Energy: Looking Ahead and Thinking Globally

*By Chauncey Starr**

I am being honored by this opportunity to open your 18th annual meeting today. On a similar occasion in 1980, I opened the 2nd annual IAEE meeting in Cambridge, England, with a talk titled *Energy at the Crossroads: Abundance or Shortage*. The issue then was a perceived limitation on oil resources, which didn't materialize. Today's energy concerns are more inclusive of long-term global issues - social and environmental, as well as economic. We now face several "walls of worry". Most "walls of worry" are a measure of our inability to clearly foresee global outcomes, rather than being well characterized threats. We usually await observable clarification of such uncertainties, with ample time provided by cautious politicians who choose the "do nothing" option when faced with doubts. Today there is some danger that publicly hyped-up fears, notably of global warming, may overcome such caution. You may recall that in the 1970s such a hype resulted in the United States foreclosing natural gas use for power generation for many years - now our favorite resource. An energy scenario must consider our new "walls of worry". My view is that technology options should be the primary tools for addressing the physical issues of global energy and environment. These may be less familiar to some of you than econometric and public financing instruments. I will try to shed some light on these technology options from my viewpoint as shaped by several decades of EPRI experience in fashioning energy technologies for national, regional, and individual purposes.

The basis of our global energy projections for the coming century is the burgeoning economic growth of the underdeveloped and developing countries, and the inevitable growth in global energy demand when this is added to more modest growth in the OECD countries. As this audience well knows, energy, and particularly electricity, is a keystone to the operations of modern industrial societies. Developing a global energy scenario requires balancing three prevailing societal trends; economic growth, consumption of energy and resources, and conservation of the environment - called the "trilemma" by our Japanese colleagues.[1]

The elements of this trilemma, (in popular terms - population, prosperity, and pollution) are interwoven with economics, culture, and short-term politics.

Unfortunately, the trilemma cannot provide an analytical optimum to direct global energy strategy. The judgments involved are so dependent on social cultures, political agendas, and time horizons, that only a neutral consensus survives (like the "no-regrets" efficiency policy for global warming). As an example of trilemma uncertainty, the balance in India is unpredictable today as its population growth may overtake economic growth. Global population growth certainly challenges all attempts to raise per capita economic welfare and all efforts to minimize the environmental effects of global energy use.

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The interactions between the trilemma components makes their projection difficult and time dependent. They are not independent variables. Demographers have shown that regional economic prosperity - in the short term - increases population by reducing infant and old-age mortality rates; and - in the long term - decreases the fertility rate by reducing the economic value of large families. The empirical finding is that modern industrial societies stabilize at low fertility rates. This has occurred after per capita economic growth rate exceeded population growth and where also traditional culture accepted fertility adjustments. The global demographic uncertainty is how much, when, and where.

And similarly with environmental degradation. On the one hand, industrialization and economic development increases the depletion of natural resources (such as forests, arable land, minerals, clean water, pure air, etc.) and also results in an increased output of waste. On the other hand, economic development also provides the investment for overcoming such degradation by more efficient use of all resources, resulting in reduced resource demand, recycling, pollution controls, etc. Such resource efficiency generally depends on the application of energy, usually by electrification. An example is the use of food refrigeration and freezing in developed countries, as contrasted with underdeveloped regions where large food losses (of up to 50 percent) and endemic gastrointestinal diseases are common. On balance, the empirical evidence is very strong that electrification can provide significant improvements to the quality of life. So the target is not reducing energy consumption but rather to encourage its most productive use.

In each society and in each time period, a balancing of the trilemma results from the empirical and political negotiations of the people of that society. We now are undertaking a novel global negotiation, stimulated by fear of an uncertain future climate change that might be induced by mankind's energy use. This is particularly difficult because unlike most site-specific negotiations, there is not an adequate fact base to provide stakeholders with benefit/cost/risk/time-scale projections of alternative choices. There exists only several future guesstimates modeled from climate, population, and economic simulations, recently reviewed by the World Resources Institute.[2] As expressed in a comprehensive 1997 paper from the MIT Global Change Program[3], the projections from such models depend greatly on "...what is assumed about economic growth, productivity improvement in energy use, and the relative costs of future technologies...".

If some of the doomsday scenarios for climate change effects actually show up sufficiently to provoke a draconian response, then all projections of global energy futures become irrelevant. The required massive reduction in fossil fuel use would devastate global economies and all practical energy strategies. In comparison, the U.S. proposals for the coming Kyoto conference, as described in newspapers, are quantitatively trivial for global CO_2 emissions, are selectively damaging to the U.S. economy, but also are politically symbolic. Of course, a global effort to use energy efficiently is a clear "no regrets" policy, and perhaps Kyoto may turn to this. More practically, most scenarios of climate effects are spread over many decades. So even if they become evident, most societies given a response option of a cap on economic growth or an adaptation to a shifting climate, would choose the latter. This might mean a geographic movement of agriculture, industry, and populations, and the increased use of technologic aids and electricity. We have the historical example of air-conditioning revitalizing the U.S. south.

Of course, there remains a reasonable probability that the highly publicized global warming threat may be overblown.[4] Despite the voiced certainty of the present U.S. administration, recent climatologic findings are suggesting that man-made CO_2 may contribute only fractionally to the globe's natural climate variability. This is a question that only scientific research will resolve. Climate research takes years, and so does any action to ameliorate or adapt. Without a research base, pre-emptive actions may be ineffective and costly. Research on all aspects of this issue should be intensified. However, regardless of the scientific outcome, I believe that societies will choose to adapt to climate change, be it small or large. So our consideration of energy options is still germane.

As viewed by a technologist, we seek a mix of foreseeable technologies that might flexibly respond to future shifts in the trilemma balance. While today's mix may accommodate future technical improvements, it generally takes many decades to alter a technology's comparative commercial status, so that it is possible to roughly project roles and constraints in a projected global mix, assuming continuing trends in growth of population and economics regionally. Such a simplified scenario, based on modest growth rates, was published by Starr and Searl in 1990 [5] and replicated with minor variations by others since, provides us a rough base-case for speculation on the global mix.

As projected in this scenario, by the middle of the coming century, trends alone lead to a global energy demand roughly 4 times the present. Conservation might cut this in half to 2 times present demand by the full application of known technologies to reduce energy consumption per unit of output. This scenario also indicates an electricity demand increase of 7 times present without conservation, and with full efficiency reduced to an increase of 4 times present demand. Most of this will take place in the developing world. Even in the industrial countries, electricity demand will increase. The numbers are less significant than the inevitability of such large demand increases. Global capital investment requirements may become a restraining factor. Only a halt to global economic growth, or an apocalyptic population destruction can moderate such demand increases.

The key message of this scenario is that productive efficiency is the most effective way to reduce global energy demand, and thus the environmental consequences of energy use. Although the capital required for efficiency investment is large (almost the same as supply) past experience suggests that the indirect economic benefits of improved productivity usually makes this a wise economic investment. However, in the short-term, capital for efficiency investment competes with capital for increasing energy supply, particularly in developing countries. It is politically easier to manage the supply side of the system than the demand side.

A second message is that even at best, global energy use is likely to increase in the next half century to at least double today's. With today's fuel mix, this would mean doubling annual CO_2 emissions, even with the full contribution of nonfossil sources to the extent that they are physically and economically usable. As we would expect, the environmental movement has been enthusiastic about renewables such as solar, wind, biomass, and occasionally hydro, although their disdain for commercial nuclear power can only be considered as disingenuous. Unfortunately, all the renewables face practical barriers. Hydro is obviously limited and has ecological constraints. Biomass involves energy costs of transportation that generally limits its value to about a 25 mile collection radius around the power plant. The intermittency of solar and wind limits their contribution to peaking or intermittent supplements (diurnal availability about 15-30 percent in the temperate zone). Adding energy storage for a continuous base load supply multiplies their capital investment by a rough factor of ten or more, making them economically impractical for such use. Nuclear power is the only non-carbon electricity source that can practically meet the bulk of future global demand.

The inevitability of an increase in annual CO_2 emissions globally is a reality that must be factored into serious discussions of all long-range energy scenarios. Nevertheless, reducing the rate of increase of emissions seems desirable as this extends the time available for adjusting to whatever climate change emissions may induce. For example, a preliminary study by Karl Knapp suggests that an optimistic shift to nonfossil electricity generation and auto transportation might result in buying a few decades delay in mid-century atmospheric CO_2 levels. I will leave with you two policy questions. What level of sacrifice today should be made to obtain such delay of an uncertain threat a half century ahead? What would we do with the added time?

As a personal comment, I have been surprised that the many environmental movements so deeply concerned with the global warming threat have not actively urged international programs to promote energy efficiency in the developing world. These can have immediate effects, utilizing demonstrated technologies. Of course, such programs imply that modern industrialization and economic growth are worthwhile objectives, and they implicitly acknowledge the inevitability of global electrification and growth in electricity demand. This may be ideologically in conflict with the deindustrialization goals of some environmentalists. For example, we have the rather amazing case of Sweden today, recently studied by Nordhaus[6], where the anti-nuclear Green party is pressuring the state to abandon a low-cost nuclear electricity supply and return to higher cost fossil fuels - with a consequent sacrifice in global warming and economic growth, all against the majority wish of the Swedish public. Fortunately, energy issues are less confused in the developing world where poverty and deprivation are priority environmental targets.

I assume that electricity supply investments will be primarily based on proven technologies, and will be chosen in a framework of available capital (domestic and international), social and political stability, and national security. Cost competition will maintain the dominance of fossil fuels for decades to come, even with environmental constraints, but competition among fossil fuels and with nuclear will be intense. In spite of the past difficulties with the first commercial plants in the United States and elsewhere, nuclear power will have a growing role in countries where long-term capital intensive investments are financially secure and the delivery of oil, coal, and gas is costly. It is not

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generally recognized that the new commercial nuclear stations are capital cost competitive with conventional fossil fuel plants, and have the lowest cost fuel with the most secure supply. Only the advanced gas turbine plant is superior to all in gross electricity costs because of its very high conversion efficiency and low capital cost, which overcomes the relatively high cost of natural gas. In China the competition between nuclear power and pipeline gas will be slowly played out. In Japan and Korea, it will be nuclear power vs. imported liquefied natural gas. Clearly, these are country specific situations and very technology dependent.

An effective mix of global and regional strategies requires free access to all technologies. I am concerned that suggested government manipulations of such access by fiscal devices, such as taxation and subsidies, would distort the optimal mix that a free technologic competition could sustain over a long-term. For example, a carbon tax intended to reduce CO_2 emissions would obviously distort the free market mix. It would be a self-inflicted harm if limited to the United States. As a R&D technologist, I view selective taxation or selective subsidies as a subtle form of censorship, and as a meddlesome R&D hindrance in today's rapidly shifting and relatively free market of technologies. This should not be confused with government funding of pre-competitive science and technology, which I support. As an example, research on enhancing nature's terrestrial and oceanic CO_2 sinks appears promising and contributes to a common knowledge base. Commercial competition is a different playing field, best left unfettered.

In view of all this uncertainty, it appears to me that the core of any long-range energy strategy is maintenance of the institutional and technical flexibility needed by a globally dynamic energy structure. As a corollary, the major industrial governments have a global responsibility to sustain the long-term viability of all energy options and advanced technologies. This is beyond the economic time span of the commercial sector. New and improved technologies provide opportunities to beneficially fashion the future, rather than only to remedy unwelcome events. Obviously this is a technologist's "no regret" policy, so I recommend it enthusiastically.

References:

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[3] "CO_2 Emissions Limits: Economic Adjustments and the Distribution of Burdens", Henry D, Jacoby, Richard S. Eckaus, A Denny Ellerman, Ronald G. Prinn, David M. Reiner and Zili Yang. *The Energy Journal*, v.18, n.3, p 31-58, 1997.

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[5] "Global Energy and Electricity Futures: Demand and Supply Alternatives", Chauncey Starr and Milton Searl, *Energy Systems and Policy*, v.14, p.53-83, 1990.

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Energy Efficiency in a World of Abundant, Cheap Energy

*By Hans Jørgen Koch**

It is certainly a great honor and pleasure to address you this morning. The message I would like to leave with you is strikingly simple, it is that:

The threat of climate change means that the world, and in particular we energy professionals, must devote much more of our talent and resources to understanding and curtailing the world's burgeoning energy demand.

Some might respond that the energy markets show no evidence of an energy demand problem. I argue that it is precisely this absence of market evidence, this "near silence", that makes the situation dangerous and makes renewed efforts to understand energy demand and to pursue energy efficiency and conservation so necessary. The world's political leadership is coming to recognize the threat of global climate change, and the magnitude of the technical, economic, and political response needed. But thus far, the energy markets have been "quiet" on the issue.

Markets speak through prices and the actions of suppliers and consumers. And frankly, the "quietness" of the energy markets is evident on most, though not all, fronts. In terms of *prices,* energy markets have been unresponsive. The low energy prices we now enjoy are inhibiting the development, commercialization, and implementation of new energy-efficient technologies. As for energy *suppliers,* they are only now beginning to really come to terms with the challenge. The declaration by the CEO of BP last May that the greenhouse effect was real and that it merited concerted action was very encouraging. But unfortunately, such attitudes are still rare among energy suppliers. Turning to energy *consumers.* Here the situation has been mixed. There have been some encouraging actions taken by industrial and commercial consumers, prompted by their recognition of the potential financial and public image liabilities of not making progress soon. Individual consumers, on the other hand, are reacting very little, they are continuing to demand more energy-using goods and services, with only minor regard for the consequences for climate change.

Outside of the energy market, suppliers of some types of appliances and equipment have made impressive improvements in the energy efficiency of their products. This has not, however, been prompted by signals from the energy market. It has been the result of government persuasion and regulation and, as with industrial and commercial enterprises as energy consumers, the recognition of the potential liabilities of inaction.

The relative "quietness" of the markets makes political action all that much more necessary and all that much more difficult. Of course, you recognize the situation as one of an "externality". Well, this is an externality that cannot be ignored. It must be conquered – first by internalizing as much of it as possible through prices, and second by other policy

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