Responsible Use of Civil Nuclear Technology

Islamabad Policy Research Institute

I approach the issue of nuclear energy through the lens of climate change. The stated goal of the UNFCCC, to prevent "dangerous human interference with the climate system," is now unachievable. The challenge now is to prevent catastrophic change—climate change that would render the world of our great-grand children almost unrecognizable to us, with droughts, sea-level rise, storms, and floods that could cause massive dislocations.

Avoiding catastrophic climate change will require stabilizing the concentrations the concentrations of CO2 and other GHGs at levels that are not far above current concentrations. This will require major reductions in emissions over the next 50 to 100 years.

To put the magnitude of this challenge in context, to stabilize greenhouse gas concentrations at a level equivalent to twice the preindustrial level of carbon dioxide, emissions of carbon dioxide for fossil fuel burning would have to decline from the current level of 8 GtC/y to 5 Gt/y in 2050. For comparison, in the average BAU scenario, emissions rise from 8 to 14 Gt/y in 2050. Much of this is from coal. A large 1 GWe coal-fired power plant emits 1 MtC/y. Thus, to stabilize at an equivalent doubling, we must eliminate or avoid building the equivalent of 9,000 coal-fired power plants over the next 50 years.

There are only four options for reducing carbon emissions:

1. Reduce demand by increasing efficiency and by making fossil fuels expensive
    - BAU already assumes increased efficiency
    - Demand reductions can't do entire job; energy consumption must increase in most of the world to facilitate economic development
2. Renewables: wind, solar, biomass
    - Wind and solar are intermittent; can't supply more than ~20% of electricity supply without storage, which is expensive
    - Because of the low efficiency of photosynthesis, the land requirements of biomass are very large. To replace all of the oil used to do with biofuels (oils and alcohols) would require 700 million hectares—roughly equal to the amount that is harvested worldwide for all grains—wheat, corn, soybeans, and rice.
3. Carbon capture and storage
    - Costs unknown and likely to be high; concerns about long-term stability
4. Nuclear
    - Only low-carbon supply option deployed on a large commercial scale today, and could be greatly expanded

For nuclear to contribute, it must be expanded significantly. If world nuclear electricity production grew by a factor of 4, from the current level of 360 GW to 1500 GW in 2050, it would likely supply no greater fraction of world electricity supply than it does today (~15%), and it would provide only about 15% of the required carbon mitigation. Even if nuclear grew by a factor of 10, it would only provide only 40% of the required carbon mitigation. So if nuclear is to make a significant contribution to solving the climate change problem, a very large expansion is necessary. (A factor of 10 over is an average growth rate of < 6%/yr—achievable.) Most of this growth would have to occur in developing countries, including many countries that now have little or no nuclear generation.

This expansion in nuclear power is advisable only if it can be accomplished without significantly increasing the risks that additional countries will acquire nuclear weapons; or that terrorists will steal nuclear materials or sabotage nuclear facilities.

I am convinced that the other issues surrounding nuclear can be resolved. Nuclear will very likely be economically competitive with the other low-carbon alternatives; the next generation of nuclear plants can be adequately safe; and nuclear waste and be managed and disposed of while protecting public health and safety. I am most worried about the potential links between nuclear power and nuclear weapons.

For the near term—the next 20 years or so—I believe that the best option is advanced LWRs operated on a once-through fuel cycle, with long-term (50-100) storage of spent fuel, pending a decision to either permanently dispose or reprocess the spent fuel. LWRs are the most mature reactor type, and the only technology that can be built on the required scale for the next 20 years. The new generation of LWRs, the so-called Gen-III+ reactors, such as the new joint French-German European Power Reactor, should be at least 10 and probably 100 more safe than the LWRs built in the 1970s and 80s. The fuel itself is highly resistant to misuse: the fresh LEU fuel cannot be used for weapons, and the plutonium in the spent fuel is bound in a chemical matrix and protected by an intense radiation field.

The problem is that these reactors require a steady supply of fresh fuel. As nuclear grows, more or more countries may wish to enrich uranium and produce their own fuel. The very same enrichment technologies can be used to produce high-enriched uranium for weapons. The concern isn't that a commercial facility would be converted from LEU to HEU production, because the production of any HEU would be readily detected by safeguards. The main concern is that any country that has a commercial LEU facility would build a secret HEU facility, and a secret centrifuge enrichment plants is virtually impossible to detect by technical means alone. Another concern is a leakage of technology—either intentional or unintentional—to additional countries or groups, as has happened several times in the past—most recently in Pakistan.

If nuclear power grows substantially and uranium becomes expensive, more countries may wish to reprocess and use plutonium-based fuels. This is even more worrisome, because material accounting is inherently difficult in reprocessing plants, making it impossible to verify in a timely manner that a significant amount of plutonium has not been diverted. Fresh plutonium fuels are also highly vulnerable to misuse, because the plutonium can be separated in from uranium in a glovebox using straightforward chemistry described in standard textbooks. This could be done by sophisticated terrorist groups. Plutonium fuels would have to be accorded the same level of protection as nuclear weapons, both in transit and in storage at reactors. And if there are thousands of reactors, there could be thousands of shipments and thousands of storage facilities.

As you know, Article IV of the Nonproliferation Treaty states that all Parties have an inalienable right to use of nuclear energy for peaceful purposes, without discrimination, and this is widely interpreted to mean that any country can have an enrichment or reprocessing plant so long as they are under safeguards. Iran is testing this proposition right now. The problem is that safeguards cannot by themselves provide adequate assurance that these technologies are not or could not quickly be used for weapons purposes. As IAEA Director General Mohammed El Baradei said a few years ago, any state with an enrichment or reprocessing facility is a “virtual weapons state,” no more than months away from a nuclear weapon. Even if such a country has no interest in nuclear weapons, this could generate mistrust. Today, only a very small number of non-nuclear-weapon states have enrichment or reprocessing facilities. But in a world with ten time more reactors, there could be dozens.

This observation led El Baradei to call for a fresh look at internationalization of sensitive fuel cycle facilities and activities. In 2005, an IAEA expert group reviewed the options and issued a report on multilateral approaches to the fuel cycle. Recently, attention has focused on the idea of establishing an international fuel bank to guarantee fuel supply. Access to the fuel bank would be open only to countries without enrichment or reprocessing facilities, and who are unable to acquire fuel through normal market mechanisms. The U.S. Congress is currently debating legislation that would provide $100 million to help establish a fuel bank. In a separate initiative, in 2006 Russia has proposed creating an international fuel cycle facility, located on Russia territory. Countries would be invited to buy a share of the facility and guarantee supply of fuel, so long as they do not have enrichment or reprocessing facilities. The United States is promoting its “global nuclear energy partnership,” under which current suppliers would band together to guarantee a supply fresh fuel to all other countries, if they forego enrichment and reprocessing. CISAC is currently examining these proposals in a joint study with the Russian Academy of Sciences on the internationalization of the nuclear fuel cycle.

In my view, none of these initiatives is likely to substantially reduce concerns about proliferation if nuclear energy grows by a factor of ten. A country that fears that, for political reasons, it may be denied access to nuclear fuel through normal markets will doubt that an IAEA fuel bank or a Russian-owned facility or a consortium of current suppliers would be exempt from the very same political considerations.

One thing that might change the calculations of user countries would be believable guarantees by supplier countries to take back spent fuel, if a country forgoes enrichment and reprocessing. Being relieved of the need to manage and dispose of spent fuel would be a substantial incentive. These are elements of the Russian and U.S. proposals, but both have coupled this to an unnecessary and expensive proposal: reprocessing + fast reactors. Who will pay extra expense? Supplier states—OK.

Better idea: develop nuclear batteries.

- Small (50-100 MW) sealed core reactors, mass produced in factories and shipped to site by rail car or ship. Size more appropriate for developing countries than 1300 MW.

- Core would have a lifetime of 20-30 years. At end of life, reactor would be returned to manufacturer. No need for fuel supply and spent fuel management.

- A component of GNEP, but no funding.

- To compete economically with large LWRs, economies of mass production would be needed.
- Like commercial aircraft