World Nuclear Association

World Nuclear Association Annual Symposium
7-9 September 2005 - London

Nuclear Power Revival: Short-Term Anomaly or Long-Term Trend?

Hans-Holger Rogner

Abstract

Entry into force of the Kyoto Protocol, recent international price hikes for fossil fuels and uranium, concerns about energy supply security and surging demand for energy in key developing countries are causing policy makers to reassess the nuclear power option around the world. Countries with large populations and fast growing economies have already included an accelerated expansion of nuclear power into their national energy supply portfolios. Other countries, especially many members of the OECD, are still hoping that their efficiency and renewables' programmes will suffice to meet their respective Kyoto obligations.

Later this year, at the first Meeting of the Parties (MoP-1) of the United Nations Framework Convention on Climate Change (UNFCCC) negotiations will begin on greenhouse gas emission limitations beyond those already agreed in the Kyoto Protocol. Without some contribution to climate protection by key developing countries, and without re-involvement of the United States in the process, such negotiations are unlikely to produce agreements on greenhouse gas (GHG) emission reductions beyond the current protocol. However, nuclear power could play a key role in advancing climate mitigation and widening the number of nations currently committed to GHG emission limitations. The two flexible mechanisms from which nuclear power projects are currently excluded, the Clean Development Mechanism (CDM) and Joint Implementation (JI), could, were the exclusions reversed, become instrumental in nuclear technology transfer and environmental protection.

Most long-term studies of global energy demand and supply consistently project an increasing share of nuclear energy, especially for the period after 2030, irrespective of the presence of policies targeted at climate protection. Short-term energy outlooks usually show a declining share of nuclear electricity. With the entry into force of the Kyoto Protocol, short-term projections have already been revised upward. Still, the gap between short- and long-term projections remains

large. This paper will look at those factors that could link up nuclear power developments in the short run with the projections of the long-term studies.

The projection gap

Two years ago at this Symposium I talked about the projection gap, meaning the gap between what long-term scenarios suggest about the future of nuclear power and what short- or medium-term scenarios project. Long-term scenarios are generally more bullish.

Last year my co-author, Alan McDonald, spoke about, among other things, upward revisions in the IAEA's medium-term nuclear projections[1] for the fourth straight year, meaning at least our medium-term projections were getting closer to the long-term projections. Also since last year's Symposium, the International Energy Agency has also come out with slightly increased nuclear projections in its *World Energy Outlook 2004* (IEA 2004), and this July the U.S. Energy Information Administration increased its projections for nuclear power in 2025 in its *International Energy Outlook 2005* (EIA 2005). There has also been a lot of talk about rising expectations and a possible renaissance for nuclear power, both at nuclear conferences, at broader energy conferences and at least in the English-language general media.

But even with the positive buzz and with the upward revisions in medium-term projections, the projection gap still exists. *Figure 1* offers one illustration, comparing the IAEA's latest low and high projections (the red and blue lines) with the median for nuclear expansion (the dotted line) in the scenarios in the IPCC's *Special Report on Emissions Scenarios (SRES)* (IPCC 2000).

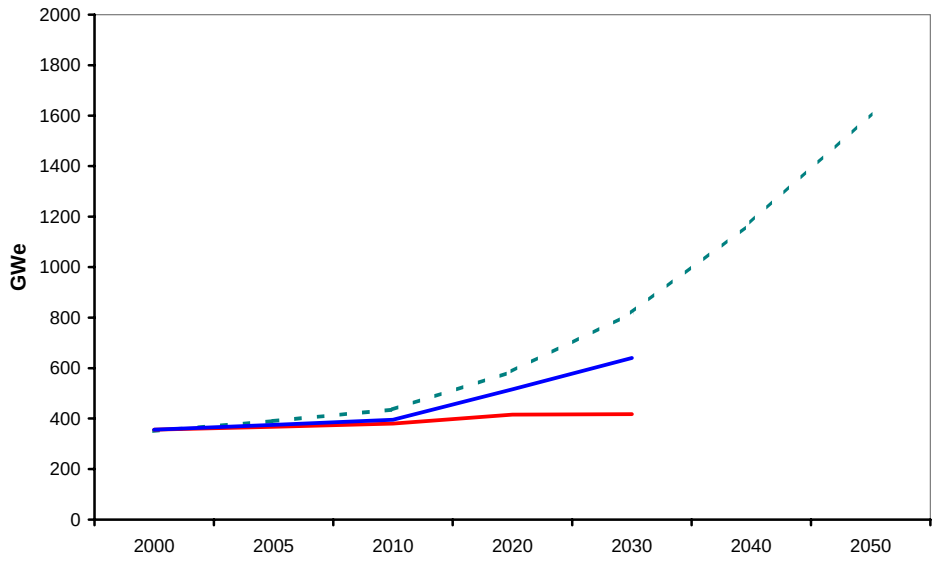

Figure 1. Nuclear capacity projections. The blue line is the IAEA high projection. The red line is the IAEA low projection. The dotted line shows the median values for the SRES scenarios.

[1] The 2005 updates of the IAEA projections are reported in *Energy, Electricity and Nuclear Power Estimates for the Period up to 2030*, Reference Data Series No. 1, IAEA, Vienna (July 2005).

There are several factors contributing to the projection gap.

Discount rate differences

SRES's long-term scenarios use lower discount rates than those most likely used by potential investors today in analyzing their options. The current front-loaded cost structure of nuclear plants, with their high initial capital costs and low long-term costs, is therefore less of a disadvantage in the scenarios than it would be for an investor in a liberalized energy market who faces higher financing charges and needs a rapid return on his investment. The models used in the SRES scenarios are thus likely to still 'buy' nuclear plants with high capital costs even when a private investor in a liberalized market would not. Of course, not all prospective investors will be private companies seeking quick returns in fully liberalized markets. Many are likely to be governments that can focus on longer-term returns, and for whom low discount rates are appropriate. But some investors will use higher discount rates than the SRES scenarios, and medium-term projections taking these investors into account will therefore, other things being equal, include less nuclear expansion.

Financial risk

Second, in the models used to create the SRES scenarios, investments are essentially risk-free. They benefit from the model's 'perfect foresight'. In the real world, there are plenty of risks that a potential investor needs to factor into his investment choice. They won't be the determining factor in every decision, but they will swing some decisions away from nuclear power, and thus lead to fewer nuclear investments than calculated in risk-free scenarios. These risks are mainly the risk of regulatory delays that raise costs at the front end of a plant's life cycle, and the risk of longer-term low demand or low prices that reduce the revenue stream in the out-years. Reducing such risks, through mechanisms like the partial regulatory insurance provided in the new U.S. Energy Policy Act, would reduce the projection gap.

Fossil fuel depletion

The SRES long-term scenarios have a planning horizon through 2100. There will be significant depletion of low-cost fossil resources (and low-cost uranium) over such a long time horizon, and a resulting continual increase in fossil fuel costs. The anticipation of higher fossil fuel costs translates into bigger shares for nuclear power. The effect is evident even early in the scenarios as the optimization models used for SRES, taking into account the fact that sharp increases in nuclear capacity cannot happen overnight, include early investments in nuclear power so that the industry and capacity are ready when needed.

Politics vs. economics

The medium-term projections start with the projects and plans of governments and utilities as they stand today. This is a conservative approach that reflects the politics of the past more than political possibilities in the future. Especially in Europe and North America the past 15 years have seen very little new nuclear construction, and this trend continues in the medium-term projections.

Conversely, the long-term scenarios of the future are based much more on economics and the comparative long-term costs of alternatives.

Innovation

The medium-term projections are based largely on today's designs at today's costs, while the long-term scenarios assume continuing technological innovation to both raise performance and lower cost. The SRES scenarios include, of course, innovation and performance and cost improvements for all technologies, not just nuclear power. So it is not clear how much of the projection gap may be due to innovation. But even if the contribution is small, we want to make sure that the importance of innovation is not overlooked. "Even if you're headed in the right direction, if you stand still you'll still get run over."

Start-up costs in new nuclear power countries

As noted above, nuclear power plants are expensive to build but cheap to run, a disadvantage in liberalized electricity markets with private investors that value rapid returns. It is less of a disadvantage in the case of government investors and/or a regulated market. But the front-loaded cost structure, plus regulatory risks, is one reason the business case hasn't yet been strong enough in, for example, the USA for any group to take the plunge on new nuclear investment. If the up-front costs are so intimidating in a rich country, they are just that much more so in a less well-off developing country. Moreover, if that developing country is new to nuclear power, it will have additional start-up costs in terms of establishing a regulatory infrastructure, a skilled manpower pool, and supporting industry. And today's politics suggest that proliferation concerns may yet translate into additional start-up costs for a new nuclear power aspirant. We recognize that Iran, the only country currently building its first nuclear power plant, is a special case. But there is a why reason many developing countries are concerned that the resolution of international differences over Iran's nuclear program does not create new barriers-to-entry for other nuclear aspirants. All these difficulties loom larger in medium-term projections that focus on specific potential projects and the obstacles they face, than in long-term optimization scenarios driven more by economics.

Our personal prejudice is that in the long run the economics are more likely to drive the politics than the other way around. Perhaps we're already seeing some adjustments taking place in the provisions of the new U.S. Energy Act, and even in the new India-USA agreement. With respect to Asia, where current and near-term expansion is centered, none of the medium-term projections yet measures up to the stated plans of China and India, so we'll have a chance in the next decade and a half to see whether the planners or pundits, as it were, were closer to the mark. In the meantime, we find the projection gap useful both for identifying what needs to be done to further nuclear power expansion, and for tracking progress.

Kyoto and post-Kyoto

The long-term SRES reference scenarios summarized in *Figure 1* assume no constraints on carbon emissions. When carbon constraints are added to such scenarios, nuclear power's role generally expands. With entry-into-force of the Kyoto Protocol in February, most of the world's developed countries are now part

of a common system of new carbon constraints, the effects of which will also be felt in some developing countries through the Clean Development Mechanism (CDM).

It is important to distinguish the direct near-term effects on nuclear power of the Kyoto Protocol's entry-into-force from the potential longer-term implications. The latter may be substantial, but the former are likely to be slight. Among other reasons, the Kyoto Protocol's limits currently apply only to the first commitment period, 2008-2012. 2008 is just three years away, not much lead-time for a new nuclear power plant.

In the longer term, if the UNFCCC goal of a stable, safe atmospheric concentration of GHGs is to be accomplished, the Kyoto Protocol's emission limits will have to be tightened and its geographical coverage broadened. This will make emission reductions increasingly expensive, as much of the low-hanging fruit will already have been harvested in the first commitment period. Especially important will be provisions for the current non-Annex B countries[2], whose GHG emissions by 2020 will have surpassed those of the Annex B countries according to a large majority of the IPCC SRES reference emissions scenarios. If these countries remain outside Annex B, the CDM will be the only international mechanism creating economic incentives for them to reduce GHG emissions.

Currently, nuclear power projects are excluded from JI and the CDM. These exclusions were part of the Bonn Agreement negotiated at the second session of CoP-6 in April 2001 and were formalized in the Marakkesh Accords at CoP-7 later that year. Their motivation was hardly the efficient achievement of the UNFCCC goals: the exclusion from any of the flexible mechanisms of any technology with clear climate benefits can only limit options, flexibility and cost-effectiveness. The exclusions were rather the result of political horse-trading, with their advocates offering concessions that more than offset, in the eyes of the exclusions' initial opponents, any disadvantages introduced by the exclusions. For nuclear advocates they were, at least in the short-term, a relatively costless concession. Few nuclear CDM projects were in prospect for the 2008-2012 first commitment period.

If the big developing countries remain outside Annex B, so that the CDM is the only international mechanism creating economic incentives for them to reduce GHG emissions, the nuclear exclusion in the CDM will no longer be a costless minor concession. It will eliminate from the CDM the electricity supply option that the IPCC's latest assessment report (IPCC 2001) estimates to have the greatest GHG mitigation potential of all electricity supply alternatives. One solution is the elimination of the nuclear exclusions in any post-2012 emission limits and rules. As noted above, it makes no substantive sense in a climate agreement. Several countries, including India and Japan, made strong arguments already at CoP-10 for doing away with the nuclear exclusions, and it is expected that these two countries are joined by many others at CoP-11 in Montreal in December.

[2] Annex B countries are those with GHG emission limits specified in Annex B of the Kyoto Protocol, essentially the developed countries.

However, while we personally believe that the elimination of the nuclear exclusions should be a priority objective when negotiating the rules for the second commitment period, rising fossil fuel prices create a potential Catch-22 for nuclear power. A project is only eligible for the CDM or JI if it is *not* the least-cost, most desirable project to begin with. In a joint study that the IAEA coordinated before the Bonn Agreement and the nuclear exclusions, teams in five Members States (China, India, Pakistan, the Republic of Korea and Vietnam) looked at possible nuclear CDM projects. For new capacity, coal-fired power generation was the least cost baseline option in each case, except for Indian sites that were more than 1200 km from the nearest coal mine. For such sites, nuclear power was the least cost option. With that exception, each case study compared its coal-fired baseline to alternatives with lower GHG emissions. In all of the comparisons, nuclear power proved to be the least cost GHG mitigation option, with mitigation costs (based on levelized generating costs) ranging from slightly over US$4 per tonne of carbon (tC) in Korea to between US$26/tC and US$57/tC in the other four countries. That is, if the next cheapest alternative for reducing carbon emissions were to cost more than these amounts, a nuclear project in any of these countries would be mutually profitable for both the host country and the investing country trying to meet its Kyoto emission limit. In fact, the range of US$4-57/tC is considerably lower than the estimated marginal mitigation costs for compliance with the Kyoto Protocol. It is also well below the US$128/tC price of emission allowances (as of 4 July 2005) traded under the EU's emissions trading scheme (ETS), although it overlaps with the US$30-35/tC reported for certified emission reductions under the CDM.

But the exception in the Indian study, where nuclear power was anyway the least-cost option for sites more than 1200 km from the nearest coal mine, represents the potential Catch-22. If coal prices rise and/or nuclear prices fall, there may be more cases where nuclear power becomes the least-cost option and thus ineligible for the CDM and JI even if the exclusions are eliminated.

An additional step for the negotiators to consider would be to bring non-Annex B countries with large emissions into Annex B with generous but quantified emission limitations. One advantage concerns the transaction costs and the liability issues of the flexibility mechanisms. These are particularly problematic for the CDM, with implementation of its additionality principle being especially intricate. Were the large developing countries, particularly those with nuclear programs such as China, India and Brazil, to be brought into Annex B with generous emission allowances, any GHG avoidance through new nuclear construction would have a more direct and immediate cash value than through reliance on the CDM. Put in terms of the prices above, an Annex B country can sell a tonne of avoided carbon emissions under the ETS for US$128. A non-Annex B country, selling via the CDM, can get only US$30-35.

It remains to be seen if, in the lead-up to MoP-1, statesmen can somehow craft the right package of emission limits and other trade-offs that would not only attract non-Annex B countries to Annex B, but would attract participation from Annex B countries that have not yet ratified the Kyoto Protocol, such as the USA and Australia.

There are of course complementary routes to broadening and strengthening emission limits, and it may be easier to encourage these independently, and

eventually promote synergies with the Kyoto Process, than to force all progress into the format of the Kyoto Protocol. One possibility is the New Asia-Pacific Partnership on Clean Development and Climate announced in July by Australia, China, India, Japan, the Republic of Korea and the USA. Right now, however, the only two points on which the initiative seems clear are: (1) that the compact the partnership will develop will be non-binding, and (2) the emphasis is on developing cleaner, more efficient technology. Otherwise, the initial announcements emphasize process over specific emission reductions. For nuclear advocates, there's no particular reason to expect additional money and effort devoted to advancing low-carbon technologies to benefit nuclear power. Nuclear power is a low-carbon option that's already here, and to the extent that the New Asia-Pacific Partnership on Clean Development and Climate creates or strengthens competitors, it's not really in the interests of nuclear power.

More interesting may be the reported imminent agreement on carbon constraints among nine northeastern states in the USA. If the reports are accurate, and depending on the details of the constraints, new nuclear power plants in the northeast might be able to turn their low carbon emissions into a cash benefit on the bottom line in a way that could not be done in the rest of the country. Other things being equal (i.e. ignoring regional differences in demand, costs, competitors, investment risks, site availability and the rest), the business case for nuclear power would become relatively stronger in the northeast and increase the odds of new build in the region. The northeast system of carbon constraints might also be actively connected to the Kyoto Protocol. If, for example, a northeast state were allowed to partially meet its emission limit by buying unused carbon allowances created by the Kyoto Protocol's flexibility mechanisms – and particularly if the northeastern system were expanded to include additional interested states – U.S. involvement in the Protocol would gradually deepen.

Conclusions

So can we predict a nuclear renaissance? What are the odds of closing the projection gap in *Figure 1*, or the even wider projection gap between medium-term and long-term projections when the latter include carbon constraints? Our bias is that while the phrase 'rising expectations' accurately characterizes the outlook for nuclear power, it is still premature to declare a nuclear renaissance. Renewables may yet be able to expand at the pace predicted by their strongest advocates, rather than at the more modest rates found in more dispassionate studies. Technological breakthroughs may bring nuclear fusion on line sooner than expected, or allow widespread coal combustion with carbon sequestration and no GHG emissions. Nanotechnology may develop solar cells that can be spread on structures like a coat of paint, or genetic engineering might yield microorganisms that use sunlight directly to split water and produce hydrogen.

More likely, however, the best energy strategies for countries will remain less dramatic. They will vary with national situations, and each will involve a mix of energy sources. New build is most attractive where energy demand growth is rapid, alternative resources are scarce, energy supply security is a priority or reducing air pollution and GHG emissions is mandated. Nuclear expansion currently remains centred in the Far East and South Asia where these factors are most immediate. But the 'area of immediacy' appears to be broadening.

The analysis of the projection gap indicates what needs to be done to close it. In liberalized markets, government incentives are needed to encourage longer-term perspectives. Regulatory and other investment risks need to be reduced. Continuing information efforts are essential to address any political and public concerns; although different countries will legitimately have different trades off among, e.g., environmental quality, jobs, occupational hazards, energy security and energy costs even where there is agreement as to the relevant facts, some opposition to nuclear power still rests on weak information. Innovation and continuing industry progress in reducing construction costs and improving operating performance are essential. And creativity is needed to reduce national start-up costs in new nuclear power countries. Possibilities include grid integration, facility and/or service leasing to various degrees, and cost-effective small and medium-size reactor designs. But we see this as an area where we at the IAEA have some responsibility to make sure the creativity doesn't end there. We need to look at what more we can actively do to address initial regulatory needs, the build-up of a skilled workforce, and the build-up of ancillary support industry. And we must continue to work to reduce proliferation concerns that, among other things, might burden aspiring nuclear power countries with additional barriers-to-entry.

References

EIA (Energy Information Administration) (2005), International Energy Outlook 2005, U.S. Department of Energy, Washington, DC, USA (July 2005).

IEA (International Energy Agency) (2004), World Energy Outlook 2004, OECD/IEA, Paris, France (2004).

IPCC (Intergovernmental Panel on Climate Change) (2000), Special Report on Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, (http://www.grida.no/climate/ipcc/emission/index.htm).

IPCC (Intergovernmental Panel on Climate Change) (2001), Climate Change 2001: Mitigation. Third Assessment Report of the United Nations Intergovernmental Panel on Climate Change, Chapter 3, Cambridge University Press, Cambridge, UK (August 2001).