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I have been asked to discuss energy for the rapidly developing nations, particularly nuclear, and what advice the Science and Technology communities might give to the policy makers. These issues cannot be discussed separately from the global warming problem. Today's energy is mainly carbon based and its use is already contributing to global warming by adding gases to the earth's atmosphere that trap heat. While there is plenty of supply, particularly of coal, scientific analysis says that we have to move away from using energy that adds more of these greenhouse gases to the atmosphere. The S&T community has to give the policy makers technical options that will allow energy use to increase, which is essential for development, while today's largest source, fossil fuels, decreases. The task of the policy makers is to devise international agreements that spread the burden in an equitable way.

Regrettably, there is no single, simple technical option. A combination of efficiency; nuclear power; renewables including bio-fuels, wind and solar; and new energy sources like fusion power has to increase while fossil fuel use decreases. The two that can make the largest contribution now are efficiency and nuclear. Fusion is far in the future. All of the renewables are important, but all suffer from shortcomings having to do with the intermittency for wind and solar and technical obstacles for bio-fuels. R&D to improve performance for all of these should be strongly supported.

Efficiency should be the first priority. Energy that we do not use does not pollute and does not cost anything. All energy demand forecasts assume a 1% per year decrease in the energy use per unit of GDP. While this is the historical average, there have been periods when it declined faster. If we could make it decline by 2% per year the energy needed at mid-century would be dramatically reduced. The technology to do this is here now - hybrid cars and trucks, for example, could reduce transportation energy needs by nearly a factor of two. There are many other options.

Nuclear energy is undergoing a renaissance. There are 20 to 25 reactors under construction today and another 50 or so in the planning stage. The driver for this is more the desire for a secure supply than it is greenhouse gas abatement, nuclear is good for both. Today's nuclear reactor designs are more efficient, simpler to operate and more modular than the last generation. Safety will always be an issue, and a good regulatory system is essential. People do ask about the chances of another Chernobyl like explosion. Reactors of the Chernobyl type were never built outside the old Soviet Union because of their potential for accidents under very special conditions. We will never know why the operators of that reactor systematically disabled every one of its safety system in some misguided experiment.

There is a concern about proliferation of nuclear weapons as reactors come into use in more nations. There is a potential for obtaining weapons grade uranium at the enrichment stage of the fuel cycle where the concentration of U-235 is increased, and from the plutonium in the spent fuel. South Africa and Pakistan produce their weapons from enrichment technology. S. Africa gave up theirs under international supervision. Libya started down this road and then abandoned it. There is concern about Iran's intentions. N. Korea, India, and Israel produced material for their weapons by separating the plutonium produced in spent reactor fuel from heavy water moderated reactors that can run on un-enriched natural uranium.

Unfortunately, there is no proliferation proof nuclear fuel cycle. The S&T community can only produce technology and devices that give early warning of attempts at diversion.

The community of nations will have to improve the diplomatic approach to limit weapons proliferation. There has been talk of a system based on leased fuel where suppliers will deliver the appropriate fuel and take it back after use. This has an enormous economic benefit for smaller nations, because enrichment and waste storage are very expensive when done on a small scale. Perhaps a workable system of some kind can be developed but any such system will have to have a sufficient diversity of supply so that no user worries about being cut off from fuel for political reasons.

To me the most important and complex policy issue is dealing with global warming. The Kyoto Protocol itself was a bare beginning and the real issue is what happens next. At the time of the Protocol the attitude of the developing nations was that the industrialized nations made the problem and should fix it. This is not workable. By 2030 the developing nations will be using more energy than those called industrialized today, and China will take the place of the United States as the largest single user.

Incentives work better than sanctions. Schemes need to be devised where it is the economic interest of greenhouse gas emitter to decrease their emissions. Caps on emissions and permits to trade are one way. Taxes or fees on emissions are another. This is going to take a lot of thought and much discussion. It would be best if a smaller group than met at Kyoto, but still representative, begin to study the problem. The sooner this starts the better for all.

I can only conclude by saying that in this area, politics is harder than physics.