Expanding Nuclear Power Worldwide To Prevent Climate Change

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Of the countries that are party to UN Framework Convention on Climate Change (UNFCCC), the two with the lowest emissions of carbon dioxide per unit of gross domestic product are Japan and France, the two countries with the greatest commitments to nuclear energy. If the UNFCCC were ultimately successful it would mean that atmospheric CO_2 concentrations would not double the current level of about 370 ppm. [1] If the world's easily-recovered uranium reserves are fissioned in reactors, about 5300 ppm of atmospheric CO_2 emissions could be avoided.[2] Other reserves could stretch the contribution by orders of magnitude.[3] Thus, nuclear energy potentially has a large role to play in meeting the goals of the UNFCCC, especially if other technologies do not live up to their promises.

Rather than allowing nuclear energy to place a central role in the UNFCCC, the parties recently agreed not to allow nuclear energy into its Clean Development Mechanism (CDM). The representatives from the European Union, especially, think it is easier to leave nuclear energy out of the mechanism than address problems with nuclear proliferation and reactor safety. Some also claim that nuclear energy is not sustainable, although, as shown above, it is difficult to support this argument on the basis of resource depletion.

Without nuclear energy, there is no reason to believe that carbon-free technologies will be adequate to meet future energy demand, especially in the developing world, unless the goals of the UNFCCC are abandoned. Simply stated, burning fossil fuel (without sequestering the CO_2) is now the most economical option for most of the developing world. This will not change unless there are dramatic developments in carbon abatement technology, or nuclear power is allowed back into the CDM. If nuclear power is put into the CDM, much additional care and thought must be added as well.

The most serious objection to nuclear power -- some would say the only serious objection -- is the possibility that it might foster nuclear weapon proliferation. Therefore, it is important that there be mechanisms to address this concern.

The Carbon-Control Framework

The details of the nuclear aspects of a future agreement are difficult to envision without first discussing the current framework for greenhouse-gas-emission mitigation. It is assumed that some sort of workable but realistic framework will survive into the future with most of the industrial countries participating.[4] It is also assumed that the CDM will survive, allowing the industrial countries to export carbon-free power technology to non-participating countries to collect credits.

The agreement to reduce carbon emissions encourages national governments to create economic incentives for constructing and using carbon-free power plants. Alternatively, they would create economic disincentives or taxes on carbon dioxide emissions. Either way, the fundamental

metric for this incentive is the "carbon value" expressed in units of $ per ton of carbon avoided. This value may be determined by fiat or by market or by a combination. In general, the more stringent the emission-reduction goal, the higher the carbon value. If there is greater international participation and trading allowed, the carbon value will tend to be lower for a given amount of carbon reduction.[5]

Suppose a power plant generating a thousand megawatts of electrical power needs to be built, and there are two choices for the fuel; one is coal and the other is a carbon-free fuel. Suppose further that (in the absence of added incentives) it costs more to build and operate the carbon-free plant than the conventional fossil fuel power plant. The owner of the plant must get some financial compensation or avoid some financial penalty for not emitting CO_2 in order that it be persuaded to select the carbon-free plant. Suppose that the power plant owner is required to obtain a permit to emit carbon dioxide into the atmosphere every month, and that the permit costs $100 per ton of carbon. Under these circumstances, a carbon-free power plant would avoid paying hundreds of millions of dollars every year for permits.

From a policy viewpoint, this type of mechanism is a good way to balance environmental and economic objectives. For corporate and other decision-makers, they will be able to make business decisions based on the information available in this marketplace. The only requirement for this mechanism to work smoothly is that investors be fairly sure that they cannot otherwise avoid the need for the permits. This mechanism could work even if dollar amount of the emission permit were dictated by governmental fiat. However, if there is a market mechanism that determines the value of the carbon dioxide permits, information about carbon values will be continually updated depending on world economic conditions. It is therefore preferable to use a system based on tradable carbon-emission permits and allow there to be a world market in permit trading.

The nation where a power plant was built would then simply show the UN body charged with climate-change treaty compliance that it is enforcing its permit laws. National governments would have no other obligations theoretically, if there were a free world market on the permits.

No nation has yet seriously adopted this type of strategy, and as a result there has been essentially no abatement of greenhouse-gas emissions in the world other than for reasons of economic downturn. In the future, if this changes, each country will try to follow its target emissions quota for each year. Control of total global carbon dioxide emissions would occur simply by limiting the number of permits issued worldwide.
Enforcement of compliance could raise some very serious political problems at the international level, which would tend to make the regime unstable. Suppose a country has an economic recession but still needs to spend large amounts of money on controlling carbon emissions. There would be strong motives for that nation's government to either stop enforcing the emissions-permit process or to withdraw from the treaty completely. This problem would nearly disappear if there were a zero-cost way of avoiding fossil fuel use. However, at the present time there are no avoidance technologies that are widely applicable, especially in the transportation sector, that have zero or negative cost.[6] The motivation to stay within the regime becomes greater if the economic costs of staying in the regime are lower. If costs are too high, the regime will collapse.

Developing countries do not, in general, want to join the agreement. Countries such as India and China intend to expand their economies significantly over the next 50 years,want an exemption because their fossil fuel use per-capita is only a tiny fraction of the average for the developed world. Therefore targeting their allocation to a previous year's emissions seems unfair to them. Some compromise could be worked out, where developing nations were not asked to fully join the international regime until their per-capita income level reaches a certain fraction of the developed world average. All of this is a current subject for debate at the international level and, for the time being, the agreement does not require that the developing nations control their emissions of greenhouse gases.

The distribution of permits within a country (by its government) is properly the internal affair of each nation. For example, France may simply distribute some permits to its large, state-owned industries and require private industry to pay a fixed fee for each allocation of carbon dioxide emission. In another country there may be an auction. In any case, each government can raise revenue by selling the permits; this revenue stream can pay for the costs of enforcement.

Governments, of course, also have the right to create and enforce all sorts of laws and regulations regarding the technologies that are allowed for energy production. For instance, local governments may ban certain energy technologies they deem to be inappropriate, possibly including nuclear power. Export of carbon-free power plants could occur under the same treaty, without additional protocols, if both the exporter and the importer were treaty members. The corporate exporter and the importer would divide the costs and profits according to their own, separate agreement.

A separate mechanism, the CDM, is required to account for construction in developing nations that are not party to the treaty. If a developed nation exports a carbon-free power plant to a developing nation, it could receive an allowance for the avoidance of an appropriate amount of greenhouse gases.

Nuclear Exports

A high-visibility template for proliferation-resistant nuclear power export is the Agreed Framework (AF) between the US and North Korea (DPRK). The effort to halt the DPRK's nuclear research assumes great importance in the present context because it holds powerful implications for the evolution of the international non-proliferation regime. If agreements that are as good or better can be made, more countries can be brought into the center of the regime. The parties to the UNFCCC should borrow from the AF to include nuclear energy in the CDM.

Under the AF, the government of DPRK has agreed to freeze and ultimately abandon its nuclear weapon program in exchange for support from foreign governments in constructing two state-of-the-art nuclear power plants in North Korea. The power plants, built under modern safety standards, using a proliferation-resistant fuel and reactor design, will be safeguarded by the International Atomic Energy Agency (IAEA). The swap, which is verifiable,[7] is a good deal for

all the parties involved. In this particular case, the money is provided by the governments of Japan and South Korea, who have an interest in stability and peace in the region.

Integrating nuclear power into the CDM would require the nations to work closely with the IAEA to set standards for reactor safety, waste disposal and nuclear safeguards. Credits would not be made available unless the recipient nation is in good standing in the NPT and dismantled any nuclear weapon infrastructure and reprocessing facilities. The countries that are already within the regime but have not accepted the current (INFCIRC/540) safeguards standards from IAEA would have to accept the new standard. The recipient nation wouldalso provide its initial declaration of materials and facilities, and have that declaration verified by the IAEA. This whole process could take as long as a few years and could cost the IAEA considerably in terms of resources. Therefore, the exporter and importer nation would be required to be in good standing with respect to their IAEA monetary obligations.

There would be special "transitioning" provisions for a weapon state such as India who wishes to receive the nuclear power plants. It would be obligated to join the NPT and agree to the INFCIRC/540 safeguard protocol. It would immediately shut down and begin dismantlement of any plutonium-production reactors that are not also used to produce electricity. Power-producing reactors and dual-use reactors would continue to operate unless replacement capacity is provided on a temporary basis by the exporter country through, e.g., small gas turbines. It would store all its separated fissile material in cans or canisters. Seals would be put in place on the frozen materials while the new power reactors are under construction. It would cease production of highly enriched uranium, but not low-enrichment uranium. During the period of time when the new power reactors are being built, the IAEA will verify the accuracy of the initial declaration of materials and facilities. The nuclear components of the new reactors would not be delivered unless the IAEA verification process was complete. When the installed capacity of the new power reactors exceeds the capacity of the old infrastructure, dismantlement of the old power reactors would begin.

The subsidized power reactor exports could only add stability to the non-proliferation regime because it would provide incentive to join and stay within the regime.[8] The NPT would not have to be amended; the process of accepting the power plants along with the enhanced safeguards would be voluntary and non-discriminatory. Low-enrichment uranium fuel will be supplied to the recipient nation under long-term contract. Reprocessing or re-enrichment of fuel would be disallowed. The spent power reactor fuel can be monitored on the site or moved to another location, such as an international or regional facility. Under the monitoring, the burnup and the history of every fuel assembly will be known and catalogued.

The new plants would come with a limited-term maintenance agreement and an initial, interim work force. During this start-up period, the recipient nation will have to learn how to perform maintenance, repairs and refueling. There will be a period where the interim work force will be training the permanent work force through an apprenticeship program.

The plant owners will not receive the subsidy unless the plant is built and operated according to international (IAEA) safety standards. If the recipient nation is not capable of running their own plants in a safe manner, the safety standards must be imported with the power plant. A

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workforce will be trained in the safe operation and maintenance of the plants. These nuclear workers will be trained how to run plants safely, how to maintain plants safely, and after a few years will have come up to the level of training which will qualify them in apprenticeship roles. A regulatory force will be trained for those countries that do not have an independent regulatory commission that regulates the nuclear industry. The regulatory force itself will have to comply with international standards.

The recipient nation would relinquish any ownership rights over the spent fuel and agree to the transfer of the spent fuel out of its territory as soon as technically possible after the fuel is discharged. Dry spent fuel storage technology is not out of the question for many sites around the world. A typical storage cask is made out of reinforced concrete, and each one weighs about 100 tons. The fuel cannot be removed unless one has a special lifting device to actually lift the entire cask and take it to a facility that disassembles it. The casks would be stored where the spacing is several meters and resolution typical of optical cameras from a low orbit satellite is about one meter, so individual casks can be easily resolved in satellite imagery. Commercial photography in the visible and infrared range may be used for verification.

Conclusion

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Nuclear energy may have a significant role to play in preventing dangerous climatic changes, especially if there are troubles expanding other forms of carbon-free energy. But nuclear energy has been blocked from admission into the UNFCCC's CDM because of the argument that it is not "sustainable," and also because of concerns about nuclear proliferation and reactor safety. Yet the resources of fissionable material, especially if uranium from seawater is included, are essentially inexhaustible. Legitimate concerns about nuclear proliferation and reactor safety can be addressed by using the CDM as a means to bring the nuclear programs of the world up to the best international standards. In fact, if done carefully, an expansion of nuclear energy under the CDM could actually reduce worldwide nuclear proliferation and reactor safety concerns.

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[1] William C. Sailor, David Bodansky, Chaim Braun,Steve Fetter and Bob van der Zwaan, "A Nuclear Solution to Climate Change?", Science, May 19, 2000.
[2] A. M. Weinberg, "Some Necessary Conditions for the Rebirth of Nuclear Energy," Nuclear News, American Nuclear Society, November 2000, pg. 47.
[3] R. L. Garwin, "The Nuclear Fuel Cycle: Does Reprocessing Make Sense?", in Nuclear Energy Promise or Peril, a Peer Review Workshop of the Pugwash Conference, Paris, Dec 4-5, 1998, Published by World Scientific Publishing, Inc., 1999, pp 139-151.
[4] The US, for now, is not participating

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[5] W. D. Nordhaus and J. G. Boyer, "Requiem for Kyoto: An Economic Analysis of the Kyoto Protocol", The Energy Journal, Kyoto Special Issue, 1999, pg. 93.
[6] The most promising technology now is probably carbon sequestration, which will probably have a significant positive differential cost. See R. H. Williams, "Advanced Energy Supply Technologies," Chapter 8 of the World Energy Assessment Report, 2000, UNDP, New York, NY, September, 2000.
[7] M. May, C. Braun, G. Bunn, Z. Davis, J. Hassberger, R. Lehman, W. Ruhter, W. C. Sailor, R. Schock and N. Suski, "Verifying the Agreed Framework," Lawrence Livermore National Laboratory, Center for Global Security Research, UCRL-ID-142036, April 2001.
[8] W. C. Sailor, "How to Think About Nuclear Power and Proliferation", Forum on Physics and Society, April 2001.