t know
- More of $100
- Disagree, at least US$ 100/barrel, energy cost will continue to increase even with leaps in technology
- 100/barrel
- 80
- 80

- Disagree60/barrel
- More likely at around US $50/barrel
- Agree in 2050
- Around 50 US $ per barrel
- New technology far away for this development.
- Implausible – oil will be at 100 US$ but less demand
- Disagree
- Maybe $50
- 100 usd
- Change - plus 100
- 50
- Unlikely
- Possible, but lower probability than over 50
- $50
- No, higher
- US$ 100/barrel
- 120
- 90
- Disagree - expect $75
- $65
- 50
- Not likely
- Possible
- Like 1 or higher. The economy survives it, but with lower interest rates and ways to survive it, we can have higher prices.
- Higher than this
- Around US $75/barrel for 5 years during transition then below US$15/barrel
- $65 per barrel

Scenario 4: Political Turmoil Over US$ 125/barrel

- Over US$ 120/barrel
- Agree (in SR)
- 60
- 150
- Higher than above
- $60
- Over 150
- Maybe
- 200/barrel
- 150
- 150
- Over US$150/barrel
- Above 150
- More
- US$140
- Over us $ 150 per barrel
- Highly plausible – then oil also at 100 US$ due to the efforts by the developed countries to decrease oil dependence
- 250 usd
- Change - plus 100
- 200

- Why not
- $200
- US$ 500/barrel
- Not very possible
- 200
- Possible
- $140
- Lower
- 150-200 and more due to disruptions with Arabic countries
- Like 1
- Possibly over US$ 200/barrel for a few years
- $90 per barrel

2.08. Environmental movement impacts

Scenario 1: Business as Usual Some impact. Irregular focusing on legislation and treaties

- Environmental movements will not impact energy markets
- Some impact on coal mines and nuclear facilities.
- Environment accident will be key driving force
- Little impact
- Agree/ price incentives of high oil prices is crucial
- Increased international legislation and treaties
- Little impact
- Warming REAL and Much" Worse"/Faster
- Local and regional environmental concerns may lead to some impacts
- OK. Also misinformation blitzes when it suits 1st world and multinational interests.
- Building of skills and pilot projects one of the major critical paths but too little too late
- In Europe
- Much more widespread consumer awareness of energy-related environmental concerns even in this scenario
- Agree, also subversion by oil companies and governments
- Increasing impact

Scenario 2: Environmental Backlash Larger impact on regulations and treaties. International coordination of strikes on fossil fuel key points

- Strikes in terms of destroying infrastructure I would consider unlikely, rather strong boycotts, blocking of infrastructure or transportation lines (e.g. For nuclear waste)
- Larger impact on regulations and treaties in particular on nuclear related facilities.
- I suppose neither strikes nor too militant actions will have much success. Soft and symbolic actions are much more efficient.
- Disagree: major strikes will not be supported by environmentalists as these strikes would result in environmental damages
- I agree with the first part of the statement. Pressures will come from consumers claiming to the producers for their responsibility
- Agree on first statement.
- Agree, but alternative sources as well on focus and slow acceptance of the merits of remedying coal and fossil fuel environmental impacts by new technologies
- Some impact
- Partly agree: but no international coordination of strikes, probably local

- Environmental movements is non-violent (through boycotting)
- Disagree – the impact of environmentalists will not increase
- OK – what do we mean by “strikes”? Violence will be counterproductive, but alternatives are fairly ineffective.
- Clean coal technologies
- Not probable
- Could be severe particularly if there is environmentally oriented violence against oil companies

Scenario 3: High Tech Full range of cooperation with high-tech and environmental movement to various forms of resistance

- Full range of cooperation with environmentally tender high-tech
- Wishful thinking, but I agree
- In agreement with "key subjects"
- Technology can help, environmentalists movements – no.
- OK. But more than “resistance”, wide range of productive activities – solutions, innovations, mass understanding of issues.
- Both groups may follow an independent path that overall promotes lower dependence on traditional energy sources
- Disagree - there will be (real or unreal) environmental concerns regarding new technological advancements
- Disagree as to degree of linkage
- Would be nice
- Agree, but serving economic interests
- Partly agree - I think hightech and environmental movement will partner in this scenario
- Is there a possible anti-technology movement waiting in the wings?

Scenario 4: Political Turmoil Focus on environmental security issues

- If the wars are serious the environmental questions are not a priority
- Agree. Reduction of obvious targets (protect nuclear sites and big water dams, nuclear proliferation etc.)
- Perhaps in this scenario there will be no environmental movement at all.
- Ignore environmental issues
- Weak movements
- Disagree, environment will come second to energy access issues
- Not exclusively
- In rich countries; in poor countries “failed states” are not able of any reasonable and efficient action
- Focus on controlling vital issues, e.g. environmental, energy, religion, social government system etc. of one’s own life sphere
- Disagree: why environmental security; if environmental deleted: agree
- Disagree – in the era of conflict more stress on overall security
- OK. Also distorting info on energy issues to justify military and subversive activities that suit 1st world and multinational interests.
- Focus may not be the right word. It may be hard to achieve focus given the turmoil
- Change - war causes environmental damages
- Probably just security
- Probable
- Big mess
- Agree -- like nuclear cleanup and extreme-biology.

- Some but mostly personal survival

2.09 Key environmental events/developments

Scenario 1: Business as Usual Many environmentalist accept nuclear power as counter global warming alternative

- Again, environmental movements won't change things
- It will be controversial, with very different national discussions
- Some environmentalist accept nuclear power as counter global warming alternative
- Environmentalist would pursue renewable energies.
- Agree. Specially is safer nuclear technology is certainly to be developed.
- It could be but I am not very sure
- Many people, but not many environmentalists
- Disagree, uncontrolled energy consumption is just as bad for global warming, irrespective of source
- Never. Wind power cheapest / >100'000MW new installations/a
- The environmentalists would not accept the nuclear energy
- I don't think so, nuclear power remains very controversial and emotional issue
- Agree with fusion development but not if fission power (III generation or present type) is concerned
- No, the technical problem associated with acceptance the fission is enormous
- Not really. But global warming pressure keeps on increasing
- Solar writ large and perhaps LENR's,ZPE – NOT CONVENTIONAL NUCS..
- Not many environmentalist, but probably many countries
- Difficult
- Nuclear power will only play a marginal role in meeting power requirements
- OK – but reluctantly since proven examples of misinformation have minimized trust in authorities.
- This would stimulate business as usual, and lead to disasters more quickly
- Agree, waste is the issue
- Not relevant, timeline too long, economic problems more likely
- Not the majority
- No, efficiency promotion
- No, not accepted but implemented anyway
- Change - not possible
- Possible
- Disagree. This is more likely if technology tempers concerns about nuclear
- Happening now. Unpredictable, as CO2 news versus bad nuke news both come in.
- Possible

Scenario 2: Environmental Backlash Nuclear power plant accident in India pollutes Indian Ocean

- They contaminate the neighboring lands
- Disagree. Given that new nuclear safety standards will be globally implemented.
- I would use this kind of disasters for the construction of wild card scenarios. They have too large impacts. But maybe, the second scenario is a wild card scenario?
- Nuclear developed in limited region
- Or worse
- Severe impacts of El Nino-related events, intensified by anthropogenic climate change, (forest fires in tropical forest areas, drought and famine in South Asia and American Midwest, severe floods on West Coast of US and Thailand, causes global outcry and global political momentum to

curtail fossil fuel emissions
- Little probability
- Might occur (This could happen in any scenario)
- Agree, could well happen
- No accident necessary. Nuclear is dangerous and too expensive.
- Possible
- Increased acceptance of nuclear as `clean'
- Improbable but not impossible. Strong measures of security
- No, they would be closed
- Can happen in India as well as in any country with questionable security discipline
- No, because the dangerous plants of fusion would be closed
- Perhaps, but other sources of pollution become more critical
- Nuclear power plant accident as a result of green strike in India pollutes Indian Ocean
- Accidents but no significant pollution
- This is absolutely baseless. Unjustified to peg future accidents to any specific country
- Probability of Accident same for US.
- Partly agree: there may be some kind of nuclear accident. At least as important: regional extreme weather events, triggered by climate change
- Not necessarily
- It will most likely to happen in the East Asia or Ex-Soviet countries
- Nuclear plants in India will operate safely
- I do not understand why in this point predictions of events, almost "fortune-telling" replaces prediction of trends/processes
- Disagree
- OK – Environmental movement cashes in & gains large power base. 5 years later, hype is exposed, and power wanes. Baby of environmentalism is thrown out with bathwater of hype.
- Lots of death and suffering, and the end of the nuclear dream world
- Maybe
- No, lack of clean energy supply to poor people
- Hope not
- Disagree, for most backlash versions I can envision. Would cause anti-nuke not systematic environmentalism.
- Not likely
- Increasing number of Katrina-like hurricane and other natural disaster create a momentum for a more rigorous post 2012 Climate Change regime.
- One key development would be the wholehearted support of environmentalists for nuclear power-seems that a trend in this direction is already beginning.

Scenario 3: High Tech Environmental-High Tech Summit

- Why?
- Good idea
- Technology resolution
- Benefits of new technologies demonstrated
- Unexpected environmental consequences (such as massive algal blooms or toxic waste excursions) because everything is very tightly managed
- Wishful thinking, but I agree
- Agree, focus will be on reduction of global energy consumption rather than environmental friendly sources
- Dynamic growth in ecological technologies (renewables, efficiency)
- More nuclear (modular) facilities built
- Recommended

- Possible
- Not necessarily
- Perhaps, but what will be the impact of that event/process/institution?
- OK – but much more effective are many ongoing discussions (mostly electronic) among global communities of interest about local and global energy issues.
- Interesting idea
- Agree; but accomplishes nothing (good follow-up to Kyoto).
- Hmm. The usual maximum prestige summits seem to get in the way of reality, not help. What does help? Wish I knew. A thousand points of life, empowerment of creativity, etc.?

Scenario 4: Political Turmoil Pipelines and refineries attacked during political problems in Saudi Arabia and Nigeria

- Pipelines and refineries attacked during political problems in USSR and Middle East
- Likely
- This could / would happen at other focal points (Central Asia …) too.
- alternative source
- Likely
- Weak-points in electrical grids in US and Europe attacked. Disruption only temporary but population very alarmed. Momentum towards domestic energy independence and less reliance on gas pipelines, imported oil.
- Terrorist attacks to nuclear plants in Europe and the USA
- Possible
- Possible
- Also possible in South America given the present political situations
- Agree, quite possible
- Likely
- In other places too
- Nuclear power plants in developed world targeted
- Not only there but everywhere in oil producing countries
- Alternate source
- Again. It is not prediction of events but rather of processes. For example, instead of the above should be: radicalization of young generations in the Middle East in their drive against Israel and the West
- OK – and 1st world political and multinational powers manipulate situation to increase control and wealth.
- Targeting of distribution systems to US and Europe as primary targets of political terrorism?
- Possible
- Likely
- Possible
- Agree and more similar
- Possible
- Agree, although incident could occur anywhere, including US
- One of many, many important aspects. But subnational groups shocking folks with a nuclear weapon is the big one.

2.10. Amount of carbon emissions (Nature processes 3 or 3.5 billion tons via trees, ocean algae. Today about 7 billion tons are emitted)

Scenario 1: Business as Usual

- 20 billion tonnes
- 25 billion tonnes
- 15
- See IPCC “A1 or A2,” Millennium Assessment “Global Orchestration,” GEO3 “Market First,” (We already spent a lot of time thinking about this. Might as well use our results.)
- Disagree: about 15 billion tonnes in 2020(15gtc in 2100)
- Stable
- 8.3billion (1 billion increase per decade)
- Big differences of values in the scenarios seem doubtful to me; do not remember the actual figures now.
- 25 bill
- Disagree; 15 billion tonnes (in 2020).
- Cannot comment without a time-point
- Comment: Do you mean carbon or CO2? And by what time? Absolute numbers are thus difficult to comment on. Relation between the scenarios could be 100:60:40:110
- These are meaningless numbers, if not compared to current output, and the recommendations of the IPPC
- Not likely, economic collapse more likely
- Probable around 10
- Are you asking for peak emissions per year? Emissions in 2010 will be at 14 Ce (equivalent, LUC included); my guess is that the peak will be at about 15, in all scenarios

Scenario 2: Environmental Backlash

- 2: 5 billion tones
- 20 billion tonnes
- 10
- See IPCC B2?, Millennium Assessment “Adapting Mosaic”? (but not a very good approximation), GEO3 Sustainability First
- Disagree: about 10 billion tonnes in 2020(5gtc in 2100)
- Dropping slow
- 7.3billion
- More like 10 billion tonnes
- 10 bill
- Disagree.12 billion tonnes.
- Cannot comment without a timepoint
- Agree but it would lie between 5 to 10 billion tonne by 2020 (If there are other treaties like Kyoto protocol).
- 15 billion tonnes
- Disagree- expect not as much improvement (6-7 B tonnes)
- 10
- Too optimistic
- 10
- 75% of business as usual
- 15 billion tonnes. Extreme flexibility without destroying global economy requires tech advances
- 10
- 10
- The big issue is whether the US, China, and Russia adopt Kyoto goals.

Scenario 3: High Tech

- 3: 3 billion tones
- 20billion tonnes
- 10
- See IPCC B1?, Millennium Assessment “Techno Garden,” GEO3 “Policy First “?
- Disagree: about 10 billion tonnes in 2020 (5gtc in 2100)
- Dropping fast
- Guess 8 billion tonnes
- 5 bill
- Disagree.9 billion tonnes.
- Cannot comment without a timepoint
- 13 billion tonnes
- 50% of business as usual
- 10
- 10
- Agree but only after 2040-2050
- 20bt
- Too optimistic
- Basically just for aviation
- International laws that protect forests (as carbon sinks) are a possibility in this scenario.

Scenario 4: Political Turmoil

- 30 billion tones
- Probably very high since coal is the only viable alternative to oil. Natural gas will be too slow.
- 30 billion tonnes
- Not much more than in scenario. 1 because of decline of global economy.
- See IPCC “A1 or A2”, Millennium Assessment “Order from Strength”, GEO3 “Security First”
- Disagree: about 15 billion tonnes in 2020 (30 gtc in 2100)
- Uncontrolled
- 20billion
- Possible
- Disagree.23 billion tonnes
- Cannot comment without a time point
- Less
- 15 billion
- 20 billion tonnes
- 150% of business as usual (agree)
- Not likely, economic collapse more likely
- Agree but no as high as 30 because it depends more on USA and China, India than entire world
- 35bt
- Will not be as high as scenario 1
- 25 billion tonnes

2.11. Status of carbon sequestration, capture, storage, science, policy

Scenario 1: Business as Usual Some moderate progress

- Sequestration at larger generation facilities

- Agree(in Medium Term)
- Little
- Little
- Increasing pressure, due to green and ethical funds
- Sequestration is a niche, not A/THE Answer – much better approaches available.
- Disagree: good progress
- Agree – if “linear scenario”
- No change. This is a very limited and totally untried tech
- Disagree - slight progress expected
- The only real carbon sequestration technique is the one with by-products. The others (ocean and earth) are doing more harm than good
- The atmosphere is already polluted; don't pollute the earth and the oceans with pumping carbon; invest more in new technologies for producing carbon nanotubes and other by-products by carbon sequestration
- Yes, but not in developing countries
- Get real, just a distraction
- Good progress
- Aggressively perused

Scenario 2: Environmental Backlash Very aggressively pursued.

- Carbon trading cost exceeding CO2 capture/ sequestration costs increase the latter
- Very aggressively pursued even at medium or small generation facilities
- Little
- Disagree – impossible to achieve
- No change. This is a very limited and totally untried tech
- The only real carbon sequestration technique is the one with by-products. The others (ocean and earth) are doing more harm than good
- The atmosphere is already polluted; don't pollute the earth and the oceans with pumping carbon; invest more in new technologies for producing carbon nanotubes and other by-products by carbon sequestration
- Moderate progress. Carbon trading cost exceeding CO2 capture/ sequestration costs increase the latter
- They will search for depullution more than sequestration
- Agree. But not enough to stop Little Ice Age.

Scenario 2: Environmental Backlash: Aggressively pursued

- Agree(in Long Term)
- Large scale, with high efficiency, low energy use
- Pursued
- Moderate
- Disagree
- Will reduce the cost of sequestration
- Moderate due to energy conservation
- The only real carbon sequestration technique is the one with by-products. The others (ocean and earth) are doing more harm than good
- The atmosphere is already polluted; don't pollute the earth and the oceans with pumping carbon; invest more in new technologies for producing carbon nanotubes and other by-products by carbon sequestration
- Agree, major utilities are looking to invest right now
- Moderate progress

- Science and storage advances; but policy non-existent.
- Not so much
- Moderately so. Solar, earth or space, could bypass a lot of this.
- Irrelevant

Scenario 4: Political Turmoil: Little

- There won't be much Sequestration.
- Little
- Nil
- Agree – other security-related issues more important
- The only real carbon sequestration technique is the one with by-products. The others (ocean and earth) are doing more harm than good
- The atmosphere is already polluted; don't pollute the earth and the oceans with pumping carbon; invest more in new technologies for producing carbon nanotubes and other by-products by carbon sequestration
- Agree for progress in developing countries, India
- Little or no progress.

2.12. Key Technological Breakthroughs

Scenario 1: Business as Usual Nextgen Coal Plant, Nuclear Ocean and land wind farms, solar towers

- The terms are not such
- Just more coal use. Not much technological change.
- Off shore wind in Europe before 2020
- Nextgen Coal Plant, Nuclear, Ocean and land wind farms, Solar towers, Fuel cell, Hydrogen production
- IGCC, Off-shore wind farm, Distributed power generation
- Nextgen nuclear.
- Toward 2050
- No nukes, too expensive
- Probably
- Fission out, fusion yes
- And hydrogen cells
- Plastic Nano PV, Genomic and artificial photosynthesis for H2, seawater AG biomass. Photocatalytric electrolysis of water, lenrs,ZPE
- Agree, but not all at the same pace
- Agree; but efficiency improvements missing
- Only solar seems to be feasible at the moment
- Return of the nuclear
- Breakthrough in power generation technologies.
- Agree – but only for changes in coal exploitation, perhaps more solar energy, wind energy – implausible.
- Several breakthroughs are withheld by IP owners until they can maximize their market exploitation
- Forget the first 2 the others could help, if used with other solar-based tech
- Disagree - unlikely to generate levers for next generation
- Agree with all but Nuclear - believe we will find another way
- Smaller progress than indicated
- New concepts diffuse poorly

- New generation of nuclear power plants
- Possible
- New economic models which don't need growth
- More nuclear power stations
- Agree, plus breakthroughs in hydrogen storage and use
- Possibly also superconductive energy grid, hybrid cars provide backup power for grid
- Agree over time scale of two to three decades
- Only wind -- a little for electricity and a lot from empty or useless declarations -- is a major part of present trends.
- They come, but maybe in the wrong places in this scenario

Scenario 2: Environmental Backlash Ocean wind cities (nanotech 3-layer sheets change photovoltaic efficiencies)

- This corresponds to the following scenario
- Fuel cell applied small towns (apartment flats, buildings) with high efficiency
- Breakthroughs in energy efficiency (buildings, traffic, greening of industry…)
- Hydrogen, IGCC-CCS, Off-shore wind farm, Distributed power generation
- Photovoltaic always limited by incident radiation. Next gen. Nuclear
- Solution of problem of continental grid dependent on intermittent solar and wind
- For 2030
- Possible
- Very likely
- In addition nextgen. Coal incl., small scale local production from gas (incl. Hydrogen), i.e. Micro-turbines, fuel cells
- Agree, the nanotechnologies already has obtained it today
- Disagree: missing are - high improvements in efficiency on supply and demand side, building-integrated PV; carbon capture
- They are not the only technologies
- Advances in the biomass production
- Agree – but only for solar energy.
- Hype culture results in several "false breakthroughs" being promoted – come back to haunt movement later.
- Maybe
- Smaller progress than indicated
- Distributed bio, solar and wind energy; Wind and solar thermal power; renewable traffic fuels
- Energy is not the only resource or environmental problem!!
- Also bioenergy
- Efficiency, biomass, solar and wind power
- Agree, plus significant use of biomass energy
- Photovoltaics are basically all or nothing. If they become economically important that makes the scenario "High Tech Economy"
- This is not the Nader I know. More likely would be technologies to drug people.
- Possible
- Also bioenergy

Scenario 3: High Tech Wireless energy transmission. If coal can be burned with low CO2 emissions, then US, China, Russia, Nigeria benefit

- I doubt wireless energy transmission
- Gasification of coal by combined cycle and sequestration of CO2
- In fact, I do not put large hopes in wireless energy transmission. I see rather hydrogen

technologies here.
- Hydrogen, IGCC-CCS, Off-shore wind farm, Distributed power generation, Advanced nuclear
- Superconducting transmission lines probably a better alternative
- Solution of problem of continental grid dependent on intermittent solar and wind
- Disagree: I do not expect that wireless energy transmission will become viable until 2020
- Disagree, real breakthrough will be drastic reduction in energy consumption
- Wind power, solar dominant
- Doubt first statement. Agree second one.
- Agree, doubts about wireless energy other than sun
- Plus solar farms
- Partly agree: missing: hydrogen, fuel cells; superconductor lines
- Not seems to be possible
- Application of the biotechnology to the production of biomass energy
- Agree – only for return to exploitation of coal
- Cheap “Clean” oil from coal technology (e.g. SASOL)
- Likely emergence of other energy sources beyond oil and coal
- Energy is not the only resource or environmental problem!!
- Disagree - unlikely to be feasible. New technologies will include growing use of marine power (wave, tidal)
- Agree others but no wireless energy transformation
- Distributed bio, solar and wind energy; Ocean, wind, solar thermal and HDR geothermal centralized power; renewable traffic fuels
- Not likely
- Energy from space, Stirling solar farms, better batteries, true brain-like intelligence managing power grids, maybe Stirling vehicles, maybe carbon-tolerant alkaline fuel cells or truly solid truly proton-exchanging electrolyte fuel cells, plug-in hybrids
- Fuel cells widely used in rural areas
- Nanoscale energy storage in ultracapacitors or advanced batteries.
- Cheap solar makes energy negligibly expensive
- The core hypothesis of this scenario, of a generic "high-tech economy" is seriously flawed. We already HAVE a high-tech economy. Multiple huge breakthroughs that would make the World economy overall much "higher-tech" than it is now are unlikely. The "Internet breakthrough" is given as an example. That doesn't quite fit the rest of the description of this scenario, but it is on a better track. It would be a good example for more specific scenarios, such as a 'hydrogen economy' scenario, i.e. consequences of a brake-through in cheaply generating huge amounts of hydrogen (but that might still require more breakthroughs, particularly in hydrogen storage) than the Internet required, which depended only on evolutionary improvements of telecommunication and microprocessor technologies). A 'breakthrough in photovoltaics' scenario might be more comparable. Or a scenario of "discovery of huge new oil reserves" in geologic formations that previously have been neglected as impossible or highly improbable locations for oil.

Scenario 4: Political Turmoil Military portable energy production, storage and transmission systems

- Massive power meaning?
- Concentrated in developed countries
- Disagree – for military purposes not needed, unless long terms “stabilization operations”; for civilian uses unnecessary
- Processed foods and water storage break troughs have spin-off impact on famine and drought events.
- Energy is not the only resource or environmental problem!!
- WMD control
- Not significant

2.13. Artificial bacteria and other micro-organisms are created to produce fuels and chemicals by 2020

Scenario 1: Business as Usual

- Likely
- Agree. First demonstration only
- May not feasible
- By 2025-2030
- At best these guys use sunlight to convert discard into useful energy. They are limited to 1kw/sqm, as is photovoltaic. Can this ever be a significant contribution?
- Don't know
- Unlikely
- Oppositions of oil companies
- Possible
- Likely by 2030 in commercial scale
- 2025
- Agree – not only for energy
- Very dream world
- Unlikely
- Possible
- Later year
- Moderately likely
- 2025-2030 more likely
- As Dr. Heineken says, by 1800. But scale and cost not enough to change awful trends in time, in present trends.

Scenario 2: Environmental Backlash

- Some cases. Environmentalist split on the issues
- May not feasible
- Actions would be more aligned- agreement under conditions.
- Maybe
- Agree – split among environmentalists with no real impact on reality
- Unlikely
- Fully agree, preference to solar sources
- Creating new life forms will be significant concern
- Yes, depends on scenario. Not in Nader world.
- Large part of environmentalists positive

Scenario 3: High Tech

- Likely
- Possible
- Likely
- Likely.
- Highly uncertain whether it could sustainability produce enough mixed alcohol fuel, for example, to power all the world's (plug-in hybrid or Stirling) cars. Great hope, requires creativity on a scale we haven't seen lately, but maybe doable.
- One possibility is the use of bacteria in down hole applications. They "eat" the thick residues and

break them down into lower viscosity residuals

Scenario 4: Political Turmoil

- Not likely
- It wont happen
- Not likely
- Disagree. Again, wars may actually accelerate these developments.
- Likely in developed countries
- Disagree – conflicts may accelerate research on alternatives
- If major economies not in turmoil then this is still likely
- Unlikely
- Change - likely but for military purpose
- Disagree - turmoil not the critical factor
- Not likely.
- May be important to WMD development and control.
- War brings technological progress
- Likely

2.14. Main transportation energy sources

Scenario 1: Business as Usual

- Not likely
- It wont happen
- Not likely
- Disagree. Again, wars may actually accelerate these developments.
- Likely in developed countries
- Disagree – conflicts may accelerate research on alternatives
- If major economies not in turmoil then this is still likely
- Unlikely
- Change - likely but for military purpose
- Disagree - turmoil not the critical factor
- Not likely.
- May be important to WMD development and control.
- War brings technological progress
- Likely

Scenario 2: Environmental Backlash Mix of gasoline, electric, natural gas, biofuels, hydrogen

- Cars will be smaller, and may use natural gas. Otherwise, we will ride the bus and walk
- Hybrid will increase its share a lot Public transport with electricity
- Hybrids rule
- Hydrogen /fuel cell technology for private vehicles, Various forms of renewable-generated electricity and LPG for public vehicles
- Agree, more hydrogen though
- Mainly as the next
- Agree – with biofuels
- Likely
- Agree but do not expect hydrogen or biofuels to develop as much

- Mix of petroleum based, electric, natural gas, biofuels, hydrogen; hybrids
- 5% private cars
- And hybrids
- Most probable
- Not even Nader could store enough hydrogen. Depends on sub scenario.

Scenario 3: High Tech: Electric vs. Hydrogen, new hybrids

- Agree. 2030
- Maybe the same mix as in the green scenario.
- Hybrid, hydrogen
- Broader mix
- Hydrogen /fuel cell technology for private vehicles, Various forms of renewable-generated electricity and LPG for public vehicles
- Yes, but more hydrogen
- Agree and more efficient public transportation and communication
- Agree, but beyond 2020
- Hydrogen will become an important source
- "Clean" transport fuels created from fossil fuels – reduces global dependencies. Later supplement hydrogen solutions
- Hopefully, but likely to still have infrastructure issues on widespread adoption
- Mix of biofuels, petroleum based, electric, natural gas, hydrogen; hybrids
- A mix likely
- Electric or mixed biofuels
- Mix of gasoline, electric, natural gas, biofuels, hydrogen
- Likely
- Fuel cells
- Possibly flywheels utilizing advanced materials. Possibly personal mass transit making cars mostly obsolete

Scenario 4: Political Turmoil Gasoline and hybrids

- Gasoline
- Alternative fuel with local supply
- More natural gas – based fuels than now
- Agree, with significant reduction in transportation
- Few hybrids
- And gas
- Disagree – conflicts in developing countries accelerate research
- Major economies still likely to explore alternative energy sources
- Agree, plus biofuels
- Petroleum based, biofuels in small-scale production and use
- Donkeys, while it lasts
- Other forms of fossil fuel and nuclear
- Same as business as usual

2.15. Percentage of all new vehicles powered by hydrogen in 2020

Scenario 1 Business as Usual

- 5%
- Dream on
- Has to be too early. Think of the infrastructure requirements.

Scenario 2: Environmental Backlash

- 10%
- Zero

Scenario 3: High Tech

- 15%
- <1 Percent but these are largely experimental and are owwned by nerds

Scenario 4: Political Turmoil

- 0%
- Zero

2.16. Percentage of all new vehicles powered by biofuels in 2020

Scenario 1: Business as Usual

15%

Scenario 2: Environmental Backlash

20%

Scenario 3: High Tech

25%

Scenario 4: Political Turmoil

3%

2.17. Percentage of all new vehicles powered by electricity in 2020

Scenario 1: Business as Usual

5%

Scenario 2: Environmental Backlash

15%

Scenario 3: High Tech

10%

Scenario 4: Political Turmoil

2%

2.18. Percentage of all new vehicles that are hybrid in 2020

Scenario 1: Business as Usual
20%
I think that China will find its niche here. Simple electrics for their citizens-- then export everywhere

Scenario 2: Environmental Backlash
30%

Scenario 3: High Tech
30%

Scenario 4: Political Turmoil
10%

2.19. Percentage of all new vehicles powered by gasoline in 2020

Scenario 1: Business as Usual
60%

Scenario 2: Environmental Backlash
25%

Scenario 3: High Tech
30%

Scenario 4: Political Turmoil
85%

2.20 Total energy efficiency gains 2006 to 2020

Scenario 1: Business as Usual
15%

Scenario 2: Environmental Backlash
20%

Scenario 3: High Tech
40%

Scenario 4: Political Turmoil
5%

2.21 Conservation gains from base 2005

Scenario 1: Business as Usual: Moderately pursued

- Major, 75% potential [or more] – with new techs.
- But gains undermined by vested interest misinformation
- Disagree- lightly pursued

- Not pursued
- Has to be aggressively pursued or it wont work, i.e. Trillion dollar advertising and marketing campaign in place to get us to consume more so anything passive will not make any impact
- Too optimistic
- As at present.

Scenario 2: Environmental Backlash Very aggressively pursued and forms of rationing and regulation

- Electric grids more efficient, many innovations in batteries, some wireless energy transmission, little hydrogen
- They will be pursued, but not attained.
- Not so aggressively…
- Sometimes based on inappropriate science/technology choices.
- Disagree - moderate
- In some countries
- Agreed... But this doesn't necessarily imply results.

Scenario 3: High Tech Not pursued but realized by more elegant technological design

- Pursued
- Pursued, too
- Pursued and realized.
- Disagree, conservation and efficiency gains a driving forces of technology development
- Pursued and realized by….
- Pursued
- New energy conservation technologies adopted
- Disagree – both tendencies
- WOULD be pursued, but in objective scientific way as issues emerge, not in evangelical mode.
- Not likely
- Moderately pursued
- Not sure what is meant here but expect technology to play a role
- Big improvement but not called "conservation." Efficiency.
- Disagree - will be pursued as well

Scenario 4: Political Turmoil Not pursued

- Aggressively pursued
- Political instability translates into innovation
- No, moderately pursued
- Not actively pursued
- Slowly pursued
- Pursued
- Disagree - pursued
- Moderately pursued
- Happens because of civic unrest
- A little pursued
- Disagree- turmoil slows it down only
- People will conserve bullets and money...
- Pursued aggressively

2.22 Energy Transmission

Scenario 1: Business as Usual Electric grids become more efficient, some nanotech batteries, little hydrogen

- Distributed power generation could play important role
- Superconductors more widely used
- Unlikely
- Little
- Grid efficiency is already very high, distribution networks need improvement; basically agree
- Energy will be mainly locally generated, enabled by combination of conservation and solar writ large techs…
- Maybe until 2030
- Bad investment and most expenditure going on fuel will prevent proactive investment
- Not much net improvement under present trends. Under stovepipe engineering and management, the intelligent grid decays into an empty buzzword, changes in regulation haphazard.
- Agree but moderate hydrogen

Scenario 2: Environmental Backlash: Electric grids more efficient, many innovations in batteries, some wireless energy transmission, little hydrogen

- It belongs to the following scenario
- Agree. Except for wireless
- Much de-centralization of energy infrastructures, therefore less energy transmitted
- Clean energy utilization will be accelerated China: clean coal technology
- Solve problem of intermittent energy sources
- Little probability
- Disagree: no wireless energy transmission
- Agree but some improvement in hydrogen
- Decentralized systems
- Distribution efficient improvements, wireless transmission for some special cases
- Disagree. Innovations hardly. No funds.
- Probably more hydrogen if used to store energy from fluctuating renewables
- No impact
- Maybe until 2030
- Agree, more hydrogen
- Perhaps in developing world
- Likely more than just a little hydrogen
- Not in Naderland. Haphazardness of regulation would get even worse, unless you talk of "Tory environmentalists" (still not great optimizers)

Scenario 3: High Tech Greater efficiencies in electric grids, new kinds of batteries, wireless energy transmission begins, some hydrogen cars

- Agree. Except for wireless
- Clean energy utilization will be accelerated. Renewable energy. China: clean coal technology
- Disagree: no wireless energy transmission
- No hydrogen
- Agree, but significant role for hydrogen

- Don't believe so much in wireless transmission of big power and energy
- Agree, but not with Wireless energy transmission
- What is meant with wireless energy transmission? Rather superconductors
- Wireless transmission - very low probability
- Maybe before 2030
- Very high barriers to entrance and strong conservative element in the Energy business with vested interest in milking the system i.e. Enron in California gives some insight
- Efficiency in throughput per wire could increase a lot and -- more important -- ability to time-shift effectively and invest intelligently, to better use renewables. Earth-to-earth wireless power transmission, merchant hydrogen not real.
- Greater efficiencies in electric grids, new kinds of batteries, some hydrogen cars
- Room temperature superconductors would help

Scenario 4: Political Turmoil Electric Grids moderately improved, military spin-offs for new kinds of batteries

- Some improvements
- Regional solution for clean energy development, with local characteristics.
- Grids fragment
- Unlikely
- Little
- Disagree; conflicts would not man that military systems/technologies/etc. Would enter the energy sector; the conflicts in developing world would harm that world itself and, of course, the rest f the world
- Military expenditures slashed with collapse of US economy. Lower tech warfare. Maintaining existing systems extent of activity
- > 90 ghz transmission of power to remote points possible, but not enough to stop WMD ultimate outcome.
- Electric grids become more efficient, some nanotech batteries, little hydrogen

2.23 Geopolitics of war, peace, terrorism and changes emerging power dynamics

Scenario 1: Business as Usual OPEC increases political power due to dramatic drop in non-OPEC supply by 2015

- And the IEA?
- Yes, but this happens before 2010
- I am no real expert, but I suppose that no such drop happens till 2015.
- 2030
- There may emerge counter-policies from the western countries
- No, alternative energy sources will dilute influence of OPEC
- Agree, but substitutes to oil progress massively and undermine OPEC.
- Non-OPEC supply could even increase
- Don't agree, non OPEC countries will look for alternative energy sources to avoid dependency
- Not really. Balanced seek between local and global power and interests.
- Globally distributed local generation will defuse these issues
- Agree, but later (2030)
- If this starts to happen, OPEC will be destabilized by (invisible mechanisms of) 1st world powers.
- Unlikely
- Unlikely, OPEC more likely to lose power as unconventional resources exploited, and alternative fuels become more common.

- Disagree- OPEC influence will lessen
- They'd try
- Likely
- OPEC may collapse due to political instability in Middle East
- OPEC dissolves
- Not probable
- Not exactly. When bigger, hungrier rates fight over cheese, even the cheese loses power. All lose power, shift to scenario 4.
- Very difficult to say, political clout?
- You are much too much inclined in the terrorist feature; The development in the WTO/agriculteral markets arena will be of much more importance

Scenario 2: Environmental Backlash: Green parties dominate European politics, increasing regulatory power

- Higher power, not dominating
- The point is, whether environmentally minded parties will dominate US and Chinese politics.
- Green parties also important in developing countries, including China, India, Brazil.
- Not dominate, may increase influence
- No. All parties will be greener.
- Not likely, conservatives parties are still stronger than green ones
- Increased influence, but will not dominate
- Disagree, no sign of it, and it would be against the green world view
- Green parties increase strength …
- Green parties will not be dominant
- Agree: leads to less energy dependence of Europe
- Unthinkable and implausible – yes, even in studies of the future some ideas are (or seem to be) like that
- Until hype is exposed and credibility lost.
- Political-terrorism hits fossil fuel systems
- Likely
- Eco-terrorism will not take place on a wide scale (the environmental movement will be driven by global warming evidence). Political terrorism as per scenario 1
- That's one possible definition of the scenario. But what kind of greens?
- Possible

Scenario 3: High Tech: Political Transhumanists and technological optimists increase in power

- I regard Transhumanists as a fringe cult which can even spoil support for high-tech!
- Technology collaboration emphasized because of political pressure.
- What is political Transhumanists??
- Agree, possibly, very p.
- Hope so.
- Agree, large technological improvements reduce strong geopolitics of OPEC
- Slightly
- I do not understand term “political Transhumanists”
- Only partially
- Not really. Humanism and soft techs prevail
- Agree with second half
- Giant corporations increase their political power
- Political global communities increase activities and effectiveness – redistribute power.

- Unlikely, fascists promising easy life will dominate and technology
- Not probable
- Slight possibility
- Disagree; would say instead that perhaps a new version of OPEC emerges comprised of countries that hold the new high tech energy resources instead, which then exceeds power of OPEC.
- Growing prominence of Transhumanists and folks who want fast deployment of everything may have actually reduced the status of high tech and deep science, reducing odds of this scenario. But it's a mix. Better dialogue and depth is crucial to a viable case

Scenario 4: Political Turmoil: Military industrial complexes, semi-regional trading bloc,

- Conflicts motivated by economic interests
- Agree, China is thinking of oil hub denominated in Euro
- Not probable
- Agree, and OPEC comes apart at seams.
- Conflict, fear breeds fragmentation, feudalism, death.
- Agree - maybe whole regions under warlords or military occupation

2.24 Conflicts and terrorism

Scenario 1: Business as Usual Increasing diversity of groups and methods Regional war over oil, pipeline sabotage

- War for additional reasons (access to knowledge and water).
- Much less pressure on this, global peaceful trend
- Some
- Possible
- Slightly
- War over oil will be between the Big Power and oil countries nor regional power, sabotage risk increasing
- Disagree – do not make myths of “terrorism”; it’s rather a local phenomenon caused by the errors of the West in the Middle East. Perhaps some terrorists groups might attack oil. Regional wars – plausible but also with participation of external big powers
- Likely
- Partly
- Likely
- Possible
- Agreed, this is the trend. Also bad fluid coalitions.

Scenario 2: Environmental Backlash Some coordination between eco- and political-terrorism hits fossil fuel systems

- And nonfossil?
- Unlikely
- Since I regard eco-terrorism as counter-productive, it does not fit well into this scenario.
- Much less pressure on this, global peaceful trend
- Unlikely
- I strongly disagree: I do not expect major violence against fossil fuel industries as this would result in environmental damages that are to be avoided from an environmentalist perspective. Especially a coordination between eco- and political terrorism is not to be expected

- It's hard to believe in conspiracy theory saying that environmentalists and terrorists would find each other
- Unlikely
- Can happen
- Coordination not likely, disagree
- Not really green peace and others become more effective
- Disagree, but some hijack of the eco-agenda by terrorists possible
- Terrorism eco-político exageration
- Disagree – Such terrorism would have been engineered by a sophisticated command and supported apparatus equal to the state power.
- Any links (covert will eventually be exposed) between eco- and terrorist movements will prevent environmentalism gaining significant political power.
- No, political terrorists. Who are you thinking about?
- Possible
- Targets for terrorists
- Don't see likely
- And economic terrorists, with declining world economy most regions will be unhappy
- No, subject to stricter regulations
- If eco guys run the show, this may reduce.
- Possible

Scenario 3: High Tech Dramatically increased surveillance and sensor systems reduce terrorist events and conflicts.

- No, terrorism will not be reduced by technology, but by changes in socio-economic conditions and values
- I do not believe that surveillance will work out. A better (but unrealistic) solution is total transparency of bank accounts…
- Much less pressure on this, global peaceful trend
- Scope for sabotage of complex systems increases
- The conflicts are generated by the benefit of the proprietors of the technologies
- Agree, without the word "dramatically"
- Agree, also more cooperation between vulnerable installations
- Perhaps would be desirable
- It changes the nature and occurrence of events but cannot prevent them
- Web monitoring, communication and surveillance become more efficient big-small brother work together for the good of all.
- Technology does not reduce the conflicts
- Disagree – the same surveillance system would be a matter of discontent between pro-democratic and neo-Orwellian political forces
- Disenfranchised find electronic mechanisms to have their opinions/problems aired globally. Reduces move to violence, increases move to dialogue.
- But terror tactics also likely to increase in technology sophistication?
- Agree that capabilities will exist, but may not prevent
- Partly
- Unlikely,
- Not sure
- More evenly distributed wealth reduce terrorist events and conflicts
- Agree but doubt effectiveness
- New conflicts emerge as morality questions surround new energy; terrorism incidents against new energy sources (esp. As the terrorists see their countries power dropping as the "New Energy OPEC" evolves) possible.
- Only human minds can truly reduce conflict. If technology is used to reduce the true living reality

of freedom and spirit, it will prepare its own grave. There is a place for selected sensors, in their place.
- Some coordination between eco- and political-terrorism hits fossil fuel systems

Scenario 4: Political Turmoil Several national wars over energy and water. New failed states, more terrorism. Water problems destabilize India and China, lowering economic growth, coal and oil demands fall

- Water crisis in other regions
- What's with all the water questions? If you have cheap oil, you can get around water problems. Without cheap oil, everything is a problem.
- Several national wars over energy and water. In particular natural gas trade will be influenced
- Agree, except for China and India water problems.
- Partially Agree (Coal & oil demand may fall due to increase in energy efficiency)
- Conflict remain
- Agree, and much more…
- Possible but not probable
- Agree, with an exception of water wars between China and India. The main point of instability – Middle East and some of the post-Soviet energy-rich states. It would partly affect neighbors.
- Successful parts (Cities, regions) of China and India will continue to grow (supported by 1st world interests), despite crises. Poor will just get poorer. Oil/coal demand will NOT fall.
- Resource wars are likely
- Likely, US could also breaks up, Some strong states going their own way
- Possible
- Agree and potentially far worse
- Agree to trend but not extent stated
- Agree esp. Water.
- With fragmentation and WMD, causes of war also fragment and multiply and grow increasingly incoherent and neurotic
- Exploitation of Antarctic resources

2.25 Oil and gas pipeline construction factors

Scenario 1: Business as Usual Russia to Japan implications for China both tapping and investing in Siberia (Putin's offer) Also Sakhalin Island off Russia's Pacific coast. US$7 billion Japanese offer for Taishet-Nakhodka pipeline.

- Canada to US pipeline with Alaskan oil as well
- More pipelines will be built, but Natural gas pipelines are more important than oil pipelines.
- Gas pipeline to Japan will not be constructed by 2020 since Japan has LNG terminal.
- What about the rest of the world? Central Asia / Middle East to Europe pipelines?
- Undecided
- Agree, and some others as well
- Other parts of the world integrate too (e.g. South America)
- Little difference
- The days of large projects coming to a close, too little too late.
- Possible
- Yes, that's in the news.
- Possible
- Power companies are easy targets. Also gas pipleines
- Ask what would cause long term disruptions? Maybe viruses in oil.

Scenario 2: Environmental Backlash

- Negative impact from pipe line take into account
- Disagree: environmental terrorists might attack representatives of fossil fuel industries, but not oil or gas pipelines (see above). A scenario based on environmental concern is not consistent with strikes against fossil fuel pipelines
- Unlikely
- Environmental terrorists will not be serious, coordinated threat, just isolated manifestation of frustration
- Not likely
- Disagree, rather: Less new development as less demand; reinvestment as pipelines on permafrost ground suffer from global warming
- Environmentalists will be non-violent
- No, political terrorists. Who are you thinking about?
- Possible
- Targets for terrorists
- Don't see likely
- And economic terrorists, with declining world economy most regions will be unhappy
- No, subject to stricter regulations
- Again, if eco guys run things, I'd expect less.
- Possible
- Terrorists will try to find a high tech way to interfere with oil production, not just a blown up pipeline or two, but long term. How about a virus in the oil- pump gas and you get infected.

Scenario 3: High Tech

- Hydrogen yes (technologically interesting: LNG tankers? LNG pipelines?), wireless improbable
- What are the hazards of the wireless transmission of MW levels of power?
- Disagree: wireless energy transmission will not play an important role
- Possible
- Hydrogen yes, wireless only for very exceptional purposes
- Less construction
- Fantasy
- Agree plus energy from orbit too
- Not likely
- Renewable energy grids, hydrogen, wireless
- Possible
- Less new pipelines needed, more ability to monitor pipelines, far less vulnerability to temporary events like Katrina (where 10% gas cutback caused price doubling).
- Maybe

Scenario 4: Political Turmoil Political/conflict implication of pipeline deals, in particular in Indochina Peninsula

- A Global driven final solution to the Palestinian Nation State problem first; then talk about pipelines.
- Military attacks on pipelines, refineries, LNG terminals
- Also pipe lines trough Ukraine
- I do not think pipeline through Palestine and Israel will be feasible in next 10 – 15 years

- Conflicts, risks and opportunities keep on
- Confused
- Most likely, but same could be said of all regions including US states, EU etc, the current USSR? Ukraine standoff is a example
- Yes, it would be a key part of the chessboard, but everyone would lose the game (low-level Nash equilibrium).
- Must be featured in this scenario. What are some possibilities? Oil antagonists, viruses in petroleum, infiltration of terrorists into the ranks of oil technicians and geologists, etc.

2.26 Key Global/National Policies

Scenario 1: Business as Usual Carbon trading, renewable portfolio standards, enhanced CAFÉ

- International deals wont change prices
- Carbon trading, renewable portfolio standards, enhanced efforts for increased efficiency
- Energy tax, Vehicle fuel tax
- Little probability
- Moderate
- Please explain “CAFE.” Agree with the rest.
- Work/support/”Unleash” “disruptive Techs”
- Most
- They talk about this stuff, and generate lots of laws, of marginal impact.

Scenario 2: Environmental Backlash: Carbon taxes (US$50/ton?) Product labeling, Tri-car fuels, legally binding renewable goals with subsidies and incentives for cleaner cars, stock market strategies, Alt. S&T Fund, global warming lawsuits begin with Greenpeace on Exxon

- Only in case of the following scenario
- Legal binding of renewable goals with subsidies and incentives for reducing more fossil fuels dependence
- Agree (I my book on wild cards I have a global warming class action law suit against the US)
- Agree; plus: removal of subsidies
- Disagree - impossible
- Agree on some
- Possible but probably not in a period of economic stagnation
- Personal carbon allowances
- Sounds like some of the stuff some folks might do.
- Possible, but a bit narrow
- Agree except lawsuit on Exxon.

Scenario 3: High Tech: International Solar Satellite Consortium, ISTO, S&T Fun

- International Solar Satellite Consortium. Construction of hydrogen society
- Solar satellites come after 2050
- 2030
- Agree. As a new form of energy, it will be necessary to have such institutions to improve the use of solar energy
- Energy tax, Vehicle fuel tax
- Disagree: solar satellites will not be a KEY theme of a technology based scenario
- Long-term

- Can happen
- Not before the fusion power commercialization
- Agree only with S&T funds
- Fantasy
- 2030 Agree
- Agree – but why only international
- Many global communities practice activities NOT directly driven by global or national policies.
- Ughhh
- Accelerated demonstration and dissemination of renewable energy systems
- Wish I could figure out ways to cope with all the many barriers. An international fund to support multinational research in technologies for a sustainable future could get huge value for money, in principle, **IF** run competently -- which is not easy.
- Maybe

Scenario 4: Political Turmoil International systems lack support

- Plus space geopolitics
- Agree – only partial or bloc solutions – US, NATO, EU
- After enough damage, will to cooperate may increase, but risks throwing out tech and growth while tightening (as needed). Big risk as it goes crude.

2.27 Key Global/National Policies Major energy players (e.g. Will Saudi Arabia keep its dominance or will Canada challenge its position with the sand oil, and by what year?

Scenario 1: Business as Usual Middle East increases its role in world affairs. US-Japan-China increase energy dependence

- Canada will never challenge Saudi Arabia. Russia and Saudi Arabia control oil. Russia and Iran and Qatar control natural gas.
- Orinoco heavy oils!
- Disagree. Venezuela and Canada (given their large proven XHO reserves, western hemisphere positioning and growing links with Asia) will play a bigger role.
- Middle East increases its role in world affairs. US-Japan-China increase energy dependence, Balanced among regional energy supply, OPEC will decrease it role
- The giant corporations act by means of governments of the USA, United Kingdom and Russia
- Disagree with first statement, agree with the second
- US will not be willing to increase its dependancy on the Middle East
- For the next few decades, yes; after the energy rift valley Canada may become a major player
- Agree, but military strategies may change the game
- Disagree with first part but Agree with second part.
- I agree. Brazil becomes exporter of ethanol.
- India will also increase energy dependence
- Disagree – Middle East will become a hotbed of crisis – new generations are becoming more radical than they parents were and are – Hamas, Iran, etc.
- Oil sands will erode Saudi dominance, then oil shale (when economic) will result in global reshuffling.
- Agree except Mid East will decline cf oil sands after 2020
- Possible
- Agree strongly, if "role" means oil supply.
- In business as usual, Saudi monarchy continues

Scenario 2: Environmental Backlash Middle East decreases role with increasing roles from alterative energy tech from Europe-US-Japan

- Agree. Plus India and states in Africa.
- Agree; but include Venezuela and Canada.
- 2010
- Middle East decreases role with increasing roles from alterative energy tech from Europe-US-Japan
- Not likely
- Agree as previous
- No decreases in 30 to 50 years
- I agree. Brazil becomes important exporter of ethanol.
- Agree - plausible
- 2020, agree
- Not really
- Certainly a factor that erodes importance of oil over time (decades)
- Depends on who is in charge. If like Chavez, they'll talk a lot and then depend more on Exxon's re-de-privatizing the energy sector.
- Recent power shortages are some kind of weak signal pointing in this direction, also the growing dissatisfaction of citizens with the ongoing privatization trend.

Scenario 3: High Tech US – Japan on nanotech, Space Solar Power, Hydrogen suppliers

- I consider space solar power highly unlikely, but technology dependence (US, Japan and Europe lead – in the long run
- SSP - See above (And nanotech is not as relevant here either.)
- 2015
- US – Japan on nanotech, Space Solar Power, Hydrogen suppliers
- Disagree: no space solar power
- Agree, plus Europe
- No, skeptic
- Agree (with the EU included)
- Likely to happen in the long run
- I agree. Brazil becomes important exporter of ethanol.
- Increased range of sustainable alternatives reduces energy dependencies, defuses current trigger spots.
- Nope Brain drain from US to China and India will continue, most developments will happen there
- Not really
- Agree - Geothermal Energy
- Possible
- Developed countries become key energy holders with the technology available, who then create a "New Energy OPEC" and retake power from Middle East in terms of energy geopolitics.
- China and US are best posed for leadership, with Japan and some European industry folks outside government influence next. H suppliers will have trouble collecting alms for their monasteries. But mid-tiers will increase % if agile.
- Agree except hydrogen suppliers.
- Will the US announce a "New Apollo Program" for energy?
- Canada develops its tar sands and becomes a top energy player on the international stage

Scenario 4: Political Turmoil Conflicts in Saudi Arabia, China, Nigeria, Venezuela could benefit

Russia's role.

- Conflicts in Saudi Arabia, China, Nigeria, Venezuela could benefit Russia's role.
- Russia would be harmed from the total crisis.
- Disagree. Socio-political conflicts only in Saudi Arabia.
- 2010
- Conflicts in Saudi Arabia, China, Nigeria, Venezuela could benefit Russia's role. More regional relied energy supply, Russia balanced
- Russia likely to have its own conflicts
- Conflict with no winner
- Quite possible, another conflicts can happen in Central Asia
- There are no winners in these conflicts
- Agree – partly; Russia can be affected by the conflicts in the Caspian Sea Basin
- Likely, would expect Venezuela to also have major role
- Possible
- No one will benefit. Russia is open to terrorists more than the rest of Europe.
- Managing such a fund to keep it agile, to avoid wasting all funds on vested alternatives or stovepipe groups, or on bean-counters who use a kind of numerical astrology, would be an enormous challenge. I know of no single gov't agency which has shown enough agility on its own, and Ford or GM also have had problems. We also need fuel-flexibility laws to create more competition in fuel supply, new US access to space, etc.
- What consequences of a fundamentalist government in Saudi Arabia?

2.28 Number lacking electricity in 2020 (today it is 2.3 billion)

Scenario 1: Business as Usual

- 2000 million (population increase)
- 2 billion
- 1.5
- 1.5 billion
- Population growth in Africa likely to distort this statistic seriously
- 2 billion
- 1500
- 1 – 2 billion
- Urbanization to slums with some access to electricity continues
- 1,5 bill
- 1.5 billion
- 1.5 billion
- Goals impossible to fulfill, superior to Johannesburg
- 1.5 billion
- 0.5 billion
- More
- 2 B
- 3 Billion
- 1.5
- Maybe 1.8 billion. In this scenario, investments in helping people consume more energy will not be vigorously pursued after 2010.
- 3 billion or more

Scenario 2: Environmental Backlash

- 1 billion
- 2 billion
- Disagree. Should be lower.
- 1.5 billion
- 1.5 billion
- Lower
- 1000
- Agree, with growth of local solutions of electricity production in small scale
- 2 billion
- Goals impossible to fulfill, superior to Johannesburg
- 0.5 billion
- 2 billion
- 2B
- 1.7 billion
- I'd guess 3 billion, at least if it's Naderland.
- 3 billion

Scenario 3: High Tech

- 0.5 billion
- 1 billion
- Less
- 1 billion
- 500
- 1 billion
- Goals impossible to fulfill, superior to Johannesburg
- 0.2 billion
- 2 Billion
- 1.6 billion
- Maybe 0.8 billion. This is not cheap stuff, and it takes some time, and people are being born most often exactly where electricity is unavailable. Still, 0.5 billions seems a reasonable target, well worth trying for, if we can do the other stuff too.
- More

Scenario 4: Political Turmoil

- 2.5 billion
- If they survive
- 2.5 billion
- More
- Disagree. Should be lower.
- 2 billion
- 2 billion
- 2,3 billion
- 2,0 bill
- 1.5 billion.
- 5 Billion
- Population growth will continue at unsustainable levels, leading to a post 2020 crash.
- 2.3 billion
- Agreed. Until the number of humans starts decreasing.
- 2 billion
- More

2.29 Other economic elements to be considered for each scenario?

Scenario 1: Business as Usual

- Deceleration of the strong economies
- Global economical crisis similar to depression of thirties of 20th century
- There will be economic decline in all scenarios
- Energy demand growing faster as other large-population third world countries economically go the way of China and India.
- Changing of economic mix, industrial mix, is very important factor for future energy demand, IT will be major economic driving force, Energy intensive products reach peak in 2020
- Population growth
- The water becomes commodity
- Water availability and cost increasingly affect geopolitics
- Steady Cost reduction in renewables More expensive transports
- Increased role of India in energy demand And increased role of China
- Possibly other forms of dependencies between different countries
- Flow of migration (force labor)
- US $ VS. EURO VS…
- High social pressures
- High social pressures
- Use of non commercial energy which constitutes about 35 % of the primary energy basket in India
- Development of population; demographic change
- Increasing awareness on energy crisis
- Population, peasant population
- Importance of dollar in international economy
- Economic development/social transformation will accelerate electrification and provision of electricity to all
- Possibility of financial turmoil
- 1st world economic dominance grows
- Global unemployment rises
- Costs of climate change and biodiversity decline
- Increasing costs of Energy and resources diverting capital away from long-term projects
- Antarctic exploitation
- Ability of oil companies to transfer to other energy sources
- Over-reaction of markets to reaching "peak oil"
- The US fiscal deficit that can not longer be sustainable affecting the rest of the economies
- Birth rate
- See Feierabend's classic book on the "J curve." The 2010 shift in trends is apt to cause more political changes than people expect. Part of how we get to scenario 4 and messes that get in the way of growth, unless progress (scenario 3) is far more visible
- Demographic factors; turmoil in providing age security systems
- Geothermal

Scenario 2: Environmental Backlash

- Return to spiritual values that require much less material.
- Europe is the one that will first embark on renewable resources exploitation together with the alliance of other small countries that would be used as models.
- Environment will be a lesser issue for fast growing emerging economies.

- IT will be major economic driving force, Energy intensive products reach peak in 2020, but with clean production, Carbon capture and storage will increase energy use
- The ongs responds to interests of groups that are excluded from the power
- Environmental lawsuits related to energy use, e.g. Against US could affect economy negatively
- Moderate social pressures
- Moderate social pressures
- Implausibility. Environmental movements are losing the momentum. They were a kind of "mutation" of the leftist ideology. Now they are much more diversified, and subsequently, weakened. This process will be continued.
- 1st world economic dominance grows, but less
- Costs of climate change and biodiversity decline
- Apply a price to natural resources
- Move to localization and
- Biofuels

Scenario 3: High Tech

- Economic countries clusters of co-operation may emerge, and a new type of allies of advanced technologies may apply powers to the outsiders
- Technology will make global economic growth easier for most countries to achieve.
- IT will be major economic driving force, Energy intensive products reach peak in 2015, but with clean production, Carbon capture and storage will increase energy use, but much less then scenario 2
- Se impone un criterio de necesidad sobre el de propiedad para la difusión y uso de nuevas tecnologías
- Economic gains to be made from productivity improvements
- High social pressures
- High social pressures
- Genuine redistribution of wealth generation processes across planet. Poverty decreases and quality of life improves globally
- Virtual happiness
- Costs of climate change and biodiversity decline
- Gated communities - the techno divide
- Solar biofuels & geothermal

Scenario 4: Political Turmoil

- Some third world pockets of war and economic backwardness.
- Water availability and cost become source of conflict in itself
- Political pressures in some parts of the world could result in economic gains in other parts (from energy supply)
- High social pressures
- High social pressures
- 1st world economic dominance grows the most
- Costs of climate change and biodiversity decline
- Antarctic exploitation
- Survival mode

2.30 Other environmental elements to be considered for each scenario?

Scenario 1: Business as Usual

- Water crisis on the global scale
- Acceleration of the poles warming
- Water arable land
- Environmental restrictions imposed by OECD countries on agricultural imports
- Water availability, quality and cost
- Hurricanes and climate change damages
- Urban environmental degradation more pronounced because of the growth of megacities – resulting in more legislation Conflicts around available energy resources
- Forests destruction and air pollution
- Climate change Emissions of cfs Pollution
- Commensurate levels of awareness amongst populaces
- BIODIVERSITY WORLDWIDE INCREASING IMPORTANCE
- Climatic disasters High biodiversity loss
- Climatic disasters High biodiversity loss
- New government policies and regulations
- Soil loss, salinity and erosion lowers food production, ecosystems lose viability
- Urban air quality getting worse under BUSINESS AS USUAL
- Oil and gas leaks and accidents
- Climate change effects on coastlines, (i.e. Major cities) species, (food production)
- Potential massive environmental changes - e.g. Shutdown of Gulf Stream.
- Air quality

Scenario 2: Environmental Backlash

- Regulation of other dangerous elements for the atmosphere
- Clean energy options, and clean production, people will change life style
- Water availability, quality and cost
- Environmental lawsuits related to energy use, e.g. Against US
- Climate change
- Climatic disasters lower biodiversity loss
- Climatic disasters lower biodiversity loss
- Emission from use of non commercial energy such as animal dung and wood
- Removal of subsidies; change in people's behavior
- Use of the land: feeding versus fuel
- Environmental issues will lead to clean energy technology development
- PETA like org established to aggressively stamp out energy waste
- Oil and gas leaks and accidents
- Urban air quality addressed through environmental rags
- Vision of general public towards environmental. Issues
- Preference to decrease pollution over carbon sequestration
- Less energy consumption through transport, ecosystems replenish themselves and become more productive

Scenario 3: High Tech

- Greater understanding of the behavior of the atmosphere and the seas
- Water availability, quality and cost
- Posibilidad de sacar de orbita satelites sin vida util.
- Very strong pressure for more environmentally sound technologies could spark large growth in

certain industries
- Impact of nanotechnologies
- Climatic disasters High biodiversity loss
- Climatic disasters High biodiversity loss
- RF/EM pollution
- Oil and gas leaks and accidents
- Continued decline in ecosystems in techno poor regions

Scenario 4: Political Turmoil

- Hurricane control with warlike aims
- Major environmental disaster caused by global terrorist movements.
- Water availability, quality and cost
- Political factors determine access to strategic energy resources (such as oil), Sabotage and attacks to major oilfields could disrupt supply
- Use of nano technologies for war use
- Contamination of soils by biological and chemical agents.
- Climatic disasters High biodiversity loss
- Climatic disasters High biodiversity loss
- Oil and gas leaks and accidents
- Archebacteria

2.31 Other technological to be considered for each scenario?

Scenario 1: Business as Usual

- Great changes in the transportation systems – preference of mass transport (super fast trains) to individual (cars)
- Recycle based material use will be considered
- Rapid advance of robotics/automation likely to benefit countries with declining populations
- Massive hvdcs
- Globalization could play a very large role in technological developments and standards
- Negative impact of weak property rights/security, Influence of inflation and high interest rates on access to finance for technological innovation
- Difficulty of certain technologies, like the nuclear fusion: all the high technology does not have equal possibilities
- Fusion
- OGM
- OGM
- Improvements in efficiencies on the demand side; probably fusion (high-tech scenario)
- Nanomaterials, fuel cell and biodiesel developments
- Marine current power
- Business as usual must include the ongoing hunt for profitable energy sources, energy efficiency technologies, etc. As business seeks to supply a consumer demand to make a profit.
- Large-scale electricity storage
- Food, Iron, Copper, Phosphate, plastics, shortages in many materials. Loss of manufacturing and capability reducing ability of countries to make changes. Overspecialization and reliance on JIT with very little spares etc being kept
- Levels of government investment in low-carbon technologies

Scenario 2: Environmental Backlash

- Use of solar energy as a key target
- Large-scale electricity storage
- Greater emphasis on ecological building and ecological city design reduces energy demand for transportation and building heating and electricity.

Scenario 3: High Tech

- Very strong pressure for more environmentally sound technologies could spark large growth in certain industries
- OGM
- OGM
- Cold fusion
- Large scale offshore wind, modern biomass utilization are important
- Will accelerate the comment in column 1
- Very strong pressure for more environmentally sound technologies could spark large growth in certain industries
- Nanotech biomedicine
- Importance of biomass
- Off grid technologies will accelerate access to electricity to major chunks of population
- Expectations for "techno-fix" solutions may prove disenchanting and disillusioning.
- This is the only scenario where indigenous technology solutions (including energy issues) will become a natural stream, as an integral component of global innovation.
- Virtual presence lessens demand for non pleasure travel
- Access to internet and increase in PC usage
- Direct conversion of the nuclear energy to mechanical and electrical energy
- Perhaps first promising nuclear fusion plant
- Use of technological fixes for global warming- changing albedo, sequestration

Scenario 4: Political Turmoil

- Bio-war
- Bio-war
- Large-scale electricity storage
- Telecommunication technologies used to block access to energy supplies (e.g. Oil)

2.32 Other Geo-Political, War, Peace, Terrorism economic elements to be considered for each scenario?

Scenario 1: Business as Usual

- The US change of external policy that can affects oil prices
- Corporations more powerful than militaries
- Worlds transport system, i.e. Reliance on few critical choke points i.e. Suez, Panama, Straits of Homuz, etc.
- Distribution of wealth
- Conflict for the world-wide hegemony between China and United States
- Unemployment due to automatics/robotics and increasing machine intelligence capabilities leading to rise of Luddite orgs.
- Open religions integrated movements
- Open religions integrated movements

- ETHNICAL PROBLEMS IN US AND EUROPE
- Risks from undersupply or interrupted supply of energy growing larger as economies modernize

Scenario 2: Environmental Backlash

- Return of anti-nuclear sentiment could block further development of nuclear technology
- Open religions integrated movements
- Open religions integrated movements
- Distribution of wealth

Scenario 3: High Tech

- Global dialogue and leapfrogging K-12 education in remote areas as important to sustainability as new technologies.
- Would be curious to see if others touch on the "New Energy" OPEC that evolved from my answers to this scenario.
- Distribution of wealth
- Mining of near earth resources
- Open religions integrated movements
- Open religions integrated movements
- Improved (warfare) technologies could make impact of terrorism so much bigger

Scenario 4: Political Turmoil

- Improved (warfare) technologies could make impact of terrorism so much bigger
- Access to new generation of weapons at low cost
- Open religions integrated movements
- Open religions integrated movements
- Changing economic and political scenario will largely impact energy issues, much beyond what meets the eye today.
- Very high probability of permanent political/economic/military instability in the Middle East.
- Distribution of wealth
- Corporations more powerful than militaries

Other Comments (scenarios not specified)

- Social elements to be considered: Global population growth, Spread of western influence over India and Africa
- The scenarios are too optimistic. Breakthroughs are assumed. The possibility of a very near term oil shock is not considered. Given field declines, lack of discoveries, terrorism and political instability, I think far less desirable scenarios, occurring much sooner than anticipated, are likely. Also, the most likely scenario causing a drop in demand is not war, as assumed here, but rather a pandemic and resulting population decrease.
- Useless survey technique depending on fear-based assumptions. Should organize around a real goal, at least 2 kwe/person ASPA, and then recognize what is required to meet that goal.
- Failure of Social Security (social state)
- The US economic growth up to 2020
- The US external policy in the Middle East that can affect in an indirect manner the oil prices.
- Population and income growth in china and India will require adjustments, with lower consumption of fossil fuels across all nations, due to interdependence.
- The scenarios read as though oil use will continue whereas I believe most developed countries are already moving away from such reliance. Technology leapfrogs in developing countries could also be factored in.

Appendix 4.3: Respondents Comments to Round 1, Section 3

3.1 Total from all sources

- Based on IEA
- To answer these questions I would consult with the scenarios of the IPCC, Millennium Assessment, and Global Environmental Outlook (GEO-3)
- 3% annual growth in energy consumption will continue, especially because of demands of newly industrialized countries
- Will double
- Severe depression similar to break up of USSR will cause huge drop in energy usage

3.2 Oil (conventional ranges)

- World production will be flat, but will last a while. We may see small declines in the next two years.
- Due to increased recovery factors with new more advanced technologies
- Assuming new oil discovery & enhance oil recovery
- Will remain constant
- Huge demand destruction, private cars much fewer and much smaller. Conspicuous consumption bad for health

3.3 Unconventional oil from tar sands and shale

- Tar and share respectively
- Fuels like Venezuela Ormilusion will be relatively inexpensive to use in ships etc but Oil tars will be too costly from an energy point of view
- Will increase, but overall available will hold constant
- WILL INCREASE

3.4 Natural gas

- The production rates should increase by about 5% per year world wide. But US declines will be troubling
- WILL INCREASE
- Will increase with off-shore discoveries
- Huge decline in regional supply causes industiral demand destruction, most industry moves to stranded Natural gas deposits and very little increase in LNG

3.5 Methane gas hydrates

- 5% of demand

3.6 Coal (conventional)

- Production should increase at about 5% per year
- WILL INCREASE
- Clean coal technologies
- Lack of investment and planning means that easily mined open cast coal will need to be replaced with underground mines, cost and difficulty will reduce tonnage
- Production to decrease with introduction of clean coal technologies.

3.7 Coal processes total from liquefaction, oxygenated, gasification

- Depressed economies and temporary enegry surpluses keep energy prices deflated

3.8 Nuclear fission

- Some new stations and old stations continue to be nursed but low energy prices and harsh economic conditions prevent investment in new plant. Industrial capability absent in many countries and not sufficient foreign financial reserves to pay for plant
- Technology will allow new plants by 2020 if wanted

- No major increase
- Some increase

3.9 Nuclear fusion

- Nothing there
- Some hope
- Needed also for space projects
- World just not investing enough NOW

3.10 Solar (Photovoltaics on earth, solar power towers, solar thermal, and space solar power)

- The wealthy will have their own power and cost will not be an option
- Will increase as we approach 2020
- Initiating exponential growth at the moment and with great ecological benefits
- The most development alternative energy
- Significant growth rates, but still small absolute contribution
- Some increase but wont stop economic decline.

3.11 Wind

- Some increase but wont stop economic decline.
- Hopeless
- Will become economically viable at many places
- Initiating exponential growth at the moment and with great ecological benefits
- Should be developed quickly
- Relatively easy technology and will fit in with Countries desires to create jobs and indigenous energy

3.12 Hydro

- Limited sites
- Will not increase due to environmental impacts
- Could be increased

3.13 Geothermal

- Relatively easy technology and will fit in with Countries desires to create jobs and indigenous energy
- Real CO2-Free
- ground source heat pump should be used widely
- Small
- Will increase where available (Iceland)

3.14 Tides

- Promising energy source
- Big schemes unlikely to come to much, besides with declining fishery stocks tidal areas probably more important in terms of eco system

3.15 Traditional Biomass and waste

- Some increase in Developed world increased focus on Forestry for land husbandry and rehabilitation
- Growth in waste use

3.16 Other biomass Methanol Ethanol

- Not a factor
- Decrease due to increasing food and water problems
- Traffic biofuels, industrial CHP, municipal CHP

3.17 Others?

- Many of the items that mankind uses energy to produce now will use natural flows

Appendix 4.4: Respondents Comments to Round 1, Section 4

- A grand scheme like Apollo for energy
- A successful post-Kyoto international agreement that really reduces GHG emissions to 1970 levels.
- CAFE, appliance, and building energy-efficiency standards with teeth.
- All vehicle license fees and insurance costs rolled into fuel prices, i.e. these are no longer based on flat fees but prorated on a vehicle/fuel-use bases, which would better demonstrate actual costs to the driver and provide a greater economic incentive to drive less.
- A chip in a smart vehicle ID card or keyless entry device provides the fuel pump or the cash register at the gas station with the multiplication factors necessary to calculate the vehicle and owner/insurance-specific total charge.
- Heavy-vehicle road taxes (also rolled into fuel price) that cover the true cost of wear and tear of roads caused by these vehicles and which would make rail transport more cost competitive.
- Massive increase in government funded energy-efficiency and alternative fuels research.
- Here are some: 1) education to raise awareness 2) significant investments in "what if" simulation and visualization software 3) re-adjustment of budgets for related basic scientific research but most of all: the passionate declaration and embrace of a mission to truly care about the future: the NOWafter, not just the HEREafter.
- Seawater agriculture along the desert coastlines of the world (begin by planning salt-loving plants on beaches of areas like Somalia) could make biofuels competitive at today's oil prices.
- Establish INSOLSAT for the coordinated development of Space Solar Energy systems as INTELSAL helped orbital commutations satellites.
- Create a global R&D fund those technologies like carbon sequestration and space solar energy that are not likely to attract venture capital and/or individual government funding, but would be of value to humanity as a whole. –
- You ought to include some unexpected breakthroughs; e.g. albedo control and down hole tailored organisms for reducing viscosity of residuals.
- Also a political blockbuster like OPEC denominating its oil sales in Euros.
- And, an idea of international consort of energy interests informed by federal union, treaty and poll, as: The utility of the union to our (own) political Energy prosperity the insufficiency of the present confederation of Electric product and distributing utility to preserve that union the necessity of a governing personal private and secure energy accounting system, based on an Energy Standard, and a calorie based economy, at least equally energetic with the one existing, developing, and proposed, to the attainment of this object the conformity of the proposed [design constituents] to the true principles of Just Governing Energy System(s) its analogy to our own personal private and secure constituent state
- Lastly, the additional security which its adoption will afford to the preservation of that species of governing system, to liberty, and to property -access, to energy system(s)account.

Other comments

- The most direct "Ocam's Razor" approach would be to launch an all-out "Apollo Moon Project" style of program to achieve alternative / renewable resource enabled energy independence within a specific definable timeline, say 10 years, in which specific milestones can be defined as markerpoints within this program lifetime. A major socio-political limitation to "grand scheme" programs is a lack (apparent or real) of specific markerpoints, i.e., initiation, deployment and endpoint strategies which can give clear, understandable, and if necessary, revisable goal thresholds by which the performance metrics of the program can be measured.
- That being said, 3 specific points can be made to support the efficacy of such a program:
- There is considerable evidence that public acceptance of such a program is very high, both on "conservative" and "liberal" ends of the political spectrum. This is a socio-political climate unique to this current time (among the general public), and has a very high probability of remaining consistent over the next decade, independent of the actual political orientation of the administration which may be in office.
- Hybrid economic development models, in which co-investment mechanisms between public institutions, and private ventures, are becoming much more acceptable, and within the scope of longterm feasibility than in previous times. Furthermore, a highly granular, localized approach to developing energy related products and infrastructure is likely to become the norm, as opposed to the exception, in such future endeavors. In short, we are no longer confined to the megascale, monolithic, "one solution fits all" paradigms of a previous era. Specifically, in the context of this type of program, it may well be the absolute requirement that specific fuel and energy solution sets will be tailored to the resource, infrastructure, and "economic patterning" of specific regions which can most readily adapt to, and profit by, the solution sets rendered for and within that region. ***This type of program can be dramatically catalyzed by aggressive tax credit and investment related incentives.***
- Even though many of the technologies and development threads to be initiated in such a program (as listed below) date back many years, in some cases back to the mid '70's, it is extremely important and relevant to note that the timelines to critical markerpoints in development and deployment are remarkably different than previous times, i.e., 10 years of development in current time is a much accelerated rate of progression compared to the same length of time from 3 decades ago. This is primarily because of the synergistic interrelationship of various technical and scientific domains, such as materials science, biotechnology, chemistry, solid state physics, computing, systems engineering, and various other related domains which currently converge, in many overlapping examples, into what is now referred to as applied nanotechnology.
- It should also be noted that any comprehensive program initiated along these lines, as stated above in item 2, will in many cases benefit from a localized / granular approach to development and deployment. However, even though there will be specific sub-categories and variations linked to specific regions, an overall "umbrella" of technologies can be specified here, many of which can be deployed at an accelerated pace compared to previous times, in part catalyzed by the rapid and ever accelerating pace of applied nanotechnology
- Solid state batteries (replacing current lead/acid batteries) – electric and hybrid / electric vehicles
- Low cost organic semiconductor solar and thermal voltaic materials – coatings, paints, laminates, tiles
- High efficiency LED lighting – home, business, industrial
- "Smart" building materials, dynamic and passive (including solar and thermal voltaics) – integrated sensing and monitoring, "energy efficient" design
- Solid state hydrogen storage cells – hydrogen powered vehicles, localized power applications
- Liquefied coal synthetic fuels – recent developments in catalysis and nanomaterials make this a much more commercially viable option than in previous times
- Organically derived hydrogen – hydrogen derived from genetically enhanced micro-organisms, and other organic media
- Optimized thin films, membranes, and nanomaterials – low cost fuel cells in vehicles, and many localized power applications

- Next generation wind systems, both on and off grid – on the side of energy generation, the efficacy and MTBF (maintenance overhead) of current and emergent wind turbine designs can be greatly enhanced by newly available materials and manufacturing methods; on the energy distribution / storage side, developments in storage media, and transmission lines both can be accelerated in parallel to accommodate
- High efficiency / "near" superconductive materials - mission critical / geographically specific transmission lines
- Space borne orbiting solar collectors, using a modernized sealed system, high pressure steam turbine to electrical conversion mechanism, beamed to the ground in the form of low density, easily convertible micro-wave energy
- The above is only a partial list of the more "obvious" options that are currently available to be embarked upon in such a program.
- The most relevant point to note here is that it is the ***combination*** of the above mentioned options, along with others mentioned in other documentation, as a mosaic within such a comprehensive program, that will yield the results most needed to obtain the overall goal of energy independence within a foreseeable future timeline.

Another Comment

- 1 In my opinion, the scenarios have not been designed correctly enough. Scenarios 2 and 3 as most optimal could have been merged and, possibly, enhanced by Scenario 4.

- 2. It is absolutely not rational to be interested when this or that kind of fuel gets exhausted, No doubt that oil and gas will get exhausted already in this century, the Earth has a finite size and therefore fossil energy resources are finite.

- 3. If one agrees to the logic of items 1 and 2, then science, government authorities and business should concentrate their efforts on total and urgent search for new energy sources.

- For this purpose, the above efforts should be complemented by international efforts, such as those undertaken by the European Union under FP6 and FP7.

- To make a roster of all experts who could contribute to that development and search and or to bring new ideas in regard to new kinds of energy or their sources.

- To lead inventory of all available operating time in this direction.

- To establish an annual award, not less significant as the Nobel prizes, in the energy field.

- To organize Internet-conferences (competitions) among different age groups, starting with schoolchildren.

- To introduce in all technical educational institutions an obligatory course in energy and energy efficiency.

- Financing - to introduce a new (global) tax to be imposed on both countries and companies, especially those that mine and re-sell fuel energy resources. A tax rate should depend on energy consumption.

- Search for new energy sources can be made in boundary areas, such as space energy (planets having a huge weight move at a large velocity using energy yet inaccessible to humankind.

- Human energy is insufficiently studied. For example, the encyclopedia of energy efficiency cites a kind of psychic energy that is insufficiently investigated. Take the information spread around the

globe about a woman who lifted the wall that fell on her child. After letting the child free ten men could not lift the wall. Such constructions as pyramids in Egypt or New Grange in Ireland were built with the use of energy inaccessible to us today. Kirlian effect should be studied most closely.

- International joint scientific energy research should necessarily be coupled with environmental protection and economic studies.

- On item 2.32. Organization of inter-confessional fora on struggle against terrorism with participation of leading figures in policy, science, art, religion, business and especially experts in the environment, energy, international relations, and economists.

Appendix 5. Respondents Comments to Round 2 (Draft Scenarios)

Responses to the scenarios drafts

Scenario 1: "The Skeptic" (a Business as Usual Scenario)

1.1 There was a public opinion survey taken the other day to see what people thought about our present situation and outlook. The pollsters found that the percent of the people they sampled said they thought they were better off in 2005:

- AVG: 36.795
- (responses: 55; 30; 90; 10; 24; 10; 5; 60; 60; 2 in the world, 5 in the US;40; 15; 25; 90; 70; 60; 42; 30; 20; 30; 20; 20; 20; 45;40)

1.2 and the percent of the people who said they thought that in 2040, 20 years from now, things would be much better than today:

- AVG: 38.614
- (responses: 75; 50; 35; 50; 19; 40; 1; 80; 60; 1 in the world 2 in the US; 15; 20; 5; 70; 30; 70; 78; 25; 55; 20; 30; 20; 50; 40; 50)

1.3 What would make this speech ["The New Fire"] more plausible?

- The idea that western countries in their energy policy are hostages to manipulation by left leaning and terrorism financing actors.
- Specific near term incentives to gain public support.
- To show the makers to policy all the scenarios possible and to indicate if it is desired to reach certain scenario is necessary to do this and the other to show all the scenarios possible and to indicate if it is desired to reach certain scenario is necessary to do this and the other.
- To emphasize the demand side reductions such as taking the bus to work and increasing insulation.
- What would make this speech more plausible is the effective implementation of all what is said. However, what is noticed is the fact that many leaders are not ready to fulfill all their says.
- Introduction of environmental damages and reaching sustainable development.
- To put more emphasis on environmental aspect.
- If it also would have an energy consumption reduction policy integrated…
- The United States would have to change its concept of leadership. Not leadership arising from unprecedented military dominance but based upon mutual dialogue. It is likely impossible, not necessarily only under the actual administration. The threat of such a conciliatory approach is that

some of the enemies of the US would perceive it as a sign of weakness. In addition, by making such offers, the US wants to replace international organizations, like the UN. Therefore such a course of events is highly unlikely.

1.4 When people today wonder how the world has developed as it has, most often they point to… as being responsible.

- The fellow-citizen.
- Corrupt politicians and “the best Congress money can buy”
- Developed countries
- Oil companies
- The technological innovations or advancements
- The lack of commitment to achieve a more wealthy and socially balanced international community
- The USA and OECD countries
- Irresponsible, counterproductive environmental extremism
- The government and oil companies
- Short-sighted nationalist policy makers
- Existing business interest and a mix of persistent policy short-termism.
- USA
- A mix of ignorance, "failure of Imagination" and, in the U.S., a "terminally Tactical" approach/outlook
- Business power and leaders' incentive system and its short term profit making prioritizing to long-term visions
- The U.S
- The consequences of the ever reduction of non renewable energy sources, was never understood by the majority of the world population
- The lack of courage to change of lifestyle and more engagement in civic society entering in public decision-making process.
- Multinational companies.
- The so-called Oil Age in the 20th century.
- Unfettered global capitalism.
- Overwhelming dominance of the ideology of liberal market and desires of new emerging powers (China, India) to consume more energy necessary for increasing standards of living of their populations.

- Mainly the USA, but also Japan and other G7 countries plus China and India and Brazil.

1.5 If you asked presidents of oil exporting countries why things have turned out as they have, they say, most often

- It's your own entire fault.
- Greediness and wastefulness in oil consuming countries.
- Because they were dragged by the market.
- Oil companies are responsible.
- Is the increase or the rise of world demand
- That no one is interested in energy efficiency programs
- We were held hostage by American engineering companies and price fixing cartels of oil companies.
- That no other energy source can compete with oil, especially for transportation fuels.
- We only sell what they demand, we don't make them take it.
- That consuming countries have made too little investments in technology.
- Oil consumers never reached the same concentration in buying powers as oil producers did through OPEC. This became even more evident after the emergence of China and India. A buying cartel was not a realistic option.
- Their should have been consumption standards for all vehicles.
- The short sightedness of political leaders unwilling to take decisions for the future.
- The world took the "easiest path, let inertia instead of analysis/foresight guide them.
- We only operate according to the laws of supply and demand in the global market, and that is the "religion" generally accepted and followed allover the world. We are not capable to change the rules of the business game.
- That the U.S corporations' interests were put before the interests of the current and future peoples of the world.
- The consuming countries energy agencies have continuously underestimated the capability to increase our petroleum production capacity and consequently have embarked the consuming countries in very costly alternative energy projects that are not economical
- That it is not their business, but the problem of their oil and gas importers
- That the market failed (this may go beyond the scope of this scenario, but a move towards re-regulation of energy related markets could be an outcome of this scenario)
- Complain about oil being cheaper than water.

- That this is the best of possible outcomes. That it was the policy of the West and of the new emerging big markets for whom assuring possibility of increased consumption was a primary strategic goal.

- Reckless oil and energy consumption is to blame

1.6 On the other hand, oil company presidents say:

- We have done whatever we could.

- They are doing the best they can.

- Because the shareholders demanded greater gains per year.

- They are doing the best that they can.

- The costs associated with the extraction, exploitation and other indirect cost associated with oil availability.

- That the market dictated the way to follow.

- We were never allowed to charge the true replacement cost of crude oil.

- Exactly the same, compounded by stupidity & political correctness in western countries.

- Our hands are tied.

- That they just make business.

- The lack of a solid alternative and shared policy strategy that would allow us to research in alternative energies did discourage us from doing that.

- Price is set by supply and demand, and there is no need for governments to get involved.

- Countries owning petroleum deposits must be disciplined

- We provide/provided the means to maintain the status quo…

- We must react to the market situation according to the long-term price predictions and not give too much attention to the short-term fluctuations. There is not shortage of oil so far in our business horizon and we rely on the price information.

- We have many decades of supply left to us.

- In line with our policy to maximize our shareholders interest, we continue to invest in both upstream and downstream of the oil business, in line with our scenarios of future supply and demand with their corresponding price structure, within the limits.

- They are only doing their business and don't take care how to save the world.

- That Western government taxes on oil are too high.

- Many things that turn out to be untrue.
- That they had to deal with the above attitudes of the governments and societies, so they tried to respond to the market demands.
- State controlled oil production is to blame.

1.7 As can be seen, the world was doing pretty well until about 2005, when efficiency was at its peak The easy conservation targets such as…. were being harvested.

- Increasing energy-efficiency in industrial production processes.
- Speed limits.
- Electrical energy, solar, hydraulics, wind.
- Switching to smaller cars and insulating houses more.
- The use of other types of energies.
- 10 – 15 %
- Energy from natural renewable and efficient home energy devices.
- Large-scale industrial use.
- Taxing SUV's and requiring fuel efficient cars.
- Insulating for cold.
- Reducing CO_2 emissions; reducing power consumptions by achinery, introducing ICT for intelligent homes and transport.
- Domestic heating and lighting, better fuel injection, better electrical installations, etc.
- Automobile mileage and "insulation"
- Substitution of old facilities with new technology.
- 10%
- High-efficiency engines and savings in heating systems etc.
- Taxation for air plane fuels/ in Europe harmonized patterns for the promotion of renewable energy (e.g.: feed-in tariffs), which were on the other hand to low to support major breakthroughs or structural changes.
- More efficient vehicles and less wasteful industries.
- Car engines in the USA.
- More hybrid cars, higher coal and gas use, etc.

1.8 Carbon trading became a game with loads of experts and their computer models leading the way. CAFE was beefed up almost everywhere. Another policy that changed was:

- Energy labeling as it got only very limited results
- Tax incentives for low energy using vehicles
- Mechanisms CDM of the Kyoto protocol
- Coal was used more
- The promotion of other sources of energies, like solar energy, biomass and the fission
- The efficiency regulations for domestic and industrial devices and systems
- Oil for produce exchanges with poorer oil rich countries
- The growth of natural gas use was restricted, because of CH_4's role in alleged anthropogenic global warming
- Public promotion of larger dwellings
- Transport with the introduction of access charging in city centers and just-in-time mobility and energy supply diversification
- Towards compulsory renewabales use
- Support for "Tele-Living", virtual vice physical - reduced physical travel.
- Combined heat and electricity generation and micro plant utilization in a distributed consumption pattern
- A price loading was applied to non-renewable energies in OECD countries whilst renewable were subsidized.
- Elimination of import tariffs for ethanol and other biofuels, in consumer countries, which has promoted an increase in the production level of such products in developing nations
- International efforts dealing with reduction of hydrocarbon emissions.
- Unrealistic prestige projects, which were doomed from the beginning due to too high costs (or may be even physical unfeasibility)
- Loose environmental permits for new industrial developments.
- The mandatory ethanol component use agreement for gasoline and diesels.

1.9 One spot that's a bit brighter than the rest in this grey picture (no pun intended) is terrestrial solar energy. Although space solar projects (1.03) have foundered as a result of… terrestrial solar (photovoltaics, solar thermal and solar power towers) now accounts for a healthy 1% of the world's energy supply.

- Transportation problems from space to earth

- Development of hydraulic energy
- High costs
- Their promotion and their advertising to the public
- Their large economic cost
- Lack of technical skills to develop them and a protocol for space orbiting
- Their inability to generate energy even close to that required to put them into orbit
- Their technical non-feasibility
- High costs
- Lack of willingness of nations and states to change their building codes to permit new solar energy conservation and generating devices.
- Costs and storage limitations
- The cost of space access.
- Oil corporations' interests dictating public policy in the U.S and a reduction in funding for NASA, ESA and ASA (Australasia Space Agency)
- Underestimating the amount of the energy transmission losses to the earth stations, which rendered the projects economically non viable
- Decline in the field of space research
- High costs and difficult logistics
- Lack of raw materials required building them.
- Technological barriers and high costs.
- Exorbitant costs and technological obstacles.

1.10 Some analysts think the anti-oil mission of the terrorists is to cause democratic governments and secular economies to fail so that fundamentalist governments can take their place in some oil-producing nations. There may be another reason:

- Religious extremism in other regions of the word, including the West
- Withdrawal of Western troops and corporations from Moslem countries to "purify" the Islamic caliphate
- The political and economic interests to obtain the control of the oil companies
- Taking control of oil rents so that their leaders can become rich

- Terrorists, mostly from Arab or Muslims countries, would like to see the rise of the price of the barrel of oil in order to enrich many Middle East countries.
- To disrupt the well being of western societies
- People in terrorist friendly countries feel that it is oil that has enslaved them
- Terrorism has increasingly become a protection racket, functionally indistinguishable from organized crime
- They want the industrial countries to butt out of their domestic politics and stop supporting dictatorships to keep their oil flowing.
- Larger differences in the living standards between elites and usual people in oil producing countries
- Keeping the status-quo; avoiding reforms in Arab countries and alienating the moderates; maintaining wealth concentration around oil exporting industry and discouraging more widespread wealth creation in other sectors
- Oil refineries, processing plants, and storage facilities represent an "American" presence in foreign countries and, for this reason, are "targets of opportunity" for the opposition, such as terrorist groups.
- Persuade Western democracies to become Islamists
- Rise of major Luddite reactions to the rapidly [far too rapidly] developing changes due to the ongoing technological revolutions
- To save the oil sources for the future generations and for achieving proper negotiation power in the business
- Terrorists hate the U.S, particularly corporations whose cultural colonization threatens their cultures. Attacking U.S (and allies) oil suppliers and distribution networks is a way of demonstrating weakness in the U.S culture and way of life.
- The supply disruptions associated to terrorist attacks continues to increase/maintain a high risk premium within the oil price structure, which contributes to weaken the western economies
- To undermine democratic governments by pushing them to adopt so strict and hard security provisions that actually they will be changed to some extent in police states
- Increasing oil prices to increase support and revenue for terrorist groups.
- To increase uncertainty in the rich countries.
- Keeping oil prices artificially high as an attempt to world domination.

1.11 So, yes, I am a skeptic. It seems to me, I've heard it all before. What people miss most about the old days is

- Lagging acceptance of new technologies (in ageing societies) and the missing will and courage to creatively develop and – stubbornly – bring about solutions to problems.

- Man’s ability to overcome resource limitations
- Oil engines in cars
- Driving and not wearing heavy coats inside
- There were other types of energies used
- The drive to eradicate poverty in the world
- Having someone they could believe in, who tells the truth if indeed anyone knows what truth is any more
- Vacations in distant places, varieties of foods from around the world
- There haven't been any. The good old days were in 2000 when we could have started making a difference. According to this scenario, the rich and powerful used every ploy in the book to maintain their illusions. I hope this scenario turns out to be wrong
- That words and deeds do not meet.
- The certainty on how players behave in repeated games (see gae theory). The certainty of being exclusive masters of their own destinies; unless the type of game is anticipated or assessed at different levels (for different players)
- Unlimited use of inexpensive emergency by all.
- Stability
- The essential evolutionary "predictability"
- Mutual respect (more than in the old days) and cooperation
- Their trust in governments to do something about the problems. It's common knowledge now in the U.S that the government isn't really running the show - it's the oil and oil-dependent corporations pulling the strings.
- Global warming, earthquakes, hurricanes and pandemic scares, were only a minor nuisance in the past when we compare with the major concern that they are today
- The feeling of security and hope
- The vision of a future where energy was cheap and abundant (which was given beautiful names like hydrogen economy or the fusion age)
- The relative security and stability of oil prices and supplies.
- The ability to squander energy for pure fun.
- That they have lost a chance to coordinate their efforts in the global scale to improve energy policy. Egoistic interests of nations have prevailed both in getting access to energy sources and in common policy of developing new sources and energy saving. Instead of launching joint research project (EU + USA + China), each country has developed its own policy for obtaining energy sources and for energy saving-oriented research

- Closeness to nature, and a simpler ungadgeted life.

1.12 What would make this scenario more plausible and useful?

- I have a small problem with figure 4: the projection curve should show higher price volatility to be compatible with page 5, third paragraph; you might mention this in the text. Investors hate price volatility. Secondly, the drop after 2015 should be steeper to reflect the recession as on page 7, second paragraph.

- The economic crisis intensifying in Moslem areas – a rich elite and an ever-growing multitude of young, poorly educated, unemployed youths. Result: overthrow of elitist regimes in Egypt, Saudi Arabia, Arab emirates, etc. to shift control of oil suppliers to Moslem extremist groups; introduction of military actions to secure oil supplies; confrontation between China/India and the West to control oil supplies, manipulation by Moslem regimes to pit China/India against West. Development of new technology to ease energy problems. For example, nanotech assembly and manufacturing.

- To collect and introduce more information regarding the development of renewable energy technology in the world in your document must be very useful.

- The impacts of India (consumption and technical genius), Brazil (strong national policy of energy independence and a nation-building pioneer spirit), and Russia (vast resources and resurgence of totalitarianism with corrupt capitalism) should probably be added. Brazil could become a model of energy commonsense. Then there is the African case: as "wealthy" nations feel the pinch, they are likely to drop much pretense of humanitarianism with the result that Africa would suffer ever-greater chaos and re-colonization of energy resource-rich regions. Elsewhere, Africa could start to seriously depopulate through disease and inability to buy energy intensive products, like fertilizers and vehicular fuel to move goods and people across the vast distances.

- To create scenarios of futures so that people notice themselves of which they are our options of future. I think that China will reach the strategic balance at 2012 with the U.S.A. by effect of their program of SSBN. On the other hand, in that year I consider that the U.S.A. controls more 70% oil of the world, on the basis of their next incursions in Iran and another one of diplomatic order/political in Venezuela, reason why the only form that it has left to reduce the accelerated growth of China is the rise of the price of petroleum to $150.

- That high oil prices cause a "great Depression" There is no way that the current economy can transition to new low energy use technologies such as the Sedan car without a major economic recession. This will definitely cause political upheaval and a return to isolationism.

- Psychological component is missed or underestimated. Events such us those manifestations in France of youngsters full of anger by xenophobe and loose of hope can be repeated anywhere. People can just become tired enough of their poverty to make protests violently against their own people. How governments can moderate those reactions if they exclude them?

- First of all there is a great need of full implementation of policies designed on promotion of renewable energies, like PV, by policy-makers in various countries, either developed or transitional economies. Secondly, there must more financial support of researches dealing directly with new sources of energies, which are not damaging to our environment. There is also a need of promotion of these new sources of energies to the general public leading to the energy substitution.

- Taking it out of an USA context and making it more global

- Stronger recognition of already-present demographic trends (especially in Europe, Russia, and Japan), which are going to have pronounced effects on various countries' priorities & economic vitality in the next two decades.
  b. Stronger recognition of the influence of governmental regulation and NGO-style legal obstructionism on energy developments. These could seriously impede so-called renewables (land-hungry & visually-unattractive wind factories and solar arrays) if left to grow -- but could lead to a blossoming of nuclear power instead if reduced.
  c. Recognition of the looming conflict between OPEC/Russia and (primarily) the European Union over sharing the economic rent on oil. Current EU members' tax policies mean that EU governments are taking the lion's share of the overall economic rent from oil -- much larger than the share going to OPEC governments. It is quite conceivable that those OPEC governments which are faced with declining production may seek to go over the heads of EU governments and convince EU citizens that the oil taxes they are paying to EU governments should instead go to poor OPEC countries.
  d. Eliminate the distracting extreme left-wing bias in the language, which simply serves to discredit the whole scenario.

- Within its presuppositions, it's fine. It does betray a gross ignorance of what the US in particular and Europe and the UK to a lesser extent have done over the decades to produce such a mess, especially in the hostility from the oil producing countries. They are not forcing us to take their oil. We are the addicts, they are the drug dealers. A useful scenario would identify what's maintaining the addiction.

- The challenge of new gene technology in the energy production is not much discussed

- The scenario is rather plausible. The forecasts could be unfortunately reliable. Maybe stressing that other actors within the developed world would emerge (China and India will be developed) and that would create a more multipolar (and more unstable) situation. But there are always opportunities in this (such as energy technologies might well come from these new actors as well). They happen indeed to step directly into new technologies without taking the burden of legacy technologies (e.g. in ICT they adopt directly wireless technologies and innovative services, such as mobile payments/banking; while existing legislation and conservatism hinder these developments in developed countries). Thanks for the scenario

- Well done!!! Some refinements mentioned above.

- The high prices will lead to high purchases and investments by the oil rich countries and the world economy will find equilibrium at higher prices; high oil prices will compel users to move towards, conservation and to alternative fuels.

- Make the technology bits more realistic. There are MANY techs on both the production and conservation side which, given acceptance of the accelerating energy double whammy of prices and warming, would be supported/applied with fairly rapid and efficacious impacts.

- It takes into account only proximate causes (immediate causes of conflicts and possible outcomes from a battle between them; the Westernized world seem to position itself strategically in a very vulnerable position, one must agree with the scenario. But the scenario would become more credible if also some of the ultimate causes would have been dealt with more rigor and without prejudices. (those behind the proximate causes and intentionally and causally capable to produce them. In this scenario the ultimate cause behind terrorism (a proximate cause of conflict) is assumed to be willingness to destroy the world and people! It is not very plausible even about the terrorists.

- If this is for the U.S - it's OK as is. If this is intended to be world-centric, then references to the Super Bowl and the US Federal Reserve etc need to be altered as 'the world' doesn't jump to

these tunes (particularly Pacific Rim / Australasian countries). A general comment: the exercise so far seems to be overly focused on oil (possibly as a result of the U.S over-reliance on it?) whereas many countries in Europe and Australasia have already accepted the need to switch to renewables and innovation has resulted. Scenarios for energy in China (developed in Australia in 2002 prior to the $25bil China LNG contract) anticipated China's leapfrogging oil dependency and moving straight into alternative forms (gas, hydro, fuel cell, biofuels etc). It seems to me the Skeptic scenario is about an inward-looking U.S.

- Venezuela oil belt of 1360 billion barrels oil in place and reserves in the process of being certified of 236 billion barrels, deserved to be mentioned in the non-conventional energy section.

- I miss the description of consequences of continuing pattern of energy consumption in the field of environment (global warming and its consequent effects-draught, climate changes, huge environmental migration), and in the field of international relations – many wars could be expected both among gas and oil importers as well as among the gas and oil importers and countries producing the oil. At the same time I miss the description of expansion of oil prospectors in new regions, e.g Africa. Yet today it is apparent, how some growing consumers, e.g. China, trying to dominate oil production in Africa (Sudan, Angola)

- First of all: congratulations for this daring BAU scenario! Two general remarks: I gave it to a colleague to read and as he is not as fluent in English, he said he found the sophisticated language difficult to understand. (I can't really support this point, but you may consider it nevertheless). What is more important is that the perspective taken is quite US-centered. Narrowing the "State of the World" down to developments in the US and China offends a little our Euro-centered picture of the World. What would need a little more explanation in my view: Figure 2 implies that most of the world's energy demand growth is due to China. But the section on the sedan chairs hints more in the direction that China is developing energy efficient goods (cars at least) for their internal market and is exporting them in the long run. Why is the demand growth still so high? It seems China was quite aware of the necessity to improve efficiency. Is this different for other fields (e.g. industrial production?) Or is figure 2 misleading in the sense that the absolute growth comes mainly from the US?

- If prices were given in Euros, as the dollar will seize to be relevant.

- I think this whole scenario is written much to USA centric in the interpretation of dynamics and realities.

- I have many doubts about oil-terrorism. We should not put terrorism everywhere. Although there are many definitions of terrorism, but one factor is important: terrorism has a very important demonstration effect. The damage is not done for the damage itself, but for sending a message to the society, enemies and allies. In the case of oil, the situation not necessarily will be like that. If they become radical, anti-Western, there will be no terrorism, or scarce. If they are liberal, they may have problems with terrorism. Sorry once again. At present it is only Kuwait and some of the small Gulf states that are rich in oil and can be seen as liberal. Who other is liberal – Saudi Arabia, Iran, Iraq? In my opinion this part of the scenario is misconceived.
  A. The scenario is very detailed but it is missing the political impact of the possible energy shortages. For example, an interesting question is arising whether potential energy shortages will stimulate international cooperation, or on contrary, the world would return to an epoch of conflicts for resources.
  B. An interesting historical precedent should be recalled. The past wars were caused by the will to obtain access to resources – food, minerals, wealth of the invaded nations. At present, with an increase of efficiency of agriculture nobody is willing to invade for having "Lebensraum" or to conquer the resources. In the future when a pessimistic scenario will become true, the world can return to an old age of wars for resources (back to the 1st half of the 20th Century).
  C. As I have mentioned above, the "liberal" countries are not so numerous among the oil-rich

ones. Unfortunately, I am afraid that the countries of the Middle East will become more radical and more extremist. This threat may become a stimulant for an enhanced effort to invent alternative sources and to improve energy savings.
D. The part on terrorism is not relevant to reality. The main security-related challenge before 2025 will be whether scarcity of oil and increasing demand will not cause tensions. Will the world turn for military force and dominance to gain access to the oil-rich countries?
My overall assessment of this scenario is quite positive. It provides a comprehensive and coherent vision. The remarks I enclosed should be treated as a small contribution to the improvement of quality of this and other scenarios.

- It seems to be presented from a point of view that mostly reflects a US mentality, not a more balanced global or world mentality.

Scenario 2: Environmental Backlash

2.1 Other backlashes from nature included:

- Increase incidents of migrations of animals and diseases due to changing climates. This kills off local species and increases environmental changes in every corner of the globe.
- Sea level rising will destroy some cities near coastline. Sand dust storm will hurt lungs of residents.
- Fresh and saltwater bodies experienced massive blooms of noxious or useless vegetation as a result of rising temperatures and increased nutrients from waste discharges.
- Acidification of the Oceans from CO2 deposition resulted in the extermination of hundreds of species of marine life.
- Vast migration of people away from places of ruined life conditions to anywhere escalated the backlash and made it a violent global disaster and the radiation pollution from the accident spread toward the populated continent of India and elsewhere around causing bitter political dispute between the states.
- Increased numbers of flooding including Europe.
- Skin cancer and other sun intensity related problems increased.
- To galvanize a movement, I would expect there to be more direct impacts and indirect impacts from the radiological incident emphasized. For example, one possible text modification “massive fisheries collapse, first in the Indian Ocean as a result of the accident, causing food shortages in much of south Asia, then subsequently in other fisheries, as fishing pressures are re-directed. Consideration of a mention of direct mortality associated with the incident, or airborne widespread contamination leading to crop loss/failure in south Asia may also lend credence. Radiation causing the loss of plankton in the Indian Ocean, decreasing the biological oceanic CO2 absorption capacity, directly leading to a record annual increase in atmospheric GHG concentrations as measured at established monitors. This record increase leads to an acceleration of global warming impacts beyond the most pessimistic expectations. Consider that losses to populations from global pandemics will decrease energy/environmental stresses from human populations, some positive environmental aspects may be forthcoming from the reduction of demand on global production and consumption.
- Flood, geological disaster.
- Natural and man-made factors caused the food deficit in China. Diseases caused by industrial pollutions become more and more, especially in the countryside.
- That the frequency of the acid rain is now speeding in most area around the world, especially in north America and east Asia. And the sanitation of drinking water is also another major problem in most developing countries, especially for those poor.
- Great tsunamis destroy many major cities coastwise. Living environment in lots of cities turns unendurable because of worse heat island effects and air pollution thanks to intensive carbon-oriented energy consumption and irresistible urban sprawl. Rural areas are entangled by non-point pollution due to a strong requirement on food supplies.

- Extinction of biology, soil erosion because of deforestation, flu caused by migration of animals and so on.

- Large-scale forest fires that occur more and more frequently and destroy forest ecosystem irretrievably.

- Decreasing of biodiversity, erosion and degradation of land, disease caused by human's ignorance.

- Water/air pollution is a major threat for hundreds of people who lack safe drinking water or clean air.

- Extinction of biology, desertification and so on.

- Massive forest fires -- which turned out to be due to mismanagement (primarily the reduction in logging demand by environmentalists). Rapid spread in malaria, including to previously clear areas in Europe and North America -- which turned out to be due to the elimination of DDT and other insecticides demanded by environmentalists.

- Submergence of Gulf Stream in North Atlantic by Fresh Water runoff from Greenland icecap - Europe goes Cold, Rising Water Levels - MANY Coastal regions [where most people live] inundated.

- A doubling of the number of smog and heat alert days in major urban centers, accompanied by a doubling of premature deaths.

- Ever-increasing climate-related natural disasters like fires, floods, etc.

- The increase of tornadoes and hurricanes around the world.

- The failure of the Asian monsoon due to climate change lead to crop failure in South Asia. The effects on rice production were catastrophic leading to a regional food crisis in 2012. The event was directly attributed to anthropogenic climate change by a number of studies with high certainty.
- Sub-Saharan Africa experiences massive famine killing 20 million people due to severe droughts in 2009, 2010, 2012, 2013, 2015 and 2017. Rotstayn and Lohmann (2014) shocked the world by proving its causation was anthropogenic climate change.
- Persistent Organic Pollutants (POP's) mixing and interacting in the environment begin to show serious and significant human and animal health effects in industrialized nations. Numerous toxicological incidents in major cities spread panic and paranoia in the local population.
- Extremely powerful hurricanes effecting especially Americas; severe flooding and draughts are experienced in countries all over the world.

- Increase in the level of the oceans, submerging many coastal cities. Increase in the number and severity of hurricanes worldwide.

- Increase in global insect driven plagues.

- Decline in species, salinisation of arable land, NOx and small particle matter pollution.

- Global warming on this scale is likely to shift crop yields to more northern and southern latitudes, causing parts of Siberia, for example, to become a viable breadbasket. This would shift geopolitics as well. Falling crop yields will be felt in the more equatorial regions.

2.2 Environmentalists were brought in to work with company engineers to redesign their businesses, incorporating diversification into alternative energy sources, "green agribusiness," seawater agriculture, massive tropical forest growth programs for carbon credits, and

- Found it to be a complete waste of time. And that it was not the companies like ExxonMobil who were to blame, but people themselves who want the lifestyles that companies like ExxonMobil provides. They discovered that the market is about the best way to induce change.

- To plant elephant grass on large scale. To plant plants that is able to fix / solidify grits in desert. Converting seawater to hydrogen.

- Rising sea levels, threatening low lying coastal regions and islands.

- The burst of innovation by the largest corporations encouraged governments to tighten environmental legislation mainly by the widespread use of environmental taxation and emission trading systems to ensure a level playing field in the industries concerned.

- Space industry and small scale, modularly manufactured and assembled nuclear fission units, micro-turbine and other local-scale fuel cell or hybrid energy technologies.

- Energy service providers for demand side efficiency & savings.

- Technology to increase the ozone layer again and to build up ice and snow at the two poles and to educate the population in cutting down on energy consumption.

- I would also consider a policy interaction here as well. Although the threat of legal action does motivate business, policy also needs to be in place to accelerate business investment. For example, in the US the Bureau of Land Management has just released a Programmatic Environmental Impact Statement for the development of wind energy. This policy allows development on 70% of the western United States, in the area with the highest resources. The policy not only allows this development, but also expedites the process and streamlines the permits within a comprehensive framework. Another example is also the conversion of the current/former infrastructure associate with oil and gas to renewable energy. The footprint of oil and gas operations provides access to areas rich with wind and solar resources, along with the infrastructure of pipelines and power lines necessary to development. For example, an abandoned oil/gas well is converted to a wind energy site, and the pipelines to carry hydrogen (if electrolysis is used) along with the power lines to carry current are in place. The oil and gas companies could then become truly energy companies. To achieve this conversion, the economic and policy incentives must be included or mentioned prior chronologically to the oil/gas to energy company conversion.

- Spaceflight for extraterrestrial life and new mankind habit, ecological architecture.

- Advance energy utility efficiency.

- Industrial production chains of ecotype, changing the pattern of dealing with the waste of production into the pattern of utilizing the waste of production effectively.

- Recycle / reuse waste heat energy from manufactural, mining and power industries. Stimulated compulsive laws on high energy-performance urban development. Implement green transportation planning and relocate sites of human settlements.

- Cleaning production and cycling economy for industry park arrangement, massive grassland planted in temperate zone, etc

- Exploiting non-pollution means of energy utility or transformation such as wind electric power generation.

- Organic agriculture, cycling economy and cleaning production, dessert agriculture, utilization of green energy; circular economy; cleaning production and cycling economy

- Massive public relations campaigns (modeled after the successful BP efforts of the early 2000s) to fool people into believing that they were becoming "green" when in fact they were continuing business as usual.

- I think you have missed the most logical target in all this. The environmentalists know that nothing happens without finance and that's why they target the World Bank, G8, Big Finance Institutions. In this scenario you would expect these attacks to become ferocious, calls for people to withdraw their money, civil disobedience etc. My draft book was on this subject. You are welcome to a copy to glean more ideas here.
- Perhaps the active use of gene technology for the development of bioenergy plants/microbes is not in line of the probable risk-avoiding/irrationalism of the scenario. At least those countries with real energy problems would try to use that possibility

- Synthetic Phptosynthesis for H2, Genomic biologics for H2 via Photosynthesis, Highly efficient [entire visible spectrum plus] photocatalytic electrolysis of h20 for H2, Nano plastic efficient PV
- economic instruments to modify individual consumption of fossil fuels such as road pricing and carbon taxes.

- Large-scale efficiency drives. More active carbon markets evolve with strong civil focus on company activities.

- The standardization and internationalization of carbon taxes.

- Sustainable technology campuses are set-up in cooperation with high-tech. companies and communities, to develop new local needs based technologies. Life Cycle Analysis (LCA) and standardised compability (allowing hardware and parts to be swapped and replaced e.g. in cars) become the new vision. Environmentalists became extensively involved in training and education seeking to influence human behavior in a way that would lead to decrease in energy needs.

- Wind, solar and wave energy projects sprang all over the world

- Fighting corruption in ONG and government.

- And fund programs for global energy saving and water cleanup.

- Desalination activities for seawater. (which is the other alternative to raising seawater tolerant crops)

2.3 Many wealthy individuals to support the Global-Local Energy-Environment Marshall Plan (GLEEM Plan). For example:

- The government simply taxed polluting activities, and allowed the market to adjust by itself to the problem

- Voluntary 1%-tax payment to UN fund for energy technology development and transition

- I am not so sure whether they were successful. The success was in getting rich people to fund projects. It's more questionable whether the projects they were convinced to fund where right in their scope and their agenda.

- These individuals become investors to fund research into promising technologies, such as concentrating solar power (CSP), solar photovoltaics, biopower and wind. The investments are launched in developing countries, alleviating the need for the consumption of liquid fuels at stationary applications (remote generators, etc.) thus allowing these fuels to be available to markets for transport purposes. This technology transfer combined with an transfer of fuel availability dampens fuel price increases, lowering the economic impacts to those countries suffering without alternative means to transport goods while stimulating the economies of developing countries.

- Environment audit in companies, ecological risk evaluating in new project

- Many bigger investors would like to invest those promising and sustainable projects rather than other projects.

- In China, more and more Eco-Industrial Park are constructed and more and more people would select green productions even if they are expensive.

- Companies from Fortune Top 500 list (esp., energy, electronic and financial companies)

- They echo this plan in every occasion, propagandize it, and adopt the same way to organize their own production, of course, massive capital were donated to support scientific research

- There are there are more and more relatively wealthy families China which prefer green productions even if they are expensive.

- They prefer make more expenditure to publicize environment effects of their production, it would give their company high reputation.

- A fund was laid to collect charity from wealthy person for the purpose of helping non-green company redesign their procedure

- Adopt the same way to organize their own production, donated to support scientific research

- Many wealthy media figures painted their private jets a nice shade of green. At the annual get together of the beautiful people at Davos (swept clean of ordinary people, except servants, and protected by the Swiss army with "shoot to kill" orders for protestors), the airstrip almost looked like a lawn due to the acres of green planes.

- In this scenario Brazil will become powerful exporters of fuel. What about the instable nature of the Soviets while they hold one of the keys to continuing European oil supplies. There are new biofuels around the corner - Jatropha and Cellulosic Ethanol from biomass are the two leading contenders. We have lots on these in our client study. The biggest roadblock to biofuel usage are long-term cost levels vs oil and speed of regulatory change. There is no formalised world trading market for biofuels today but signs of one forming. In this scenario I'd suggest it would be fully functioning

- Scientists for Global Renewal was established. Besides the promoting of the GLEEM, the other reason was to oppose the irrationality (working without evidence) of many activist groups e.g. related to the use of gene technology. Its own World Energy Prize

- Dean Kamen, the engineer who invented the Segway, has developed a low cost environmentally benign source of fresh water in parts of the developing world deprived of this resource, called the Slingshot,- and over time this tool changed the face, health and quality of life for most of Africa

- Seriously wealthy indiviuals increasingly see their duty in becoming involved in poverty alleviation - using the MDGs as benchmark.

- not only governments but many wealthy individuals contributed to global environmental causes and programs.

- A group of European Philanthropists known as 'Clarimonde' set up a massive early action plan for developing countries, to supply them with sustainable energy, technology and thereby economies that 'leapfrog' the wasteful stages experienced in 'Western' industrial development and address poverty. Celebrities and 'people of media' became massively involved in setting new 'green' trends by their own example.

- GLEEM please take the M out

- India's richest entrepreneur supporting water cleanup efforts in Asia, and China's billionaries club investing in desert erradication programs in Africa, Asia and South America.

- in Europe, the club of 100 richest individuals, bought several millions of acres of land, and created a network of private nature reserves.

2.4 Other elements of the GLEEM Plan

- To limit the profit and technology license fee of products that have huge impacts to energy conservation and renewable energy development. The principle is the same as treating medicine against Aids, Birds flu etc.

- Establishment of a World Environment Organization to serve as an umbrella for the major multilateral environment agreements and a framework for harmonizing them, providing a common dispute settlement mechanism, and technical assistance to ease the burden of compliance on developing countries

- Massive partnership program for women and men of family life cycle planning and prioritizing the primary needs for energy development

- International Agreements on taxation of fuels for international transport (both air and water)

- I think one has to add religious/faith groups into the education program as well as indigenous and marginalized groups

- Education for youth

- Establishment of a special agency to help developing countries to improve their energy production and utility level.

- The science and technology forum should be hold to exchange the lessons and successful experience among the partnership member countries termly

- Cooperation with other international organizations with all kinds of forms

- Form an affiliated group of world high-class environmental specialists, working for clear and concrete objectives, while contributing to good practices/ 2.4 set up assessment systems on different spatio-temporal scales and publish annual reports to public

- A authoritative unique Global Green Label accepted by all countries and a series of technological and management standards be set

- Recommendation and harmonization of environmental legislation, especially to developing countries, and between developed and developing country, respectively

- Massive acceptance of Green Production and the recognition of the authority

- A committee was built to make the entire plan available and time-dependent valid and give publicity all over the world

- Scientist in different counties work together to find the new energy or the new or cleaning way to use the tradition ones

- Creation of a task force to hunt down and kill the miscellaneous Marxists, anarchists, & nihilists who used the environmental movement as a cover for various kinds of criminality.

- Nothing here about how corporations had seen the opportunity of biofuels and begun early investment in plant creating unlikely partnerships e.g. Cargill and Tesco (just announced). These early entrants will make a killing in this scenario but as with Bird Flu will be forced to share their secrets and lose their patents. Measurement will improve that means one energy source can be directly compared to another on all is impacts and results Biofuel costs will fall as feedstock yields increase

- A key role was given to Scientists for Global Renewal -anti-irrationalism association. It decides who gets the World Energy Prize.

- Adoption of a triple bottom line model as a basis for international financial assistance through the World Bank and UN Development Programme whereby social, environmental and economic pressures are balanced with due regard and priority to all three.

- Establishment of a World Environment Council for long-term planning to avoid environmental destruction.

- The launching of a Post-Kyoto Protocol that was both economically and environmentally beneficiary to both rich and poor countries.

- • Local Energy Management Agencies (LEMA's) become standard in all local and municipal authorities worldwide. Set up to implement and manage local energy plans to maximise community energy production and efficiencies at the local level. Decentralised needs based energy systems become a highy-valued goal in communities.
  • Energy Systems Technology based on simple Information Technology becomes common place, managing and monitoring energy demand at appliance, building, community, city and national levels.
  • LCA energy ratings of all consumer products becomes standard, and valued by consumers and investors.
  • A global technology transfer initiative is significantly advanced, focusing particularly on developing countries to enable economies develop on low carbon paths early in development.
  • GLEEM set up special Citizen Section with numerous local branches in countries all over the world providing training, advice, and assistance to individual citizens in becoming more

environmentally friendly. The Citizen Section offices have extra funding for assistance and training of unprivileged.

- Promotion of manpower intensive businesses in less developed countries to both help the environment and generate export-related economic activity and social wellbeing.

- At local level, regulation.

- A little bit ironical – establishing a controlling and coordinating bodies allowing to make GLEEM 's efforts more efficient. Then it will be necessary to establish a controlling body to the controlling body, etc., etc., Speaking seriously, the GLEEM idea sounds very interesting. However, it includes an important TRAP. It is assumed that the forthcoming energy problems CANNOT be solved in a way proposed so far, i.e. liberal market mechanisms + "techno fix" (belief in a mechanisms according to which humanity will be always able to solve its problems thanks to sel;f-regulation of nature and human innovativeness). Of course, it would require further discussion but the concept of GLEEM reflects this important doctrinal, more or less hidden assumption. For example turning UNESCO into another world universal educational institution. / As a specific point I would suggest efforts to change cultural patterns of consumption in the developed world. But it is rather difficult to achieve without economic incentives, although some efforts can be undertaken. How to make the SUVs non-fashionable in big cities?

2.5 Rooftops from Egypt to Ecuador are getting solar panels. However, one of the biggest retrofits that helped alter the energy situation was

- Using coal instead of oil and gas and using cleaner coal burning technology. Although it didn't help global warming, but the economy simply had to adjust to the global warming problems as they arose.

- Converting water to hydrogen and driving vehicles with hydrogen in around 2020

- Improved insulation of existing building stocks.

- Requiring all power plants using fossil fuels to capture and store CO2 from the smoke stack emissions

- Thermal/cooling insulation of buildings with conventional and new materials developed and maintenance of water pipe and other infrastructure against environment hazards.

- Improved air conditioning devices

- One can't really say but one has to retrofit air conditioning and retrofit other electricity using parts

- Development of low-cost highly efficient energy storage systems that complement the solar roofs and other developments, allowing individuals to go "off-grid", the beginning of a distributed energy system has begun. The development of highly efficient electric water heaters, space heaters and refrigerator systems that utilize the energy generated from solar roofs, decreasing home GHG emissions along with slowing the rising demand (Households are the second fastest growing demand area after transport, heating the largest portion in OECD, followed by water. Lighting is a small component.)

- Direct use of solar energy source

- That the massive use of polar energy for cooking and other daily use

- That cars and trucks can be driven by more different fuels
- Develop new technology for saving and find new energies through all kinds of ways
- Pre- and post-analysis on life-cycle ecological loadings of every technological retrofit before installment
- Better use of natural light for heating, lighting, as well as saving electricity, and driving vehicle
- To invent a new technology for generating electricity in a large scale and without pollution
- Make good use of natural light for heating, lighting, as well as saving electricity, try to find new energy to take place that used now
- In some countries government just prohibit to use traditional fossil energy in special vehicles
- Find the new energy or the better way to use of the tradition energy
- The death of suburbia. With people no longer able to afford the high costs of energy, families were forced back into cities where they lived huddled together in high density units. With the end of air conditioning (due to environmentalist objections), much of the southern US was abandoned. The beneficial side effect was that energy use dropped dramatically, along with the standard of living.
- People's increased awareness, helped by promotional advertising, that cut all forms of wasted energy from switching lights off, car sharing etc. You haven't got energy blackouts helped create awareness
- That after hard disputes also the options of the new gene technology were realized. The role of Scientists for Global Renewal -anti-irrationalism association was decisive for that. It was especially important for the production of new biofuels (compare transportation)
- 30% plus efficient direct conversion [thermal-to-electric] to recover/utilize "waste Heat, biomass fuels in lieu of Petroleum/natural gas USING SAME INFRASTRUCTURES
- Addition of hybrid electric engines to cars trucks and buses with the recharging of these engines provided by renewable energy sources - principally wind power in areas close to oceans and large water bodies. Wind turbine efficiency at low wind seeds has
- energy efficient principles being applied to new housing stock in the developing world. By employing passive solar design (and later shadings where necessary), effective lighting and simple insulation principles, many thousands of new homes can contribute to energy savings.
- the advancement in nanomaterials that could absorb solar energy more efficiently and under almost any circumstances.
- Advancements in heat controlling paints, surfacings and insulation helps to reduce building energy consumption by controlling temperature in the interior relative to the ambient temperature (retaining heat in the cold and releasing it in warm periods). Extensive usage of geothermal energy for heating homes and water.
- The massive implementation of CO2 sequestration in existing fossil fuel power stations and home heating systems

- Proper building standards (insulation, spatial orientation, ratio of windows, efficient heating/cooling systems, localized energy production.

- Development and recycling of non-fossil environmentally friendly natural earth materials for worldwide mandatory use in roads and highways construction thus eliminating the use of asfalt on a planetary scale. Furthermore, this green earth technology was assigned for production only in less developed nations (Africa, South America, Asia), to assist their quicker development.

- When world's governments decided in a unanimous action to retrofit their buildings (government as a launching customer).

- Restoring importance of the black coal. Thanks to the new methods of minimizing the pollution caused by coal, several new applications of coal heating were introduced. Similarly, a new technology of producing liquid fuels and gas from coal allowed diminishing reliance upon oil and gas.

2.6 A magnesium alloy with a modified nanostructure was shown to store enough hydrogen to allow a vehicle to drive 500 km back in 2010, but commercialization has been slow because

- All these ideas suffer from the entropy subsidy problem. Any alternative energy is (due to physics) a lower valued fuel source in economic terms. This means that as the economy adjusts to these alternatives, the level of macroeconomic productivity will decline. In essence they will all create massive economics recessions in order to switch over.

- The logistics and infrastructures first have to be established.

- Technical problems, such as the requirement for operation at 350-400 ˚C, still have not been economically resolved. And, there is a vicious circle of risk aversion: no hydrogen supplier has been able to support the massive level of hydrogen distribution infrastructure needed to entice vehicle manufacturers and drivers to whole-heartedly switch to hydrogen. Chemical hydrides and carbon nanostructure materials operating at lower temperatures than metal hydrides are becoming competitive, at least in R&D trials.

- Lack of consumers' trust in safety

- Resistance of groups still trying to sell their established products; more expensive; no network of stations for replacement which might be a problem in general because why would one build these network of replacement stations if there is a newer better technology available in 5 years down the road …..?

- Small increase in temperature may imply difficulty in handling the block, should the point of the temperature change be relatively low. Difficulties may also exist in the manufacturing of magnesium nano-structures (These reasons are purely speculation on my part, my expertise does not extend to materials science!)

- The cost in high and the tech is not well-rounded

- The cost of the production of metal hydrides is too high

- How to get the hydrogen into the magnesium alloy conveniently or easily in the gas station is a key problem. And perhaps because the price of the device set is too expensive.

- Its price and people don't know if it is safe

- Large initiative financial input to start and support a correspondent network of "recharging" gas stations serving this new kind of vehicle
- The condition of road, weather, and so on are different in different region and in different time.
- Its cost of manufacture remain to be reduced for average person can afford it
- it will take a long time for mass to accept a new technology, as well as its price is much higher than the ordinary one
- The high price make the affordable consumer limited and the safety rate is low
- Maybe the higher price and the limited instrumentation
- Hydrogen embrittlement of metals -- which had been widely discussed in the scientific community but totally ignored by the environmentalists -- led to a series of devastating accidents with high mortality. Although the WEO tried to hush up the problem, the word got out. Environmentalists then realised that hydrogen was not a source of energy, only a carrier. Hydrogen had to be manufactured, and the processes were inefficient and led to more pollution than using the basic energy sources directly. Hydrogen came to be seen as the ultimate con -- where the environmentalists could not deliver what they had promised.
- I think the impact nanotech will have in the reference period will not be as great as you indicate. Nanotech is more likely to be emnerging than growing rapidly.
- Because ethanol and liquidized natural gas are cheaper
- The global demand for magnesium has exceeded the supplies, resulting in higher prices than most people can afford, resulting in an overall shift away from driving cars to using transit
- Demand was low. The weight of Hydrogen-driven cars also counters other energy efficiency improvements.
- Of very high production costs.
- The volatile world magnesium market due to the collapse of the Chinese production industry affecting the resource price. High financial costs.
- Of the cost associated to it and the lack of a massive distribution network for the product
- Overall economic balance of the hybrid systems is not yet very positive
- Cumbersome recycling
- These tended to explode.

2.7 The greatest growth the kilowatt-hours of electricity from solar between 2010-2020 was due to:

- People using them directly on homes, although with no appreciable cost benefit over coal.
- The high energy content of luxury goods and the refining of large amounts of exotic elements required for catalysts and alloys to produce the low-CO2 and energy “efficient” technologies – and to recycle them.

- Mandatory installation of solar electricity and water heating systems in all new commercial buildings_(roof panels and coated windows) in all OECD countries and the 10 largest non-OECD countries.
- Drop of PV cost in thin film technology
- Higher efficiency and cheaper solar panel or solar paint availability
- Initiatives that started in California to increase solar production. As per the CEC website - The California Public Utilities Commission is committed to solar resources for assuring the reliability of the state's electricity system. The proposal, issued Dec. 13th, would provide $2.8 billion of incentives toward solar development over 11 years. It also develops complementary policies and rules, sets new incentive levels, and addresses program administration. The program as the "California Solar Initiative" or CSI. California has often lead the way in air regulations, renewable energy, etc.
- 2030:_40%
- The great progress we have made in the technology of the transition efficiency of solar energy into electricity
- The technology development of the sunlight panel
- New technology which can help people gain steady and plentiful electricity from solar
- policy on subsiding solar power industries or reducing their taxes and
  2) policy on compulsive proportion of purchasing solar electricity towards extensive end-users
- The development of advanced technology and the rise of price of traditional fuel such as oil
- Advancement in manufacturing engineering of equipments for generating electricity
- The progress of new technology and the demand decrease of traditional energy because of the rising price and ethical education
- New technique concerning the major problems of solar energy
- The new technology
- Cheap covering materials collecting solar energy
- Solar concentrators and Nano-plastic PV ([highly in-expensive, efficient).
- Doubling of the cost of fossil fuel combined with a halving of the cost of solar panels
- Demand in the developed world.
- Consistent reductions in the cost of solar technologies, matched by improvements in their efficiency of energy production, allow these technologies supported by GLEEM to be transferred en masse around the globe.
- (Apparently there is an error in the previous sentence since 2010 is repeated) a major breakthrough in the efficiency of the energy collection system, associated with the utilization on nanotechnology

- Growth in Africa
- Quantum technology leaps
- Solar to hydrogen conversion on sunny spots.
- Three measures. First, sending satellites with a large surface antennas to the Space and to the Moon and building a system of energy transfer from there (so far I have any fancy functional idea how energy could be transferred from there). Second, a discovery of extremely efficient transformation of the solar energy into other forms of energy – batteries + something yet unpredictable (in technological terms). Building more classical batteries would require to take large surfaces (Sahara turned into a solar energy basin???) Third, placing high energy consumption industries on the space stations and/or on the Moon – it is rather a longer-term perspective. / As far as I now there are some natural barriers for wind energy – a fan and turbine on each roof, or on each 100 square meters? Field turned into the forests of wind-fans?

2.8 In the meantime, what is important to understand about electric production and transmission today in 2020 is

- Coal will likely be the biggest source of electricity.
- Coal is still the main energy source for power generation around 2020. The important work is developing technology to reduce its pollution and emission.
- Its high importance for the developing process in poor countries.
- The same billion-plus people who lacked adequate safe water in 2005, since 2000, also lack adequate electricity for machine power, though they now possess many of the low-power devices used by highly developed societies. They constitute an economic drag on all societies and a source of potential revolt. Financial and energy costs of slowing greenhouse gas production severely harmed accomplishment of world water supply goals
- Electric load is fluctuating in every time scale from instant to year and more and growing in trend-like fashions, which makes it economically and technically vital to design the electric energy system as a whole and not to separate any basic production (not adjustable power) design from the rest (adjustable according to the load) . If not observed the system will be economically very much more expensive and technically more vulnerable. With the central grid system there is a need for local small scale production units near the loads, which can only be met by some fuel cell and micro-turbine technolies in addition to conventional small-scale power production and combined heat/cool and power production.
- Grids have to a large extent been re-designed to handle rising shares of distributed generation
- There is an evolving decentralized network for energy, whereby the consumer is generating much of the energy needed in the home and for transport via renewable energy and efficiency improvements, decreasing the need for electric energy transportation
- Saving fossil energy source and exploiting for direct use of solar energy.
- Which is the most potential way to gain enough safe energy and which is worth to develop
- That more and more electricity are produced by the renewable resource ,while less and less is lost in the process of transmission

- New idea
- Facts and estimates of current situation and scenarios lying on different technologies
- To make use of new energy sources and new technology
- The efficiency of energy transformation and transmission
- The new technology
- The efficiency of producing and transmission
- To make use of new energy sources and new technology
- That raising the voltage in transmission lines the loses can be reduced. Therefore, more energy can be produced without consuming fuel.
- That the cost of electricity has increased dramatically, as it has become clear that all the "green" alternatives have much lower "energy amplification" than the old coal & nuclear plants, i.e. they provide much less energy output per unit energy input. In addition, the "green" sources are less reliable -- patients have died in hospital operating rooms when the wind driving their turbines died at an inopportune moment. A black market has sprung up in making & selling (illegal) gasoline-powered generators for domestic & small business use. Rather similar to Prohibition in the US in the 1920s, laws to require the use of "green" energy have resulted in many opportunities for corruption as people seek to salvage some of the life they once knew.
- That much of the world had no access to electricity in 2006 but now it does
- Much higher than now projected for that date.
- How to take electricity cheaply to the hundreds of millions of people who still have not even seen a light bulb.
- Efficiency gains since 2000 have exceeded population growth leading to a reduction in absolute consumption.
- World research to produce electricity via nuclear fusion
- That the global momentum is now irreversible in terms of continue moving or migrating towards a full "green" non-fossil power generation and energy world economy.
- That it locally destabilizes climate.
- There's still a chance that high-temperature superducting wire technology will significantly decrease transmission losses on some of the major transmission lines.
- That if any "remote" sources of energy are discovered/introduced/put into action the TRANSMISSION of large amounts of energy can become a barrier. SO perhaps remote sources of energy ("producers") of energy should be accompanied by the consumers using this energy without transferring it elsewhere – manufacturing companies on the space stations

2.9 What would make this scenario more plausible and useful?

- If it were mentioned that a massive economic recession would result during the transition to these alternatives and that most of them will be completely useless otherwise we would already be using them. Also the idea of entropy subsidies needs to be added. Most people don't understand what that means. It has to do with the fact that as the price of oil goes up, other alternative energy resources become more expensive. For example building a nuclear power plant is a lot more expensive when oil is expensive, the result being higher capital costs and therefore higher nuclear power costs.

- Leaders and theologians of major religions found hitherto elusive common ground: protecting "Creation". The side effect was that religious conflicts have lessened significantly from the levels seen in the previous two decades. Whether this represents a respite or a solution to such disruptions is yet to be discovered._ Allow for innovative chemistries to find a way around the high non-renewable energy inputs to make hydrogen; e.g.: Catalyzed, simultaneous application of ultraviolet light and microwave and similar "tunnels" through low efficiency electrolysis finally paid-off around 2015, reducing the need for brute force electrical splitting of water into hydrogen and oxygen. This also reduced expected demands for nuclear or other electricity by 50%.

- More emphasis on government imposed CO2 taxes and ambitious emission trading systems – with progressively smaller and smaller caps on the total amount of emissions permitted. This will drive the private sector to invest in the development an take up of the new technologies. Governments would not in general be the main investors in such technology. Citizens must be persuaded that paying more for electricity, water, vehicles, etc. Is good value for money since this is the way we will purchase environmental sustainability.

- To outline how the profit interest status quo behavior of companies and their stakeholders harnessing short term advantages might be overcome with violence or with violent pursues in court and demonstrations, and who then are the organizations to execute the programs. Further, the turbulent situation activates also the organized crime to execute its power to people and companies, how to mange with powerful crime organizations; need a stronger police forces and army for protecting civil rights? How all the positive possibilities available might find commercial channels from development institutions to industry and service business and to consumers?

- Some more ideas how consumers' lives change both in industrialized and in developing countries

- Comment is integrated in the document. Thank you for the opportunity to participate

- Humankind morality improvement, attaching more importance to science and educational

- Collect more suggestions from energy experts, environmentalists and engineers, spread propaganda and collaborate with governments and researchers and so on

- The fuel utilization structure(how many percent fuel is oil, gas, hydrogen, and so on) in the future perhaps make this scenario more plausible and useful

- It need the cooperation of many people all over the world including scientists , common people, politicians, and so on

- Add individual descriptions towards major countries and regions separately

- Maybe we need some model to predict whether there will be such catastrophic natural disasters in the last two or three years, and whether there will be a really unite between different countries, such as between developed countries and developing countries because of a lot of conflicts of interest always exist

- To modify the scenario into several versions according to acceptors' occupational background will make it more plausible and useful.

- It require more hard work of scientists to prove the facts which had badly effected or will effect our life, as well as the authorities support and the mass understanding

- It is more helpful to predict the effect on global economy, and how it will work if less traditional energy to support the world farming, producing, transporting system

- Need more research; enhance the cooperation between developed countries and developing countries

- The electrical energy produced by generating plants has to be supplied to the consumers by using long high voltage transmission lines. Why high voltage? Because the higher the voltage the lower are the loses. Forty years ago, Canada introduced first the 750 KV transmission lines. However, there are few such transmission lines in the world. The reason is that the extra high voltage lines are expensive and the investors have no incentive to spend money in order to reduce the loses. Consequently, by lowering the existing loses, a significant amount of electrical energy could be produced without consuming fuel. Thus, the emission of carbon dioxide could be diminished.

- Frankly, this scenario is entirely implausible. It sounds like it was put together by a teenager who had read about Marx but never heard of the Soviet Union. It completely ignores human nature, and largely ignores the immutable laws of physics. If it were to be more useful, it should include a more realistic appraisal of the motives & actions of the environmentalists, and of the consequences of their behavior. Are hard-line environmentalists going to accept the massive land-use changes involved in growing biofuels (where? in National Parks?), or in turning desert coastlines into factory-farmed monocultures? Are environmentalists who are concerned about invisible nuclear radiation going to accept the massive use of invisible microwave energy transmission to & from satellites, with birds dropping out the sky? What will be the likely consequences of environmentalists crippling the status quo on energy and at the same time preventing the emergence of any real alternatives? There is a clear danger of the kind of terrorist environmental movement so admiringly described in this scenario degenerating into mere criminal gangs. (It has already happened with political terrorist groups like the Irish Republican Army). There is also a clear danger of civil strife, even up to civil war, between citizens concerned about their declining standard of living and the environmental extremists they hold responsible. Are the bureaucrats in the postulated WEO going to be as corrupt and ineffective as the current crowd at the UN who deny DDT to African countries while children die needlessly of malaria? How will central planners in the WEO turn out to be more effective than their counterparts in North Korea? Rather than this pointlessly Pollyanna-ish scenario, it would be more useful to have a realistic version -- in which there was recognition of the consequences of the choices that societies will have to make about energy. If we could have a world in which energy was plentiful, reliable, cheap and green -- we would all choose it. The fundamental issue with this scenario is that if we want energy to be "green", we are going to have to give up one or more of "plentiful, reliable, cheap". The scenario should explore in a physically realistic way which we give up, and what the consequences will be for ordinary people.

- What was the role of America, the EU, South America in all of this and the outcomes for them? How did business respond? Was poverty (particularly in energy supply) still prevalent? What about the possibility of energy wars (or at least serious standoffs)? Who were the winners and losers? And, most importantly what are the implications and suggested solutions that we should all be working on now!

- The role of Scientists for Global Renewal -anti-irrationalism association.

- I thought it sounded great! I have one suggestion. I would not use the names of real institutions or actual people. You could use something like "one major international oil company, based in the US" or "one international philanthropist, based in NY" etc., etc. I thought that this would make it more "politically" acceptable.

- Try to relate the impacts of climate change to the individual and his/her life style and health - anticipating that when this done there would be more public support for national or international efforts aimed at reducing greenhouse gas emissions.

- Several environmental disasters and increasing discomfort for humans as a result of fuel shortages and temperature changes.

- More aggressive responses and attacks from angry environmental groups!

- Perhaps, more story, less detail… The scenario is too unwieldy. The numerical information describing the past and present situation should be real (taken from official sources). Examples of inconsistent numerical information: P.3 '…reduce greenhouse gas emissions to 1970 levels.' This is not useful in terms of climate policy as it involves about a 50% cut in emissions. The current discussion in climate policy circles is trying to agree cuts of the order of 60-80% in emissions by 2050. Therefore the cut detailed should be much more drastic and given the cultural conditions in the scenario could even exceed this as there is no 'safe' level of emissions. Also it should be expressed either as a % reduction or as an atmospheric concentration in parts per million (ppm),'1970' is not the kind of parlance which would be used in the climate field and is therefore not useful. P.8 '…cars and trucks used to account for about 33% of CO2 emissions.' This is not an accurate metric, in 2000 cars and trucks comprised about 12.9% of CO2 emissions (see World Resources Institute 'Navigating the numbers' 2005). P.15 '…humans still emit about 9 billion tonnes of carbon per year.' In 2004 globally 28 billion tonnes of carbon (GtC) were emitted. With population growth up to 2020 and reliance still on coal and gas this is not realistic even with carbon capture, it would have to be of the same order to be a realistic metric. Also the original 'post-Kyoto' target detailed on p.3 would constitute about 15 billion tonnes, and therefore is far above what is achieved in 2020 (9 billion) and therefore again an unrealistic metric as it is a huge over-delivery (as above, see WRI 2005). The scenario is rather difficult to read. Suggestion: either cut some of the detail or spread the detail over a longer story line. The change towards environmentally oriented way of living seems to be mainly based on technological development and innovation, which doesn't give the scenario much diversity. The transformation of human behavior is rather underplayed, however the change of human behavior seems to be crucial for many of the changes portrayed to take place.

- Less corruption in ONG and government of all countries

- Implement global birth control policies to reduce overall energy consumption, which is basically a direct result of human consumption.

- This scenario has a taste of one big disaster, but furthermore everything nice & sunny. More or less. Could add some unsolved or unsolvable problems...

- I'd make more of the composite materials for vehicles (ala "Winning the Oil Endgame" and less on biofuels (because of the high costs in fossil fuels to grow that much in developed countries, and because buying it from developing countries that can grow sugar cane more economically wouldn't reduce our dependence on "foreign transportation fuels"). As for being more useful, this is a pretty expensive future to get to. I would think it would help if you did a "retrospective" on what "greening" approaches contributed most to reaching this world... Continued good luck.

- - First, growing awareness of “real” threats among the world population. The “catastrophe” seems to be one of good signals

  - Second, better understanding of social mechanisms.

  - My major methodological doubt about this scenario is that it is assumed in somehow concealed way that the level of institutional intervention should be increased against the actually dominating liberal economic approach together with the beliefs in “techno fix”. This scenario is based on an assumption – “more institutional involvement + ‘techno-fix’”.

  - In addition, I am not sure whether we can so decisively talk about the “global warming effect”. I am not a specialist in the field but my scientific skepticism forces me to ask a question whether it will be a long-term tendency – what is becoming a common truth, or perhaps, it is but a long-term (20-30 years?) fluctuation. (Saying less scientifically, after an experience of one of the longest and coldest winters of some 20 years in Eastern Europe, and writing this during a cold spring, I can hardly accept the prophecies of the global warming – of course, it is a kind of a joke of a skeptic.)

Scenario 3. Technology Pushes Off the Limits to Growth

3.1 The NBIC technologies are proving to be the key to a very bright future where

- The development of new energy sources
- Limit will be in the political and economic area (strongly liberal economy with the small solidarity and insurance instruments.
- Intellectual and physical luxuries, as well as necessities, can be accessible to even the poorest societies, if political systems can evolve to keep pace
- Economy and society are based on knowledge
- Few boundaries remain for those in the 'connected world' which has replaced the 'developed world'. There are no energy shortages; the world has mostly overcome the hunger problem.
- Synthetic photosynthesis is used to manufacture hydrocarbons -- still the best form of fuel for mobile equipment -- and to use energy more efficiently in a wide range of different applications.
- We can really speak about unified technology.
- The machines increasingly do the work so efficiently that the cost of goods continues to plummet, tremendous "wealth" created.
- Beginning with renewable energy sources like solar, one could be sure that its only a matter of time for mankind to cope with future energy demand.
- Annual average agricultural outputs per hectare have nearly doubled and inputs (fertilization, irrigation) have been reduced
- There is a variety of energy sources, since renewable clean resources, such as solar, wind, geothermal, sea tides, sea currents, temperature difference, generated and utilized locally are substituting traditional non renewable sources such as coal, oil and gas and eliminating the need for mega centralized power plants and long power lines. At the same time new technologies have drastically reduced power consumption for most products and systems.
- Enough resources are dedicated in a coordinated manner for its development.-
- A green-based world economy is now here to stay, albeit with some limitations in terms of diminishing world poverty and inequality
- A constructive, mutually supporting effort to develop both these "yang" technologies but also the yin capabilities yield the kind of balance and inner stability in motion needed to sustain that motion. The adaptive web-based education to the other half also plays a crucial role.

3.2 other energy drivers playing an important role, like

- Electric, magnetic, hydrogen, fuel cells and Solar energy
- Bioetanol, bio-oil, biomass, wind power, nuclear power and sun power.

- What is told above about the Club of Rome's views by 2000 is a lie, ironically indeed, there is no evidence in the Limits to Growth report nor in the dossiers of the Club of Rome confirming the claim; Is the lie a part of this scenario or just part of the information war by WEC and IEA launched already by Herman Khan and Hudson institute in 1970s? It should be made explicit. I assume that the lie is not aimed to be part of the Millennium Project view of Club of Rome.

- A major change in consumption and conservation politics. Clearly, the Club had hoped to stimulate this, but it happened rather late.

- Climate change!!!, advanced energy generation technologies, new low-energy demand side technologies, behavioral and consumption change in the wealthiest nations, pervasive energy efficiency improvements (both generation and consumption) and decentralized electricity generation

- Marine current energy, energy conservation

- The demise of the environmental movement. Public distrust of extreme environmentalists had been rising as the mild warming of the late 20th Century gave way to the sharp cooling trend of the 21st Century. That distrust turned to disgust after a groundbreaking study in the New York Times showed how the UN and environmentalists had conspired to keep DDT off the market, even though they new that poor children in Africa were dying at a rate of 3,000 per day. Led by former members of Greenpeace, the people of the world turned overwhelmingly against the politicization of environmentalism. In the cold light of the new dawn, citizens realized how much blood was on the hands of the extreme environmentalists, and how many human lives had needlessly been ruined by false alarmism. This created a much more realistic climate, in which the benefits & costs of energy sources like nuclear fission could be considered. Nuclear power has grown rapidly around the world, and is now a key element in the "proper energy mix".

- Virtual presence replacing real presence

- Comment: Increased prices as demand for commodities exceeds their supply is the main driver for investing in - but more importantly, taking up - new technologies. Learning by doing and economies of scale then gradually cause prices to fall. Technology should not be presented as "manna from heaven". The role of markets must be mentioned.

- The major opportunities for conservation arising as secondary and tertiary technology revolution effects/impacts including tremendous energy reductions for computing, 30% plus efficient direct thermal-to-electrical energy conversion at low temperatures and factors of 5-to-8 dry weight reduction for transportation vehicles.

- Technology is making possible inaccessible remote areas to become available new oil and gas production and off-shore technology application at sensibly environmental areas

- Distributed power and heat generation at buildings and at homes from natural gas, biogas energy intensive industry has built their own power plants: mainly nuclear Traffic uses biofuels

- Space development have promoted energy generation from space resources, such as high efficiency solar cells, solar wind for propulsion, development of in situ resources from asteroids and comets. Advanced technologfies such as the utilization of lunar helium 3 for fusion power are still in the predevelopment phase as others such as matter antimatter. While a new space economy is being developed, totally independent form Earth's, such process is still in a very preliminary phase and will take several decades to be fully operational and in an ongoing development phase.

- Entering into force new regulations on application of Kyoto Protocol

- Reduced world population growth as even poorer nations move toward single child families, growing distaste for material consumerism beyond base middle class needs, and global resurgence of spiritual values that foment simpler closer-to-nature life styles

- The First Report to the Club of Rome portrayed a very pessimistic scenario -- but by explaining very clearly what would lead to it, they helped us understand how to avoid it. The Second Report actually did identify solar thermal sources, which some have dismissed as old and mundane, but have led to breakthroughs, which are one important part of the serious positive scenario -- along with breakthroughs in space solar power and batteries and grid technology.

3.3 China, a rising economic power is now leading the way in car technologies and

- Train, air & maritime transport

- Nuclear power (for electricity)

- Home heating

- Solar power satellites technologies

- And building climate control technologies; biofuels, efficient energy transmission

- Oil made of coal, UCG (underground coal gasification), ultra clean and ultra fine coal water slurry

- Circular economy technologies reducing resource usage

- Also in the development of modular nuclear power plants -- which are very resistant to weapons proliferation and extremely safe, a big issue in a country like China that used to lose hundreds of coal miners each year along with uncounted people from coal-caused air pollution. China has exported their nuclear power plants aggressively in developing countries, which underpinned their tremendous economic growth. Before the eclipse of environmentalism in the early 21st Century, western environmentalists used to whine about the Chinese export of nuclear technology. But their complaints had zero effect on Chinese policy, and the passage of time simply showed how wrong the western environmentalists had been.

- Carbon capture and storage in coal-based power plants.

- In Nano and Bio technologies - keys to the incipient revolution[s] in human society and civilization including both alternative energetics [e.g. seawater AG] and conservation approaches.

- Most of what has been described are things under study and it is plausible to see them happened

- New technologies are being developed in transportation that will lead to TransNet, an integrated transportation system, that will include all systems, road, railroad, pipelines, utilities, parcel , cargo and others in a single system , being physically separated from the natural ecosystem, will occupy only about 0,3% of land area , compared to traditional systems, and will be capable of generating its power locally from renewable sources and the vehicles running in it will utilize such power on the spot, eliminating power lines and fuel stations. TransNet will start experimentally on short distances but following its first results and benefits will be introduced in the global scale in connection with a new artificial ecosystem, physically separated from the natural one, obtaining several benefits and solving most current planning and territorial problems.

- New technologies in marine and railroad transportation

- Green water use optimization technologies

- In CO2-free oxygenated coal gasification (clean coal), source of both electricity and methanol fuel. China will remove the CO2 from these plants, not because of the Kyoto Treaty, but because they can make money using solar energy, CO2 and water to make methanol fuel.

3.4 On average, the world energy intensity per unit of GDP has steadily decreased, even though our energy consumption is still increasing thanks to major new technological breakthroughs like

- The new energy sources: fuel cells, magnetic and solar

- Biofuels, nuclear, wind and sun power

- Long dreamed of ”boutique” enzyme and catalyst chemistry for food creation and processing, container and structural material (primarily plastics) manufacture and, of course, fuel production from previously inefficient or useless sources and b) safe drugs for adjusting body tolerance and temperature sensation to high and low temperatures wireless transmission lines

- Ocean thermal energy conversion, domestic micro-generation systems, the new ‘ultra-lights’ vehicles and cooperative ‘super-grid’ links between Europe, the U.S., Africa and Asia; meanwhile some technologies have increased energy consumption such as entertainment technologies, e.g. the ‘Dream Catcher,’ an energy intensive virtual experience.

- Futuregen project, advanced energy storage technology

- Actually, the decreasing energy intensity has not been due to any major technological breakthroughs. It has been due to the steady accumulation of incremental improvements in energy efficiency throughout the entire economy. It has also been driven by the steady rise in the real price of energy, which has resulted in structural changes in societies -- denser housing, reduced travel, manufacturing closer to the point of sale.

- More energy efficient machines based on smart materials.

- Comment: In high-income countries per capita consumption of energy is growing very slowly - and mainly in the transport sector. In developing countries, energy use grows more rapidly with income growth because the levels of energy use per capita are still very low. There is no particular link between technological "breakthroughs" and energy consumption.

- Reduced power for computing/electronics enabled by carbon nano tube electronics, saline/seawater AG biomass/biofuels including distributed/inexpensive/small scale bioreactors and Nano-Plastic Inexpensive PV.

- Like the cellular phones, new energy technologies will be applied at less developed countries, too.

- TransNet and its ocal generating power system, nanotechnolgy applied to solar cells having increased its efficiency, developments of temperature variation as alternative energy source, wearable personal power systems, fuel cells for energy storage and 80% overall reduction of energy consumption for traditional products compared to the year 2006, ranging from HVAC systems, processing and manufacturing power, machinery and others.

- The extension of new uses of the electrical "vector" on everyday life.

- Distributed power generation that have brought basic services to most of the world's population
- Lower cost Internet access and new educational tools available over the Internet. (But really, the growing ability of formerly poor people to afford cars and larger homes would be the major driver of greater energy consumption.)

3.5 Advances in oil exploration that continuously increase the base of economically recoverable conventional and non-conventional oil:

- Tropical forest
- Biofuels (etanol, oil).
- In situ bacterial liquefaction of high viscosity oil
- Chemical extraction techniques for oil shells
- Combustible ice in sea bottom
- Most significantly in the development of microbial processes for enhanced oil recovery. Genetically modified organisms have been introduced into old, known reservoirs and have liberated much of the 2/3 of the original oil in place that had to be left in the reservoir at abandonment.
- Comment: This is good, but should be foreshadowed at the beginning of the paper - by referring to the role of markets in stimulating technological change.
- Utilization of non-biologoical deep earth-produced hydrocarbons.
- The flattening of China and India growth rates will impact on oil prices and they themselves in other fuels, in order to have a low price of 100 $/bls
- The first "commercial production of non conventional natural gas
- In-situ upgrading of extra-heavy crudes
- A mystic's view -- God will allow us to see the really big new oil technologies only after we do our homework in other areas, to stop wasting the oil we have so much. No dessert until after dinner. But even so, recovering all conventional oil only doubles or triples that base.

3.6 However, the technical issues to sustain a controlled plasma interaction will still need a lot of future research and

- Safety in operation and nuclear trash
- Political stability.
- The technology needs social and risk assessment
- Might well be overtaken and rendered obsolete before achieved by earthbound solar and “space energy” beamed from satellites
- Technological development

- Significant international investment and cooperation; to develop plants that can be operational at commercially viable levels.

- Long time

- Nuclear fusion has finally been recognized as a false hope with the present level of technology. However, the realization that so-called "nuclear waste" was in fact usable fuel has revitalized the nuclear fission energy industry, creating the single largest incremental source of new power.

- Thorium and accelerator proton flow based nuclear power is still only a future promise.

- The alternative Fusion approaches require serious research including P-B11 Aneutronics, Muon - catalyzed low temperature, scaleup of LENR's, and new "triggers" such a fast lasers, isomers, anti-matter and pyro-electric crystals.

- Other alternatives of exotic technology must be studied to allow everal alternatives for future needs, but with the required basis of utilizing only renewable and non-polluting sources as well as to reduce the energy requirements for all activities.

- Geographic location and confinement of "ultra high temperature" plasmas

- Giant amounts of money

- Many believe that magnetic bottle fusion on earth will never be economic. It still requires vast heat-to-electricity fluid cycles, the kind which provide a floor to the cost of power from coal and fission, and no chance to break those price barriers -- while new solar technologies show clear evidence that they can, in time, without issues about nuclear materials cycles. But the other mainstream form of nuclear fusion, laser/pellet "inertial fusion" is expected to reach breakeven ten years before ITR; when suitable (D-d) pellets are fused in a vacuum, electric currents emerge DIRECTLY, with no need for heat chambers. But this may be easier to do in space than on earth.

3.7 Furthermore, new technologies and better materials also improve transmission line efficiencies and

- Electricity

- Cheaper (high share in the tube)

- Interestingly, this success hinges on the esoteric pure science work of solar astrophysicists who eventually discovered in 2013 the phenomena and techniques for forecasting solar magnetic storms and designed long-lived Mercury orbit satellites to monitor solar activity. Their discovery earned them three simultaneous 2017 Nobel prizes in Physics, Economics and Peace, since it was such a critical linchpin. These developments made possible the management of regional and inter-regional macro-distribution systems that would not unexpectedly blow their breakers.

- Demand management

- Reliability, the profound lesson of electrical grid failures of California and Moscow must be overcome.

- This section on the Energy Internet would get a 12 year old thrown out of his high school physics class. It is at odds with the known laws of physics. When electricity is transmitted, there is an

inevitable loss of power, which increases with distance. That is why electricity generation closer to the point of use is so much more efficient overall.

- Research indicates serious possibilities for near room temperature super-conducting.

- Power grids have become the precursor of TransNet, the all integrated transportation grid, including all pipelines and utilities connections, as part of a global Master Plan denominated Planet Earth Terraforming that will transform all the global territory with an artificial ecosystems, separated physically but integrated functionally with the natural one.

- Better reliability

- Final mile consumer use.

- Reduce the cost of connecting renewable energy sources to the grid. Radically new automated grid management systems combining new chips, new SAC (sensors, actuators, communications) and new algorithms make it possible to juggle the supply and demand for electricity more effectively across time, which is essential to getting full use from renewable energy sources, intelligent appliances and car batteries.

3.8 The new cars are not only cheaper but also run on any possible combination of biofuels and electricity, reduce fuel emissions substantially, will be able to plug-in anywhere along the energy "Internet" and

- Clean local sources

- Political stability

- To reach velocities

- Readily and cheaply reparable; for example construction is modular so that items such as batteries can be fully recycled as well as reused in other of vehicles.

- Again, this is garbage. Electric cars require batteries, which are made with heavy metals which are known to be hazardous to health and which have an INFINITE half-life.

- The increasing "Tele-Everything capabilities are seriously reducing physical transport requirements of both people and "product". Increasing use of onsite "fab-Lab" manufacturing.

- (I understand that this is on technology, but where will China get the bio-fuel from? It does not look likely that they will be able to grow their own in the 2020s with the encroachment of the Gobi Desert, growth of the population and the seizing of the country-side for more and more building projects.)

- The proposed TransNet transportation system, where all power will be supplied by the system itself and not by the vehicles. Such system will allow initially the utilization of hybrid cars and later, with mag lev propulsion and automatic driving system will revolutionize global transportation

- Reduce the distances covered integrating the cars fleet

- Travel along the global "green earth materials non-asfaltic intelligent highways" linking the world, as for example, in the South America-North America-Asia-Europe-Africa planetary superhighway, via the Bering straigths giant bridge.

3.9 Other planned energy projects involving these new biotechnological developments include

- Other agriculture or excrement fuels
- To use biomass from forests
- Making relatively rapid acting bacteria, lichens and fungi that will remove airborne CO2, attack rocky constituents of poor soils (particularly tropical laterite soils) to release nutrient elements and produce organic matter to create productive soils.
- Artificial producing fuel bacteria
- Shale oil and tar sands extraction; using bacteria to produce fuels from various wastes
- Ethanol derived from cellulosic biomass
- Making of ethanol from bark using microbes and using genetically modified salt-resistant rice.
- The Sahara Ocean project, whose main scope is to change and made livable a deserted area while directing all excess water coming from the Poles melting in order to avoid that the rise of the ocean water could destroy costal cities and a big part of the land territory. In such a project, large algae growing lagoons will provide raw material for the production of biomass fuel.
- Decontamination biotechnologies that eat hydroacarbons and produce green by-products that safely reincorporate into the earth.
- Once liquid fuels are taken care of (a rather huge milestone in itself!), the next big step is to integrate the new technologies more efficiently into the petrochemical and plastics industries, and even develop new mass commodity materials.

3.10 The theoretical potential of hydrogen as an energy source is certainly incredible

- Safety and custom people restrain the development
- Is not cheap and a little dangerous.
- It is, after all is said and done, only an intermediate convenience product
- It is not economically competitive
- Subject to persistent technical difficulties; it won't be utilized on a large-scale until these problems are overcome
- It is not hopeless to reduce electricity consumption for splitting water and find out suitable material to store hydrogen.
- Garbage! Garbage! Garbage! Even the authors of this piece admit that hydrogen has to be extracted from compounds with other elements -- which takes more energy input than the hydrogen will release when it is oxidized in a furnace or a fuel cell. Hydrogen has ZERO potential as an energy source -- NONE! NADA! If this scenario is to have any credibility at all, it has to honor the laws of physics. Hydrogen is not, and will never be, a source of energy on earth. At best, it will become an energy carrier - taking power from nuclear power plants to the place where it is finally used.

- Is dwarfed by ZPE - which has some 10-to-the-108 times chemical energy density. Several very interesting schemes to tap ZPE are underway with success expected.

- The main goal to reduce energy needs is not only to find alternative sources, but to eliminate the need in itself without damaging the economy and its activities. The reduction of 90% of the need for trips, with such systems as advanced telecommunications, the elimination of trips for shopping or other moving activities by incorporating a mag lev running parcel transportation system to run in the TransNet system and connecting domestic terminals with distribution centers and workplaces will further reduce the need for transportation . The commodization of personal transportation, i.e., personal vehicles running in TransNet will be owned by the utilities companies, will save on traffic, parking space, fuel consumption and consumers will only pay for point to point transportation saving on vehicle maintenance, wear, insurance and all other traditional expenses related to car ownership.

- Safety is a big issue

- It is also still a rather inefficient low energy content fuel

- An ill-conceived fantasy according to many. Hydrogen is an energy carrier, not an energy source. Electricity is also a carrier and a much better carrier in many ways; an efficient world energy economy would certainly continue to use more and more electricity as one of its carriers, particularly for use in industry and large buildings. For cars, the sustainable economy of the future may well use some mix of electric batteries, heat batteries and methanol as primary energy carriers, instead of hydrogen.

3.11 What would make this scenario more plausible and useful?

- To develop clean and safe energies and energies also found in the new superpowerful magnet materials that develop movement of vehicles by magnetic fields

- Shall be a little shorter

- The scenario is more an inspiring and very informative vision rather than a scenario.

- Strengthening Interdisciplinarity and cooperation in research and innovation. Encouraging investment in research and technological innovation. Improving human performance. Increasing the role of social sciences and humanities in relation to Converging Technologies

- Not plausible. “The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil.” The reason the Stone Age ended was because there was bronze. Bronze is a better material. It did take technology to use it, but it is inherently a better material to use. When you look at your Table 1 it is clear that Oil is one of the best energy resources because it has better characteristics than any other. That is why we are in the oil age. To leave the oil age you have to have an inherently better energy resource, and none exist. This is explained in, “Scarcity and Growth considering oil and energy.” Even the other energy sources that seem better than oil such as hydrogen and plutonium, are not better when other physical measures of energy value are used, such as the “State Grade,” again see “Scarcity” for an explanation. The whole anorobic explanation of methane creation deep under ground is impossible since this would have been going on for millions of years, and we would have nothing but methane in our atmosphere as the deep methane releases through volcanoes and other tectonic forces. To make this more plausible, you have to simply say that human kind must endure a collapse, and start to live in smaller homes, consume less, travel less, work more in farming, and that the population will probably decline.

- Introducing social factors that will seriously affect the technological scenario depicted here. This scenario is typical of technological optimism –" if it can be done it will be done." But that is not the real world. Social aspects can seriously limit the resources made available for technological developments (as the Iraq War is now constraining education and infrastructure developments). Technology may also lead to bioterrorism that can decimate large areas of population and set back the envisioned progress. Put another way, THIS SCENARIO OFFERS A PURE TECHNOLOGICAL PERSPECTIVE,. IT IS AS IF TODAY'S ENERGY PICTURE WERE TO TOTALLY IGNORE "BIG OIL" -- THE POWERFUL OIL INDUSTRY - AS WELL AS THE ARAB OIL POWER WITH ITS RAMIFICATIONS. EXAMPLE: MOSSADEQ OVERTHROW BY U.S. AND BRITAIN IN IRAN IN THE 1950S BECAUSE HE THREATENED NATIONALIZATION OF THE OIL INDUSTRY, LEADING TO THE SHAH AND THEN TO KHOMEINI. ALSO, OF COURSE THE TWO IRAQ WARS.

- General Structure
  In comparison to the second scenario, overall, this scenario reads better. However, there are still a number of pieces of texts that are extremely packed with highly technical detail (almost not digestible). Except the readability, there are number of other (serious) weaknesses:
  - there is almost nothing about society, the ways of living, governance, demography and their link to the energy situation;
  - there is very little about the environmental consequences of technological developments; climate change was not mentioned once;
  - the scenario seems to be based on only two major driving forces: technological advancements in energy sector and increasing demand for energy;
  - in general, it reads as a long list of possible technological advancements in energy production, transportation and so on… the story is not dynamic, does not portray various changes and developments that led to it; does not incorporate political situation, societal and cultural change.
  - no scenario logics that would be played out differently in all three scenario stories were identified.
  - Reading the scenario it is rather difficult to identify the challenges and opportunities, and that is the main purpose of such scenario, I would imagine, to stimulate decision-makers thinking.
  Specific details:
  The scenario is quite strong on creativity and this would be a very strong feature if the scenario had a centennial or millennial timescale, but on a 14 year timescale it is a significant weakness as it systematically becomes implausible through overestimating change for the applicable timescale. This is a consistent feature e.g. Chinese car industry, the availability of fossil fuels, the bacterial production of fuels. This is accompanied a parallel denigration of established technologies, which are already making significant contributions such as wind and solar, which is excessively pessimistic about their potential and not reflective of what is plausible and realistic, even with current conditions (see: World Energy Council's survey 2001 http://www.worldenergy.org/wec-geis/publications/reports/ser/overview.asp) There is wind, sun and tidal currents everywhere, it just depends what is likely to be economic (as with fossil fuels) and as described within this scenario with technological change this situation always improves. The WEC proposed in 2001 that renewables are both 'technically feasible' and have a 'plentiful resource,' the barrier to their further development is the dominance of fossil fuels. In general technological developments will occur but are implausible on the timescale presented, plausibility would also require a description of more limited fossil fuels and the influence of the climate change issue. The WEC 2001 also reported the 'adequacy' of the resource base but highlighted the implications of environmental concerns particularly climate change. Although the creativity and style is strong in this scenario, it is an extreme scenario, which has cast-off plausibility in favor of the radical, weakening its usefulness.
  Climate change (and the need to reduce greenhouse gas emissions, to limit warming to prevent 'dangerous interference' with the climate as per the UNFCCC) has no specific mention. In tandem with rapidly increasing energy demand it will be a key driver as it currently is. For plausibility and usefulness it would have to feature specifically and as a constant consideration. If this scenario assumes that UNFCCC
  Kyoto process has failed this has significant international political and policy ramifications which

are not reflected anywhere in this scenario. If it succeeds as appears both plausible and likely since the COP in Montreal (December, 2005) it is likely to be the single biggest driver in global energy policy for the rest of the century. Particularly as the science hardened in the mid-1990's and now has consensus, at least among climate scientists but increasingly even in the US media (http://www.time.com/time/magazine/article/0,9171,1176980,00.html). The most recent research is tending to show that the more serious impacts are now more likely e.g. see; /http://www.washingtonpost.com/wp-dyn/content/article/2006/03/02/AR2006030201712.html/http://news.bbc.co.uk/2/hi/science/nature/4660938.stm
The Scenario is too 'Americocentric' (and also 'Sinocentric' in terms of industry) particularly where it describes how US policy drove world developments. The US is not likely to be the sole driver of world policy for the foreseeable future as it has been slipping behind in recent years. A parallel discussion of European or Asian policy would be more relevant here.
The $2 figure for European oil price in 2005 is incorrect. It reached this figure in the UK but not in the rest of Europe.
The WEC and IEA statements on the 'adequacy' of the global energy resource were short term for the WEC and to 2030 'and beyond' by the IEA in their most recent reports. They highlighted however that there are uncertain economic and environmental costs, and that these have serious implications. In the WEC's 2001 survey they acknowledged that there were two schools of thought on oil (pessimistic and optimistic) but favoured the pessimistic, as proven oil reserves fell. There appears to be an element of re-writing history in the opening statements.
The discussion of the bacterial process and how it can 'take care' of the carbon sequestration problem is scientifically erroneous and implausible. The amount of land or sea area required to physically support the apparatus that would allow a sufficient bacteria complex to absorb direct sunlight would have to cover an enormous area incompatible with current land uses. The sequestered carbon would then have to be stored indefinitely (and not combusted) to prevent the carbon escaping back to the atmosphere. The process to stabilize or effectively lower CO2 concentrations in the atmosphere (and solve the 'carbon sequestration problem' while there is accompanying sustained global fossil fuel consumption), even with large scale operations, would take millennia. In the meantime with sustained fossil fuel consumption climate change would already have crossed tipping points and lead to 'significant and irreversible change' such as the melting of the Antarctic and Greenland ice sheets, and the earth would have undergone significant warming and other impacts.
'Chickenless' and 'cowless' meat would likely be subject to substantial risks of process contamination, pathogens and genetic mutation. Aside from cultural perceptions of inherent risk or ethics, to describe these processes as 'avoiding animal problems' is to ignore far greater risks until the technology is tried, tested and proven. It is implausible to assume that these would become either culturally acceptable or scientifically proven within the timeframe to become commercially viable.
The assertion that the 'green revolution' avoided millions of Indian deaths in the 1970's is a spurious connection, which might be best avoided. Agricultural output increased poorly in India in the 1970's by just 2.1%p.a. in comparison with stronger growth in other Asian nations such as Thailand.

- What worries me is the MPs tendency to produce more and more and longer and even longer texts. This is an example of where I a) found it extremely difficult to contribute as the blanks often refer to very specific aspects and b) felt overwhelmed by the sheer abundance of detail and text that one can only partially digest. I am skeptic how scenarios like this can make an impact, because who will be able to take in, even read through, so much detail? I would wish for much more "easy to take in" and "easy to take compare" kind of elements, and more structure. For example, for all energy scenarios, you could have a short version of the key elements of the scenario at the beginning (not longer than one and a half pages) plus tables or boxes that recur with different content for all scenarios, giving info on the percentage of energy sources, main technology breakthroughs, etc. Apart from the perspective of communicating results and concentrating on clear messages, I also find it difficult to ask any leading energy expert to

contribute to a scenario that has 18 pages and he is asked to read and take in all this and then fill in some few blanks …

- First, the scenario has to be made to conform to the laws of physics. Second, this scenario seems to differ only in tone from the previous "environmental extremist" scenario. What is the value of having two scenarios that are functionally so similar? Third, the only major new source of energy possible by 2020 is an expansion of nuclear fission, using the so-called "nuclear waste" as fuel for a new generation of breeder nuclear reactors. It is pointless to draw up a "technological" scenario, which turns its back on known technology -- for no plausible (or even explained) reason. Fourth, there is the possibility of synthetic photosynthesis allowing the direct manufacture of hydrocarbon fuels. This is mentioned in the scenario, but is buried under a mass of technologically-unfounded ramblings about non-feasible alternative energies. Synthetic photosynthesis should get more attention, and some of the wilder ramblings should be trimmed. Fifth, it would be worth including a more considered analysis of what the impacts of declining oil demand would have on the shaky societies of the Middle East, Russia, and Venezuela. The geopolitical aspects deserve some consideration -- possibly encouraging continued oil imports by countries that could theoretically (in the scenario) live entirely without them.

- There are of course a lot of risks with different new energy sources. I think that a global critical network of scientists or a global "virtual assessment network" with basically positive attitude towards innovations would promote the scenario.

- More emphasis on how markets work if governments become serious about capping carbon dioxide, and as conventional oil becomes scarce (relative to demand) and therefore expensive. It is not a tragedy if prices of energy rise (including their environmental costs) while incomes are rising even faster.

- Go COMPLETELY Green.....

- Science and technology, the human resources dedicated to it and the timely funding a bit more spread around the world

- Kardahev scenario is limited to energy consumption and territorial expansion as main progress parameter. In reality there are other factors that measure a civilization progress, mainly its control on its individuals utilizing technology. The effect of singularities is ignored in Kardashev theories, we must consider that Singularity One, AI smarter than humans, Singularity Two, virtual human immortality by periodical rejuvenation systems, Singularity Three, mind uploading, which could be feasible in the next 50 years, may completely change the general society picture, altering its values and allowing the possibility of nearly limitless space expansion and human evolution with new life forms, with perfect physical renewable bodies and limitless intelligence. Due to such possibilities, energy compsumption must be consider a temporary parameter to measure progress and evolution. Current requirements call for
  1-Drastic reduction of energy requirements by more efficient technology to be applied to all products\systems
  2-Creation of adequate energy resources from renewable, non polluting sources
  3-Terraform Planet earth to update its territorial systems to new technologies and future requirements of a multibillion and growing rich population
  4-Develop space as a future alternative for human expansion, creating artificial and modular expansion planets systems, initially in the solar system, later in extrasolar systems, utilizing local energy sources, sun, space matter and stars

- Time and free human mind

- Greater human understanding on a global scale as a prerequisite for really advancing towards solution of world energy and socio-political and economic problems. The great economic powers

must be more human-oriented instead of more-business oriented in dealing with planetary problems.

- On the R&D side, the most urgent need is to prove out the key uncertain but promising technologies to allow energy from space to substantially beat coal and fission on cost for 24-hour power. There are two (complementary) ways it could be done -- by using lunar materials (now in US plans) or by performing D-D pellet fusion in space. For the latter, we especially need to prove we can design the laser, and we need to show how adaptive smart antenna technology can be used to reduce the cost of beaming power to earth all the way to the grid to 2-3 cents per delivered kwh. But it is equally important to set up a new international consortium, with $15-20 billion set aside, to pay for the new required RLV (for which designs exist) and to market launch services, and to plan the massive deployment and sale of the new electricity source.

- A breakthrough in laser technology applied to nuclear fusion

Scenario 4. Political Turmoil

4.1 The price of gasoline quintupled overnight, spot prices were never more volatile, long-term contracts for oil were abrogated, trading in carbon rights was suspended, electricity and gas disruptions multiplied, many banks closed and

- Led to an aggressive mood of panic, fear and suspicion, from which the "no strangers" group emerged. NSG demands an end to globalization and pleads – in many industrial countries – for a nearly complete end to immigration, opts for self-sufficient economies and is believed to be strongly connected to the rising nationalist and racist political parties in Europe and other countries.

- The world financial disrupted with problems of cash to various parts of the world.

- Rich oligarchs and lesser survivalists began retreating into their respective prepared sanctuaries

- The costs of the transport go off and originate a fast shortage of supplies of foods and products of first necessity, creating inflation and originating the paralyzation from the main factories at world-wide level (with some exceptions at U.S.A.) by lack of supplying of materials and energy

- Social unrest and ad hoc demonstrations for proper action or against inactivity of governments spread out, people started to move to country side if they only had any places or relatives there in order to sustain some living conditions or to prepare for even worse, militia groups arouse and fights between groups occurred; Russian government saw the situation offering room for new intentions and Russian politics on Baltic countries and Northern countries especially on Finland, were re-negotiated in order to guarantee free operations to the Baltic see, and to enhance advanced technology cooperation and St. Petersburg electricity supply from Finland and Northern countries network. The Russian army which was assumed to be only of minor actor showed up in its conventional modes of army very strong and well trained for local scale operations.

- Unrealistic terrorist could have gone for the oil production in many countries already in a simultaneous fashion. Furthermore by 2020 water might be a better target than oil

- Terrorism is the symptom of a social turmoil in our global village. Fighting the symptoms and not the causes is not a solution. See the book of Zbigniew Brzezinshi “The Choice” Global Domination or Global Leadership

- Al-Khaida was satisfied and accelerated war in the Iraq

- Food production stop growing

- Global GDP declined by 50 % as large parts of the work force could not reach its work place.

- The overall effects ere greatly amplified by serious software and EMP attacks against key societal infrastructure nodes, effectively threw society, worldwide, back to the 1800's.

- Food supplies & international trade were disrupted. France responded to the crisis, as President Chirac had warned five years previously, by launching a series of nuclear attacks, which decapitated the governments of Iran, Pakistan, North Korea, and Syria. The consequences of the turmoil were surprising. In some places, people pulled together -- the entire political class was run off; justice became swift & terrible; those lawyers who were not shot were given work in the fields; local factories were opened to replace essential products that could no longer be easily imported; and well-regulated militias assisted the people in keeping public order and protecting

borders. In other places, politicians postured as chaos descended -- followed by thirst & starvation, and eventually the peace of the grave.

- Business worldwide was seriously disturbed, including food, medicaments, and other essential supplies.

- Large differences in energy price levels and indicators of energy shortage became apparent. Although part of the difference could be explained by the location of the oil facilities targeted, it also became very clear which countries are better prepared to cope with oil supply disruptions. Sweden, for example, was only slightly affected.

- Increase of poverty

- The New York, Tokyo, Paris and London exchange markets collapsed.

- Markets crashed globally leading to an instant recession as investors became very afraid, market confidence has not yet recovered.

- The black market for scarce commodities flourished and crime increased

- The speculative game of big capitals that has taken advantage the state of hyperinflation of the world to achieve big interests; and they staying the establishment based on the interests of the oil multinationals and of the industrialized countries that they maintain like one of the main energy source the petroleum.

- Stock markets in many nations collapsed. Along with the collapse of long-term contracts would also come increased concerns over protection of equity oil, and place the Chinese in a very powerful position.

- Whole consumer market price shock: social troubles till civil war (harder as oil shock of the 70th)

- Communications disruptions caused by overload, power failure or malicious attack lead to failure of manufacturing operations and impact on goods delivery, including the food supply. In addition, electricity and water reticulation systems break down because of failure of the communications-based control system. The power and water systems fragment and island, leading to pockets of availability and areas of depletion. Local strife caused by conflict over these limited resources can be expected.

4.2 Other suicide attacks targets were:

- Done to present if necessary, to counter attack or overcome the situation.

- Key makers of high technology drilling, pipeline and refining equipment needed for repairs and three of the most productive research facilities for alternative energy research. This is similar to the “keystone bombing” of German ball bearing and machine tool plants during WWII.

- Main subways around the world and special in European railway lines (subway between UK and France)

- Main oil delivery and distribution harbors around the world and the oil industry maintenance services and supporting industry plants.

- Water.

- Spain (railway) and London
- Venezuela
- EMP attacks upon Pumping stations - both pipelines and ports.
- The LNG terminals in Europe and in Qatar, disrupting water-borne gas supplies. Interestingly, and fortunately, terrorists wasted a large number of their bombs on nuclear power plants -- damaging the paintwork but otherwise doing no serious harm.
- Venezuela, Mexico and Bolivia.
- Saudi Arabian export facilities at Ras Tanura, Abqaiq, and Jubail
- Venezuela and Trinidad
- The Caucasus and Nigeria, where explosions at pipelines interrupt the production for several days
- Ghawar in Saudi Arabia, Hassi Mesaoud in Algeria and the Burgan field in Kuwait which was almost completely destroyed and is still burning.
- Nuclear installations and hydro dams.
- To strangle to the developed countries that they depend on the petroleum like energy source, since the biggest oil region in the world is in an area extremely unstable and low control of the biggest terrorist nets in the world.
- Fields in Angola, Nigeria, and Sudan.
- Russian German gas (oil) pipeline northeast See; Mediterranean pipeline in Egypt, Israel, Turkey.
- Nigeria and Alaska, but it must be pointed out that the scenario pictured above would result in seriously reduced oil demand.

4.3 What really needed to be done [to increase security] was

- A serious and worldwide reflection on the roots on preventing terrorism, not just stopping it or its executors before the deed.
- Oil plants in AFRICA: Nigeria, Libya, Angola, and Equatorial Guinea.
- The obvious: for the vast majority of people to be become “sick and tired, and sick always comes before tired” and revolt against both the terrorists and do-nothing power elites. A first-ever worldwide social contract was needed, as had often been achieved at national and regional levels in the past. The question remained as to whether the level of pain had yet become severe enough to allow that revolutionary fusion to occur – a 1780’s French revolution, as it were.
- To identify, to make pursuit and to reduce to all the terrorist groups around the world. In order to make such task is necessary
  1.- to reinforce the familiar bows.
  2. - to improve the formation of teachers, giving them a new roll
  3. - to reinforce the civil attitude of people

4. - to make participate to people actively to identify groups that make initial operations that attempt against the society

- Safeguarding and prioritizing the vital operations of the society during the chaos against induced criminal maneuvers and citizens' ad-hoc bursts of violence, and capability to protect people as much as possible and enhance their self-management.

- This whole scenario is written in such a simplistic way to just cover oil and very western even USA style prediction that it makes no sense to add something to 4.3 as the premise is too simplistic

- To avoid dependence on few sources of critical commodities

- A coordinated approach without national prerogatives.

- Calm down the growing world polarization, fast, before a line would be crossed that would make human extinction near-inevitable.

- A massive Intelligence campaign to determine intentions, at the granularity of the individual, worldwide to enable pre-emption.

- The expulsion or elimination of all those individuals who were threats to the safety and survival of the community as a whole. Interestingly, some of the areas that were hardest-hit made the necessary transition. Habeas corpus was suspended. Trials took place within hours, and the guilty were executed immediately. Organizations that were suspected of having been infiltrated by ecoterrorists, like the Sierra Club & Greenpeace, disbanded themselves. Some Moslems in western countries voluntarily took oaths of allegiance and relentlessly hunted down Islamic terrorist sympathisers. Places that were spared the worst of the 2011 violence tended to react more slowly to the new world order, and paid a heavy price for it.

- To start considering strategies to move from a confrontational world towards a meaningful search of solutions, avoiding force and replacing it with dialogue.

- To identify the terrorists' sources of weapons and funding, and to reduce most countries' dependence on imported oil and imported natural gas

- To maintain control

- Serious international diplomacy to begin resolving the various issues that gave the militants their power base and raison d'etre.

- Sharpen political negotiations between regional blocs

- An appropriate reaction of the world leaders, especially of the developed countries, to look for a the world politics of consent with regard to the search of new energy sources, limiting the repressive armed action that of time of calming the things to ignition a true hell. Even leaving side the big interests of the oil multinationals.

- To install an international oil (protection) patrol.

- Pray. The scenario sketched represents a total breakdown of civil order, and nothing less than a return to pre-industrial society can be envisaged. A dramatic decline in population is inevitable, and may provide the basis for the construction of a new society.

4.4 Oil-related political hot spots occurred in the Caucasus, China, Japan, the Arctic, Nigeria, the Persian/Arab Gulf, Russia and

- Libya
- Antarctica, where demand had finally shattered any semblance of accord on preserving the natural heritage.
- Mexico and Venezuela
- On the routes of oil transport caused not only by threat of terrorist attacks but by state pirates.
- The outcome can be a world-wide economic depression with unpredictable social consequences
- Baltic area (potentially)
- Venezuela
- The North-Sea (debate between England/Denmark/Norway on which country was entitled to new deep-sea deposits in international waters, burdening EU consensus; you deal with this question below at The Arctic)
- Alaska, Mexico and Venezuela.
- Venezuela.
- Europe, South America, and the Caribbean.
- Ukraine, and Belarus
- Venezuela
- Mexico
- Latin America's biggest producer Mexico
- Other oil and gas-producing developing countries
- South America, especially in Venezuela and Bolivia where a growing block "antinorteamericanos", seeks to attempt against the stability in the continent. And The Antarctic, where are the biggest reserves of minerals of the world.
- Canada
- USA/Canada/Alaska – on the other side, not the arctic (west passage)

4.5 Iran's power and influence grew in the region, and its overt support for the Shi'ites in Iraq effectively ended the tenuous Iraqi national cohesion. What followed were

- The general turmoil in the Middle East and North Africa.
- Highly emotionalized squabbles over almost every conceivable topic, which both increased intra-Islamic terrorist acts and took some pressure off the western nations.
- The union of new organized terrorist groups of Iran and Iraq against the western interests

- Two Muslim states in Iraq and a new kind of tensions between the Muslim countries in the area and new and different ties between them and Russia, China and EU and US: world energy division

- Increasing tensions and undeclared wars

- Deepening ethnic/religious extremism (religion as ideology) creating widespread chaos as extremist groups do not recognize the authority of any state.

- The breakup of the region into effectively warlord territories, with greatly reduced trade between them.

- Political repercussions that intensified terror antagonisms.

- Agreements between Iran and Turkey to construct an energy corridor for export of Iranian gas and oil to Europe via Turkey. The route was carefully chosen to bypass areas under Kurdish control.

- To maintain this situation

- Years of political unrest in the Middle East. Iraq is still in the grips of civil strife and ethnic tension, while Israel has become increasingly jittery fearing both terrorist attack and neighboring states losing their restraint in the face of increasingly hard-line and xenophobic political developments across the region. The years of political strife have lead to an ingrained anti-Semitism in many which has been reflected in the conduct of some political leaders

- Further faction splits and increased turmoil in the region

- A growing confrontation ethnic religious that will continue accentuating conforms to a bigger intervention of the developed countries.

- Periods of increased intervention by many of the Persian Gulf states determined to prevent the chaos in Turkey from radiating outward, as well as prevent further Shia organization and cohesion

- (Smart) civil wars

- The invasion by the U.S.A. of Iran as a form to have the total control of the countries of the Middle East and therefore to have its petroleum supply assured

4.6 China was able to leverage its vast holdings of US debt to prevent US criticism of its civil wars and tactics. As a result

- The US decided to freeze its relations with China.

- China began to exercise subtle leadership of the UN Security Council, supplanting the US.

- High levels of unemployment, inflation and hopelessness not to have a short exit term

- The rich China of Western standard of living and the poor China separated.

- The so-called “market forces” must be replaced by a new system capable of maintaining a balance between “supply and demand”. Our emerging global village is a new world that needs new rules

- Oil pipe from Russia to China

- People feel that nobody is supporting peace and western values

- The world decided to switch from the dollar to the Euro as the world Monetary standard and the world foreclosed on the Massive U.S. International Debt. The U.S. Economy tanked.

- China reverted to its historical pattern of provinces breaking away from the central government. The Beijing government hastened the process by attacking Taiwan after 2011, seeking to unify the restive Chinese people behind them. All those Chinese leaders succeeded in doing was provoking President Rodham-Clinton into launching the largest nuclear attack in history. She will forever be remembered as the leader who killed more human beings than Mao, Stalin, Hitler and Genghis Khan put together. Regional warlords, commanding what was left of the Chinese military, surged into the vacuum left by the elimination of organized government in China. From that point on, China was a restless confusion of temporary alliances between warlords claiming to speak for the whole nation. Some of the more decadent western countries went along with the pretence, until they too collapsed.

- There was a relative improvement in the oil situation. However the overall economic situation continued to worsen.

- China became increasingly dependent on Russia for oil and natural gas supply

- Chinese President Xing directed additional financial and scientific resources into China's renewable energy programs. Already world leaders in solar-powered fuel cell technology, China rapidly assumed a superior position in bio-fuels, wind and wave power. These renewables, supplemented by the seemingly unlimited supply of gas from the Australian LNG contract, enabled China to become the first super-nation to break its dependance on oil. Until now, only smaller countries such as Sweden, Finland and Denmark has achieved this.

- Of energy public policy

- Through its persistent condemnation of Chinese interior policies, Europe has gained significant moral weight in global politics through the vacuum left by the retreat of the US.

- There was no curbing power to stop conflicts from spreading further

- Of this China had looked for new markets of petroleum and it has increased their exchange especially with developing countries, but this doesn't stop the process separatist that will continue in peak. That’s true because in my opinion what China wants its to be the countries number one in the world that why they trying to make some kind of arrangement with countries in developed so they can win some territory for their future.

- Chinese intervened militarily with harsh tactics and effectively shut down the western provinces

- China is attacking and regulating like in Tibet, Taiwan by military

- China controls its internal situation immediately and continues producing the amount of petroleum that needs for its normal functioning

4.7 Tensions still remain high while the oil and gas pumps are on hold, and

- The demand of energy is increasing across the world.
- A desperate Japan is hurriedly seeking ways and places to extract ocean-bed methane hydrates, for which environmentally safe technologies do not yet exist.
- And some skirmishes product of the lack of fuel in the zone
- Leads to permanent presence of US navy on the area to protect Japan's interest.
- According to the father of President George Bush, the most dangerous enemy of the US is the lack of economic stability. If the young generation of leaders won't understand that mankind is a unitary system that is manageable as long as there is cooperation, the future is bleak
- War seems unavoidable
- Frankly -- it makes no sense to invoke the "World Court" in this scenario. It is much more likely that the United Nations and all its bureaucracies were collateral damage from 2011, when the US and Japan decided that they had more urgent needs for their limited funds.] [A more credible scenario would be that Japan would seek to play off different elements in China against each other.
- The U.S. realizes that they have essentially no major effective military leverage in the region and withdrew.
- No comment.
- Japan became a major purchaser of LNG. Some of the LNG originally destined for U.S. and European customers was redirected to Japan.
- Trying to have a deal
- Trade relations have deteriorated once more with China trying to out-compete its neighbor both in the export and its own internal market in many areas traditionally dominated by the Japanese such as the automotive industry. Japan has threatened on numerous occasions to take a take a case against China to the WTO but has so far been reluctant as it is still an important market.
- The situation remains tenuous.
- The control on the reservations of petroleum and natural gas, it is extremely important as much as for China as for Japan and while you exist divergences the possibility of a conflict is imminent.
- Japan has moved closer to declaring its rights to militarily protect its interests and citizens in the East China Sea.
- Both parties finding an anti-offensive strategy by 51: 49% and, doubling the pump efficiency.

4.8 The United States has yet to sign the UN Convention of the Law of the Sea. If the World Court does not resolve these issues, or if one or more parties do not accept its ruling, then

- Then another world war would be not far.

- Private capital will not invest. However, state capital backed by gunboats well might invest in hopes of gaining oil and gas, even (or especially) if court action were to take a long time. The niceties of paying retroactive penalties, while enjoying “nine-tenths of the law” ownership could be seen as worthwhile.

- U.S.A. will have to handle the dispute by means of official notices of the international organisms in order to fulfill the signed international agreements, independently of the convention
- there will be a resource war (hidden from the public) between US and Russia over the resources and finally a kind of a “resource-rippentrop”-pact is agreed between these two countries leaving others to accept.

- Go on free liberation policy and problems

- Strongest countries will impose their will

- Again, it makes no sense to assume that the World Court -- which long ago lost any credibility -- would have any part to play, or would even still exist in this scenario.] [It would be more credible to imagine a world in which the weak -- Norway, Denmark, Canada -- sought face-saving deals in which they received some royalties from Russians or US entities which were exploiting whatever resources they could find.

- This may become a hot spot for confrontation between former allies.

- The United States and Russia will divide the Arctic Ocean into regions under U.S. military protection and regions under Russian military protection. Shipping lanes will continue to operate

- It is likely that Russia, Norway and Denmark will form an alliance against the USA, and Canada will likely remain neutral. Norway produces an ancient manuscript, which clearly shows ownership of the North Pole rests with a pre-Viking dynasty, which once ruled the areas now known as Denmark and Norway. This agreement is honored by the World Court and rights are vested in the indigenous peoples of both countries. Canada and Russia are quick to reach agreement with the Nordic alliance and secure access to certain drilling rights in specified areas. The USA continues to pressure the World Court to overturn its decision and several US corporations are exposed whilst trying to bribe the World Court.

- Will be a conflict

- Many fear trade sanctions will be introduced across the board. There are more extreme views held in some quarters in both Russia and the US where old ‘cold war’ tensions are resurfacing and there have been numerous ‘incidents’ in the Barents Sea where US submarines have been met with a cold Russian reception

- Years long debate will ensue with environmentalists’ stance against polar exploitation gaining credibility.

- So to prevent the interests of the power unpolar of the world and under the logic of the war for the petroleum, they can decide to intervene militarily.

- USA/Canada and Russia sharing rights and strengthen as build up their refinery capacity, Norway and Denmark loosing

4.9 The NDPVF has become a serious threat to the Nigerian federal authorities, with the NDPVF spearheading a secessionist movement which keeps Nigeria in a state of instability, and

- The intervention of the international community, Europe especially.
- Uncertain for the foreigners and investments that reside in this country, coverall considering a possible taking of the government by the insurgents
- Nigeria was seen to run into chaos with its vast resources of oil which was regarded as unacceptable in the world situation and several governments sent their armies to take hold of the country just causing more vigorous violence to spread out.
- Instability in a part of the global village has the tendency, if not contained, to spread. According to knowledgeable economic analysts, the major problem of Africa is not poverty but corruption. Unfortunately, this is a worldwide problem. Regrettably, the solution suggested by the Dalai Lama is theoretical. See his book “Ancient Wisdom, Modern World” Ethics For The Next Millennium.
- Prevent the country to be a key player in the oil supply
- Africa remained a confusing mess of conflicts, as so much of it had been since the end of the colonial era. After 2011, Nigeria broke up along religious and ethnic lines. Tribes in resource rich areas of Nigeria and other African countries sought alliances with militarily-strong entities from the previously-developed world. In exchange for a share of the proceeds, outsiders protected the resource-rich enclaves and ensured that their products got to market -- uranium and other minerals, as well as oil & gas. Africans adjusted to the new realities better than some of their European counterparts, who had grown soft & vain in the long years they were protected by the strong arm of the US. The Africans had never forgotten that "all power proceeds from the barrel of a gun", and quickly learned to put the new rules of the game to their own use.
- No comment
- Nigerian oil exports fell to very low levels
- Corruption
- A crackdown by the government following a failed coup has ignited tensions even more.
- Underdevelopment under corrupt leaders.
- The logic in the falling states, is not similar to the logic of the developed countries, therefore the internal conflicts continued and these they will affect to the main source of revenues in detriment of most of the population and avoiding new investments in the oil sector.
- Ongoing corruption and poverty lend a growing well spring of popular support to the movement. It’s likely that the Nigerian government will be removed; wither forcibly or by popular demand.
- Disruptive actions are supported by foreign interest groups – only the investors winning
- Which spreads rapidly throughout West Africa. Other oil-rich areas such as Guinea, Gabon and Senegal get drawn into these conflicts and the entire region degenerates into tribal strife. Oil supplies are maintained only at great cost and are uncertain and unreliable.

4.10 The future of Saudi Arabia and the Gulf Region seems to depend, more than ever, on

- NO, Canada will separate more from the United States and try to keep Canadian oil and gas for itself. That is they will keep energy in Canada from expanding too fast in order to make it last longer, and get higher prices for it outside of Canada to any buyer, not just the US

- Intervention of the international community, Europe especially.
- Work of the commissions of peace to reduce the tension between the groups in conflict and to try to retire the religious component of the fight, for obvious reasons
- The manipulation of masses by religious leaders. A few centuries ago, France was for a while under the rule of two Cardinals. Now, modern religious leaders are equally hungry of power. Unfortunately, the communist system convincingly demonstrated that power without wisdom and political skills, is a recipe for an inevitable economic disaster.
- EU
- An agreement of the leading countries
- Safe sea-lanes of passage.
- Tribal loyalties. In retrospect, it was clear that oil money had been the only thing separating Gulf countries from Afghanistan. The disruptions following 2011 hit ordinary people in the Gulf very hard -- as should have been expected in an area that was so dependent on desalinated & pumped water and on imported food. In the chaos following 2011 and the French nuclear strikes on certain Gulf countries, millions of human beings died in a remarkably short time, mainly because of loss of water. When the dust cleared, most of the people left in the oil producing regions of the Gulf were non-Arabs -- the Asians imported to do most of the work. The Asians took over, and with outside help fought off the mostly ineffective Arab efforts to reclaim the oilfields. The extent of the collapse of Pan-Arabism became clear when Israel reacted to Palestinian attacks after 2011 by launching a full invasion of the Territories. No Arab faction rose to help the Palestinians --! worse, tens of thousands of Palestinians seeking to escape into Jordan and Egypt were murdered by the local populations. With the end of the UN and the extermination of the jihadists, the Palestinian problem was finally solved. In one of the strangest turns of history, by 2020 the Holy Land had become one of the more peaceful & stable parts of the world. The Jews welcomed peaceful Muslim & Christian Arabs to live among them. The biggest problem Israel faced was limiting the number of prospective Arab emigrants.
- Enforced political stability.
- The development of democratic forms of government under an Islamic legal framework
- The region developing alternative economic streams, reducing its own reliance on oil to produce wealth.
- Governments and their close relations
- The attainment of a more egalitarian society, democratic in governance but respectful of Islamic tradition
- Their ability to supply oil and gas at low prices and their internal conflicts being resolved
- To maintain the stability based on the princess and sheiks of the petroleum, avoiding in being involved in the Islamic fundamentalism
- Then rise and fall of the extended new AU (African union) to ARUB/Arabians

- The high prices of petroleum as long as they continue being protected by the U.S.A. that maintains their interests in that Region of the world

- Isolation and protection of the oil-producing regions. Unfortunately this will come only at great cost, and this may not be affordable for the cash-depleted western nations.

4.11 This has led to many joint endeavors to develop technological breakthroughs for stretching the amount of oil extracted from any one well, conservation techniques that improve efficiency, cleaner uses of coal, and

- NO, Canada will separate more from the United States and try to keep Canadian oil and gas for itself. That is they will keep energy in Canada from expanding too fast in order to make it last longer, and get higher prices for it outside of Canada to any buyer, not just the US

- Conversion of bitumen to synthetic crude oil; carbon dioxide capture and storage

- Methods involving the use of some kind of renewable energy.

- Disposing and reusing mining wastes

- Fuel cells, solar energy and other new combinations of biocombustibles available

- Advancing OTEC technology in Sargasso see for hydrogen production

- NEW TECHNOLOGIES are desperately needed to allow the US to develop its ability to lead the world to a brighter future. The creative forces of researchers around the world are providing new ideas but the “market forces” seldom listen. Why? The ROI is not big enough.

- Wind and water power and hydrogen revolution

- Green Energy.

- (Finally) the development of shale oil. One of the major unexpected changes from 2011 was the elimination of the environmental movement. Environmentalism came to be held directly responsible for letting the US become so dependent on imported energy. Most of the great foundations -- Carnegie, Ford, etc -- were sued into oblivion by victims of 2011. It had long been observed that only wealthy countries could afford environmental extremism, and after 2011 the US was no longer a wealthy country. The most popular video of 2012 showed drilling rigs rolling right over extremists who lay down on the tundra in an attempt to stop them. Communities now competed with each other to attract new industries, including oil developments and refineries -- in a reversal of the environmentalists Not In My Back Yard syndrome

- Enhanced uses of natural gas.

- More efficient and cleaner use of wood and forestry products on a small scale. Canadian voters successfully blocked the export of low-cost Canadian electric generation to the USA

- H2 energy use

- Development of low carbon technologies and diversification of supply to renewable energies and nuclear

- Even hydrate technology

- The development of alternative energy sources and the dependence of traditional energy sources with high technology that you/they diminish to the minimum the environmental impacts, will generate strategic alliances especially among developed countries. But the development of energy sources like the nuclear one, in countries that face conflicts or uncertainty, constitute a source of future conflicts. Efforts to create serious international governance structures that require compromise and give and take negotiations have largely failed over the past twenty years. Ethnic groups and countries are looking out for their own interests. An electronic iron curtain has come down between the knowledge-able and the knowledge-less. The decay of family and social values, corruption, and transnational crime became the governing elements in the system. The decay of family and social values, corruption, and transnational crime have become the governing elements in the system. Few seem to care about the environment or their neighbors. One wonders if the world has entered a new kind of World War III.

- Closer defense and military cooperation between the two nations

- Gaining deeper new oil (res)sources

- Protection of the environment

- Improved conversion technologies for converting coal to electricity, hydrogen or other usable energy form.

4.12 What would make this scenario more plausible and useful?

- This is a really depressing scenario that brings together all fears about the future – which is also its problem. People tend to react to this kind of scenario with something like "Oh, these Future Pessimists again. It can't become this bad. So maybe making it more a patchwork of "Mostly bad, but also some good aspects" might help…. For example, you keep stressing that values decay and hedonistic individualism prevails (without that fact seeming to play a decisive role in the scenario logic – as a reaction to such a catastrophe as Terror V. 2 the opposite seems rather plausible as well, a withdrawal into the family and the personal, private, "taking care of each other, which is the only thing we can control as the world got out of control and politics seems to be unable to fix it."

- This is all about politics. This one is more plausible than the others, but it could have more. In addition there will be a lot of economic problems. What has to be talked about is the massive unemployment, the stock market downturns, and the bankruptcies. How people will have a hard time keeping their houses, how they will end up with borders in their houses to pay for heat, and how people will make do on less money. It will be a great depression scenario.

- The present scenario is the worse in terms of what people are expecting from the future on energy supply and demand. The scenario could only be plausible if the international community ignores the grievances of radical Muslims living in regions of oil supply, intensification of the greediness of Western Nations, lack of renewable energy, political instability in regions of oil and gas supply, tensions among Western Nations, the uncontrolled rise of China in the world arena. The useful of the scenario is on ways and means various nations will use it to get out of the world turmoil.

- As it is mentioned the causes of this worldwide crisis are located in the decay of the family and social values, the corruption, and transnational crime. In order to try to solve this the mentioned thing in paragraph 4.3 is required 1.- to reinforce the familiar bows. 2. - to improve the formation of teachers, giving them a new roll 3. - to reinforce the civil attitude of people 4. - to make

participate to people actively to identify groups that make initial operations that attempt against the society

- ”Simulation” of the political responses and citizens’ responses to the events described and assumed. Observing more explicitly the transportation of energy around the world from the source places to the distribution places and further to the places of consumption.

- less US centric, less oil centric, less Islamic the bad guy centric, more critique how western economic structures and policy decision play a role.

- The Internet was created by the genius of mankind. Having the possibility to better communicate, sooner or later people will wake up and realize, that an ethical behavior can be much more profitable for every human being then confrontation or manipulation is.

- On the 1. page: Who, or what is Transnat. org. crime? On the 2.page no "19 martyrs", but "19 terrorists"

- Assuming a global GDP-decline by 50% after Terror V2, energy demand will rebound only slowly as will economic development. Time required for reconstruction will be much longer than expected here, especially with regard to the paragraph above. If 70% of 2010 level would be achieved by 2020 that would be a wonder.

- For all the misuse of the concept -- we cannot afford to ignore the very real dangers related to WMD in these kinds of scenarios. It is precisely the escalation to the first use of truly large-scale WMD (most likely nuclear weapons in the hands of a subnational group or political faction), which puts the human race into a path (paths) from which extinction is more likely than survival.

- Go GREEN.....

- The scenario should pay more attention to the political ramifications of the major changes subsequent to 2011 -- the end of the UN, probable civil wars in North America, Europe, Russia, & China. There would likely be a regression in living standards in the West to 1950s level -- which would obviously be quite bearable. But poorer countries could no longer afford the vast social safety nets they built in richer times. This might trigger significant social changes -- possibly a religious revival, certainly a much greater focus on individual responsibility. It would also be likely that there would be a lot more "localism" -- Brazil might flourish while Germany collapsed; locally-generated nuclear power would be adopted in a number of countries, replacing imported oil & gas; some countries might resort to military rule; the basics of ensuring food supplies would loom much more important; with the decline of international trade, many jobs would be created in western countries; poor nations that were already closer to subsistence levels might recover from the effects of 2011 faster and outpace developed nations. Humanity would survive!

- It is a brilliant and well worthwhile essay. However, it seems to be heavily from US perspectives. More input from Chinese, Japanese and Indian perspectives would be helpful.

- It calls attention on the need to approach anti-terrorism with a more humane attitude. What lacks in the scenario is the fact that world activities and supplies would be paralyzed, forcing the alternative of a truce or a nuclear war.

- It should be substantially toned down so that it sounds less like a Hollywood movie and more like reality. The scale of damage to oil facilities should be much more modest. The whole thing should not be so dramatic. Dependence on oil and gas should decline in such a way that some countries are not seriously hurt by this scenario.

- If we continue the tension and fight of energy supply, high-energy prices and increase of poverty.

- The scenario is quite strong in developing the story of political strife but this is not accompanied by enough breadth in terms of other drivers and nuances that show how the system evolves over the timeline. Using common scenario logics with the other scenarios would help here. The single issue focus on politics, but also the excessive focus on oil as an energy source is an apparent weakness. It would benefit greatly from enhanced consideration of other sources of energy particularly the expansion of renewables, nuclear and coal likely under this scenario with such deep concerns over security of supply. It would also benefit enhanced consideration of other key drivers including climate change (the global political ramifications as well as the impacts such as water shortage), other environmental issues such as air pollution likely with the implied increasing fossil fuel use, demographic changes, and technology. The mention of other factors making the world unstable is something, which should be expanded and reintegrated back into the scenario to give it more breadth and depth.
  The discussion of the competition for polar resources should be accompanied by some discussion of the strong global public opposition likely to the exploitation of a pristine environment to obtain the fossil fuel resources, which would have actually lead to the melting of the ice caps. Climate change would again require mention here as melting the ice caps is a 'significant irreversible impact' which leads to run away global warming of many degrees with severe impacts that can occur even on decadal timescale due to the enhancement of climate feedbacks. The political, social, economic and environmental implications of this are enormous and should be part of the narrative.
  This political facts based scenario would be more useful if it supplied some description of the energy pie throughout the world resulting from 'political strife' and the other drivers, which should be discussed. This could give a greater engagement for the reader with how change has occurred and what the result of this is for the energy picture in 2020.

- Increasing tensions in the Middle East and firmer signs of oil depletion.

- We have to create a serious international politics to help and prevent all kind of disasters in the whole world so in that way people can compromise and help to stop other war between countries because we all are the world and what we wave we have to share it with people that needs. That the international organisms as the Organization of the United Nations, take their protagonistic paper in impelling a system of balanced energy supply among sources of traditional energy with renewable energy sources and that this project is implemented equally at world and not alone level in the developed countries.

- I think the ingestion of disease packets in the terror attack unnecessary for this scenario – the damage to energy infrastructure is definitely significant without adding on an additional action which really isn't addressed anywhere else in the alternate future. I find the idea that Russia will pursue nuclear energy for power generation a little unlikely – their wealth of natural gas, chronic corruption, and budgetary constraints, even with higher energy profits, would make large scale nuclear energy cost prohibitive. I think that it would be interesting to consider the possible negative effects of closer ties to Canada – if the US feels its energy security is more closely linked with Canadian security, it provides a strong impetus to "interfere" and move unilaterally to secure oil supplies, borders, sea lines, etc. Canada may view these actions with more hostility than we imagine. I also find it far more likely that Nigerian govts will fall due to their chronic corruption and the spreading realization that the poor are being robbed blind. When this occurs, it won't take terrorist groups to bring down the regime. And if the govt is taken over by parties interested in spreading the wealth and addressing poverty, then distribution/access to/security of oil supplies could be further threatened. One interesting scenario to consider is the possibility that if Angola and Sudan are targeted, China would take a huge hit in its energy sector, possibly increasing the tension between China and Japan as well as leading to a more winner take all attitude for energy competition in South Asia

- When other countries threaten the hegemony of a country, the world is in danger of a Third World War. We must remember that history is cyclical and that there has not existed an empire that was

permanent; always other nations that are hegemonic have arisen. The time of the present powers already reached its peak and others will arise but for that it will have to happen conflicts that threaten the world's population.

- This is clearly the Armageddon scenario. Not only is it plausible, it has already been forecast some millennia back. I am not convinced that this scenario is consistent, however. Some of the outcomes described above would have such a major impact on the world, as we know it that many of the other outcomes, for example a big boost in R&D would never occur. I think the next step would be to do some input-output modeling and simulation.