Decommissioning of NPP in Europe? Strategies, Risks and Opportunities – 16124

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INTRODUCTION

This paper offers a strategic perspective on the rapidly developing European nuclear decommissioning scene, with a particular focus on the German market. We will identify a number of strategic themes that might be interesting to international companies practicing in decommissioning. The market size and valuation has received attention in several studies published in the last three years due to political concerns surrounding the funding of decommissioning. This paper will focus mainly on the decommissioning and decontamination (D&D) of Nuclear Power Plants (NPPs), commercially operated reactors generating electricity for power grids. There is also a substantial developing market also in D&D of fuel cycle facilities, research reactors and military production sites. However, they represent a rather different technical and financial challenge so will not be explored here. Further, we also restrict our geographic scope to European Union members and Germany in particular, to ensure our observations offer specific value. Our principal contention is that the German national industry holds too little capacity to fully undertake its own decommissioning program; leading to a conclusion that the European program as a whole will require significant support from international companies.

EUROPEAN NPP DECOMMISSIONING OVERVIEW

Europe is predicted to become the world's largest market for decommissioning by the middle of the next decade. One third of the European Union's (EU's) 144 operational NPPs are due to close by 2025, requiring expenditure by utilities on subsequent decommissioning of €60BN+[1, 2]. Table 1 below provides a breakdown of the probable scale of NPP closures in EU member states, showing that 38 reactors will be added by 2025 to the existing stock of 73

shuttered units.Table 1: European Power Reactor Closure Status and Prediction

Country	Pre 1986	1986-2009	2010-2025	later or unknown	Total
Belgium		1	7		8
Bulgaria		4		2	6
Czech Republic				6	6
Denmark					0
Finland				4	4
France	3	6		60	69
Germany	6	13	17	0	36
Greece	0	0	0	0	0
Hungary				4	4
Italy	1	3	0	0	4
Latvia	0	0	0	0	0
Lithuania		2			2
Poland				not defined	not defined
Romania	0	0	0	4	4
Slovakia	1	2		6	9
Slovenia	0	0	1*	0	1*
Spain	0	2	6	2	10
Sweden	1	2		10	13
The Netherlands		1		1	2
United Kingdom	2	24	18	1	45
TOTAL	14	59	38	104	208

Source: European Commission report “EU Decommissioning Funding Data”, dated March 8, 2013

Such large scale forecasts however can gloss over some vital details which allow a fuller understanding of the magnitude of the D&D challenge facing Europe:

- Decommissioning strategies tend to be dominated by the national waste disposal readiness and capacity. The UK has opted for a Safestor strategy (called Care and Maintenance) as the geological repository to take ILW graphite from its gas-cooled reactors will not be ready for decades yet.
- National power security concerns and long term power prices are pushing some utilities into Life Time Extensions rather than closure at end of regulated generation. Belgium has just opted to extend Doel 1 and 2 by ten years rather than decommission these elderly units. Yet governments continue to impose severe taxes on continued generation.
- Utility cash flows, especially in these days of depressed electricity market prices, can impact readiness to commit to short term expenditure on D&D. This particularly impacts the German utilities who hold balance sheet provisions but not segregated funds for decommissioning.

Consequently, it is not as simple as the bare numbers might suggest. Similarly, the cost of decommissioning is widely variable across Europe, a cause for recent concern for regulators [3]. Assumptions made by utilities about the probable cost of decommissioning can be strongly influenced by the projected cost of dismantling works, uncertainty about licensing procedures, the estimated cost of waste packaging, interim storage and eventual disposal, the planned time period of the project, the use of utility personnel to manage and even perform decommissioning projects, and so on. A further factor impacting cost projections is the relative lack of experience in the dismantling of full-sized NPPs: most units decommissioned in Europe to date have been prototype or early generation, smaller reactors. Recent reports place the range of unit budgets for decommissioning a full sized (500MWe+) European NPP at €200-860M per reactor ($220-940M) [4,5].

Consequently, the above estimates of the total European NPP decommissioning market may be sustainable at about €60BN by 2025 assuming that some 111 reactors will be dismantled at an approximate cost of €500M each, plus waste disposal costs. Broad-brush numbers do not help companies to make business decisions. So to assess the value and attractiveness of the European market, we might address as a case study the national market which should in principle show most growth during the next decade: Germany.

PROBABLE GERMAN PROGRAMME

Germany took the decision at various levels of government to phase out nuclear power generation in 2011, following the Fukushima Dai-Ichi core melt-downs and radiation releases. A legislated schedule for plant closures has been implemented, starting with eight reactor blocks that were shut in March 2011 during an initial Moratorium. In total, 17 NPPs will be closed in the period 2011 – 2022. Figure 1 shows the phase out program in terms of generation capacity.

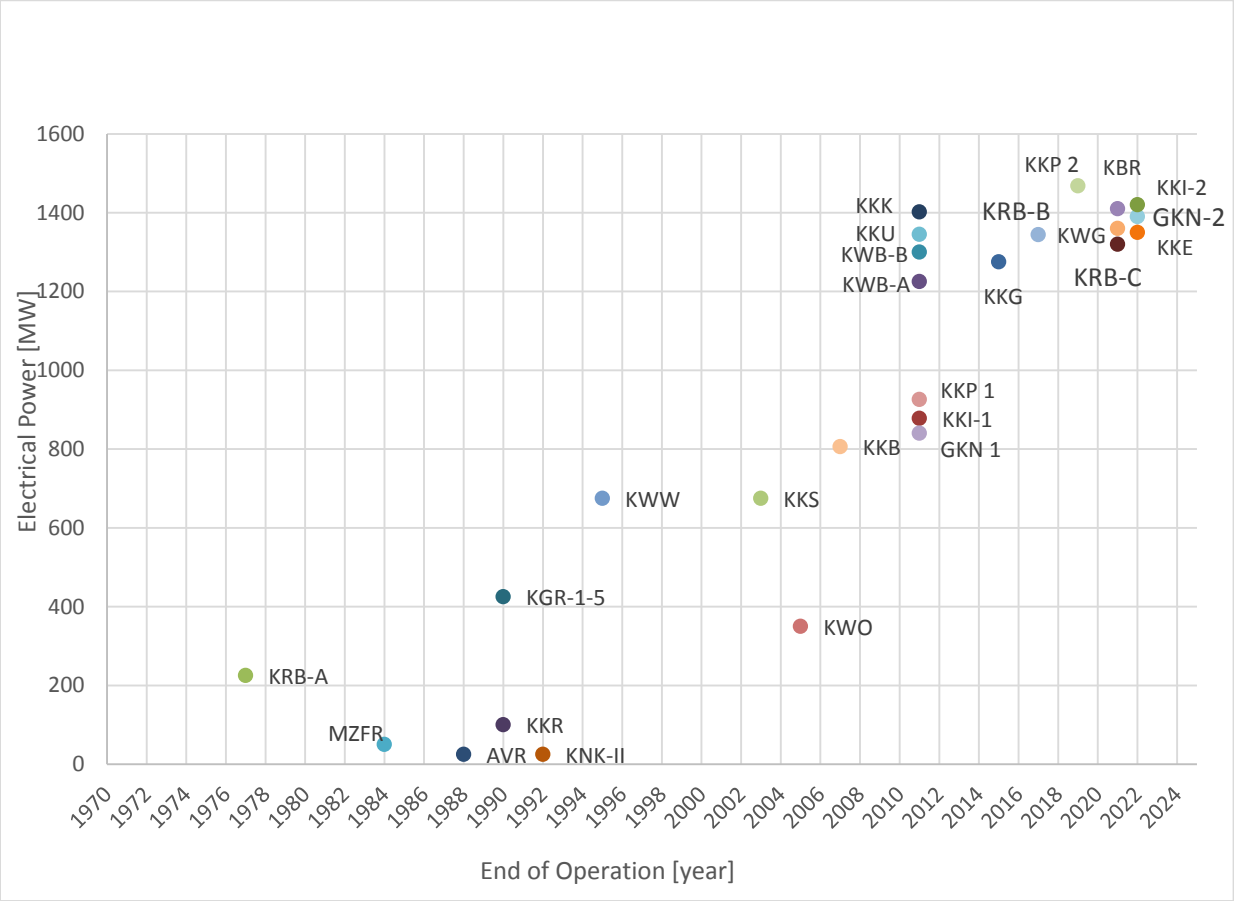

Figure 1: Nuclear Power Plant Closures in Germany (source: RWTH NET, 2015)

This overview shows that Germany is managing nine plants in decommissioning; eight in post operations shut down pending D&D; and seven plants still operating. Few have reached the end of the process. A significant point shown in the chart is that the early plants were smaller or pilot plants; the later NPPs are larger, more complex reactors. While valuable pioneering has occurred, much difficult work lies ahead.

Table 2 provides the timetable for the closure of the remaining power reactors in Germany.

	Date	Nuclear Power Plant	Number of plants
1	2011/08/06	Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1, Krümmel	8
2	2015/06/27	Grafenrheinfeld	1
3	2017/12/31	Gundremmingen B	1
4	2019/12/31	Philippsburg 2	1
5	2021/12/31	Grohnde, Gundremmingen C, Brokdorf	3
6	2022/12/31	Isar 2, Emsland, Neckarwestheim 2	3

Source: Nuclear Phase Out law (AtG 13)

Phasing of the program

Figure 2 shows the number of blocks shuttered awaiting decommissioning. This forecast draws directly on the legislated closure program then assumes that the utilities manage decommissioning over a 15-18 year period from closure: five years for post-operations (de-fuelling, licensing etc); and then 10 to 13 years for dismantling. There are numerous risks and impacts that might prolong this schedule; few that might shorten it. Consequently, the curve might flatten out, stretched over a longer period; or it might just suffer a timeshift to the right by a few years. Either way, the peak still looks pronounced.

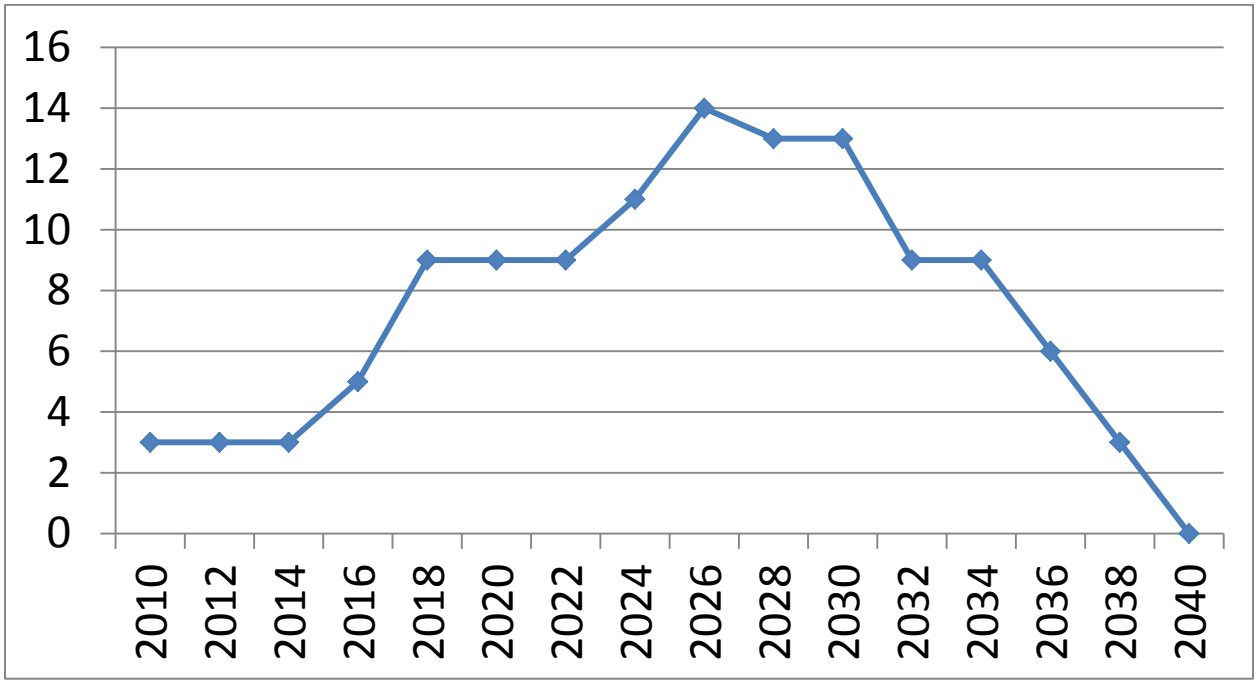

Figure 2: NPP D&D Timetable in Germany (source: RWTH NET, 2015)

The immediate observation from this schedule is that the number of blocks entering various stages of decommissioning in the 2020s will rise dramatically, followed by a gentle decline in the 2030s towards zero. This program represents an interesting opportunity for the industry that supports the utilities, but some severe challenges also as the capacity required may strain the resources of all parties (see below). One simplistic view is that the peak of 14 blocks in the mid-2020s will require a fourfold increase in capacity compared to 2012. Economies of scale and scope will doubtless offer efficiencies of deployment of resource; further, the declining call for reactor upgrade, maintenance and outage work will make resources available for redeployment to D&D. It's not that easy, however. Decommissioning work is very different to maintenance.

The accepted strategies for decommissioning power reactors include:

- Immediate dismantling: after de-fuelling and licensing, dismantling of the reactor internals and pressure vessel proceeds within about five years from closure. Dismantling sequences vary, but the complete removal of the structure is achieved normally within 10-12 years, allowing release from regulatory control.

- Safe Enclosure: after de-fuelling and an initial period of on-site work for

hazard reduction, the reactor is placed in secure containment for a lengthy period, normally 30-70 years, and most operating personnel released. The enclosure period allows decay of the reactor systems and the implementation of essential national infrastructure (e.g. a waste repository) to facilitate site clearance and release from control at a later date.

- Entombment: immobilization of hazards and containment typically in concrete on a permanent basis. This method is rarely adopted but can be suitable for certain hazardous configurations of plant.

Germany has largely adopted the immediate dismantling strategy. In part, this is due to political pressures from politicians not to “pass the buck” for decommissioning costs to future generations. Also, there has been a realistic recognition by the utilities that knowledge management will be an essential feature of safe and affordable decommissioning. The reactor personnel have the best available knowledge of the condition of the plant and its operating history, so utilizing their recollections and access to data is an important driver to undertake D&D before redeployments and retirements make it inaccessible.

The cost of decommissioning will be found from the balance sheets of the utilities that operated the reactors. During the generating life of the NPPs, all utilities accumulated funds to cover decommissioning costs as provisions on their balance sheets. These provisions were and remain subject to regulatory scrutiny to determine their adequacy. Periodic valuations were undertaken by utilities to justify the relevant costs. The German utilities did not however accumulate money in segregated funds to cover decommissioning. Therefore, to finance D&D, the utilities will have to make a significant call on operating cash flow; or sell assets which can by their nature be rather illiquid.

The range of factors discussed above can help us identify the early projects in Germany’s program. In addition to the continuing work at Obrigheim (KWO), Würgassen and Stade, we expect that Philippsburg 1 (KKP1) and Neckarwestheim 1 (GKN1) will see a start to dismantling work by 2017; Isar 1 (KKI1) and Biblis A and B will follow soon after; other reactors closed in 2011will follow as soon as licensing, resources and finances permit.

STRATEGIC CONSTRAINTS AND CHALLENGES

The German program faces a number of headwinds arising from different quarters. These major issues will increase uncertainty, delay progress with dismantling and push up costs. The main risks for the program may be summarized under the following headings.

- Law suits against governments – the utilities sued governments at various levels about the politically driven premature shut-down of their reactors. German plants were among the most efficient nuclear generators in the world by 2011 and their operational safety record was enviable. However, faced with overwhelming democratic pressure to shut NPPs after Fukushima, federal and regional governments acted quickly to reduce the political hazard. Utilities consequently launched law-suits alleging unlawful denial of use of assets, and the total damages sought may approach €30BN (source). Until the cases are determined by the courts, some NPPs are theoretically still ready to generate power.

- Disposal uncertainties, costs and technical requirements – the political case for a spent fuel repository has never been concluded and a new public commission is considering all the possibilities afresh. The decades of delay and substantial additional cost will fall partly to the utilities. The Konrad mine for low and intermediate level wastes is approved, but seriously late in its preparations to receive waste. Decommissioning utilities will be obliged to provide interim storage for waste until shipments can commence in the mid – 2020s. Acceptance criteria are not yet fully determined, so some uncertainty remains and disposal costs continue to mount. The utilities and governments may seek to settle the lawsuits in return for a clear transfer of liability for waste.
- Cash flow of utilities – low power prices and over-supply of renewables has undermined the profitability of many generating assets in Europe, especially in Germany. Major utilities with large coal, gas and nuclear fleets are suffering, impacting the cash available to finance decommissioning. Therefore, some utilities can be expected to defer dismantling work for as long as possible.

- Licensing procedures – the scale and scope of decommissioning work might overwhelm the regulatory departments of regional environment ministries who are charged with practical oversight of NPPs. Decommissioning requires a new license, which has to be prepared and justified in full compliance with the Atomic Law. Some regional level ministries have no experience of decommissioning licensing; others view this as an opportunity to tighten practices on nuclear sites further.

- Self-perform – the German Works Council system gives employees a strong say in major decisions and normally results in job preservation strategies. All utilities are electing to manage D&D work themselves, some even to perform the tasks with their own blue collar personnel. While it may not offer the most efficient route to the desired end state of a site, it helps a diversified utility avoid major industrial disputes. On the other hand, many site personnel recruited in the 1970s and 80s are now not far from retirement. By the mid-2020s, the utility employed workforce will be smaller.

EUROPEAN INDUSTRY RESPONSES

The EU has a qualitatively strong decommissioning industry with many of the big names in the trade firmly established in Germany: Areva, Westinghouse, Siempelkamp, etc. However, European industry and specifically German industry has not had to provide decommissioning resource capacity on anything like this scale before. D&D projects have previously been managed as one-offs, on a smaller scale, such as Kahl or Obrigheim, not part of large multi-site programs.

To compound the difficulties facing the German industry, most companies have been forced to downsize and consolidate activities. The Nuclear Phase Out terminated planned utility investments, and curtailed outage projects and operational support. Lower power prices have obliged utilities to cut routine operational spending and contractors have borne the brunt of cost cutting. Just when the industry needs to be investing for decommissioning, it is at its weakest in resources and financial strength.

The German nuclear industry is highly competitive and has successfully diversified into foreign projects in UK, China, USA and elsewhere. It will surely compete fiercely for the project scopes required by the utilities over the next 20 years. But right now, international players looking to enter the German market have their best opportunity.

STRATEGIES FOR SUCCESS IN GERMANY

It is tough to enter the German market in the face of determined indigenous competition, a language barrier that deters many and a regulatory culture that is quite unique in the nuclear world. Any company seeking to become a participant should understand the scale and length of marketing investment required to build successful customer relationships and to become accepted in the industry. The significant risks discovered by previous contenders:

- Time horizons for business development too long
- Costs of local recruitment and complexity of local labor laws too high
- Difficulties delivering projects profitably due to unforeseen regulatory or operational requirements or changing environmental conditions
- Determined local competition with broader customer relationships outflanking new entrants before they can become established.

Every new market opportunity presents risks and conventional solutions and mitigation measures are available to improve the prospects of success; and some unusual possibilities created by the circumstances of the German market.

1. Partnering – especially where the international player brings specialist capabilities in short supply and can also offer the German partner reciprocal access to an international market.
2. Local acquisitions – traditionally opportunities to buy German nuclear companies have been difficult for foreign investors to spot; with more open financial markets and greater willingness to involve international players in the German market, occasional M&A possibilities will be found.
3. Building a broader co-operation with a utility customer to participate in business elsewhere. Most of the utilities want to offer their personnel a long term future in D&D. Where companies can support this aspiration, their short term offer will be more attractive.
4. Founding a local company with German personnel. Specialist companies will find it possible to set up business if supported by a strong overseas parent. Track record is vital, so new startups will find it hard to compete.

To succeed in the German market, an international company should become an accepted member of the industry, contributing to the broader success of the industry as it faces the enormous challenges of the Nuclear Phase Out. Participation in conferences and industry events is a good introduction to the German nuclear environment. In the short term, the dearth of projects may continue for a year or two yet; however, in the medium term there will be a glut of opportunity for those who can become established in time.

CONCLUSIONS

The European market for decommissioning services is approaching an inflection point. Within ten years, it may be the largest in the nuclear world with 144 closed NPPs. Germany is a leading example of the challenges posed. Its own program will require a sharp acceleration in decommissioning capability and capacity, as the utilities and supporting industry move from decommissioning one off smaller reactors to managing multiple reactors across many sites in parallel. This is a more complex challenge at an organizational level than seen before, and it is highly likely that international industry will play an important role in delivering the services required.

A €30BN+ market is highly attractive. Germany's decommissioning program will experience many headwinds; delays are inevitable due to the political involvement at many levels. For companies prepared to invest with a longer term perspective however, the opportunity might be appealing. The German market is more open that it has ever been to international participation, and the right strategic approach now may create a long term position in not just the German program, but the rest of the European D&D market as it expands over the next two decades.

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