Sustainable Energy Systems for the 21st Century

(transcript)

Keynote at the Delhi Sustainable Development Summit 2004
New Delhi, February 5th, 2004

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Energy is not only at the center of sustainable development, but at the center of development itself. The improvement in human life expectancy over the last two centuries could not have happened without high-level energy inputs, whether for household use (for cooking or illumination), or in the form of chemical fertilizers to raise crop productivity, or for transportation and industrial purposes. Energy is critical for sustainable development because it is not only necessary for economic development, but also because this necessity drives societies towards environmentally unsound energy use and could severe compromise our planet.

There are three challenges to achieving sustainable energy systems:

First is increasing the availability of energy. Successful sustainable development in the 21st century will undoubtedly require major increases in total energy use. To power the economic growth needed to improve living standards beyond subsistence levels for people currently living in economic isolation, rising economies like India and China will need to adopt measures to increase their energy levels. The same will be true for impoverished regions in sub-Saharan Africa, which are not yet part of the global economy.

Second is the question of environmental sustainability of energy use at the local scale. All forms of energy use involve local environmental risks and trade-offs – the use of biomass may exacerbate local deforestation, while the use of fossil fuels involves problems of environmental pollution.

The third major issue, probably the most complex and least resolved, is prudent global management to make energy systems safe for the global environment. This is especially true with the climate system—a challenge that was not recognized until 30 years ago (although climate science itself is a little over 100 years old).

Let me highlight, therefore, a few points about the first and the third issues.

Increased Availability of Energy

There are two quite distinct aspects to the issue of energy availability—need for a new energy system and global constraints in addressing primary energy needs.

The first issue important in increasing the availability of energy is the urgent need for a new energy system. There are about two billion people on the planet that need to be brought into a modern energy system. These people are outside of the electricity grid and they rely overwhelmingly (sometimes exclusively) on biomass for their local energy needs. For instance, several countries in sub-Saharan Africa rely on local biomass for more than 90% of their primary energy needs. Local biomass is too inefficient and scarce for economic development and improved survival levels. Conversion to modern cooking fuels is important for environmental reasons (biomass fuels undermine the local environment and exacerbate deforestation); health reasons (acute respiratory infection takes the lives of two million children each year because of the use of biomass as a cooking fuel indoors); and to reduce the burden of poverty on women (throughout the impoverished world, women's lives are spent walking excruciating distances fetching firewood and carrying huge loads all day to cook food). Almost nothing has been done about this in the poorest countries.

Getting the poorest of people onto a modern energy system entails two issues. First, it cannot be done on market basis alone. The reason that people are not on a modern energy system is that they are too poor to pay the necessary capital costs and other costs. If we continue with our policy against subsidization, we will continue to have millions of people off the energy grid, and they will continue to experience extreme suffering, economic isolation, and failure of achieving sustainable development. We will need large-scale global subsidization to help impoverished people become part of a modern energy system, for which we have neither an international consensus nor financing. We only have international institutions that work at a local scale to address the access to the electricity grid and other local means of power (for transportation and small-scale industry). Leaving millions to live off biomass is not sustainable development; it is not even civilized. We need to introduce new energy resources – liquid petroleum gas and cooking stoves – that are part of a modern system. Subsidization will play a critical role in making this happen.

The second major issue is whether global constraints are compatible with the increased primary energy needs of a growing global economy. As China, India, and other parts of the developing world grow rapidly in the 21st century, their primary energy requirement will also increase massively. At the global level, there does not appear to be a constraint in the amount of the fossil fuels available, but it does not necessarily come in the type or place that would be most convenient for global growth. For example, while fossil fuels are probably abundant enough to provide primary energy for rapid growth in the 21st century, much of it comes as coal, tar sands, shale oil, etc., and there will be increasing limits to the availability of petroleum.

Some American policy-makers unwisely view the question of petroleum as a great struggle ahead. I think that it is not coincidental that we have increasing militarization of the Middle East, since some believe that there is going to be a scramble between the United States, China, and perhaps India and others, for an increasingly scarce supply of petroleum. However, there are technologies for converting one kind of fossil fuel into another. If we are short of petroleum, coal and other fossil fuels can be converted into petroleum. Synthetics provide a means to ensuring that aggregate supplies rise to meet the global needs. However, this kind of flexible energy system in the future will require investment today in research and development of alternative sources of fuel, and investment in new infrastructure. These investments will take at least 20 years before reaching fruition.

Making Energy Systems Safe for the Global Environment

Supposing an increase in energy availability, and supposing we subsidize energy to meet the needs of two billion of the poorest people, then we will come to the next great challenge – simply increasing energy availability will risk causing major global climatic and ecological change. Greenhouse gases (GHGs) and carbon emissions resulting from fossil fuel combustion are increasingly understood to be major threats to the global environment. We have a modern global economy that depends overwhelmingly on fossil fuels and these fuels are currently leading to about 6 metric tons (Gtons) of carbon emissions per year. If we continue with the current technologies, this figure is bound to double or triple during the course of the 21st century. We have already gone from a pre-industrial carbon concentration in the atmosphere of about 280 parts per million (PPM) to the current 370 PPM, and we are on a trajectory where the 'business-as-usual' approach could triple carbon concentrations in the atmosphere relative to the pre-industrial rate.

This could have devastating consequences for the global ecosystems—one being global warming, which is a GHG effect on average temperatures. However, now we understand that the effects could be far more pervasive and dangerous than global warming. First, the effects would not be restrained to just warming but would lead to massive changes of climate systems and more extreme weather events. According to *Science* magazine (Jurg Luterbacher et al., "European Seasonal and Annual Temperature Variability, Trends, and Extremes Since 1500," *Science* 5 March 2004; 303: 1499-1503), the heat wave in Europe, in the summer of 2003, which claimed about 20,000 lives, can be attributed to anthropogenic climate change. The probability of this kind of extreme event was calculated to be 1 in 5,000 years, if it were purely random. However, most likely, it was not random, but was probably a sign of long-term climate change. Massive changes in precipitation patterns are anticipated. Certain studies that try to downscale the global effects suggest that the Indonesian archipelago, for example, could suffer chronic drought as a result of the long-term changes that are underway. Hundreds of millions of people who depend on rainfall for their survival would suffer tremendous distress and dislocation under such profound climatic changes.

The increased carbon concentration in the atmosphere could also change the chemistry of the oceans. Some of my colleagues have studied the effect of rising carbon concentrations in the ocean, which are changing the ocean's chemistry and putting the coral reef systems around the world at extreme risk—not because of warming but simply because of the rise in acidity in the top layers of the ocean, and the corresponding effect on calcification in coral reef development.

There are increasing suggestions that the changes in ecological zones changes that would accompany global warming and precipitation changes could lead to a mass extinction. An estimate in *Nature* magazine (Chris D. Thomas et al., "Extinction risk from climate change," *Nature* 427, 145-148, 8 January 2004) projected that about 40% of the endemic species in regions that were studied in this report would have a high risk of extinction by the year 2050 under the current trajectory of climate change. In other words, ecological disaster is on the horizon.

The situation warrants immediate remedy. One way or another, we have to control the levels of carbon emission, but this comes with an unwieldy baggage of analytical, economic, and geopolitical challenges. To stop economic development is no answer. A sensible path would be to find ways to combine economic growth with an increasingly reorganized energy system, which would entail greater efficiency of energy use and low carbon emission per unit of energy.

There is a lot of debate and scientific uncertainty about how much energy efficiency, both in terms of energy per unit of economic output and carbon per unit of energy, is needed to reach a sustainable balance in the global ecological system. Some important scenarios are being built as part of the IPCC (Intergovernmental Panel on Climate Change), and, briefly, the conclusions are as follows:

- Energy efficiency has an important role to play, but will not suffice by itself. It will not be feasible to reduce the amount of energy per unit of economic activity sufficiently in order to stabilize the carbon concentration in the atmosphere at a safe and prudent level. An energy system involving reduced emissions of carbon into the atmosphere will have to be created.
- Considering current technologies and trajectories, renewable energy resources have a significant role to play but are unlikely to suffice by themselves. This means that wind, solar, and other renewable energy resources will play an increasing role, but they will be neither adequate nor economically affordable to solve the problem of carbon emissions throughout the 21st century. This implies that we need alternative approaches that go beyond renewable energy. One possibility is to greatly expand nuclear power, which strikes many as horrendously dangerous.
- Considering the inadequacy of renewable and nuclear resources, we are left with fossil fuels. During the coming decades, we need to find ways to convert one kind of fossil fuel into another so that we do not have to rely on petroleum for transport needs, but can use coal and other fossil fuels. The major constraint, of course, is that fossil fuels are the source of climate change, so we need to find ways to both use the fossil fuels and make them safe and prudent – that is, find ways to decarbonize fossil-fuel-dependent energy systems. One of the ideas is carbon capture and sequestration, which seems increasingly critical as perhaps the best option for addressing the problem of increasing energy availability while limiting carbon emission. The notion, simply put, is that improved engineering will allow the capture of carbon gases emitted in combustion, and allow us to put them away before they enter the atmosphere.

The question of carbon sequestration raises significant technological and ecological issues. Geological or chemical captures are the two ideas on the drawing board, and neither is proved, understood, or economically viable at this point. Geological capture involves pumping carbon dioxide into geological reservoirs – for example, abandoned mines or geological domes that were once used for oil and gas recovery. This is already being done in few places—most notably in Norway (by Statoil), where carbon dioxide is being put into geological reserves. However, some think that the geological approach will be insufficient, because carbon dioxide can leak and there are not enough safe reservoirs for the massive levels of storage that will be needed. Chemical capture, a possible alternative, is when carbon dioxide is mixed with minerals; for example, magnesium ores are treated to capture the carbon and form magnesium carbonates, which are more stable compound that can be put back down into mines or buried in landfills.

We face an issue of extraordinary complexity for two reasons. First, it involves the whole world's energy system. Second, the effects of climate change will be felt differentially across the world, and these differential effects, scientific uncertainties, and long lead times, require investing massively in research and development. The big losers are likely to be countries like India, which are not big contributors at this point to the climate change, and the lesser losers are likely be the US, which is contributing about 25% of the carbon despite having only 4.5% of the world's population. The US solution to the problem is to adopt a "head-in-the-sand" attitude and just ignore it. The leading financial newspaper in the US, the *Wall Street Journal*, dismisses issues of climate change as pseudo-science. It is easy for the *Wall Street Journal* editorial board to ignore this problem because it is not going to destroy us for at least another 25 years.

The practical solution would be for the major energy-consuming (either currently or soon-to-be) countries of the world, including the US, the European Union, India, China, and others, to sculpt a plan not for the next 10 years but for the next 100 years. This strategy has to be a comprehensive one, which identifies problems, locates solution, and decides who pays for them. Maybe the broad answer will be to introduce massive levels of carbon sequestration in China and India so that as these countries use their vast coal deposits in the future, they do so in an environmentally safe way. This may be the best approach for minimizing the global cost, but perhaps other industrialized nations should be asked to help pay for it, not just India and China themselves. So, the solution and deciding who pays for it could be quite different things, making the challenge extraordinarily complex.

Ensuring energy availability for all is the lesser problem. Reducing carbon emissions and engaging in prudent management and stewardship of the global environment remain completely unsolved problems. It will take global leadership, the scientific leadership of the IPCC, and it will take leadership of countries like India and China and other major emerging economies to emphasize that, although it is the US and Europe which are at fault, they are ready to sit and talk about the next 100 years. The developing countries have to go against businesses-as-usual to avoid being losers in this process, and to fulfill their places as major contributors on the world stage in the decades ahead.