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Perspectives on consolidation in the nuclear industry

Geoff Varley

Scene-Setting

Liberalisation, or deregulation, of electricity markets has had a significant effect on nuclear generators and utilities. In the past, baseload operation was a given and market rates for electricity in no way threatened the forward generating cost of the '*nukes*'.

The harsh truth nevertheless has prevailed that in many cases new nuclear build has not been a viable option for a long time, at least wherever typical private investor financial conditions have been imposed, i.e. high internal rate of return and a relatively short time for the return of capital, albeit for capital investments with a life much longer – by decades.

Of course some reactors *have* been built in recent times, notably in Japan and France, but also in other countries. Economic conditions in these cases have been different – government ownership, national policy regarding energy security and higher prices for imported competing energy sources variously have provided a platform for new reactor investments.

But now in some regions – for example, parts of Europe where significant excess generating capacity exists – deregulation has driven spot electricity prices down (in some cases below forward generating costs), forcing the nukes to refocus how they run their businesses. The exotic, the sophisticated, the luxurious, the comfortable – one might say the way of the past – rapidly gave way to a straightforward economic realism. The margin of excess capacity in Europe is expected to reduce over time to a more reasonable operational reserve level, which may ease competitive pressures somewhat, but the same basic economic reality will prevail.

Utilities to a greater or lesser extent have changed, or at least have changed their thinking about fuel cycle strategies, for example in the back end where, for some, interim storage delivers lower near-term cash flow compared with recycle commitments. Procurement practices have been modified as well – notably through reductions in front end inventories.

Utilities have been forced to take a dispassionate, rational view of their positions in the market. Leadership to some extent has transferred away from the nuclear 'engineers', with the likes of the electricity traders and the mergers and acquisitions experts assuming

an elevated status in the utility hierarchies. But the impact of the commercial imperatives has also rolled out and down to all levels, interestingly with some positive impacts. Nuclear reactors still need solid engineers and managers to run them and it appears that those who have come through the experience of deregulation find themselves in a more efficient and effective working environment, with more accountability. The efficient discharge of duties for competitive reasons tends to be part of a virtuous circle. For example, focussing on doing something more efficiently has been found by some to bring benefits in the area of safety. An interesting side note to this is that the numbers of experienced and newly qualified staff respectively willing to stay or enter nuclear generation is dwindling, so smaller workforces are to some extent an unavoidable necessity.

Having presented a cameo picture of the environment in which the nuclear utilities operate, the remainder of this paper is devoted to describing and analysing the impacts on the nuclear fuel services industry.

The Consequences of Over-Optimism

The projections of installed nuclear MW up to the early 1970s were very enthusiastic in what was still a relatively formative period for the industry *(Figure 1)*. The fuel services supply industry correspondingly invested in facilities that would turn out to be of a size far in excess of actual market needs.

By the early 1990s we arrived at the following situation:

- 11 NSSS suppliers (ABB, CANDU, CE, Framatome, GE, Hitachi, Minatom, MHI, Siemens, Toshiba and Westinghouse) but new orders running at only one or two per year on average as a maximum. Projects in progress were still considerable, however, running at something like 30 to 40 in this period.

- More than 40 uranium concentrates suppliers in 24 countries with nominal capacity sufficient to provide in excess of world reactor requirements, whilst secondary supplies were delivering 20 to 25 percent of market demand.

- 5 UF_6 conversion service suppliers with the four western converters operating at an average utilisation of slightly less than 60 percent.

- 4 enrichment suppliers with a combined capacity in the order of 53 million SWU per year and reactor requirements of about 60 percent (albeit with the smallest supplier utilised 100 percent).

- 16 fuel fabricators delivering in excess of 25 fuel designs (plus variants) – one for every 15 or so reactors in the world – and overall only two thirds utilisation of assembly capacity.

Trade restrictions and agreements were coming into force to control the flow of materials and services from the FSU, which had caused depressed market prices for uranium and enrichment in the late 1980s. This afforded some protection for the suppliers. In addition there were some traditionally relatively closed western markets – for example in the

fabrication segment in Japan, in France and Germany – as well as all sectors in Eastern Europe and the FSU.

Some markets were much more open to competition and the buyers in these countries accordingly tended to pay lower prices for products and services. The NSSS vendors clearly were not in a halcyon period and the uranium producers also would be unlikely to speak now about any great days in the early 1990s. The converters, enrichers and fabricators were not in serious trouble at this stage but the portents for the future were not good, especially for the fabricators. With average fuel burnups increasing progressively – motivated principally by the desire of the utilities to alleviate spent fuel storage and to reduce back end costs – future market volumes were set to reduce, in spite of modest growth for installed nuclear MW.

In 1990 the average discharge burnup for BWR fuel in Western Europe and the U.S. was around 30-32 GWd/MTU but by 2000 this had increased to about 37-40 GWd/MTU. In the PWR segment the 1990 figure was about 37 GWd/MTU and the 2000 figure about 45 GWd/MTU. In one decade the amount of fuel fabrication needed per MWd generated dropped by 20 per cent. In Japan the achieved burnups have lagged behind performance in the U.S. and Western Europe but the trend has been in the same direction.

Reducing volumes clearly impact the fuel fabricators but they also have an impact in the back end of the fuel cycle, with fewer assemblies of higher burnup to be dealt with. The requirements for enriched uranium are relatively independent of average burnups, however, except in so far as different fuel management schemes demand higher or lower fuel enrichments. The economic optimum tails assay in enrichment has a role to play as well. For the economic conditions that have prevailed at various times through the 1990s this has had an impact in the range of 5-10 per cent on uranium and enrichment requirements.

Focussing for a moment on fabricated fuel volumes in Western Europe and the U.S., *Figure 2* illustrates how these have changed over the last couple of decades in comparison with how they would have changed without the burnup increases that have taken place. In 1980 fabrication overcapacity was more than 100% of reactor requirements. Had the average discharge burnup stayed at the 1980 level, fabrication capacity and reactor requirements would have been in balance by 2000. Burnup increases however caused requirements to stay well below capacity.

This background information indicates quite vividly that not everything in the garden was rosy for the nuclear fuel services industry. Too much supply was chasing the market requirements, with the effect that market prices came under severe pressure, as the suppliers fought to hold on to market share. Measures to adjust the balance were necessary.

The Consolidation Story So Far

Uranium Concentrates

Consolidation in the uranium concentrates sector started much earlier than in the other fuel cycle sectors. The changes observed in the 1990s represent very much the *tail-end* of

overall developments. Progressively, primary supply has been concentrated into the control of a smaller and smaller number of supplier companies.

In 1980, 65% of non-FSU primary supply by volume came from the top 12 companies but by 2000 this share was controlled by just six companies. The extent of concentration is emphasised further if FSU supply is included and if control of Russian HEU feed also is included. On this basis in 2000 market presence of the top four companies equates to approximately 60% of supply, with the top two having 40%.

The change in geographical diversity of primary supply outside the FSU over the last two decades is shown in *Figure 3*. Diversity in terms of the total number of producer countries has changed and the distribution is different today but consolidation has not resulted in any material loss of diversity across a range of politically stable and reliable supplier countries.

UF_6 Conversion

In the late 1990s, in the face of severe pressure caused by the entry of low cost secondary supplies, several converters imposed voluntary cuts in production and these still hold today. More recently BNFL announced that they will exit from this market after 2006 and that they are not seeking new business. In the meantime, BNFL' s uncommitted excess capacity is being made available to Cameco. The exit of BNFL from conversion will see utilisation of Western capacity increase from about 80% today to the range of 90 to 100% after 2006. Modest increases in operating capacity may even be needed if the feed from 30 MT Russian HEU does not all enter the market.

Enrichment

The enrichment sector is somewhat different to the uranium and conversion market sectors because there is a technology dimension to take into account and the related cost implications. The suppliers using diffusion plant technology have only a proportion of their nominal capacity that is competitive, due to a combination of the intrinsic characteristics of the facilities and the electricity price structures that prevail where these energy hungry technologies are located. In contrast, the suppliers with centrifuge technology aim to have their capacity highly utilised (close to 100 per cent) and in general this is achieved. Whereas investment in diffusion plant technology is a thing of the past, the cost of incremental advanced centrifuge capacity is illustrated as being competitive in today' s market conditions by Urenco' s ongoing programme of centrifuge capacity expansion. The U.S.-Russian HEU deal, under which USEC is executive agent, has reduced the USEC production required to fulfil delivery commitments. The closure of one of the USEC diffusion plants was an inevitable consequence.

In 1990 the suppliers in the U.S., France and Russia produced and delivered more than 90 per cent of reactor SWU requirements, with Urenco having a significant market share only in Europe. Today actual production by the three Western enrichers is heading for approximately an equal distribution just a few years from now.

A casualty of the competition has been the atomic vapour and molecular laser isotope separation technologies (AVLIS and MLIS). MLIS never quite made it beyond the laboratory scale whilst significant demonstration facilities were constructed for AVLIS.

This once much vaunted technology (pursued in the U.S., France, Japan and the UK) was soaking up large amounts of R&D money and the projected total production costs were not sufficiently attractive in comparison with advanced centrifuges. At the point when key decisions about future investment had to be made, the outlook for nuclear power programmes, especially in the U.S., was not strong. Accordingly, it was realised that potential investors would not be attracted to putting up large amounts of risk capital to construct large AVLIS type plants, with the size of the worldwide nuclear power programme in the long-term subject to considerable uncertainty and projected by some to be under serious threat of near-term contraction.

Today, advanced centrifuge technology is seen as the future. The market has two ‘haves’ and two ‘have-nots’. The ‘have-nots’ currently have not demonstrated any credible alternative, so this provides a significant driving force for the prospect of consolidation in the enrichment segment, allied to the earlier expression of interest on the part of German and Dutch shareholders in Urenco to sell their shares. In the background is the likely restructuring of BNFL, the third shareholder in Urenco. How things develop remains to be seen, but consolidation to a smaller number of primary enrichment suppliers is a distinct possibility.

Fuel Fabrication

Through the first half of the 1990s, consolidation in this market sector could best be described as ‘internal’ i.e. a belt-tightening and internal optimisation approach to reduce costs, without any significant loss of capacity. But as the defence of market share in Europe turned into a price fight in the second half of the 1990s, it became obvious that something had to change and that excess capacity would have to be closed.

The result so far has been the rise of the mega-vendors – Framatome ANP, Global Nuclear Fuel (GNF) and Westinghouse (BNFL). The Western markets now have just two PWR fuel suppliers but still three BWR fuel suppliers. Some capacity has been lost on the PWR side but very little so far on the BWR side. Utilisation has increased in the PWR segment well into the very healthy range (> 80 per cent), whilst BWR capacity utilisation remains sub-optimal.

Near-Term Consequences

In conversion, the announcement that BNFL will exit the market after 2006 appears to have caused the market price to strengthen somewhat but utilities would appear not to be under serious threat of significant price escalation, since the Russian HEU feed options held by two of the converters will tend to place a cap on prices if anyone tries to go too high.

In the enrichment sector, if consolidation from, say, four to three major enrichers does happen, then average prices can be expected to adjust to reflect acceptable returns on capital invested in that process, subject to the specific competitive environment in individual markets – but consolidation has not happened yet. Prices recently have risen in the U.S. but that has been for the entirely separate reason of the USEC anti-dumping and countervailing duty trade cases brought against the European enrichment companies.

In the fabrication sector, the degree of competition in the PWR segment clearly has been eroded. In addition, once the initial reorganisation and optimisation takes place over a two to three year period, the number of design options available to the market can be expected to reduce. Where prices go will be related in part to how successful the suppliers are in managing their cost structure, but history tells us that competition is the biggest determinant of final price.

In the back end, which by design has not received much attention in this paper (as it is a complex and very large subject in its own right), as already stated, the volumes and characteristics of spent fuel both have important consequences, as well as policies/strategies. Taking a brief diversion onto this road, on the policy/strategy side of this picture, there have been a number of developments that indicate a trend away from reprocessing and recycle among a majority of the utilities formerly having commitments to the so-called close cycle route. These include the government edict in Germany that no more spent fuel shall be shipped to reprocessing after 2005, the development of interim storage facilities like ZWILAG in Switzerland and the beginnings of a search for centralised storage in Japan. The world-wide attention to international spent fuel initiatives, such as that proposed by Minatom of Russia, may include a reprocessing step but the utility customers contracting for such a deal would not receive any of the products recovered in reprocessing. Accordingly, from their perspective, it would look like an ultimate disposal solution, with no recycle complications.

In Europe the need for all of the current reprocessing capacity beyond this decade is not assured. Further developments in the consolidation and privatisation of the nuclear utilities is anticipated and the remaining competitors will have to decide if the reprocessing and recycle alternative is compatible with being competitive in electricity markets.

This is all jumping ahead in leaps and bounds but, if reprocessing as we know it today is unable to cement a position as a strategy of choice by sufficient utilities, then the implication is a consolidation of options in the back end. In the absence of an international initiative like the one proposed by Minatom, most utilities will be left with interim storage and the hope of something beyond. That is not to say that one day there could not be advanced reprocessing and transmutation of wastes etc., but realistically that is a long way down the road if it ever comes to fruition. This begins to enter a time period when we don’ t now what energy markets will look like, what electricity generation technologies will be available and, specifically, whether or not nuclear power will be competitive and needed.

On the topic of spent fuel interim storage, currently there are probably too many vendors of technology solutions and the market leaders tend to be relatively small companies. Some sort of shake out in this sector of the back end industry is possible.

Returning to the front end of the fuel cycle and fuel fabrication in particular, let us speculate that the BWR segment consolidates into two main supplier groups, as is already the case for PWR fuel. This will represent pretty much as far as things could go in terms of the number of vendors, so the next consolidation possibility would be the number of manufacturing centres. The extent to which this can develop in part will depend on the appropriate trade restrictions and tariffs on nuclear fuel imports to Europe and the U.S. If

these are reduced, or eliminated, the fabrication suppliers will have much greater flexibility to shop around.

Life does not stand still and the average PWR discharge burnup in Western Europe and the U.S. is expected to increase from about 45 GWd/MTU today to 55 GWd/MTU within this decade. A similar sort of advance is expected for the BWRs and the Asian market will see similar proportional increases, albeit lagging behind in absolute terms, especially in Japan. In other words something like a 15 to 20 per cent drop in reactor requirements for LWR fuel fabrication is forecast, absent a significant increase in net MW installed or a major upturn in the capacity factors of the existing reactors. Looking at reactor operating statistics there might be some marginal help from improved performance but most of the hard work in this regard already has been done. Significant new nuclear MW is a long way off and the business decisions of the fabricators in the next five years will not be affected much by such long-term prospects.

The majority view is that the three fabrication suppliers in the U.S. very soon are expected to be single manufacturing (assembly) site entities – FANP in Richland, GNF-A in Wilmington and Westinghouse in Columbia. In Europe the biggest group, Framatome ANP, currently has three manufacturing sites at Romans in France, Dessel in Belgium and Lingen in Germany. A contraction to two sites will probably be a relatively near-term move and an eventual contraction to one site is not implausible. This introduces the idea that the Russian fuel fabricator TVEL could become more integrated into the European market. TVEL already has a role as a manufacturing subcontractor for reprocessed uranium fuel, so why not as supplementary capacity in transition phases as the number of manufacturing centres elsewhere contract? Questions of supply security, of course, would have to be answered.

Is Consolidation Good or Bad?

Good or bad always depends on which side of the fence you sit – that of the buyer or that of the supplier. But what can be said is that consolidation is not an unusual occurrence. Indeed, to use a golfing metaphor, it is pretty much *par for the course*. For example, the world-wide commodity industry across aluminium, copper, coal, gold, zinc and nickel saw considerable merger and acquisition activity over the last year or two amounting to almost $30 billion in transaction values.

The principal reasons cited for consolidation include:

- A response to consolidation in the downstream customer sector that caused a shift in power away from the upstream producers
- Operational synergy and related cost saving potential
- Prices below the *trigger* level for investment in new mines
- Need for geographic diversification – global supply for global customers

As for the principal effects of consolidation, it is a little early to tell – certainly in the nuclear sector. Outside nuclear in the commodities markets, there is the expectation that it will raise *trough* prices in down cycles, as the belief is that producers (controlling a greater share of capacity) will be more disciplined and will act more quickly to hold back production when prices are depressed. In the nuclear industry the recent statement from Cameco that construction of the Cigar Lake mine development "may be delayed for one

or two years until prices recover" would seem to be an example of this. Price impacts are one obvious consideration but non-price factors also could be affected. For example contract flexibility might diminish.

When consolidation occurs – in any industrial sector – the suppliers typically will refer to enhanced long-term security of supply and production cost efficiencies, while the buyers quite rightly will be concerned about loss of competition. One of the things that differentiates the nuclear fuel services industry from other industries is that it is a multi-sector industry with intimate links between the sectors. An interesting question to ask is whether or not a large vertically-integrated supplier can gain sufficient control of one sector to force cross-sector bundling of services. For example, could a fabricator gain sufficient market share to make uranium purchases from the same company a condition of sale, or *vice-versa*? If so, then single sector suppliers could be marginalised.

In the end there has to be some belief that the competition authorities will make the right decisions. The recent rejection by the EU competition authorities of the GE buy-out of Honeywell perhaps gives some crumb of comfort to the utilities.

Consolidation in the fuel fabrication industry on a corporate level has happened relatively rapidly and both sides of the market seem to be unsure about the nature of the future relationship they will have, or want to have. From the supplier side there has been talk of partnerships for the good of all parties, even as a prerequisite for maximising the potential cost savings of consolidation, with competitive bidding flagged as an obstacle to the long-term good of the utilities. However, historical evidence would tend to suggest that competition generally improves the lot of the buyer, and that is something that should not be given up lightly.

We are experiencing interesting times.

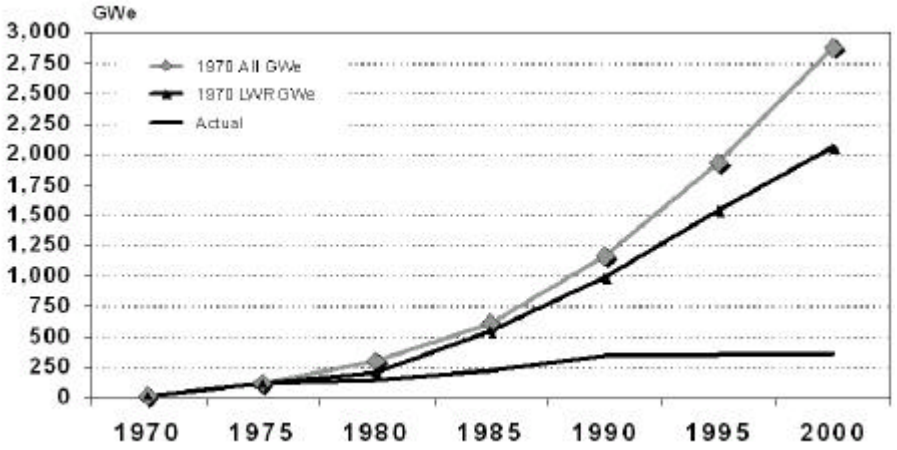

Figure 1: *1970s Nuclear MW Forecast Compared with Actual MW Installed*

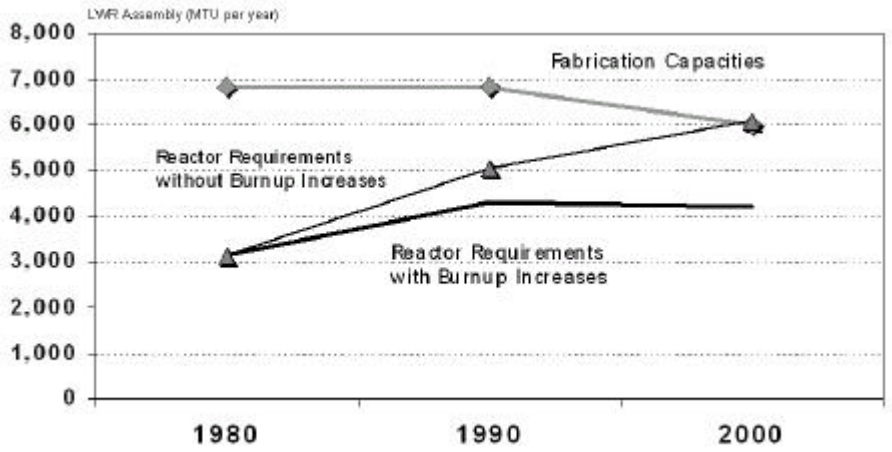

Figure 2: *LWR Fuel Assembly Volumes 1980-2000 Western Europe and US*

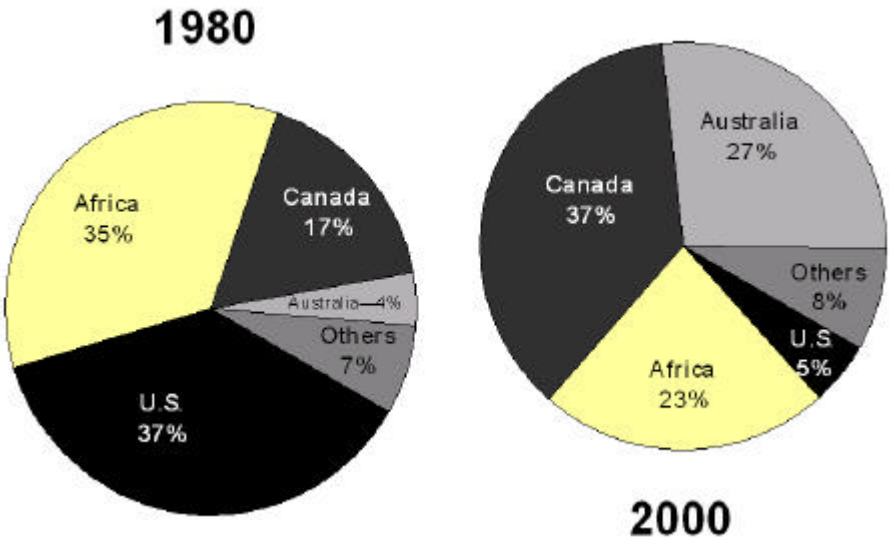

Figure 3: *Geographical Diversity of Primary Uranium Supply Outside of the FSU by Volume - 1980 and 2000*

