Nuclear in France – what did they get right?

With its fleet of standardised, load-following nuclear reactors and range of domestic fuel cycle facilities, the French nuclear programme is certainly unique. But it is not without critics

By Steve Kidd

As interest in nuclear power has escalated worldwide, many countries have looked to France to learn what can be achieved in a substantial, strategic national energy programme. France now derives over three quarters of its electricity from 59 nuclear reactors, thanks to a long-standing energy policy, based on a mixture of economics and energy security. The power utility EDF is also now a substantial net exporter of electricity and has plans to build new reactors both at home and overseas based on the latest technology. France also has capabilities in each area of the fuel cycle through Areva. In particular, reprocessing capacity and technology is a major export earner from these activities. The country is also a leader in advanced nuclear technology, having invested heavily in research and development.

What are the key factors that underlie this performance? The French government decided in 1974, just after the first oil shock, to greatly expand the country's nuclear power capacity. This decision was taken in the context of France having substantial heavy engineering expertise but few indigenous energy resources. The argument was that because the cost of uranium is a relatively small part of the overall cost, nuclear energy made good sense in minimising imports and achieving greater energy security.

This, essentially, remains the key to French energy policy today. With the addition of the low greenhouse gas emissions from nuclear now an important further argument, the strategy remains essentially unchanged. It is this consistency of energy policy-making, sometimes in the face of strong opposing forces, which is the obvious foundation of success. Even critics of the French programme accept that it has been a great scientific, technological and engineering achievement, but without firm and consistent government backing this would have been impossible. The human element in this must be emphasised. The French programme has been led by a technocratic elite, drawn largely from the *Corps des Mines*, but backed by successive generations of well-educated and trained experts. Many of the brightest young people in France have found their way into the nuclear industry and have enjoyed stable and rewarding careers in their chosen area. So any country thinking of a substantial nuclear programme must be prepared to stick with it over a long period of time and also be prepared to devote a notable part of its human resources to it.

The other key area that stands out in France is in the standardisation of reactor types. The first eight power reactors were gas-cooled, as championed by the Atomic Energy Authority (CEA), but EDF in the early 1970s then chose pressurised water reactor (PWR) types, supported by the new Eurodif enrichment capacity. Choosing a reactor type that has proved to be very durable, capable of running consistently with minimal problems, was obviously very important. Apart from one experimental fast breeder reactor (Phenix), all French units are now PWRs of three standard types designed by Framatome, now Areva NP. This is a much higher degree of standardisation than anywhere else in the world (there was another large fast reactor –Superphenix – commissioned but subsequently closed down). This can be contrasted with the experience in the USA (over 100 reactors, all of which are essentially different) and Japan (a similar-sized programme to France, but with a much greater number of reactor types). The degree of standardisation has undoubtedly created substantial economies of scale for the French industry and cut power generation costs.

All this has, of course, cost a great deal of money. It is estimated that half of the total was self-financed by EDF, about 40% by commercial loans and the remainder by the state. Early in 2009, EDF estimated that its reactors provide power at EUR0.046/kWh (including capital costs) while power from the new EPR units at Flamanville and Penly is expected to cost about EUR0.055-0.06/kWh. The back-end costs (reprocessing, waste disposal, etc) are actually fairly small when compared to the total kWh cost, typically about 5%. From being a net electricity importer through most of the 1970s, France now has steadily growing net exports of electricity, and is the world's largest net exporter. In fact, electricity is France's fourth-largest export. (And next-door Italy, without any operating nuclear power plants, is Europe's largest net importer of electricity, most of it ultimately coming from France).

One point to note is that France's nuclear reactors comprise 90% of EDF's capacity and hence they are used in load-following mode and are sometimes even closed over weekends. This means that the load or capacity factor is relatively low by world standards, in the high 70s as a percentage. It is generally accepted that this is not an ideal economic situation for nuclear plants. It is also notable that all but four of EDF's nuclear power plants are inland, and require fresh water for cooling. Eleven of these 15 inland plants (32 reactors) have cooling towers, using evaporative cooling, the others using river or lake water directly. With regulatory constraints on the temperature

increase in receiving waters, this means that in very hot summers, generation output may be limited.

Another key element of French energy strategy has clearly been developing Areva to cover the whole of the fuel cycle. It is possible to have a nuclear programme without the attendant fuel cycle infrastructure, therefore relying on the world market. But with a lot of reactors and industrial capability, it makes sense to cover at least some of the areas with domestic supply. French uranium mining has now ended, so investments have been made in good uranium deposits around the world and mines subsequently developed, for example in Africa and Canada. Conversion, enrichment and fuel fabrication facilities have been developed at home, and have excellent export capability.

It is, however, the back end of the fuel cycle where the French approach has differed from much of the world. A closed fuel cycle based on reprocessing and recycling of mixed oxide and reprocessed uranium fuel has been adopted. Although the economics of a closed-loop fuel cycle have often been questioned, the closed cycle must be seen in light of the French holistic view of the fuel cycle and waste management. From this point of view, usable fissile material should be recycled to minimise the amount of high-level waste that must, eventually at least, go to a deep geological repository.

CRITIQUES

Despite admiring glances from overseas, the French programme is not without its critics. Support for nuclear among the French public seems to be at levels very close to the European average, but with a rather stronger anti-nuclear element than is apparent in countries where nuclear has not been a subject of any great interest or contention for many years, such as the United Kingdom. There is, however, a degree of intellectual criticism of the French programme, as exemplified by Mycle Schneider's report produced for the Greens-EFA Group at the European Parliament in late 2008, entitled *Nuclear Power in France – Beyond the Myth*.

This employs the typical anti-nuclear tactic of bombarding the reader with a long list of possible negatives, in the hope that at least one will hit home. Some of the points made, however, are certainly worth serious examination.

The complaint that the whole process in France has suffered a 'democratic deficit', driven by an elite against proper public scrutiny and control, is not at all persuasive. France's nuclear programme is no more than a microcosm of French industrial strategy as a whole, marked by a strong degree of central planning and identification of likely industrial 'winners' which the state then chooses to back. One may not personally like the concept of this, nor many of the individuals involved. But as a democracy, the French people have had ample opportunities to suggest something different. That they have generally supported it is to their credit – maybe there have been some shortcuts taken to get decisions implemented, but most people would probably accept that the ends justify the means.

A more substantive critique asserts that France has over-invested in nuclear, which has meant that power has had to be exported or 'dumped' on the French market, encouraging the use of both space and water heating through electricity. This can be regarded as both economically and environmentally wasteful. A case can certainly be made that a share of nuclear in national electricity generation of over 50 or 60% is less than optimal, given that nuclear plants are not ideally suited to meet peak power demand. Yet cheap electricity from nuclear can be seen in alternative ways. It is a good thing if it cuts customers' bills, but bad if it raises consumption in a way deemed unnecessary or wasteful. France's electricity consumption per capita is relatively high compared with countries of similar economic structure, but it is vital to see the complete picture.

It is important to note that nuclear accounts for only 16% of final energy use in France, so hydrocarbons (substantially imported) are still the most important element in energy supply. The transportation sector is crucial and nuclear has not yet penetrated this – nuclear can, indeed, therefore be overstressed as a technology for curbing carbon emissions and enhancing energy security. The appropriate questions, however, are where would France be without it – in a better or worse situation – and are the admiring glances from overseas entirely misplaced? The answers are, of course, that the pride many French people undoubtedly take in their nuclear programme are indeed justified. They have relatively low carbon emissions per capita and cheap electricity too, with enhanced energy security (from the power sector at least). A large nuclear sector is clearly a major contributor to each of these. The fact that energy consumption needs to be curbed as much as possible in each area and that there is a notable problem of fuel poverty only puts France in the same boat as most other nations.

Other criticisms of the French nuclear programme essentially amount to little. The usual anti-nuclear arguments about nuclear proliferation, safety, waste management and decommissioning can be trotted out, but French policy and practices seem very sound in all these areas. One interesting issue is whether, in addition to building and supplying fuel for more reactors at home, EDF and Areva can contribute substantially to nuclear growth in many other countries. This includes both established nuclear nations like the United Kingdom and USA, but also potential new countries in the Middle East, Asia and Africa too. Lots of nuclear cooperation agreements are being signed, but it remains to be seen how many will result in operating reactors within the next 20 years.

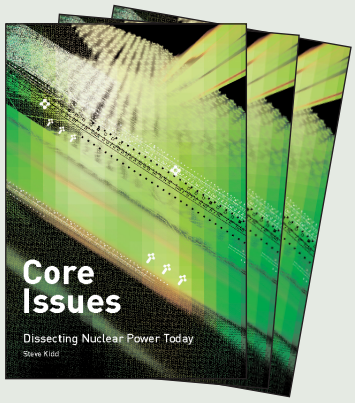
Steve Kidd is Director of Strategy & Research at the World Nuclear Association, where he has worked since 1995 (when it was the Uranium Institute). Any views expressed are not necessarily those of the World Nuclear Association and/or its members.

Core Issues

Dissecting Nuclear Power Today

Core Issues by Steve Kidd is now available

Written for the nuclear industry by one of the sector's most well-known experts, *Core Issues* covers the entire nuclear power business, particularly nuclear fuel, economics and public acceptance.



Core Issues – Dissecting Nuclear Power Today **by Steve Kidd (ISBN 9781903077566), published by *Nuclear Engineering International*, is now available in hardback priced at £20 including delivery.**

Copies can be ordered from:
Nuclear Engineering International, Progressive House, Maidstone Road, Foots Cray, Sidcup, Kent DA14 5HZ, UK
Tel: +44 (0)845 155 1845; Fax: +44 20 8269 7877
email: cs@progressivemediagroup.com
website: www.neimagazine.com/coreissues