

MAGNOX DECOMMISSIONING DIALOGUE

REVIEW

OF

TECHNICAL & LOGISTICAL ASPECTS

OF THE

1ST DRAFT REPORT

STRATEGIC ACTION PLANNING WORKING GROUP

OF

7 OCTOBER 2004

LARGE & ASSOCIATES

CONSULTING ENGINEERS

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REVIEW OF THE 1ST DRAFT OF THE STRATEGIC ACTION PLANNING WORKING GROUP OF 7 OCTOBER 2004

SUMMARY:

This Review examines the 1st draft of the SAPWG report assessing the way forward to determine the optimum decommissioning time scale to be adopted for the UK's Magnox nuclear power stations.

INTRODUCTION

Convened by the Magnox Decommissioning Dialogue Main Group, the Strategic Action Planning¹ Working Group (SAPWG)² was set the task of identifying the relevant *issues* and *uncertainties* for a range of time scales or *strategies* that might be considered appropriate for the decommissioning of each of the series of Magnox nuclear power stations located in the United Kingdom.

It is not the purpose of this Review³ to examine the SAP process⁴ deployed for this but, more to the point, to determine if the outcome of the SAPWG's deliberations satisfied the SAP objectives identified by the Environment Council⁵ of:

- Identifying the short-term actions/decisions needed to keep a *strategy* open; and
- setting the timeframes during which actions/decisions have to be taken to maintain a range of *futures* possible.

In other words, what needs to be done now and in the near future to establish a specific and viable decommissioning strategy and, once established, at which times in the future do

¹ For an explanation of the SAP process and the terms used, see the Environment Council note http://www.the-environment-council.org.uk/docs/Strategic%20Action%20Planning%20_SAP_%20process2.pdf

² The SAPWG was established in November 2003.

³ This review concentrates on technical and logistical aspects of the SAPWG report, leaving detailed consideration of the economic/financial aspects to the financial expert engaged by The Environment Council.

⁴ SAP seems to be a recent development of traditional conjoint analysis used to assist in management decision making, sometimes referred to as Strategic Choice Analysis (SCA) and there is also the Analysis of Interconnected Decision Areas (AIDA) which is applied to decision-making in mutually exclusive options. Essentially, these techniques are within a family or problem structuring methods (PSMs) for decision support that are designed to assist groups of diverse composition to identify and focus upon consequential actions, being an advancement on the critical path approaches developed by the building and construction industries – see Bennett J et al *Trusting the Team the Best Practices Guide to Partnering in Construction*, Thomas Telford Partnering, London 1995.

⁵ See foreword of SAPWG 1st draft report of 7 October – for ready reference the terms used are set down with a hypothetical example in the bottom row as follows:

<i>STRATEGY</i>					
<i>RELEVANT/GENERIC ISSUE</i>	<i>UNCERTAINTY</i>	<i>NOW</i>		<i>LATER</i>	
		<i>ACTION</i>	<i>EXPLORATION</i>	<i>DEFERRED DECISION</i>	<i>CONTINGENCIES</i>
Decom Technology	Will it be available	Identify R&D Costs	Compare to other industries	what to do if not available	Extend time if necessary

decisions have to be made (and what are these decisions about) to maintain the particular decommissioning approach open over the years.

DEFINING THE STRATEGIES – DECOMMISSIONING SCENARIOS

The SAPWG examined three decommissioning *strategies* or scenarios (Section 2.3), these being:

- (1) Prompt, uninterrupted decommissioning
- (2) Some prompt decommissioning + medium-term deferral of complete decommissioning
- (3) Some prompt decommissioning + long-term deferral of complete decommissioning

SAPWG gives little further explanation of the derivation of the bases for these scenarios other than reiterating the BNFL *Safestore Strategy*,⁶ from which the three SAPWG scenarios seem to directly derive. The prompt decommissioning option (1) includes a 15 year period during which conventional structures (including fuel ponds, etc) are demolished and the site generally prepared for final dismantling and clearance, which is reckoned to occupy another 10 or so years so, all in all with defuelling, the site is to be cleared in 30 years or less.⁷ The other two scenarios (2 & 3) includes much the same care and maintenance (C&M) preparation period, followed by two options of periods of C&M or deferral (indicative, ranging from 30-50 to 100 years) until final demolition commences.

However, the government's declared decommissioning strategy⁸ calls for the shortest practicable time frame in that "*Decommissioning operations should be carried out as soon as reasonably practicable, taking all relevant factors into account . . .*". Even though government policy recognises that "*decommissioning operations may, however, involve two or more separate stages spanning a number of decades*", there is clearly a preference for the so-called prompt decommissioning strategy.

Surprisingly, SAPWG has not considered (or at least reported upon) the other decommissioning scenarios identified by Magnox Electric in its 1997-8 study for the Health and Safety Executive (HSE) Quinquennial Review.⁹ In this study fifteen decommissioning options were identified, three of which were rejected prior to final submission to the HSE. Interestingly, these three rejected decommissioning scenarios included an immediate and two deferral schemes which were to be completed with the (radio)activated circuit immersed under water.

⁶ Walden P, Taylor D, *Reactor Decommissioning in a Deregulated Market*, World Nuclear Association Annual Symp, September 2001 – London.

⁷ The SAPWG Summary Report of 5-6 November gives 20 years for completion of the prompt scenario.

⁸ i) *National Policy on Decommissioning*, White Paper Cmd 2919 and ii) *Decommissioning in the United Kingdom*, September 2004 – see also *A Public Consultation on Modernising the Policy for Decommissioning the UK Nuclear Facilities*, DTI, November 2003

⁹ Nuclear Electric (the predecessor to Magnox Electric) first carried out a Best Practicable Environmental Options (BPEO) study for the decommissioning of Magnox power stations in 1989/90. As required by the HSE, Magnox Electric carried out a more extensive revised BPEO study in 1997/98 using multiple attribute decision analysis (MADA) which evolved to a list of 15 decommissioning options. At that time Magnox Electric rejected 3 options although the HSE required Magnox Electric to review the appropriateness of rejecting these options (which included immediate and deferred underwater dismantling), at its next quinquennial review in 2005-6 which was to take account of a wider stakeholder involvement (ie the present Magnox Dialogue). The Magnox Electric MADA study is not a publicly available document but see *A review by HM Nuclear Installations Inspectorate Magnox Electric plc's strategy for decommissioning its nuclear licensed sites*, HSE February 2002.

Arguably, the rejected immediate underwater scenario, without the long C&M preparation lead-in period, is much more akin to government policy than the prompt scenario (1) adopted by SAPWG.

In Section 6 (Learning Points from SAP – p65) SAPWG notes that (in the earlier pre-SAPWG Dialogue process) there are “*various conflicting and contradictory factors*” that make it impossible to isolate a single decommissioning scenario (1, 2 or 3) that all stakeholders could support. That said, nothing further is given in identifying these factors, how they interrelate, and what the individual strengths and influences of each respective factor are.

In fact, this largely unsubstantiated approach (here being fundamental to the choice of the most apposite decommissioning scenario) is a common failing that runs throughout the SAP process as worked by SAPWG. Generally, this is that decisions and choices are arrived at apparently without full exploration of the factors involved or, if full exploration has been completed, it remains hidden because in the SAPWG report there is no open substantiation and no citations of any of the authoritative sources that may (or should) have been referred to.¹⁰

TESTING THE STRATEGIES – SAP PROCESS

As I see it, there are two major *uncertainties* associated with prompt decommissioning: These are i) possibly intolerable levels of radiation exposure to those dismantling the radioactive structures and wastes and ii) the lack of provision of an off-site waste management facility, particularly for intermediate-level wastes (ILW).¹¹

In this respect, I would have expected SAPWG to have referred to the continuous and relative short time scale decommissioning operations now finalising for the single reactor Magnox stations at Latina (Italy – 15 years to completion, commencing 2005)^{12,13,14,15} and Tokai-1 (Japan – to be completed by 2017 with just 7 years allocated to completely dismantle the pressure vessel and graphite core),¹⁶ for which detailed information on the approach and the projected time scales to completion are available.^{17,18}

¹⁰ It is surprising that this 80+ page draft SAPWG report has no reference citation whatsoever. Moreover, the undated *List of documents used/produced by the SAP Working Group* mainly refers to Dialogue records with just a few new sources of technical and financial/economic information and data. Also, the SAP approach seems to involve making *assumptions* (p16) where there is uncertainty about a feature of a scenario – it gives the possible non-availability of an ILW off-site facility as example of this - but any *assumptions* that have been made are not listed clearly in the report.

¹¹ Managing Radioactive Waste Safely, DTI, September 2001 and Managing the Nuclear Legacy, Cm 552, July 2002

¹² Bolla G, et al, *The Decommissioning of the Latina Nuclear Power Plant*, WMP01 Conference, February 2001, Tucson

¹³ SOGIN Mission Statement of 2002 at <http://www.eu-decom.be/europe/otherprojects/italy/sogin-mission.htm> . Although fuel pond decontamination work has already been completed, other than this little C&M work has been undertaken to date at Latina. – the design scheme for prompt decommissioning was completed in 2002, the decommissioning duration of four stages will require 15 years, starting in 2005 and completing in 2020.

¹⁴ *British Nuclear Group – Latina Nuclear Power Station*, <http://www.britishnucleargroup.com/index.aspx?page=14>

¹⁵ Large J H, *The Proposed Immediate Decommissioning of Latina Nuclear Power Station*, R3069-A9, Magnox Decommissioning Dialogue

¹⁶ Large J H, *Review of Japanese Sourced Papers on Decommissioning*, R3069-A5, Magnox Decommissioning Dialogue

¹⁷ At Latina 15 years has been set aside for the complete dismantlement and decommissioning to a cleared site, commencing 2005 on the proviso that the national radioactive waste facility will be operational by 2009.

¹⁸ For a general discussion of these issues see Jackson, I, *Past, Present and Future – Decommission Improbable*, Nuclear Engineering, Viewpoint, Nuclear Engineering International February 2004

Each of these programmes has sufficient confidence¹⁹ in the dismantling methodology to maintain personal worker dose levels to within their own ICRP-based²⁰ radiological dose management regimes, although complete decommissioning of Latina is dependent upon a national repository for wastes being available in 2009. Further evidence of industry confidence to maintain personal radiation exposure to acceptable levels is given by the United Kingdom Atomic Energy (UKAEA) in its strategy document²¹ modifying its plan to bring forward reactor decommissioning by 50 years because of availability of off-the-shelf robotic tools, enabling it to reduce its previous 'safe storage' target of 85 years to 35 years and thus yielding a saving of £1.5bn over the initial projected cost of £6.3bn.

Despite Italian, Japanese and UKAEA publicly aired confidence in advancing robotics, the SAPWG (Section 5, Scenario 1, p26) analysis identifies robotic availability to be an *uncertainty* that carries forward with its *exploration*, *deferred decision* and *contingency* negatively charged elements acting against this prompt decommissioning scenario (1). Also, no clear cross linkage is established between availability of robotics and tolerable levels of radiation exposure to the dismantlers and the public (Section 5, Scenario 1 – p29), whereas the dismantlers' dose (but not the public dose) would be strongly and inversely linked to the deployment of robotics.

So far as the availability of a radioactive waste management route, SAPWG itself has identified a fall-back option whereby the waste is stored on site until a permanent off-site facility is available (Section 5, Scenario 1, p27-28).

There are a number of problems with the SAPWG analysis of Scenario 1:

- **First, no analysis seems to have been undertaken on how decisions and actions taken in the *Now* time frame could significantly influence any decision to switch to and progress with either of the deferred scenarios (2 & 3) in the *Later* time frame. The point here is if it would be possible to have considered just a single prompt scenario (1) with sufficient flexibility built in to enable deferral to be opted for if technological or socioeconomic hurdles were encountered later.**
- **Second, SAPWG does not seem to have investigated the necessity for the 15 or so year period required for preparing for the so-called C&M state of the power station site, that is could not this C&M period be much shorter? The Japanese, Italians and (more recently) the UKAEA do not include for a distinctive C&M preparation, so it is not clear why the C&M preparation period is included in the prompt scenario (1), illustrated by the chart comparing the three scenarios (Section 4, p19).²²**
- **Obviously, there is likely to be considerable differences in the extent and detail of preparations required for the prompt (1) and deferral (2 & 3)**

¹⁹ Bolla G, et al *The Decommissioning of the Latina Nuclear Power Plant*, WMF01 Conference, March, Tucson

²⁰ International Commission on Radiological Protection – ICRP 60

²¹ UKAEA, *Strategy Statement* – NCE, 14 October 2004, Inst Civil Eng – UKAEA submission to the DTI, September 2004

²² Although the text is somewhat confusing on this – see 2nd bullet point, p19

scenarios – SAPWG should have investigated this, particularly in terms of the time and cost²³ implications for the prompt scenario (1).

SAP GENERIC ISSUES -v- DECLARED GOVERNMENT STRATEGY RELEVANT FACTORS

The requirements of government are set out in its *Decommissioning Policy Statement*⁸ in terms of ‘Relevant Factors’, these being equivalent to SAPWG’s ‘Generic Issues’ which are developed in Section 3 and applied to the SAPWG tables of Section 5.

The match between government and SAPWG factors/issues and SAP *uncertainties* (or sub-issues) is as follows for the prompt decommissioning scenario (1):

	HM GOV RELEVANT FACTORS		SAP GENERIC ISSUES	SAP UNCERTAINTIES
a	ensuring worker and public safety	✓		
b	maintaining site security	✓	Security	Consequences of terrorism during handling
c	minimising waste generation and providing for effective and safe management of wastes which are created	✓	[?] Facilities	ILW packaging - B205 and Vitrification - Temporary on-site waste stores - Permanent off-site storage for ILW & LLW - Asbestos managed disposal
d	minimising environmental impacts including reusing or recycling materials whenever possible	✓	Environmental Impact & Control	Decom within time frame and regulatory limits - Discharge limits being reduced - EIA consent ²⁴ Coastal changes (global warming) - Storms, etc (global warming)
e	maintaining adequate site stewardship	✗		
f	using resources effectively, efficiently and economically	✗		
g	providing adequate funding	✓		
h	maintaining access to an adequate and relevant skills and knowledge base	✓		
i	using existing best practice wherever possible (BPEO)	✗		
j	conducting R&D to develop necessary skills or best practice	✓	[?] Skills & Personnel & Technology	Sufficient skills available Robotic development/availability
k	consulting appropriate public and stakeholder groups on the options considered and the contents of the strategy	✓	Stakeholder Engagement	Public support or opposition - Practicalities of involving stakeholders - Waning of stakeholder interest
	Sustainable Development ²⁵	✗		
l			Social-Economic/Local Community	Tourism, property values and land use
m			National/International Policy	Sufficient and protected funding Stability of costs Regulatory derived costs – safety & timescales Doubts on off-site transport
n			Regulatory Control (tacitly assumed adhered to in government Relevant Factors)	Impact of worker dose limit Impact of public dose limits ILW/LLW packaging requirements Increased security risk Change of Free Release levels & traceability Environ impact of accidents and incidents Relaxation of dose limits for prompt decom

²³ Outlook on Decommissioning Costs, Nucleonics Weekly, 27 Sept 1990

²⁴ Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999. SI 1999 N° 2892. HMSO 1999

²⁵ Sustainable Development has been added to the *Relevant Factors* in the latest draft version (September 2004) of the government’s requirements.

				Maintaining records
o		Transport		Acceptability of transport frequency
p		Structural degradation		Appropriate maintenance levels of structures

For the prompt decommissioning scenario (1), the above table shows that whereas much of the government’s relevant factors have been covered by the SAPWG process,²⁶ there remain important areas and topics of government requirement that have not been considered.

In setting out the *generic issues* and thence the *uncertainties*, SAPWG should have adopted the government’s list of *Relevant Factors* as an underlying template, expanding this as it found appropriate.

Another shortfall of the SAPWG process is, again across the board, the range, quality and depth of examination posed via the *uncertainties*. There are a number *uncertainty* entries against *generic issues* in the Section 5 prompt scenario (1) that illustrate this shortfall:

i) **Environmental Impact and Control**

Here, amongst other SAPWG entries, is the *uncertainty ‘Consent under ELA regulations’* which (it is assumed) refers to the *Nuclear Reactors (ELA for Decommissioning) Regulations*.²⁴

Schedule 1 of these regulations sets out the information to be included in an environmental statement and, similarly, Schedule 2 establishes the criteria for determining further assessment. Almost all²⁷ of these could have been included as SAP *uncertainties* to broaden the depth and rigour of the SAPWG examination process of this important environmental protection aspect.

ii) **Terrorism and Malicious Acts**

There is just one *uncertainty* relating to terrorism listed against a security *generic issue* in the SAPWG report (Section 5, p36). Thus, excluded is a whole range of design basis threats (DBTs)²⁸ and potential terrorist actions against decommissioned nuclear facilities and radioactive material transportation.^{29,30,31,32,33}

²⁶ 2nd column colour codes linked by the colour-coded items of the 5th column.

²⁷ Schedules of *The Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations*

²⁸ Large J H, Marignac Y, Submission to the International Atomic Energy Agency - Convention on the Physical Protection of Nuclear Material (CPPNM) – IAEA InfCirc/274 & InfCirc/225/Rev.4 - IAEA Requirements on Design Basis Threat Assessment - *Non Compliance of Eurofab LTA shipment from US to France on UK Vessel: Security and Physical Protection Issues*, IAEA 20 September 2004

²⁹ Maerli, et al, *The Threat of Nuclear Terrorism: Nuclear Weapons or Other Nuclear Explosive Devices*, IAEA Symp, International Safeguards: Verification and Nuclear Material Security, Nuclear Terrorism, IAEA-SM-367/19/04, November, 2001

³⁰ Cameron, G, *The Threat of nuclear terrorism: Intentional dispersal of radioactive material – sabotage of fixed installations or transport systems*, IAEA Symp, International Safeguards: Verification and Nuclear Material Security, Nuclear Terrorism, IAEA-SM-367/19/05, November 2001

³¹ Bunn, G, et al *Reducing the Threat of Nuclear Theft and Sabotage*, IAEA Symp, International Safeguards: Verification and Nuclear Material Security, IAEA-SM-367/4/08, 29 October, 2001

³² i) Large, J H, IPPNW Global Health Watch, Rethinking Nuclear Energy and Democracy after September 11, 2001, *The Aftermath of September 11: Vulnerability of Nuclear Plants to Terrorist Attack* International Physicians for the Prevention of Nuclear War and Physicians for Social Responsibility, September 2004 ii) Large J H *The Implications of 11 September for the Nuclear Industry*, United Nations for Disarmament Research, Disarmament Forum, 2003 No 2, pp29-38, http://www.unidir.ch/bdd/fiche-article.php?ref_article=1910, iii)

The SAPWG response to security issues is to defer to the Office of Civil Nuclear Security (OCNS) as a *Now Action*, but this alone is unlikely to address all of the security and related issues that could arise during the entire decommissioning period. This is because OCNS has to await receipt of the security aspects raised in the nuclear safety case which, for the overall decommissioning period (prompt or deferred), has yet to be (to my knowledge) submitted by Magnox Electric.

An array of such security issues have been addressed by the International Atomic Energy Agency (IAEA),³⁴ and these could have been adopted to seed the SAP process in this respect.

iii) **National/International Policy:**

A central plank of national policy is that the “*hazards presented by the plant (should be) reduced in a systematic and progressive way*” which is also a strong determinant of the Health and Safety Executive (HSE) decommissioning and waste management policy.³⁵ The Environment Agency also has a role in decommissioning, in both immediate and longer terms.³⁶ Under the all-encompassing Nuclear Installations Act 1965 the period of site licence responsibilities does not end until the HSE is able to declare that there is no danger from ionising radiations on the site, thus Magnox Electric’s radioactive waste management strategy has to be intimately linked to its decommissioning strategy. However, the specific site clearance criteria are likely to pass from the Act to the awaited radioactive contaminated land legislation when enacted. In fact, the government’s insistence of best practicable environmental options (BPEO) being applied at each Magnox site might result in varying standards of clean-up across the sites, rendering effective uniform contamination control across the board difficult.³⁷

Very little consideration is given to the international dimension and restraints to decommissioning in the SAPWG process, although much is available in the open literature. For example, the International Atomic Energy Agency^{38,39,40} sets out guidelines for the overall approach, the European Commission viewpoint aims specifically at the environment impact⁴¹ and the ‘Thematic Network on Decommissioning’ commenced in 2001, and the OECD provides a measure on the

Large J H & Schnieder M, *Vulnerabilities of Nuclear Plants to Terrorism*, Oxford Research Group Seminar, Rhodes House, Oxford, December 2002

³³ *Assessing the Risk of Terrorist Attacks on Nuclear Facilities*, Parliamentary Office of Science and Technology, Report 222, July 2004

³⁴ *Safe Enclosure of Nuclear Facilities During Deferred Dismantling*, IAEA Safety Reports Series No 26, 2002

³⁵ Bacon, M *HSE policy on decommissioning and radioactive waste management at licensed nuclear sites* Nuclear Energy 1997 36 1 13-19

³⁶ *Decommissioning of Nuclear Installations: The Environment Agency’s Role And Objectives*, Environment Agency, September 2002

³⁷ The Radioactive Waste Management Advisory Committee’s (RWMAC) *Response to the Government’s Public Consultation on Modernising Policy for Decommissioning the UK’s Nuclear Facilities*, RWMAC February 2004

³⁸ *Planning, managing and organizing the decommissioning of nuclear facilities: lessons learned*, IAEA-TecDoc-1394, May 2004

³⁹ International Atomic Energy Agency *Regulatory Process of the Decommissioning of Nuclear Facilities* Safety series 105 IAEA.

⁴⁰ International Atomic Energy Agency *Factors Relevant to the Decommissioning of Land Based Reactor Plants* Safety series 52 IAEA 1980

⁴¹ *Environmental Impact Assessment for the Decommissioning of Nuclear Installations*, EUROPEAN COMMISSION (CASSIOPEE, University of Wales, ECA Global), Rep. EUR-20051 EN, June 2001

costing.⁴² Other international treaties and conventions that impinge upon the UK decommissioning strategy include transboundary liability, such as the Paris Convention,⁴³ and the Earth Summit⁴⁴ with requirements for sustainability and justification of such developments, and that the UK government is signatory to the OSPAR agreement which effectively commits the UK nuclear industry to work quickly towards a ‘near zero-release’ practice by 2020.

These exemplified topics (environment, terrorism and national and international), along with other aspects as applied to decommissioning, provide a wealth of information that would have enabled comprehensive (and much more ordered) *issues* and *uncertainties* lists to be applied to the SAP process.

The SAPWG does not seem to have been particularly systematic in its compilation of the *issues/uncertainties* list, indeed the *issues/uncertainties* listed in Section 5 suggest a lack of basic research and reference to readily available policies, information and data. The result of this is that the scope and depth of interrogation via the *uncertainties* is not at all as probing as it might have been - indeed, certain on the *uncertainties* seem to be drawn from ill-informed sources and others are somewhat shallow.

Also, it is not at all obvious from the Section 5 tabulations how much regard SAPWG has given to national government and regulatory keystone requirements (and to international treaties, etc). Much more emphasis should have been placed upon government and related policies in seeding the *issues* and *uncertainties* lists of the SAP process.

In this respect, it is disappointing that the SAPWG did not address BPEO and sustainability issues, the latter which SAPWG redefines as ‘intergenerational equity’, although despite this rebranding it is not included in the tabulation process of Section 5.

CROSS LINKING, CORRELATING AND WEIGHTING THE SAP TABULATED INFORMATION

The SAPWG tabulations (Section 5) comprise individual entries of *uncertainties*, *actions* and *decisions* arranged in a reasonably logical stream against particular *issues*. In each *issue* stream the rationale of the progression is generally forward (in this case in time) but there is no formal means by which decisions in one *issue* stream can be related to another *issue* stream, even though the two streams may share common *uncertainties* and/or be influenced by mutual (conjugate) factors.

In other words, since each of the *strategies* (the decommissioning scenarios **1, 2 & 3**) are bound to contain potentially composite *issues*, so there must arise probabilities that two or more *issues* will combine (or influence each other) in mutual or complementary ways.⁴⁵ The

⁴² *Nuclear Decommissioning, A Proposed Standardised List of Items for Costing Purposes*, OECD NUCLEAR ENERGY AGENCY/IAEA/EUROPEAN COMMISSION, Interim Technical Document, OECD, Paris (1999).

⁴³ *Convention on Third Party Liability in the Field of Nuclear Energy of 29th July 1960*, as amended by the Additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982 – known as the Paris Convention.

⁴⁴ UN Conference on Environment and Development (UNCED) Rio de Janeiro, June 1992 – otherwise known as the Earth Summit.

⁴⁵ In statistics and probability analysis this is described by Bayes’ theorem and is illustrated by the Venn diagram..

SAP process, as adopted by the SAPWG, seems to have no mechanism by which *issues* can be related and composite outcomes forecast (ie there is no numerical scheme or framework adopted to facilitate this). However, there is occasional evidence in the detail of the tabulations that the SAPWG has linked an action in one *issue* stream to another *issue* but, that said, there is nothing in the tabulations to quantify the strength and probability of mutuality of the union so identified.

Much the same applies to valuing or weighting the importance of the *uncertainties* and *decisions*, either by some form MADA⁴⁶ or, more simply, by a head count of the members of the SAPWG who were for or against a particular topic. Whereas the SAPWG report refers to preferences for (and, indeed, fundamental objections against) particular strategy scenarios (p18), there is no attempt to quantify which, if any, strategy is favoured (or disfavoured) by the majority of individual members of SAPWG.

SAPWG concludes (p18) that the “*explorations and actions identified, taken in their entirety, are the most appropriate way of objectively testing preferences and objections and enabling decision makers to move forward in an informed way*”. However, this is not a particularly convincing way forward when the reader is actually burdened with the task of sifting through the numerous *issue* strings of the Section 5 tabulations.

To simplify this, the inclusion of a weighted preference list, or highlight table, would have assisted the new reader to a better understanding of the SAP outcome.

There is a novel although useful table-graphic (p66) which indicates the forecast trends (greater or lesser) of *uncertainties* that are common across the three decommissioning scenarios (1, 2 & 3). Although not numerically quantified, the arrowed trends provide a sense of the difficulties of forecasting so far into the future for the two deferred scenarios.⁴⁷ It would have been useful to have applied a similar forecast to the *uncertainties* within a single scenario, particularly that assumed for prompt decommissioning (1).

No doubt, the individual members of the SAPWG may well have understood, learnt and benefited from the SAP exercise, but the SAPWG report fails to effectively disseminate this in a way that can be readily picked up by the ‘decision makers’. The forecasts and outcomes arrived at by SAPWG might be better communicated if elements of cross-linking and quantification (ie more objectivity) had been included, and understanding of the tabulations of Section 5 would be greatly improved if summarised (say) in terms of the main or *generic issues*.

Perhaps, the principal outcome of the SAPs exercise is that it has bound together an exclusive knowledge group (SAPWG) but who are quite unable to effectively communicate^{48,49} to others occupying the fringes of what is, after all, the complex, multi-disciplined subject.

⁴⁶ MADA – Multiple Attribute Decision Analysis or Multi-Criteria Decision Making – for general example see Belton V., *Comparison of the analytic hierarchy process and a simple multi-attribute value function*, European Journal of Operational Research, Vol.26, 1986, 7-21 and for a specific study of concrete service longevity see Öberg M, *Integrated Life Cycle Design - Application to Concrete Multi-Dwelling building*’, Licentiate Thesis. Report TVBM-3103. Lund University. Division of Building Materials, Lund, Sweden, 2002.

⁴⁷ Under Funding Availability the forecast that the validity of costs estimates now and into the future will remain constant seems a little odd.

⁴⁸ Could it be as in the maxim ‘cannot see the wood for the trees’ or, perhaps, akin to Hans Christian Anderson’s ‘The Emperor’s New Suit’ where the invisible cloth serves the function of SAP, so far as the bewildered onlookers perceive!

SAPWG FINDINGS AND OBSERVATIONS – VALIDITY OF THE LEARNING POINTS

The SAPWG report identifies (p69) the **key issues** to be:

- Availability of skills and personnel
- Availability of off-site waste routes
- Stakeholder support/opposition
- Funding availability

although SAPWG ascribes no particular order to the importance of each of these and states that the other *uncertainties* identified in Section 5 should not be ignored. On each of these key *issues*, which it confusingly refers to as '*Learning Points*', SAPWG notes:

Availability of Skills and Personnel: For the prompt scenario (1) possibly lack of sufficiently qualified and experienced personnel to take on the task of decommissioning all 11 Magnox sites if adhering to the present close down schedule. For the deferral scenarios (2 & 3) concerns over maintaining a staffing resource through the deferral periods and then training up sufficient numbers for the final dismantling phase years ahead.

In fact, the staffing resource for prompt decommissioning has been addressed by the United States Nuclear Regulatory Commission (NRC)⁵⁰ for the early transfer of managers, here in the United Kingdom BNFL has considered retraining and transferring operational staff to decommissioning,⁵¹ jointly the Highlands and Islands Enterprise with Caithness and Sutherland Enterprise have established a decommissioning training centre to address short term issues,⁵² the University of Manchester has established a School of Nuclear Graphite Research (2001) with an obvious interest in graphite moderated reactor decommissioning, and Lancaster University offers a Masters in Nuclear Decommissioning and Environmental Clean-Up.

In other words, both professional and skills related training is currently underway and, no doubt, as the decommissioning demand grows (as it will with such a large decommissioning inheritance now emerging) these and other institutions will respond accordingly.

⁴⁹ This lack of communication is, perhaps, illustrated by the lack of any reference to (or the inclusion of an appendix or similar) to cover the attendance and involvement of Tony Webster's expert opinion on transport from the DTI Radioactive Materials Transport Division on 28 July 2004.

⁵⁰ *Changes in Staff Regulatory Oversight of Decommissioning Commercial Nuclear Power Reactor Plants*, Policy Issue Information SECY-02-198, November 2002

⁵¹ One option is to utilise the existing plant operations team both to manage, and to a certain degree, to carry out the decommissioning. This has the advantage that the human resource is already there, and is familiar with the plant. The disadvantage is that operations staff have no decommissioning experience, and retain an 'operations' mentality towards discharging the work. However, there is evidence to suggest that co-operation between the utility (with its site and regulatory experience and vested interest in discharging the liability) and decommissioning experts with clear prior experience of organising and discharging decommissioning projects is the most effective combination.

⁵² <http://www.hic.co.uk/Default.aspx?LocID=0fnewk8b.RefLocID=0fihiesv5007lat.Lang=EN.htm>

Availability of Off-Site Waste Routes: SAPWG correctly identifies that there is presently no off-site route for intermediate-level wastes, particularly for the prompt decommissioning scenario (1), and that the existing Drigg facility for low-level wastes may not have sufficient capacity when the all of the Magnox stations enter decommissioning.

In dealing with this, SAPWG identifies the option of retaining all of the wastes on site to enable prompt decommissioning (1) to proceed but it chooses not to submit this to the SAP process, instead leaving it to the outcome of the Committee on Radioactive Waste Management (CoRWM). For SAPWG to defer to some future CoRWM outcome is an odd decision because, first, it is such a core aspect of any decommissioning strategy that cannot be set aside and, surely, the SAP process aims at tackling such uncertainties.

Stakeholder Support/Opposition: Here, SAPWG opines that the SAP process has been the salvation of the impasse that the Timescales Group of the Magnox Dialogue found itself in, although it does so a little more reservedly with “*. . . because of the complexity of the issues and variability of viewpoints, it did not prove possible in the first phase of the Dialogue to reach consensus on a preferred decommissioning strategy . . . this approach has enabled progress to be made and learning to be achieved*”.

Funding Availability: SAPWG identifies funding availability to be the most significant *uncertainty* impacting upon the choice of decommissioning scenario and that restraints on funding availability should not foreclose any of the potential decommissioning options. However, funding is not examined as a *generic issue* in the SAP process and it arises as various *uncertainties* dispersed across each of the three *strategies*.

This is a disappointing analysis of the funding situation in the UK, albeit with its present institutional doubts. Since funding is identified as a very dominant *uncertainty* it may have been preferable to have explored it (although it was not) as a *generic issue* in the SAP process.

Also, SAPWG could have examined overseas decommissioning funding^{53,54} to identify pitfalls and uncertainties experienced in countries more advanced in their decommissioning schemes.⁵⁵

⁵³ NRC's *Assurances of Decommissioning Funding During Utility Restructuring Could Be Improved*, US General Accounting Office, Report to the Honorable Edward J Markey, House of Representatives, December 2001

⁵⁴ i) *The Decommissioning and Dismantling of Nuclear Facilities: Status, Approaches, Challenges*, OECD/NEA 2002, ii) *The Decommissioning and Dismantling of Nuclear Facilities in OECD/NEA Member Countries – Fact Sheets* OECD/NEA 2002

⁵⁵ Several studies have been made about the costs of decommissioning: The US NRC and the Nuclear Energy Agency (NEA) made estimates of decommissioning costs (1993) which were 10 to 15 percent of original construction costs, although it has been subsequently shown that these costs have the tendency to rise strongly. Data of nuclear facilities which are closed and have been or are being decommissioned, show much higher real decommissioning costs than estimated before.

Like the UK, French policy is to spread decommissioning over 50 years or more primarily based on the accrued savings arising from discounting. The UK nuclear utilities also assume that decommissioning would become cheaper in the future as robot and decontamination technologies are being developed, although the UKAEA recently (2004) stated that robotic availability and costs may have now optimised.

The US tends towards immediate decommissioning with, for example, decommissioning of the Yankee Rowe nuclear power plant, closed in 1997, effectively commenced in earnest in 1998 and is planned to be completed in 10 years into greenfield condition by 2006. Decommissioning costs were first estimated at US\$368 million, but inside two months cost estimates went up to US\$508 million due to increased spent fuel storage costs. At this time the US Department of Energy has yet to remove

A cursory comparison of decommissioning costs experienced so far, even in account of the difficulties of making such comparison, suggest that Magnox Electric's projected decommissioning costs at US\$ 1,250M (£700M) per station (2001 values) for its physically large and radioactive waste voluminous twin reactor plants might well be somewhat conservative, particularly since it excludes waste management costs.⁵⁶

In terms of decommissioning costs per MW_e installed, the OECD⁵⁷ identifies that in spite of cost variability, costs (2003 values) of decommissioning to be below US\$ 0.5M per MW for nearly all water reactors but are significantly higher for gas-cooled reactors (ie Magnox) at around US\$ 2.5M per MW, with the major components for gas-cooled plants of cost being dismantling and waste treatment and disposal, each accounting for around 25% and 45% of the total costs respectively.

Applying the OECD estimates to some sample Magnox Electric plant yields a range from Bradwell (2 x 173MW) US\$ 865M to Sizewell A (2 x 325MW) US\$ 1,625M or to Wylfa (2 x 655MW) US\$3,275 if the concrete pressure vessel reactors are included. Or, if the average station size of 530MW is taken then the OECD estimated decommissioning costs per station would be, on average, US\$ 1,325M.⁵⁸

the irradiated (spent) fuel from the site - which is now projected to remain on site until 2010 – all of which is subject to legal proceedings with a claim of US\$191M against the DOE by the operator.

For example, real decommissioning costs of the 1150-MW US Seabrook NPP are estimated at US\$324 million (in 1991 US\$), but nominal costs when dismantlement begins in 2026 are estimated at US\$1,600 million (in 2026 US\$). Generally spoken, decommissioning of smaller nuclear reactors is more expensive than of larger ones, if expressed in dollars per MW. Many uncertainties exist and will remain for some decades, because no large reactors with normal operating lives (20-30 years) have been dismantled yet.

Of the smaller commercial power plants, the US Shippingport 72-MW, PWR, operated from 1957 to 1982, was partially dismantled from 1985 to 1989 at a cost of US\$91.3 million, although only the nuclear parts were dismantled. Niederaichbach, Germany, 100-MW, heavy water Reactor, operated only 18 days during period the 1972-1974. From 1987 to 1995 it was decommissioned to stage four, at a cost of US\$191M (DM280M). Japan Power Demonstration Reactor (JPDR), Japan, 45-MW, BWR, operated from 1963-1976 from 1986 to 1993, it was dismantled to stage three at a cost of US\$143M. Superphenix, France, 1240-MW, fast breeder reactor, operated from 1986-1997 with present estimates of decommissioning costs are US\$5,000M, and Tokai-1 in Japan is reckoned to cost in 2003 terms 2,327M US\$. Cost estimates made in 1993 by the US NRC for decommissioning of nuclear power stations are about US\$300,000 per MW (or US\$300M for a 1,000-MW nuclear reactor) which is much lower than the costs of the examples given above, varying between US\$1.210 million to US\$4.032M per MW.

Decommissioning costs expressed per MW installed capacity are as follows:

Plant Size MW _e type	Tokai-1 Magnox - 166 1 reactor	Neideraich 100 HWR	JPDR 45 BWR	SuperPhenix 1,240 FBR	Shippingport 72 PWR	NRC 1000
US\$/MW _e date ⁵⁵	11.6 - 2003	1.91 - 1995	3.18 - 1993	4.032 - 1998	1.267 - 1989	0.3 - 1993
Comments	Prompt Scenario	Operated only 18 days, totally dismantled	Dismantled to Stage 3	Estimated for total dismantlement	5 years - nuclear circuit only	Generic Model (PWR/BWR)

⁵⁶ TWG Working Document T25, 16 May 2001 – the decommissioning costs of £700M per station given in this paper exclude treatment, storage etc., of operational wastes, longer term management of contaminated ground, disposal of intermediate wastes and on site storage of intermediate wastes if no disposal route is available. Also, note that the installed MW capacity of the individual Magnox stations ranges from 60MW for each of the 4 reactors at Chapelcross to 655MW for each of the 2 reactors at Wylfa.

⁵⁷ *Decommissioning Nuclear Power Plants: Policies, Strategies and Costs*, Nuclear Energy Agency, OECD 2003

⁵⁸ This close match of the average OECD and Magnox Electric decommissioning costs may not be that surprising since Magnox Electric (Messrs Holt and Woollam) were amongst the UK respondents to the OECD's questionnaire and, of course, the UK Magnox and AGR installed units are the largest group of graphite moderated reactors globally and thus expected to dominate any data for this type of reactor.

As well as Funding Availability, SAPWG might have given greater and detailed consideration to Magnox Electric's projected decommissioning costs, particularly examining which of the element making up of these costs could vary in light of *uncertainties* over any deferral period and the availability of a final radioactive waste management route.

RESPONSE TO REQUEST FOR EXPERT REVIEW OF SAPWG REPORT

My instructions required me to give regard to issues identified by a number of participants of the Dialogue requesting this expert review of the SAPWG report.⁵⁹ These are set down in Appendix I.

OBSERVATIONS AND CONCLUSIONS

For brevity I shall limit my overall observations to two major areas of the SAPWG work, these being i) the depth and reliability of the understanding of technical and logistical (and, perhaps, the economics and financing) aspects of decommissioning, and ii) the way in which these aspects are presented in the SAPWG report.

- i) **Depth of Analysis:** I find the depth of analysis for many of the *issues* identified to be somewhat shallow and poorly researched, and I consider there to be a number of key *issues* that SAPWG has failed to identify.

This might be improved in the final SAPWG report by including a full reference citation, particularly, by laying out and explaining the *assumptions* at the front end of the SAP process and, if at all possible, by somehow indicating which, if any, of the *uncertainties* derives from lack of knowledge by SAPWG (or individuals within it) or in that the technology, financing, legislation or whatever, has yet to be developed, confirmed or enacted to enable a particular SAP *issue* to be resolved.

- ii) **Presentation:** SAPWG presents its findings via the Section 5 tables, noting "*that these should be studied to aid understanding . . . to advise decision makers, decommissioning planners and others on what decisions, actions, explorations, etc. could be taken to progress the subject*".

However, there are 39 pages of tables containing more or less 150 separate strings of *actions* and *explorations*, with each of these strings being generated by a sub-issue or *uncertainty* stemming from a *generic issue* that is linked to one of three decommissioning *strategies*. The strings themselves are not interrelated, correlated or weighted in importance or preference, the *generic issues* do not cover all areas of government policy and the prerequisites of the regulatory framework, and the three BNFL-defined decommissioning *strategies* have been adopted without further examination.

The tabulated presentation that SAPWG asks the reader to study and understand is a mind boggling array of sometimes disparate and subjective information and opinion. Whereas members of the SAPWG may have learnt a great deal about decommissioning strategies via this process, in the absence an inordinate amount time being spent of picking through the SAPWG report and its tables, I doubt this to

⁵⁹ Magnox Decommissioning Dialogue: Expert Review of the Strategic Action Planning Working Group's (SAPWG) Draft Report, undated (c14-10-2004), The Environment Council.

be a particularly effective way of forwarding SAPWG's observations and findings on multi-disciplined and complex matter of decommissioning the Magnox nuclear power stations.

In conclusion: SAPWG set itself the task of identifying the short-term actions/decisions needed to keep the *strategy* open through the intermediate and longer terms, and then to set the timeframes during which these have to be taken to maintain a range of *futures* possible.

It has completed this although the actions and decisions included in the SAP tables lack clarity and resolution being insufficient, in my opinion, to be that much help to the decommissioning decision makers identified by SAPWG. On the decommissioning scenario options and timeframes, SAPWG concludes that all three scenarios are feasible without any preference so, in this important respect, the SAPWG report make no real contribution to moving forward the decommissioning debate.

A disappointing report that has got itself somewhat fuddled by being too absorbed in its own assessment technique (SAP), so much so that it has lost focus on the real issues of decommissioning the closed down Magnox nuclear power stations.

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APPENDIX I

QUESTIONS FOR THE TECHNICAL EXPERT

1) EXPERIENCE RELEVANT TO DETERMINING DECOMMISSIONING STRATEGY

The relevant feature about the UK programme of Magnox nuclear power stations is that these are graphite moderated, gas cooled reactors. Other than the UK advanced gas-cooled reactors (AGR) and the former-Soviet graphite-water moderated reactors (RBMK- Chernobyl type), most other graphite moderated reactors are relatively small research or development units (such as the US TRIGA and UK Harwell research reactors such as GLEEP), military plutonium production reactors (such as the defunct N° 1 and 2 atomic piles at Windscale, at Los Alamos and at Beloyarsk in Russia) and prototype demonstration reactors, notably the 33MW_e Windscale Advanced Gas-Cooled Reactor (WAGR) which closed down in 1981 with complete dismantling of the concrete bioshield scheduled for 2040.⁶⁰

Experience of physical dismantling of the (radio)activated circuits and components of commercially-sized reactors of this type is very limited. The Magnox-Electric units at Berkeley are the most advanced example, although at Berkeley the dismantling so far has not intruded into the primary reactor containment (reactor pressure vessel - RPV) to any substantive degree.

Essentially, the main decommissioning challenge presented by the Magnox reactors is the large size and volume of the activated components. Unlike a typical pressurised water reactor (PRW) where the RPV weighing 100 or so tonnes can be crane-hoisted as a single unit without intrusion into the activated volume of the reactor (such as at Shippingport),⁶¹ the Magnox reactor RPV is much larger with, for example, at Sizewell A each pressure vessel of the two reactors being ~20m in diameter of several thousand tonnes total weight,⁶² all of which has to be dismantled in situ.

Decommissioning strategy is determined from a composite of government policy, regulatory requirement and, to some extent, by public acceptability. Government policy centres around a best practical environmental option (BEPO) approach, although sustainability and justification.

The regulatory process in advance of decommissioning being given the go ahead is subject to quinquennial review. The last Health & Safety Executive assessment (2002) of Magnox-

⁶⁰ Best, T, *Decommissioning the Windscale AGR: the UK Demonstration Project for Power Reactor Decommissioning*, IBC Conf Decommissioning, London 2002

⁶¹ Shippingport, US, 72 MW, Pressurized Water Reactor, operated from 1957 to 1982. It was partially dismantled from 1985 to 1989 at a cost of US\$91.3M (US\$1.267M per MW). Only the nuclear parts were dismantled, not the conventional parts. Shippingport wastes were delivered to a federal waste facility, to Hanford and to Idaho by barge. The RPV, with a weight of 153 tonnes. At closure, the radioactivity of the Shippingport core was only 1,000Tbq, which had decayed to 600 TBq when dismantling began three years later. Shippingport was a commercial demonstration PWR at 72MW_e and present commercial units, such as Sizewell B in the UK is of ~1,300MW_e capacity with estimated radioactivity levels in a closed commercial nuclear reactor after 30 years of operation being at least 300 times larger than that at Shippingport.

⁶² Sizewell A, Suffolk, 290MW_e each of 2 reactors, commissioned 1966 and scheduled for closure in 2006. Each RPV is 20m diameter fabricated from ~100mm carbon steel plate, totalling about 1,500 tonnes of activated steel per reactor, enclosing ~2,250t of graphite moderator.

Electric's 2000 quinquennial review required the operator to review and justify why three decommissioning strategies had been rejected, and that it should subject its overall approach to decommissioning to wider stakeholder consultation.

2) **RELEVANT DECOMMISSIONING STUDIES & DOCUMENTS PRODUCED FOR THE DIALOGUE**

Refer to main text – a document that might have been made available to SAPWG would have been the Magnox-Electric MADA decommissioning study of c1998/9.

3) **RELATE THE REGULATORY GUIDANCE ON REACTOR DECOMMISSIONING**

Refer to main text.