World Nuclear Association Annual Symposium
8-10 September 2004 - London

Nuclear Expansion: Projections and Obstacles in the Far East and South Asia

Alan McDonald

Medium-Term Projections

Each year the International Atomic Energy Agency publishes updated medium-term nuclear energy projections. These now extend to 2030. The 2004 edition has just been published, and its projections are shown in *Figure 1*. The dark green bars on the left show the historic expansion of nuclear capacity around the world. In the early 1970s growth was rapid, averaging 30% per year from 1970 to 1975. Growth then slowed in the later 1970s and 1980s because of (1) decreased electricity demand due to the delayed decoupling of economic growth and electricity growth as a consequence on the 1973 oil crisis, (2) cost escalation due to high inflation, (3) growing environmentalist opposition and, (4) particularly after the Three Mile Island accident in 1979, increased safety requirements. Since 1986, modest growth has allowed nuclear power's share of global electricity production to stay stable at about 16%. That is, average nuclear production growth has kept pace with average global electricity consumption growth, about 2.5%/yr, for 18 years, since 1986. Capacity growth has been slower, but because of capacity factor increases, nuclear production has steadily matched global electricity growth for almost two decades.

It is striking, although probably largely coincidental, that the dramatic flattening of the curve takes place in 1986, the year of the Chernobyl accident. All the cancellations and the drop in orders happened before Chernobyl. However, they appear in these statistics afterwards.

The bars on the right of Figure 1 show projections, in the last four years, that are the Agency's 'low projections'. The low projections essentially assume no new nuclear power plants are built beyond what is currently under construction or firmly planned today, plus the retirement of old nuclear power plants on schedule. It means the industry finishes what is in the pipeline now and then stops – nothing more. In 2001 and 2002 we only projected through 2020. The red bars on the right are the low projections done in 2001. The yellow bars are the low projections done in 2002. Starting in 2003, we extended our projections out to

© World Nuclear Association 2004

2030. The dark blue bars are the low projections done in 2003, and the light blue bars are the new low projections done just this year.

Clearly the low projections are getting more optimistic. Back in 2001, they projected a global peak in 2010 and a fairly steep subsequent decline. The next year, for the projections done in 2002, the peak was still there in 2010, but the subsequent decline was not as precipitous. By the time of the 2003 projections, the peak had moved out to 2020, but there was still a subsequent decline. This year the peak is still at 2020, a little higher than projected last year, and the projected decline is becoming relatively flat. There is a definite pattern, which is the pattern one would expect if annually asking the question, "What's in the pipeline right now?" to a growing industry.

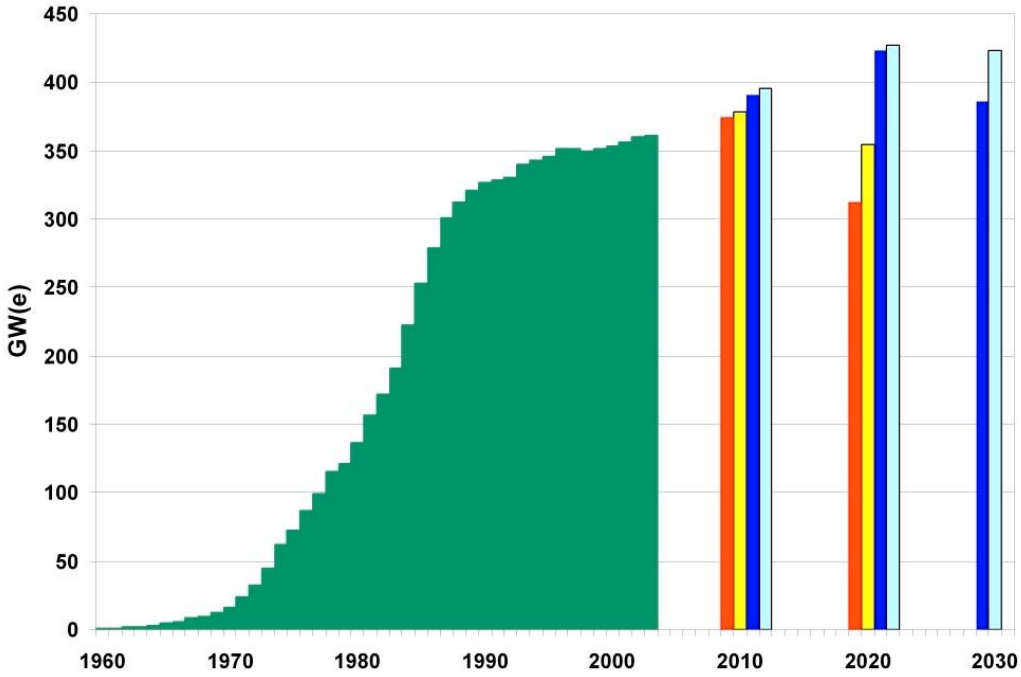


Figure 1. Historical growth in global nuclear capacity and the IAEA's low projections for the years 2001, 2002, 2003 and 2004.

Figure 2 shows the same statistics for the IAEA high projections, in which the assembled experts from around the world look at every proposal that has been floated and incorporate the ones they consider reasonable, on a reasonable schedule, assuming a generally bullish, high growth investment environment. The first thing to note is that the scale is different. Nuclear capacity is significantly higher in these projections than in the low projections in *Figure 1*. The latest low projection peaked at 427 GW(e). The latest high projection, shown in *Figure 2* in light blue, is at 592 GW(e) and still climbing in 2030. The second thing to notice is that there is less change, and a less consistent pattern of change, in the high projections from year to year than there was in the low projections. Taken together the two pictures make sense for an industry that has reasonably good prospects, but is not growing explosively. The list of reasonable medium-term projects at the high end is fairly stable, and each year more and more of these get promoted from just being a promising prospect to being an actual project in the pipeline.

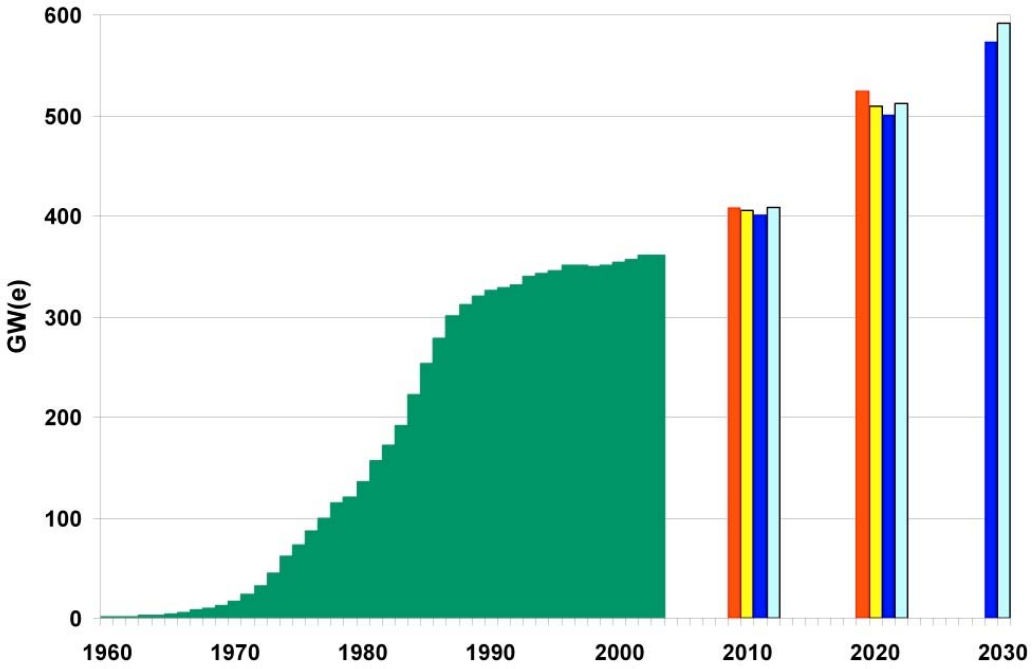


Figure 2. Historical growth in global nuclear capacity and the IAEA's high projections for the years 2001, 2002, 2003 and 2004.

Before looking at the regional breakdown of the projections, we should note that in both sets of projections, even the high projection, nuclear growth starts to lag behind global electricity growth. So nuclear power's share of global electricity goes down. In the latest low projection it drops from 16% today to 14% in 2030. In the high projection it drops further, to 13%. That may seem counter-intuitive. What is happening is that, in the high projection, not only is nuclear electricity growing faster than in the low projection, but so is overall electricity use. And in fact overall electricity use is growing sufficiently fast that the differential between it and nuclear power is growing more than in the low projection, and thus the nuclear share drops more.

We should also note that both our high and low projections are on the low side compared to long-term scenarios. Specifically, the median of the 40 scenarios of the Special Report on Emissions Scenarios (SRES) to the Intergovernmental Panel on Climate Change (IPCC) is above both IAEA projections. Nuclear power basically looks better the more long-term the perspective, and the SRES *median* has nuclear power growing by a factor of 2.5 by 2030 and providing 27% of global electricity.

From this summary of the global picture, let us turn now to the regional breakdown, looking just at the projections, not historical data. In the IAEA's low projection, shown in *Figure 3*, the two most distinctive features are the contraction of nuclear capacity in Western Europe and the expansion in the Far East. Actually capacity growth is also huge in percentage terms in the Middle East – South Asia region. It grows by a factor of six, but from a small base. There is some small net growth in Eastern Europe and basically no change in North America.

© World Nuclear Association 2004

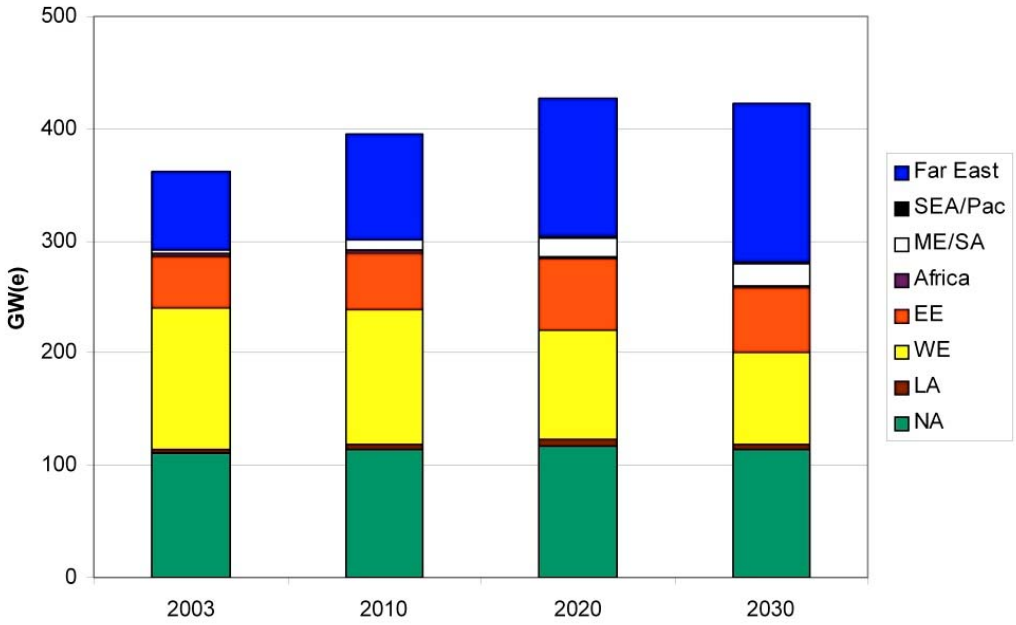


Figure 3. Regional distribution of global nuclear capacity in the IAEA's low projection.

In the high projection, shown in *Figure 4*, there is capacity growth in all regions. But the Far East still leads the way with 100 GW(e) of net new capacity in this projection between 2003 and 2030. By 'net' we mean capacity additions beyond any construction to replace retiring nuclear plants with new nuclear plants. Eastern Europe adds 40 GW(e) net. The Middle East – South Asia region again has the most impressive growth rate, adding 31 GW(e) to increase capacity by a factor of ten, equal to average growth of 9% per year. But still, 45%, nearly half the world's additional capacity to 2030, is in the Far East in this projection.

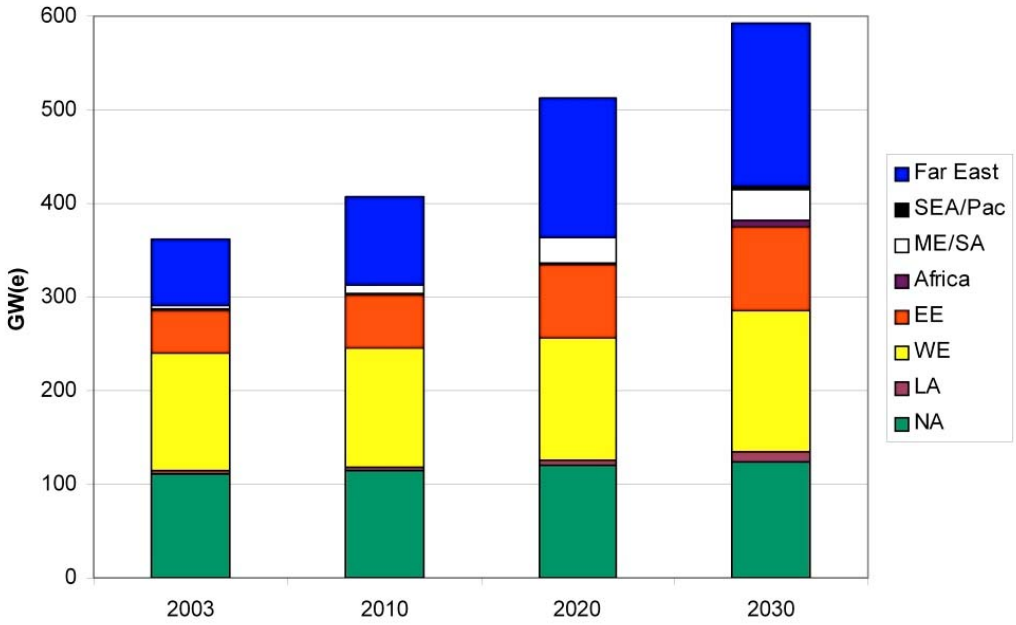
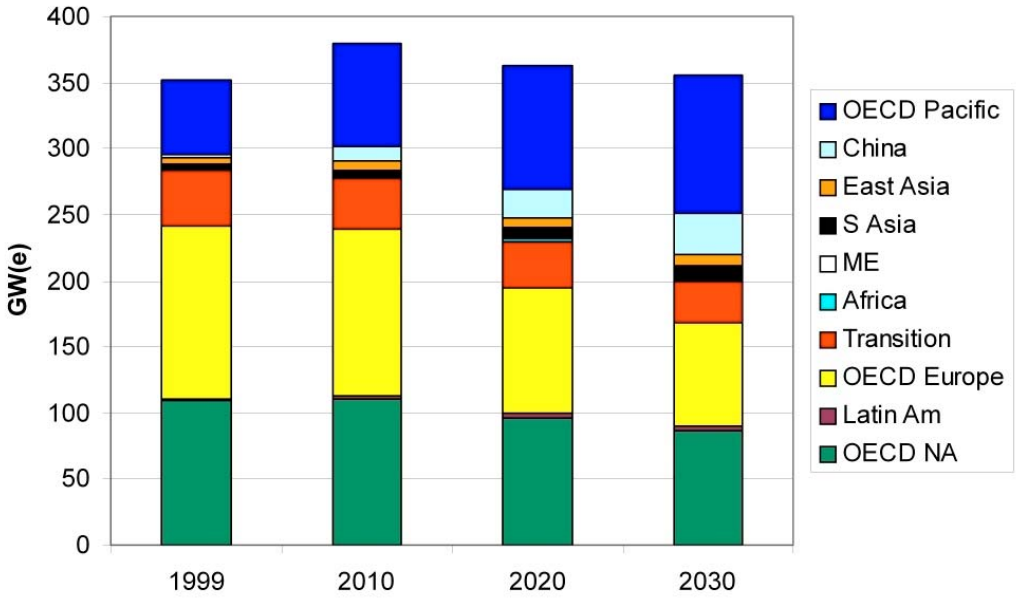


Figure 4. Regional distribution of global nuclear capacity in the IAEA's high projection.

For comparison, *Figure 5* shows the regional breakdown of the nuclear capacity projections in the OECD International Energy Agency's (IEA's) latest reference scenario, from 2002. The IEA reference scenario tends to match the IAEA's low projection, and in this case it matches the low projection we did in 2002, with a peak in 2010, a subsequent decline, and similar values. The updated 2004 IEA projections are due out October 26, and our expectation is they will shift in the same, more bullish direction as the IAEA's.



Slide 5. Regional distribution of global nuclear capacity in the IEA's low projection.

The Projection Gap

As noted earlier, long-term scenarios tend to show a greater dependence on nuclear energy than do these medium-term projections of the IAEA and the IEA. Why?

First, the long-term scenarios are based on computer models that, in choosing the optimal investment for today, incorporate such factors as depletion of low-cost fossil fuels in the course of the 21st century. Most power plant investments affecting the medium-term scenarios are unlikely to be based on similarly forward looking analyses.

Second, the medium-term scenarios are based largely on today's technologies and their current costs, while the long-term scenarios allow for greater improvements in technology and cost.

Third, while the current politics of nuclear energy have a significant impact on the medium-term scenarios, the choices reflected in the long-term scenarios are based much more heavily on economics, not politics.

© World Nuclear Association 2004

Finally, the perfect-foresight optimisation models used in building the long-term scenarios make all investments essentially risk-free. Current plans underlying the medium-term scenarios, however, reflect the politics of countries where opposition to nuclear investments might make them a significant financial risk.

These points suggest several policy directions for governments that would like to encourage nuclear expansion closer to the higher trajectories of the long-term optimization models than the more modest medium-term trajectories of even the IAEA high projection. First, to the extent policies can encourage longer-term perspectives, taking into account the depletion of low-cost fossil fuels, they should shift the economic calculation toward nuclear power. Second, to the extent they can accelerate technological learning in the nuclear field, and associated cost reductions, they would encourage nuclear expansion. Third, to the extent they can reduce political nuclear opposition in some countries and allow decisions based more predominantly on economics, they will benefit nuclear power. And, fourth, to the extent they can reduce the financial and regulatory risks associated with large nuclear investments, they will also encourage nuclear expansion.

We would like to highlight just two challenges associated with the second and third of these, cost reductions and political opposition.

Cost Reductions

Two interconnected contributors to cost reduction are innovation and 'learning-by-doing', i.e., that experience breeds improvements – in technology, in management and operations, and, consequently, in costs. And there is a potential virtuous cycle where experience reduces costs, which speeds expansion, which speeds experience accumulation, and additional cost reductions, and so on. But for the virtuous cycle to get started, and keep going, there must be a promising market that provides a sufficient profit incentive to spur innovation investments, and then to expand fast enough, and 'learn by doing' fast enough to compete in the race with alternative technologies that are also continuously innovating and learning.

Innovation in reactor and plant design has been largely centered in countries that have led nuclear power expansion in the past. But much of the projected future expansion, as shown in the figures above, will be in the developing countries of Asia, and it would be helpful to tap into the greater potential for virtuous cycles and learning-by-doing created by the higher growth in the main expansion regions. Applying the store of knowledge and expertise from centers of past nuclear expansion to centers of current expansion is not necessarily straightforward. Developing regions may find their instinct is to be cautious about innovative designs from outside, asking essentially, "Why should we buy it if no one in your country wants one?"

The resulting challenge is to speed up the rate at which the market in developing countries, where demand is growing fastest, can provide the learning-by-doing for innovations from outside – as well as, or in conjunction with, innovations from inside – to keeping the virtuous cycle spinning. The challenge is essentially one of finding creative risk sharing arrangements that strike the right balance between

the reassurance needed in the expanding market country, and the profit incentive for innovation needed by aspiring exporters.

Asia's largest nuclear power countries, Japan and the Republic of Korea, will have an important role to play. But the major players will be determined not by geography but creativity. Those who recognize the new situation and adapt most wisely, will drive the solution.

The IAEA can also contribute in at least three ways. First, the Agency provides to interested Member States assistance in capacity building – in creating or expanding capabilities in energy system planning, in regulatory and safety oversight, and in infrastructure support. Included also in our capacity building activities is a relatively new program specifically on nuclear knowledge management, of which the Agency's participation in the World Nuclear University, inaugurated at the time of this symposium last year, is one important component. All this strengthens the potential of new expansion countries to be active partners in the virtuous continuous improvement cycle.

Second, the Agency promotes direct communication and exchange explicitly on the subject of innovation between developed and developing countries, between supplier countries (current and potential) and user countries (again current and potential) through our International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which includes China, France, Germany, India, Indonesia, the Republic of Korea, the Netherlands, Pakistan, the Russian Federation, Spain, South Africa, Switzerland, Turkey and European Commission.

Third are the Agency's on-going contributions to worldwide safety improvements, to safeguards and security, and to progress on the long-term disposition of spent fuel and radioactive waste. Failure on any of these could stop nuclear expansion abruptly. The Agency's contributions are designed not just for substantive improvement, but to provide the transparency, double-checks and assurances that politicians and publics need.

Non-Proliferation

Finally we should mention proliferation concerns and political opposition. Proliferation risks seem now to be a rising concern, and may affect nuclear expansion in developing countries, and particularly countries interested in introducing nuclear power capacity where they currently have none.

At the end of June, at the time of the 50th anniversary of the connection the 5 MW reactor at Obninsk, in the then Soviet Union, to the Mosenergo electricity grid, the IAEA convened a major international symposium in Moscow and Obninisk and decided to mount a major press campaign, using the occasion of the 50th anniversary, to place stories in media around the world about the status, prospects and possibilities of nuclear power. We took part in quite a few interviews as part of the campaign and learned, one, that you cannot force the news. Many of the interviews yielded stories, but some only appeared on August 10th or 11th, right after the steam leak at Mihama-3 in Japan created some breaking nuclear news, although the accident had nothing to do with nuclear technology per se. But that's all right. It's important that the stories around the world after the Mihama-3

© World Nuclear Association 2004

accident included information on why Japan has nuclear power in the first place, and why there are good reasons in many places around the world to build more nuclear power plants.

But another lesson was that proliferation concerns seem to be higher in the public eye than they used to be. There were many questions about proliferation, and a number of the stories included quotes from anti-nuclear spokespeople emphasizing proliferation risks. This contrasts to the situation even a few years ago in 2001, when in the exhaustive debate about nuclear power at the Ninth Session of the UN Commission on Sustainable Development (CSD-9), even the countries most strongly critical of nuclear power barely mentioned proliferation concerns.

The media are not the only ones to express concerns about proliferation risks. The IAEA Director General, Mohammed ElBaradei, has emphasized the need to strengthen the global non-proliferation regime in a number of forums over the past year, and in June laid out a series of 13 proposals in a speech at the Carnegie International Non-Proliferation Conference in Washington. Others have also cited the importance of strengthening the regime and offered ideas and proposals of their own.

Progress on many of the proposals will depend on much that happens outside the nuclear industry. But one area where the industry may be important to any success that is achieved concerns proposals to consider limitations on the production of new nuclear material through reprocessing and enrichment, possibly by agreeing to restrict these operations to being exclusively under multinational controls. These limitations would need to be accompanied by proper rules of transparency and, above all, by international guarantees of supply to legitimate would-be users.

The Director General has set up an Expert Group, which held its first meeting last week in Vienna, to identify issues and possible multilateral approaches to strengthening controls over sensitive aspects of the front and back ends of the fuel cycle. There is a lot of history to review, there are many key new developments to consider, and it will be a major challenge to identify possibilities that combine promising mixes of political and economic incentives, that promise real non-proliferation benefits, that facilitate – or at least do not obstruct – the spread of nuclear power benefits to those that want them, that attract participation from all parties needed for success, that are robust across the plausible range of possible global nuclear power futures, and that are equitable, non-discriminatory and fair. It's a tall order, and we'll have to see what this group can accomplish.

Even on the restricted topic of multilateral approaches to the fuel cycle, much lies outside industry's purview. But the more profitable an option – the more economic incentives it can offer – then the better are its chances of success, other things being equal. And industry should take a major role, and interest, in the creative thinking needed to rework or move beyond the options of the past.

Ultimate success will require substantial political will, but also a lot of creativity, and critical thinking, from all quarters. But a successful initiative must be attractive to industry as well as politicians, and the most likely source of the

creative thinking to make that happen is the industry itself. It is a topic worth additional attention these days, both because of the importance of strengthening the non-proliferation regime in its own right, and because of the impact it will have on nuclear expansion, on spreading the benefits of nuclear power and on connecting the unconnected.

© World Nuclear Association 2004