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DIRECTORATE-GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT D
BUDGETARY AFFAIRS

Budgets

Budgetary Control

Nuclear decommissioning: Management of costs and risks

STUDY

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NUCLEAR DECOMMISSIONING:

MANAGEMENT OF COSTS AND RISKS

STUDY

Abstract

The decommissioning of the shutdown reactors in Bulgaria, Lithuania and Slovakia is financially supported by the European Commission. The Budgetary Control Committee of the European Parliament has commissioned Öko-Institute with a study that analyses the best practice of selected decommissioning projects and contrasts those with the management in the three eastern European cases.

The study identified best practices in the organization of the decommissioning projects in Germany and France. The comparison with the three eastern European countries identified several areas where the process organisation should be urgently improved and a clearer attribution of responsibilities is required.

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LIST OF ABBREVIATIONS

APEC	Atelier pour l'entreposage du combustible (Fuel handling and treatment facility of the reactor at Creys-Malville, France)
AREVA	French company selling nuclear reactors and providing nuclear services
ASN	Autorité de Sûreté Nucléaire (French nuclear regulating authority)
BIDSF	Bohunice/Slovakia International Decommissioning Support Fund
BMF	Federal Ministry of Finance (Bundesministerium der Finanzen, Germany)
BWR	Boiling water reactor (reactor type with steam generation within the reactor vessel and direct use of the generated steam in the turbines)
CEA	Commissariat à l'énergie atomique (French **R&D** organization operating research reactors)
CIDEN	Centre d'ingénierie de la déconstruction et de l'environnement (French decommissioning engineering center, subdivision of EDF)
CO_2	Carbon dioxide, gas, used as coolant in some gas cooled reactor types
D_2O	Heavy water, used as moderator/coolant in some reactor types
DM	Deutsche Mark (former German currency, roughly 0.5 €/DM)
DP RAO	Радиоактивни отпадъци (state-owned Bulgarian Nuclear Waste Management organization in charge of decommissioning, english synonym: **SE RAW**)
DRC	Direction des déchets, des installations de recherche et du cycle (Waste Research and Fuel Cycle Facilities Department, subdivision of **ASN**)
DGSNR	Direction Générale de la Sûreté Nucléaire et de la Radioprotection (former French safety authority)
DSR	Direction de la Sûreté des Reacteur (French regulator, subdivision of **IRSN**)
EBRD	European Bank for Reconstruction and Development
EDF	Electricité de France (majorly state-owned operator of nuclear reactors in France)
E.ON	German electricity producer and operator of several nuclear power plants
EC	European Commission
EU	European Union
EWN	Energiewerke Nord GmbH (Federally owned organization for the decommissioning of six reactors of soviet design in Greifswald and Rheinsberg, Germany)
FBR	Fast breeder reactor type, un-moderated and liquid sodium cooled reactor
FDP	Final Decommissioning Plan (overall description of the decommissioning of the facility, includes all technical steps, description depth and further details subject to the tasks it is prepared for)
G7	Group consisting of the finance ministers of the U.S., the U.K., France, Germany, Italy, Canada and Japan (the wealthiest seven countries)

GCR Gas cooled reactor (reactor type with gaseous cooling agents such as **CO2** or **He**) and a graphite moderator

GDR German Democratic Republic (former East German state, operated six nuclear reactors)

GovCo Previous name of JAVYS (Jadrová a vyraďovacia spoločnosť), GovCo a.s. was changed by the Ministry of Economy of the Slovak Republic in 2006

GW(el) Billion Watt electric power

HCTISN Haut Comité pour la Transparence et l'Information sur le Sécurité Nucléaire (French Commission for nuclear safety communication)

He Helium, noble gas used as coolant in some gas cooled reactor types

HLW High level radioactive waste, waste with high or very high concentrations of radionuclides, mainly spent nuclear fuel, vitrified liquids and cutted cladding from the reprocessing of spent fuel, requires active or passive heat removal during storage and handling as well as extensive shielding during handling

HTGR High temperature gas cooled reactor, helium cooled reactor with graphite moderator around fuel pebbles

HWGR Heavy water gas cooled reactor, reactor type

HWR Heavy Water Reactor (reactor type moderated with deuterium oxide **D2O** instead of normal water)

ICEDA Installation de Conditionnement et d'Entreposage de Déchets Activés (waste treatment and conditioning facility at Bugey nuclear power plant, France)

IDSF International Decommissioning Support Fund (Superordinate term for international support for decommissioning projects; includes **BIDSF**, **IIDSF** and **KIDSF**)

IIDSF Ignalina/Lithuania International Decommissioning Support Fund

INPP Ignalina Nuclear Power Plant (State-owned operating company of two nuclear power plants of the 1,500 MWel **RBMK** type near Visaginas/Lithuania)

IRSN Institut de Radioprotection et de Sûreté Nucléaire (French nuclear research and nuclear expert organization)

JAVYS Jadrová a vyraďovacia spoločnosť, a.s., state-owned organization for decommissioning of nuclear reactors in Slovakia

KGR Kernkraftwerk Greifswald (five nuclear reactor units owned and decommissioned by **EWN** in the State of Mecklenburg-Vorpommern)

KIDSF Kozloduy/Bulgaria International Decommissioning Support Fund

KKR Kernkraftwerk Rheinsberg (nuclear reactor owned and decommissioned by **EWN** in the State of Brandenburg, NE Germany)

LLW Low level radioactive waste (waste with low radioactivity content not requiring active heat removal and extended shielding when handled)

LWGR Light water graphite reactor type, moderator is graphite, coolant is water, russian design: **RBMK**

MEE Ministry of Economy and Energy (Bulgarian Ministry in charge to control the organization **DP RAO**/**SE RAW** responsible for decommissioning)

MLW Medium level radioactive waste, waste with higher concentrations of radionuclides, does not require active heat removal, but requires shielding when handled

NDA Nuclear Decommissioning Agency (state owned company to control decommissioning of reactors in the **UK**)

NMP Nuclear Management Partners (Consortium selected as consultant to decommission the Sellafield nuclear complex in the **UK**)

NNF National Nuclear Fund for Decommissioning of Nuclear Facilities and Management of Spent Nuclear Fuel and Radioactive Waste, Slovak Republic

NPP Nuclear power plant

NRA SR License application for Decommissioning of Bohunice **NPP**

PHWR Pressurized heavy water reactor type, moderated and cooled with heavy water under pressure

PMIS Project Management Information System (versatile IT tool to collect, store, arrange and display data and information in a project-related work environment)

PMU Project Management Unit, external or internal division to prepare, oversee, control and update sub-projects for decommissioning

PWR Pressurized water reactor (reactor type with cooling water under high pressure, steam generation in a secondary circuit)

RBMK Реактор Большой Мощности Канальный, Reaktor Bolshoy Moshchnosti Kanalniy (High Power Channel-type nuclear Reactor of soviet/Russian design)

R&D Research and Development (namely nuclear reactor research)

RMS Risk Management System (a series of arrangements to detect, analyse, evaluate and limit risks of different kinds)

RWE Rheinisch-Westfälisches Elektrizitätswerk AG (German electricity producer and operator of nuclear power plants)

SE Slovenské elektrárne Company, originally responsible state enterprise company for the operation of Jaslovské Bohunice in Slovakia

SENA Societé d'Énergie Nucléaire Franco-Belge des Ardennes (former French-Belgian company operating nuclear reactors)

SE RAW State Enterprise for Radioactive Waste (Bulgarian company in charge of decommissioning, Bulgarian synonym **DP RAO**)

SGHWR Steam generating heavy water reactor type, moderator and coolant is heavy water

SR Slovak Republic

UJD SR Úrad jadrového dozoru Slovenskej republiky (Nuclear Regulatory Authority of the Slovak Republic)

UK United Kingdom

VAK Versuchsatomkraftwerk Kahl (first power reactor in Germany, finally decommissioned to Greenfield status)

VATESI Valstybinė atominės energetikos saugos inspekcija (Lithuanian State Nuclear Power Industry Safety Inspectorate)

VVER Водо-водяной энергетический реактор, Vodo-Vodyanoi Energetichesky Reactor (**PWR** of soviet/russian design)

WWER Pressurized Water Reactor of soviet/russian design, also see **VVER**

ZLN Zwischenlager Nord (Decommissioning waste treatment and interim storage facility for spent fuel, LLW- and **MLW**-wastes and large components at Greifswald/Germany)

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EXECUTIVE SUMMARY

Background

During the process of accession to the European Union, Bulgaria, Lithuania and Slovakia committed to shut down several older reactors. As an act of solidarity the EU and a number of donor countries committed their assistance to cover parts of the necessary decommissioning costs, for which previously none or only insufficient funds had been collected and were not available when needed.

In 2011, several years after the shutdown of the reactors, during which predominantly the EU had provided considerable support, the European Court of Auditors assessed the effectiveness of the financed activities and identified several serious deficiencies.

Following the report, the Budgetary Control Committee of the European Parliament, which examines implementation of the EU budget, decided to assign Öko-Institute with an independent assessment of the decommissioning process. The tasks of the assessment were to identify best practices in decommissioning nuclear reactors in Europe, to compare these with the practices in the three (former accession) countries and to derive recommendations from this comparison.

Aim

The investigation to identify best practices in Europe was structured as follows:

1. An Europe-wide inventory identified 88 reactors in a shutdown and decommissioning state. They cover a large variety of reactor types, ages, operating years and power outputs.
2. Three countries - France, Germany and the UK – dominate the overall decommissioning projects by number, types and operational age, so that the identification of best practices is focused on these three countries.
3. From these countries, the examples of EDF in France, Sellafield Ltd. in the UK and EWN in Germany were selected for a more detailed analysis, because these were promising to yield representative state-of-the-art approaches for identification of best practices.

The investigation of the three selected examples concentrated on the following questions:

- How is the organisation that manages the decommissioning constituted?
- How closely and effectively is the control over the organisation that manages the decommissioning designed and applied?
- How is project and risk management practiced in the managing organisation?
- How, and with which experiences, are the regulatory bodies approached by the managing organizations?
- How, and with which results, are cost estimates for decommissioning performed?
- How is the decommissioning knowledge and experience of the existing workforce at the sites used and which measures are taken to transfer as much experience as possible to the decommissioning phase?

Best practices identified

From the investigation of the three examples in respect to these questions it was concluded that

- The examples of EDF in France and EWN in Germany provide promising and successful elements for the identification of good practices in decommissioning, while the UK example provides less merits,
- The example of EWN shows that the establishment of a tight and strict control institution overseeing all strategic decisions of the management is advantageous and highly recommendable,
- The organisation to manage decommissioning has completely new tasks and requires different decision and work structures than energy production,
- Such a radical change in organisation needs to consider and utilize the existing experiences and knowledge to foster a state-of-the-art or good practice solution,
- Project and risk management have to be consequently developed and implemented consistently as new work forms to cope with the specific needs of a decommissioning project,
- Cost estimates are only reliable if they are based on a complete, well-planned and regularly updated calculation scheme and if escalation as well as risks are carefully considered,
- The workforce has to be completely re-organized and adapted to project and risk management approaches, and extensive training is necessary to perform the new tasks effectively.

The same criteria were applied to the three decommissioning projects in Bulgaria, Lithuania and Slovakia. In a first step, the practice and approaches in these countries were analysed by use of available sources, by interviews with responsible persons, visits to the plants and/or by numerous talks with currently or formerly responsible individuals.

In a second step the identified practices and approaches were compared with the identified best practices at EDF and EWN.

Results

The national practices in the three recipient countries and the identified best practices were evaluated on a scale from 0 (aspect not addressed at all) to 5 (aspect addressed ideally) for each country and for the different relevant aspects. This evaluation, the degree of difference and the urgency of improvements are described in country profiles and in a table summarizing the evaluation.

The largest differences between the situation in Bulgaria, Lithuania and Slovakia and the identified best practice were found for the constitution of the national managing organisations and for their control. The situation in general, and with a focus on specific items, shows that responsibilities fall to several institutions in an untransparent way, there is no clarity about ultimate decision-making. It is unclear who is finally responsible for which decisions and who is effectively in charge of controlling decisions. With these diluted and dispersed responsibilities it is to be expected that the decommissioning projects will not be performed in time and within the given budget constraints because neither the managing organisation nor the controlling institutions nor the fund contributors consider themselves responsible for decision-making and cost-efficient implementation.

Thus it was concluded that it is essential and urgent to change and improve the managing and control structures in order to achieve an effective and transparent project organization. Proposals for new management and control structures have been developed, defining the roles and responsibilities of the EU, national organizations, Project Management Units and European Bank for Reconstruction and Development. The support should be organized as co-financed and co-directed projects to achieve an effective management of the decommissioning projects and to improve the self-responsibility of the affected countries.

Recommendations

For all the aspects listed above, recommendations were made which:

- Have the potential to improve the current decommissioning projects,
- Are applicable under the current circumstances, and
- Would redirect the projects closer to the identified best practices.

A total of eight recommendations were derived to improve the decommissioning projects in Bulgaria, Lithuania and Slovakia:

- Recommendation 1: Improving national control conditions

  The introduction of EU/member state shared projects and a joint steering of the strategic decisions of the organisation that is responsible for implementing decommissioning is recommended in order to strengthen the role of the national controlling administrator and to increase the cost effectiveness.

- Recommendation 2: Towards co-shared financing

  The EU support of the decommissioning should be re-organized as co-sharing projects. Co-sharing of the costs would increase the country's interest in con-trolling the managing organisation's strategic decisions towards increased cost effectiveness. In the co-financed and co-directed projects both institutions financing the activity should equally control their effectiveness. The share should be defined with a fixed level, but allowing to reduce the EC's contribution in case of projects that are only in part related to decommissioning. The fixed level should be depending from the country's abilities, but shall not be below certain thresholds to achieve the desired goal.

- Recommendation 3: Improving responsibility of the managing organisation

  A clearer attribution of responsibilities in respect to strategic decisions is recommended. In accordance with this proposed re-organisation and under consideration of the specific conditions in this case (e.g. co-financing, shared control) a possible advanced structure of the management organisation in accordance with the identified best practice is recommended.

- Recommendation 4: Improving project and risk management

  A complete and adequate project and risk management, including the respective task-tailored IT tools (PMIS), for the decommissioning project has to be considered a state-of-the-art requirement. Improving, completing and fully implementing project and risk management should be given the highest priority. Management should set up respective work methods and tools, the controlling institutions should supervise their design and timely implementation in the managing process.

- Recommendation 5: Continuation of the good practice in licensing

  Licensing issues should be carefully considered within the risk assessment and should not be underestimated, because failures and delays in this field can have major consequences for the decommissioning process. The good practice identified so far should be continued and upgraded to match to the upcoming more sensitive work steps.

- Recommendation 6: Improving cost estimates

  Cost estimates are based on state-of-the-art. To further increase their reliability and usefulness, cost escalation and risks should be included in future estimates.

- Recommendation 7: Improving effectiveness of the workforce

  The relevance of workforce issues, such as conversion management and training, is well recognized in all three countries. Explicit training, e.g. in the less technical and more soft skill areas of project management, risk communication and knowledge management is desirable.

- Recommendation 8: Achieving clear responsibility attributions

  In any future setting clear, unambiguous and transparent responsibilities have to be defined and implemented to avoid any dilution and dispersion of responsibilities over several institutions and to avoid unclear and uncommunicated attributions.

  The national supervising institution and the EC should be jointly attributed the full responsibility for controlling the national managing organisation's strategic decisions. They should have the right and as well the obligation to completely oversee the whole performance of the decommissioning project and to steer and control the management.

  The managing organisation has to be attributed the sole, undivided and unambiguous responsibility to a) prepare the proposals and the complete background for the strategic decisions and b) for any operational decisions. This includes all overseeing, steering and supervision over organisation-internal as well as any external processes, including procurement, cost and time control.

  To control the due diligence of all financial transactions, the managing organisation should define, set up, implement and regularly audit an adequate internal control system. The national controlling institution or an equivalent (e.g. the Ministry for Finance) as well as the EC should have the right and the obligation to oversee and exemplarily check the adequacy of the management's measures to keep control over its financial transactions.

  If, in the case of Bulgaria and Slovakia, the interferences of the constitution of the managing organisation's with its non-decommissioning obligations is too complicated and may reduce the effectiveness of the management level's ability to act, an institutional separation of the decommissioning project part should be considered.

ZUSAMMENFASSUNG

Hintergrund

Während des EU-Beitrittsprozesses haben sich Bulgarien, Litauen und die Slowakei verpflichtet, einige ältere Reaktoren abzuschalten. Als Akt der Solidarität verpflichtete sich die EU sowie eine Reihe von Geberländern Teile der notwendigen Stilllegungskosten zu decken, für die zuvor keine oder lediglich unzureichende Mittel gesammelt worden waren und die zu dem Zeitpunkt, als sie benötigt wurden, nicht zur Verfügung standen.

Im Jahre 2011, einige Jahre nach der Abschaltung der Reaktoren, für die vor allem die EU beträchtliche Hilfen gewährt hatte, hat der Europäische Rechnungshof die Effizienz der finanzierten Aktivitäten bewertet und verschiedene ernsthafte Defizite festgestellt.

Im Anschluss an diesen Bericht hat der für die Prüfung des Vollzugs des EU-Haushalts zuständige Haushaltskontrollausschuss des Europäischen Parlaments beschlossen, das Öko-Institut mit einer unabhängigen Bewertung des Stilllegungsprozesses zu beauftragen. Die Aufgabe der Bewertung bestand darin, bewährte Verfahren bei der Stilllegung von Atomreaktoren in Europa zu ermitteln, diese mit den Verfahren in den drei betroffenen Ländern (ehemalige Beitrittskandidaten) zu vergleichen und aus diesem Vergleich Empfehlungen abzuleiten.

Ziel

Die Untersuchung zur Ermittlung bewährter Verfahren in Europa war folgendermaßen strukturiert:

1. Eine europaweite Bestandsaufnahme ermittelte 88 Reaktoren die abgeschaltet sind oder sich im Stilllegungsprozess befinden. Diese Reaktoren weisen sehr unterschiedliche Merkmale hinsichtlich Typ, Alter, Betriebsjahre und Leistung auf.
2. Drei Länder – Frankreich, Deutschland und Großbritannien – sind im Bereich der Stilllegungsprojekte vorherrschend und zwar in Bezug auf Anzahl, Typen und Betriebsalter, sodass sich die Ermittlung bewährter Praktiken auf diese drei Länder konzentrierte.
3. Aus diesen Ländern wurden EDF in Frankreich, Sellafield Ltd. in Großbritannien und EWN in Deutschland für eine detailliertere Analyse ausgewählt, weil man hoffte, dass diese Anlagen repräsentative, dem Stand der Technik entsprechende Ansätze zur Ermittlung bewährter Praktiken liefern würden.

Die Untersuchung der drei ausgewählten Beispiele konzentrierte sich auf die folgenden Fragen:

- Wie ist die für die Stilllegung zuständige Organisation konstituiert?
- Wie streng und effizient ist die Kontrolle der für die Stilllegung zuständigen Organisation? Wie gestalten sich Projekt- und Risikomanagement innerhalb der zuständigen Organisation?
- Wie und mit welchen Erfahrungen wenden sich die zuständigen Organisationen an die Behörden?
- Wie und mit welchen Ergebnissen werden die Kostenschätzungen für die Stilllegung durchgeführt?
- Wie werden die Kenntnisse und die Erfahrungen der bestehenden Belegschaft der jeweiligen Standorte genutzt und welche Maßnahmen werden ergriffen, um so viel Erfahrung wie möglich auf die Stilllegungsphase zu übertragen?

Die ermittelten bewährten Verfahren

Aus der Untersuchung der drei Beispiele wurden in Bezug auf diese Fragen die folgenden Schlüsse gezogen:

- Die Beispiele von EDF in Frankreich sowie ENW in Deutschland bieten vielversprechende und erfolgreiche Elemente für die Ermittlung bewährter Stilllegungsverfahren, während das britische Beispiel weniger ergiebig ist.
- Anhand des Beispiels von EWN wird deutlich, dass die Errichtung einer engmaschigen und strengen Kontrolleinrichtung, die alle strategischen Entscheidungen des Managements überwacht, vorteilhaft und sehr empfehlenswert ist.
- Die für die Stilllegung zuständige Organisation hat völlig neue Aufgaben und braucht andere Entscheidungs- und Arbeitsstrukturen als die Energieerzeugung.
- Eine solche radikale Änderung der Organisation verlangt die Berücksichtigung und Nutzung der vorhandenen Erfahrungen und Kenntnisse, um eine Lösung zu erzielen, die dem Stand der Technik oder bewährten Verfahren entspricht.
- Projekt- und Risikomanagement müssen einheitlich entwickelt und als neue Arbeitsformen umgesetzt werden, um den spezifischen Anforderungen eines Stilllegungsprojekts zu genügen.
- Kostenschätzungen sind nur dann verlässlich, wenn sie auf einem vollständigen, durchdachten und regelmäßig aktualisierten Kalkulationsschema beruhen, und wenn sowohl Kostensteigerungen als auch -risiken sorgfältig in Betracht gezogen werden.
- Die Belegschaft muss vollkommen umorganisiert und an die Projekt- und Risikomanagementkonzepte angepasst werden und für die effiziente Durchführung der neuen Aufgaben sind umfassende Schulungen erforderlich.

Dieselben Kriterien wurden auf die drei Stilllegungsprojekte in Bulgarien, Litauen und der Slowakei angewandt. In einem ersten Schritt wurden die Verfahren und Konzepte in diesen Ländern mit Hilfe verfügbarer Informationsquellen, von Interviews mit den Verantwortlichen, Besichtigungen der Anlagen und/oder zahlreicher Gespräche mit aktuellen oder früheren Verantwortlichen analysiert.

Danach wurden die ermittelten Praktiken und Konzepte mit den bewährten Verfahren bei EDF und EWN verglichen.

Ergebnisse

Die nationalen Verfahren in den drei Empfängerländern und die ermittelten bewährten Verfahren wurden für jedes Land und für die verschiedenen relevanten Aspekte auf einer Skala von 0 (Aspekt überhaupt nicht gelöst) bis 5 (Aspekt in idealer Weise gelöst) bewertet. Diese Bewertung, das Ausmaß der Abweichung und die Dringlichkeit von Verbesserungen werden in den Länderprofilen und in einer die Bewertung zusammenfassenden Tabelle beschrieben.

Die größten Unterschiede zwischen der Situation in Bulgarien, Litauen und der Slowakei und den ermittelten bewährten Verfahren wurden in Bezug auf die Konstituierung der nationalen zuständigen Organisation sowie deren Kontrolle festgestellt. Die Situation im Allgemeinen und mit Schwerpunkt auf bestimmte Punkte zeigt, dass Zuständigkeiten in intransparenter Weise über mehrere Institutionen verteilt sind, sodass keine Klarheit darüber besteht, wer letztendlich für welche

Entscheidungen zuständig ist und wer sie tatsächlich kontrolliert. Diese unklaren und verstreuten Zuständigkeiten lassen nicht erwarten, dass die Stilllegungsprojekte fristgerecht und innerhalb des begrenzten Haushaltsrahmens bewerkstelligt werden, da sich für das Treffen von Entscheidungen und die kosteneffiziente Umsetzung derselben weder die zuständige Organisation noch die Aufsichtsorgane noch die Beitragszahler verantwortlich fühlen.

Daraus wurde geschlossen, dass die Durchführungs- und Aufsichtsstrukturen zwingend und dringend geändert werden müssen, um eine effiziente und transparente Projektorganisation zu erzielen. Es wurden Vorschläge für neue Management- und Kontrollstrukturen entwickelt, in denen die Rollen und Zuständigkeiten der EU, der nationalen Organisationen, der Projektmanagementeinheiten sowie der Europäischen Bank für Wiederaufbau und Entwicklung festgelegt wurden. Die Unterstützung sollte in Form kofinanzierter und gemeinsam gesteuerter Projekte organisiert werden, um ein effizientes Management der Stilllegungsprojekte zu erzielen und die Eigenverantwortung der betreffenden Länder zu verbessern.

Empfehlungen

Für alle oben genannten Aspekte wurden Empfehlungen ausgesprochen, die

- die laufenden Stilllegungsprojekte potentiell verbessern könnten,
- unter den gegenwärtigen Bedingungen anwendbar sind und
- die Projekte näher an die ermittelten bewährten Verfahren heranführen würden.

Insgesamt wurden acht Empfehlungen zur Optimierung der Stilllegungsprojekte in Bulgarien, Litauen und der Slowakei abgeleitet:

- Empfehlung 1: Optimierung der nationalen Kontrollbedingungen

  Es wird die Einführung gemeinsamer Projekte der EU und des betreffenden Mitgliedstaates und eine gemeinsame Steuerung der strategischen Entscheidungen der für die Umsetzung der Stilllegung verantwortlichen Organisation empfohlen, um die Rolle der nationalen Kontrollverwaltung zu stärken und die Kosteneffizienz zu erhöhen.

- Empfehlung 2: Hinarbeiten auf eine Kofinanzierung

  Die EU-Unterstützung sollte im Sinne von Co-Sharing-Projekten umorganisiert werden. Die gemeinsame Aufteilung der Kosten würde das Interesse des betreffenden Landes an der Kontrolle der strategischen Entscheidungen der zuständigen Organisation zur Erhöhung der Kosteneffizienz steigern. Bei den kofinanzierten und gemeinsam gelenkten Projekten sollten beide finanzierenden Institutionen in gleicher Weise die Effizienz der Aktivität kontrollieren. Die Anteilshöhe sollte festgelegt sein, aber so, dass der Beitrag der Europäischen Gemeinschaft im Falle von Projekten, die nur teilweise mit der Stilllegung zu tun haben, gesenkt werden kann. Die festgelegte Höhe sollte von den Möglichkeiten des betreffenden Landes abhängen, sollte jedoch, um das gewünschte Ziel zu erreichen, eine bestimmte Grenze nicht unterschreiten.

- Empfehlung 3: Stärkung der Eigenverantwortung der zuständigen Organisation

  Es wird empfohlen, eine klarere Zuordnung der Zuständigkeiten bezüglich strategischer Entscheidungen anzustreben (siehe Kapitel 4.3.3). In Übereinstimmung mit der vorgeschlagenen Reorganisation und unter Berücksichtigung der spezifischen Bedingungen (d.h. Kofinanzierung, gemeinsame Kontrolle) wird eine mögliche weiterführende Struktur der zuständigen Organisation in Übereinstimmung mit den ermittelten bewährten Verfahren empfohlen.

- Empfehlung 4: Verbesserung des Kosten- und Risikomanagements

  Ein komplettes und adäquates Projekt- und Risikomanagement einschließlich der entsprechenden IT-Instrumente (Projektmanagement-Informationsysteme (PMIS)) für das Stilllegungsprojekt muss als eine technologische Anforderung betrachtet werden. Höchste Priorität sollten die Verbesserung, Vervollständigung und volle Umsetzung des Projekt- und Risikomanagements haben. Das Management sollte entsprechende Arbeitsmethoden und -instrumente entwickeln und die Kontrollinstitutionen sollten deren Konzept sowie fristgerechte Umsetzung im Managementprozess überwachen.

- Empfehlung 5: Fortsetzung der bewährten Verfahren bei Zulassungsfragen

  Zulassungsfragen sollten im Rahmen der Risikobewertung berücksichtigt und nicht unterschätzt werden, da Misserfolge und Verzögerungen auf diesem Gebiet große Auswirkungen auf den Stilllegungsprozess haben können. Die bisher ermittelten bewährten Verfahren sollten fortgesetzt und aktualisiert werden, um den anstehenden risikoreicheren Arbeitsschritten zu genügen.

- Empfehlung 6: Verbesserung der Kostenschätzungen

  Kostenschätzungen beruhen auf dem neuesten Stand der Technik. Um deren Verlässlichkeit und Nutzen weiter zu erhöhen, sollten künftige Schätzungen Kostensteigerungen und Kostenrisiken beinhalten.

- Empfehlung 7: Erhöhung der Mitarbeitereffizienz

  Die Bedeutung von Personalfragen wie z. B. Konversionsmanagement und Schulungen ist in allen drei Ländern bekannt. Zu empfehlen ist ein explizites Training z. B. in den weniger technischen Bereichen wie Soft Skills, Projektmanagement, Risikokommunikation sowie Wissensmanagement.

- Empfehlung 8: Erzielen einer eindeutigen Zuordnung der Zuständigkeiten

  In jeder künftigen Situation müssen klare, eindeutige und transparente Zuständigkeiten festgelegt und umgesetzt werden, um die Verwässerung und Zerstreuung von Zuständigkeiten über mehrere Institutionen und unklare sowie nicht kommunizierte Zuordnungen derselben zu vermeiden.

  Der nationalen Aufsichtsbehörde und der Europäischen Gemeinschaft sollte gemeinsam die volle Verantwortung für die Kontrolle der strategischen Entscheidungen der nationalen zuständigen Organisation zugeordnet werden. Sie sollten berechtigt sowie verpflichtet sein, die gesamte Ausführung des Stilllegungsprojekts zu beaufsichtigen und das Management zu lenken und zu kontrollieren.

  Der zuständigen Organisation muss die alleinige, ungeteilte und eindeutige Zuständigkeit a) für die Vorbereitung von Vorschlägen und des gesamten Hintergrunds für strategische

Entscheidungen und b) für alle operationellen Entscheidungen zukommen. Dies beinhaltet die Beaufsichtigung, Lenkung und Überwachung organisationsinterner und auch aller externen Prozesse einschließlich Beschaffungs-, Kosten- und Terminkontrolle.

Zur Kontrolle der sorgfältigen Prüfung aller finanziellen Transaktionen sollte die zuständige Organisation ein adäquates internes Kontrollsystem festlegen, einführen und regelmäßig auditieren. Die nationale Kontrollinstitution oder die entsprechende Einrichtung (z. B. das Finanzministerium) als auch die Europäische Gemeinschaft sollten berechtigt und verpflichtet sein, die Adäquatheit der Leitungsmaßnahmen zu beaufsichtigen und exemplarisch zu prüfen, um die Kontrolle über deren finanzielle Transaktionen zu behalten.

Sollten im Fall von Bulgarien oder der Slowakei die Überschneidungen der Konstitution der zuständigen Organisation mit deren Verpflichtungen außerhalb der Stilllegung zu kompliziert sein und die Effizienz der Handlungsfähigkeit der Führungsebene beeinträchtigen, sollte eine institutionelle Abtrennung des das Stilllegungsprojekt betreffenden Teils in Betracht gezogen werden.

SYNTHÈSE

Contexte

Au cours de leur processus d'adhésion à l'Union européenne, la Bulgarie, la Lituanie et la Slovaquie se sont engagées à mettre à l'arrêt des anciens réacteurs. Par solidarité, l'UE et plusieurs pays donateurs se sont engagés à apporter une aide pour couvrir une partie des coûts nécessaires à leur démantèlement pour lesquels aucun fonds ou des fonds de taille insuffisante n'avait été accumulé et n'étaient pas disponibles au moment requis.

En 2011, plusieurs années après la mise à l'arrêt des réacteurs – période pendant laquelle l'UE a été le principal soutien, la Cour des comptes européenne a évalué l'efficacité des activités financées et a mis en évidence plusieurs irrégularités majeures.

À la suite du rapport, la commission du contrôle budgétaire du Parlement européen, qui a pour mandat de superviser le budget de l'Union Européenne, a décidé de charger l'institut Öko de réaliser une évaluation indépendante du processus de démantèlement. Il s'agissait à ce titre de recenser les bonnes pratiques en matière de démantèlement des réacteurs nucléaires en Europe, de les comparer avec les pratiques des trois pays concernés (anciens candidats à l'adhésion), et de formuler des recommandations à partir de cette comparaison.

Objet

La méthodologie de recensement des bonnes pratiques en Europe a été structurée de la manière suivante:

1. Un inventaire à l'échelle de l'Europe a permis de recenser 88 réacteurs mis à l'arrêt et en cours de démantèlement. Ces réacteurs présentent des caractéristiques extrêmement variées (type de réacteur, âge, années d'exploitation et puissance).
2. Trois pays, à savoir la France, l'Allemagne et le Royaume-Uni, dominent le paysage en matière de projets de démantèlement par leur nombre, leur type et leur durée d'exploitation. Par conséquent, le recensement des bonnes pratiques s’est concentré sur ces trois pays.
3. Dans ces pays, les exemples d'EDF en France, de Sellafield Ltd. au Royaume-Uni, et d'EWN en Allemagne ont été retenus pour réaliser une analyse plus détaillée, en raison de leur intérêt potentiel pour l'élaboration d'approches représentatives pour le recensement des bonnes pratiques dans l'état actuel des connaissances.

L'examen des trois exemples sélectionnés s’est articulé autour des questions suivantes:

- De quelle manière l'organisation chargée de la gestion du démantèlement est-elle constituée?
- Le contrôle de l'organisation chargée de la gestion du démantèlement est-il étroit et effectif?
- Quelles sont les pratiques en matière de gestion de projet et des risques au sein de l'organisme qui dirige le démantèlement?
- De quelle manière les organismes responsables du démantèlement s'adressent-ils aux instances réglementaires, et quelles sont les expériences qui leur ont été soumises?
- Comment les estimations des coûts de démantèlement sont-elles réalisées et quels en sont les résultats?

- De quelle manière les connaissances et l'expérience de la main-d'œuvre existante sur les sites concernés sont-elles exploitées, et quelles mesures sont prises pour transférer la plus grande expérience possible dans la phase de démantèlement?

Bonnes pratiques recensées

Les conclusions suivantes ont été formulées à la suite de l'examen des trois exemples qui a été effectué à partir des questions précédentes:

- les exemples d'EDF en France et d'EWN en Allemagne ont apporté des éléments prometteurs et utiles pour recenser les bonnes pratiques de démantèlement alors que l'exemple britannique s'est révélé moins intéressant;
- en ce qui concerne EWN, la création d'une institution chargée d'opérer un contrôle étroit et rigoureux et de la supervision de l'intégralité des décisions stratégiques de la direction est avantageuse et particulièrement recommandable;
- l'organisme chargé de la gestion du démantèlement accomplit des missions entièrement nouvelles et a besoin de structures opérationnelles et de modes de décision différents de ceux qui sont associés à la production d'énergie;
- ce profond changement organisationnel nécessite un examen et l'exploitation des expériences et des connaissances existantes pour élaborer une solution basée sur l'état actuel des connaissances ou les bonnes pratiques;
- la gestion des projets et des risques doit être développée et mise en œuvre de façon homogène et les façons de travailler doivent prendre de nouvelles formes nécessaires pour répondre aux besoins propres des projets de démantèlement;
- les estimations de coût ne sont fiables que si elles ont été élaborées en appliquant un mode de calcul complet, bien planifié et régulièrement mis à jour et si la hausse des coûts et des risques sont soigneusement pris en considération;
- il est nécessaire de réorganiser et d'adapter entièrement la main-d'œuvre en fonction des approches de gestion des projets et des risques. Des formations approfondies sont nécessaires pour accomplir de manière efficace les nouvelles tâches.

Des critères identiques ont été appliqués aux trois projets de démantèlement en Bulgarie, en Lituanie et en Slovaquie. Dans un premier temps, les pratiques et les approches de ces pays ont été analysées à l'aide des sources disponibles, d'entretiens avec les responsables et de visites dans les centrales, et/ou grâce à de nombreuses discussions avec les anciens responsables ou les responsables actuels.

Dans un deuxième temps, les pratiques et les approches qui ont été recensées ont fait l'objet de comparaisons avec les bonnes pratiques recensées chez EDF et EWN.

Résultats

Les pratiques nationales dans les trois pays destinataires et les bonnes pratiques recensées ont été évaluées à l'aide d'une échelle graduée de 0 (aspect qui n'a absolument pas été traité) à 5 (aspect qui a été traité de manière idéale) pour chaque pays et les différents aspects concernés. Cette évaluation, le degré de différence, et le caractère urgent des améliorations sont décrits dans les profils de pays et dans un tableau récapitulatif de l'évaluation.

Les différences les plus importantes entre la situation en Bulgarie, en Lituanie et en Slovaquie et les bonnes pratiques recensées portent sur la constitution des organismes responsables au niveau national et sur leur contrôle. De manière générale et en ce qui concerne certains éléments particuliers, les responsabilités sont réparties entre plusieurs organismes de manière extrêmement large et non transparente, et il est difficile de déterminer qui est le responsable ultime des décisions et qui est réellement chargé du contrôle des décisions. À cause de cette fragmentation et de cette dispersion des responsabilités, on ne saurait attendre un achèvement des projets de démantèlement en temps utile, et dans le respect des limites budgétaires imposées, parce que ni les organismes qui gèrent le démantèlement, ni les organismes qui en assurent le contrôle, ni les donateurs ne se considèrent responsables des décisions et de la mise en œuvre rentable de tout ce processus.

En conclusion, il est urgent et impératif de changer et d'améliorer les structures de gestion et de contrôle pour mettre en place une organisation des projets transparente et efficace. Des propositions de nouvelles structures de gestion et de contrôle ont été élaborées pour définir les rôles et les responsabilités de l'UE, des organisations nationales, des unités de gestion de projet, et de la Banque européenne pour la reconstruction et le développement. Le soutien apporté devrait prendre la forme de projets cofinancés et codirigés, afin de parvenir à une gestion efficace des projets de démantèlement et d’obtenir un meilleur niveau de responsabilité des pays concernés.

Recommandations

Concernant l'ensemble des aspects évoqués ci-dessus, les recommandations qui ont été formulées

- peuvent contribuer à l'amélioration des projets de démantèlement en cours,
- sont applicables dans les conditions actuelles, et
- permettront de réorienter les projets pour qu'ils s'accordent mieux avec les bonnes pratiques recensées.

Au total, huit recommandations ont été formulées pour améliorer les projets de démantèlement en Bulgarie, en Lituanie et en Slovaquie:

- Recommandation n° 1: améliorer les conditions dans lesquelles les contrôles nationaux sont réalisés

  Il est recommandé de mettre en place des projets conjoints entre l'UE et les États membres et un système commun de suivi des décisions stratégiques de l'organisation qui est responsable de la mise en œuvre du démantèlement, afin de renforcer le rôle de l'instance de contrôle nationale et d’améliorer le rapport coût/efficacité.

- Recommandation n° 2: s’orienter vers le financement partagé

  Le soutien de l'UE au démantèlement des vieilles centrales nucléaires devrait être réorganisé sous la forme de projets partagés. Le partage des coûts permettrait d'accroître l'intérêt du pays concerné pour le contrôle des décisions stratégiques de l'organisme chargé du démantèlement, dans la perspective d’améliorer le rapport coût/efficacité. Dans des projets financés et dirigés de manière conjointe, les deux organismes qui financent l'activité devront contrôler leur efficacité autant l'un que l'autre. Le niveau de la contribution devrait être fixé, tout en autorisant la CE à réduire son apport pour les projets qui ne sont liés que partiellement au démantèlement. Ce niveau devrait dépendre des moyens du pays mais ne devrait pas être inférieur aux seuils qui permettront d'atteindre l'objectif souhaité.

- Recommandation n° 3: améliorer la responsabilité de l'organisme chargé du démantèlement

  Il est recommandé de prévoir les responsabilités de façon plus claire en ce qui concerne les décisions stratégiques (voir le chapitre 4.3.3). Conformément à cette proposition de réorganisation et compte tenu des conditions particulières prévues dans ce cas (par exemple, le cofinancement, le contrôle partagé), une mise à niveau de la structure de l'organisme chargé du démantèlement avec les bonnes pratiques définies est recommandée.

- Recommandation n° 4: améliorer la gestion des projets et la gestion des risques

  Une gestion des projets et des risques complète et adéquate prévoyant notamment les outils informatiques sur mesure (SIGP) nécessaires aux projets de démantèlement est une nécessité qui doit tenir compte de l'état actuel des connaissances.

  La plus haute priorité devra être donnée à l'amélioration, l'achèvement, et la mise en œuvre complète de la gestion des projets et des risques. Les gestionnaires des démantèlements devront mettre en place les outils et les méthodes de travail respectifs et les institutions de contrôle devront superviser leur conception et leur mise en œuvre en temps utile en cours de processus.

- Recommandation n° 5: poursuivre les bonnes pratiques en matière de licence

  Les problèmes de licence devront être dûment pris en considération dans le cadre de l'évaluation des risques et ne devront pas être sous-estimés, car les défaillances et les retards dans ce domaine peuvent avoir de sérieuses retombées sur le processus de démantèlement. Il faudra poursuivre et mettre à niveau les bonnes pratiques qui ont été recensées pour les adapter aux phases ultérieures, plus délicates.

- Recommandation n° 6: améliorer l'estimation des coûts

  L'estimation des coûts est effectuée selon l'état actuel des connaissances. Pour en améliorer la fiabilité et l'utilité, il est recommandé d'inclure la hausse des coûts et les risques s'y rapportant dans les futures estimations.

- Recommandation n° 7: améliorer l'efficacité de la main-d'œuvre

  La pertinence des questions de main-d'œuvre, telles que la formation et la gestion des reconversions, est bien reconnue dans les trois pays concernés. Il est recommandé de mettre en œuvre des formations explicites, par exemple dans les domaines moins techniques et plus généraux de la gestion des projets, de la communication des risques, et de la gestion des connaissances.

- Recommandation n° 8: définir clairement les responsabilités

  Dans toutes les situations qui se présenteront, il est impératif de définir et de respecter des responsabilités clairement tracées, sans équivoque, et transparentes, afin d'éviter leur fragmentation et leur dispersion entre divers organismes et d'éviter une imputation des responsabilités obscure et se faisant à huis clos.

  Il faudra attribuer à l'organisme chargé de la supervision au niveau national et à la CE la pleine responsabilité conjointe du contrôle des décisions stratégiques de l'organisme national chargé du démantèlement. Elles devront avoir le droit et l'obligation de superviser intégralement l'ensemble de la réalisation du projet de démantèlement et d'en orienter et d’en contrôler la gestion.

L'organisme chargé du démantèlement doit être détenteur des responsabilités suivantes de manière exclusive et explicite: a) préparation des propositions et du cadre complet des décisions stratégiques, et b) toute prise de décision opérationnelle. Cela inclut l'intégralité de la supervision, de la conduite et du contrôle des processus internes et externes de l'organisme, y compris le contrôle des achats, des coûts et des délais.

Pour contrôler la bonne exécution requise de l'ensemble des transactions financières, l'organisme responsable du démantèlement devrait définir, préparer et mettre en œuvre un système de contrôle interne et en effectuer un audit régulier. L'organisme chargé du contrôle au niveau national ou une instance équivalente (par exemple le ministère des finances) ainsi que la CE devraient avoir le droit et l'obligation de superviser et de contrôler de manière exemplaire le caractère adéquat des mesures de la direction, afin de garder le contrôle des transactions financières.

En ce qui concerne la Bulgarie et la Slovaquie, les interférences liées à la constitution de l'organisme de démantèlement avec ses obligations en matière de non-démantèlement entraînent trop de complications et risquent de diminuer l'efficacité de la capacité d'action de la direction, et il faudrait donc envisager une séparation institutionnelle de la partie associée au projet de démantèlement.

1. INTRODUCTION AND TASKS

As part of the process of their EU accession Bulgaria, Lithuania and Slovakia committed to shutdown some specific nuclear reactor units in their countries. The EU committed to support the accessing countries in resolving the burden and challenges of the shutdown of these reactor units, including support in restructuring the energy sectors concerned and in decommissioning and dismantling.

In order to make the support practicable three specific international decommissioning support funds (IDSF) were established, which are administered by the European Bank for Reconstruction and Development (EBRD). These IDSFs are replenished by contributions, the EU being the main donor.

Three decommissioning support funds were initiated and a considerable amount of donor money has been spent. The European Commission, as a major donor, contributed its part to the funds. The EBRD took over the role of ensuring that the money was spent for the designated tasks.

In 2011, the European Court of Auditors assessed the effectiveness of the EU funded programmes 1999-2010 and identified several serious deficiencies (ECoA 2011).

Following the report the Budgetary Control Committee of the European Parliament, in charge of scrutiny of EU expenditure, decided to commission Öko-Institute with an independent assessment of the decommissioning process. The assessment's remit was to identify best practices in decommissioning nuclear reactors in Europe, to compare these with the practices in the three countries and to derive recommendations from this comparison. We hereby present the report of our findings.

The report is structured as follows:

- Chapter 2 sets out key characteristics of the decommissioning of nuclear reactors in Europe and the technical, economical and organisational aspects that play a role in those projects.
- Chapter 3 outlines current practices in France, the UK and Germany and examines best practices in detail using the example of Energiewerke Nord GmbH (EWN) in Greifswald/Germany.
- Chapter 4 describes and evaluates practices in Bulgaria, Lithuania and Slovakia.
- Chapter 5 provides an overview of the evaluation results, displays those results in the form of country profiles and presents the conclusions and recommendations of this study.

The preparation of this study was only possible with the assistance and close support of numerous organisations. We would like to thank for their support:

- By answering our questions,
- Providing supporting documents and background information,
- Giving us the opportunity to discuss our issues in a very open and frank manner,
- Opening doors so that we could visit facilities,
- Providing excellent framework conditions for all this.

We thank the following organisations for their kind support:

- Energiewerke Nord EWN GmbH, Germany,
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- The Ministry for Energy and Economy (MEE), Bulgaria,
- Ignalina Nuclear Power Plant (INPP), Lithuania,
- Jadrová a vyraďovacia spoločnosť, a.s. (JAVYS), Slovakia,
- European Bank for Reconstruction and Development (EBRD), UK,
- Directorate General for Energy (DG ENER), Luxemburg.

We also thank various persons who have provided assistance in reviewing content, readability and language correctness.

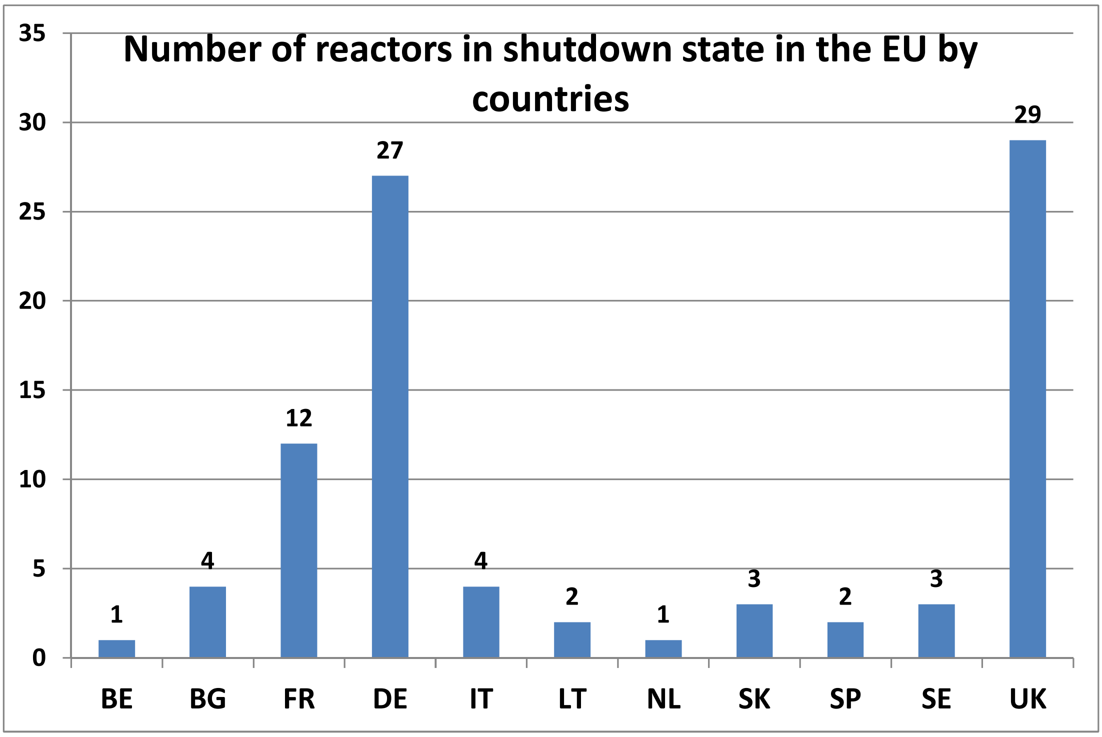
2. DECOMMISSIONING PROJECTS

2.1. THE FRAMEWORK OF DECOMMISSIONING PROJECTS IN EUROPE

Reactors in shutdown mode in EU countries

The main focus of this study is on the decommissioning of nuclear reactors that were used for commercial electricity production. 88 of those reactors[1] in the EU have finished operation and the majority of these is not yet finally decommissioned (see ANNEX 1 for a complete list of reactors). The distribution by country is displayed in Figure 1.

Figure 1: Number of reactors in shutdown state in the EU by country



Source: Authors, data derived from the IAEA-PRIS database (PRIS 2013)

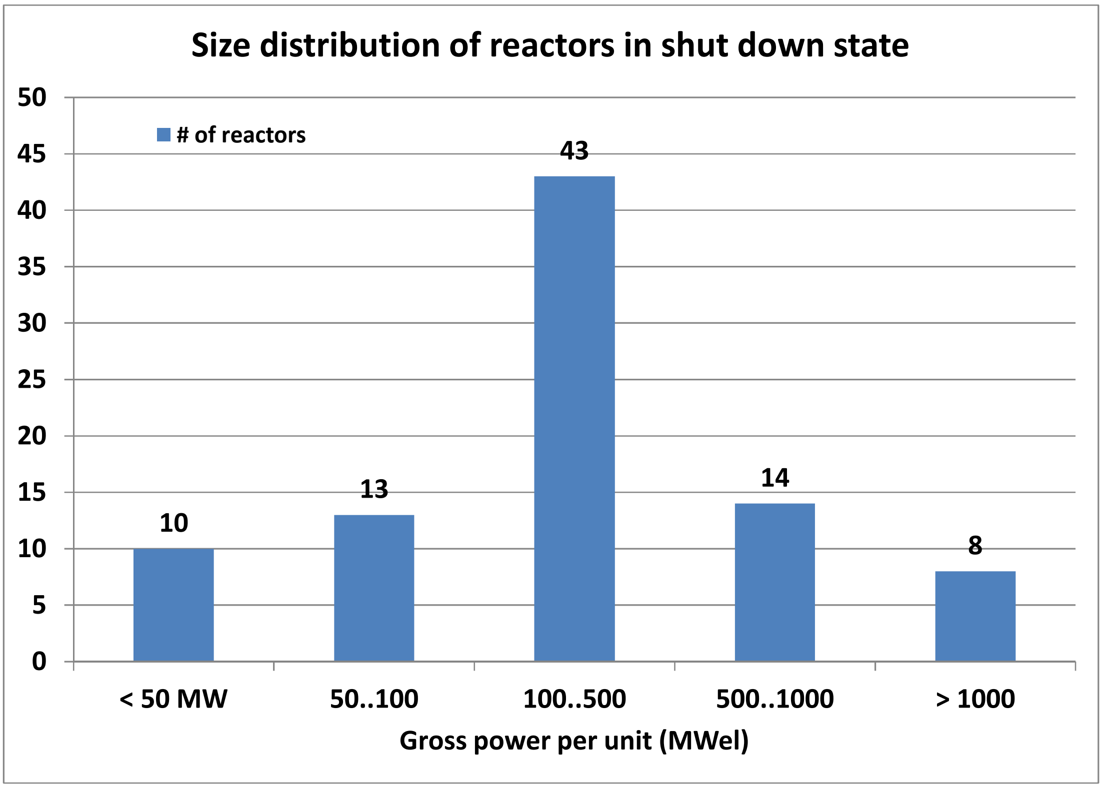
While in most of the member states with reactors in shutdown state between one and four of those reactors are in this stage, the 12 reactors in France, the 27 reactors in Germany and the 29 reactors in the UK account for 77 % of the reactors in shutdown state and are located in only three countries in the EU. So the majority of the (current and near future) decommissioning projects is concentrated in those three countries.

[1] The PRIS data base (PRIS 2013) includes all reactors that were designed and build to generate electricity. This includes reactors such as Rheinsberg NPP that were designed to or performed additional functions, e.g. in the R&D area, but no research reactors or production reactors other than for electricity generation. The database does not discriminate between reactors still to be decommissioned and reactors demolished and released from regulatory control.

Sizes of reactors in shutdown mode

In decommissioning projects, the size of the reactor plays a role with regard to certain aspects (e.g. the accumulated spent fuel, the amount of generated decommissioning wastes, time and workforce requirements and the size-dependent part of the total decommissioning costs). Figure 2 therefore displays the size distribution of reactors currently in shutdown mode.

Figure 2: Size distribution of reactors in shutdown state



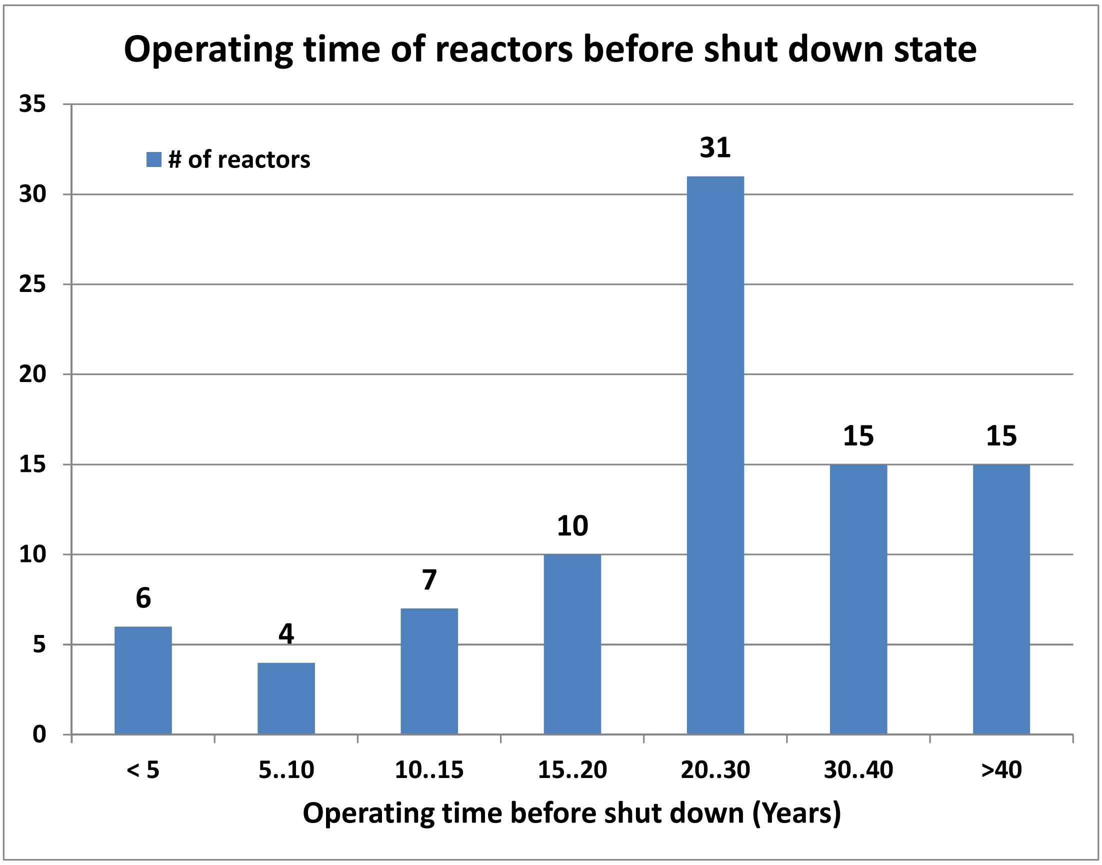
Source: Authors, data derived from the IAEA-PRIS database (PRIS 2013)

As can be seen in Figure 2 about half of the reactors currently under shutdown are in the range between 100 to 500 MW. So the majority of those reactors does not belong to the smallest <100 MWel size range, but equally is not of the larger types, >500 MWel. The decommissioning of reactors of the 50..500 MWel classes is considerably more complex, cost-intensive and complicated than that of small research or production reactors (not included here) of the 10 MW size (due to the number of systems, the size of equipment, the masses involved, etc.). On the other hand the decommissioning of reactors of the smaller sizes (e.g. 100..500 MW) class can serve as a field to gain experiences that will be necessary and valuable for the larger sizes to be decommissioned.

Operating time of reactors in shutdown state

The time over which the reactors were operated plays a further role for decommissioning. While the reasons for shutting down are manyfold (technical, safety, economical, legal, etc.) and specific in each case the operating time plays a general role for decommissioning. The longer the reactors are operated the more fuel accumulates, the higher is the neutron activation of reactor internals and of the bio shield, the deeper the contamination of surfaces and structures. This leads to a higher chance that locations and materials, to be cleaned-up and handled during decommissioning, are contaminated in facility-internal smaller or larger release events. Figure 3 shows the distribution of operating times prior to entering shutdown state.

Figure 3: Operating time of reactors before entering shutdown state



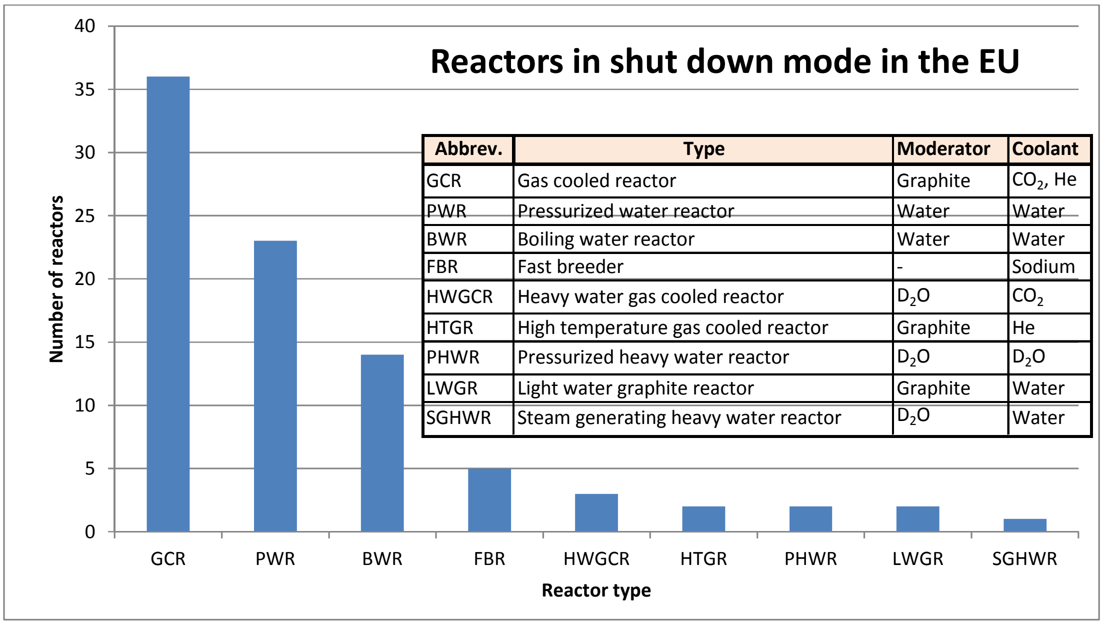
Source: Authors, data derived from the IAEA-PRIS database (PRIS 2013)

The figure shows that one third of the reactors were in operation for between 20 and 30 years, another third for less than 20 years and the rest for more than 30 years. So, on the one side, the current decommissioning projects in the EU represent the whole range of operating history duration. On the other side the majority is not representative of long or very long (beyond 30 years) operating histories.

Reactor types of reactors in shutdown state

Another factor for decommissioning is the type of reactor. The reactor types determine the technical modes of deconstruction, the waste amounts and types. They indicate specific problematic deconstruction steps potentially requiring additional R&D. The types differ in terms of the moderator (e.g. water, heavy water or graphite) and the coolant used (e.g. water, gas or sodium). The type distribution in the EU is displayed in Figure 4.

Figure 4: Reactors in shut down state in the EU by type



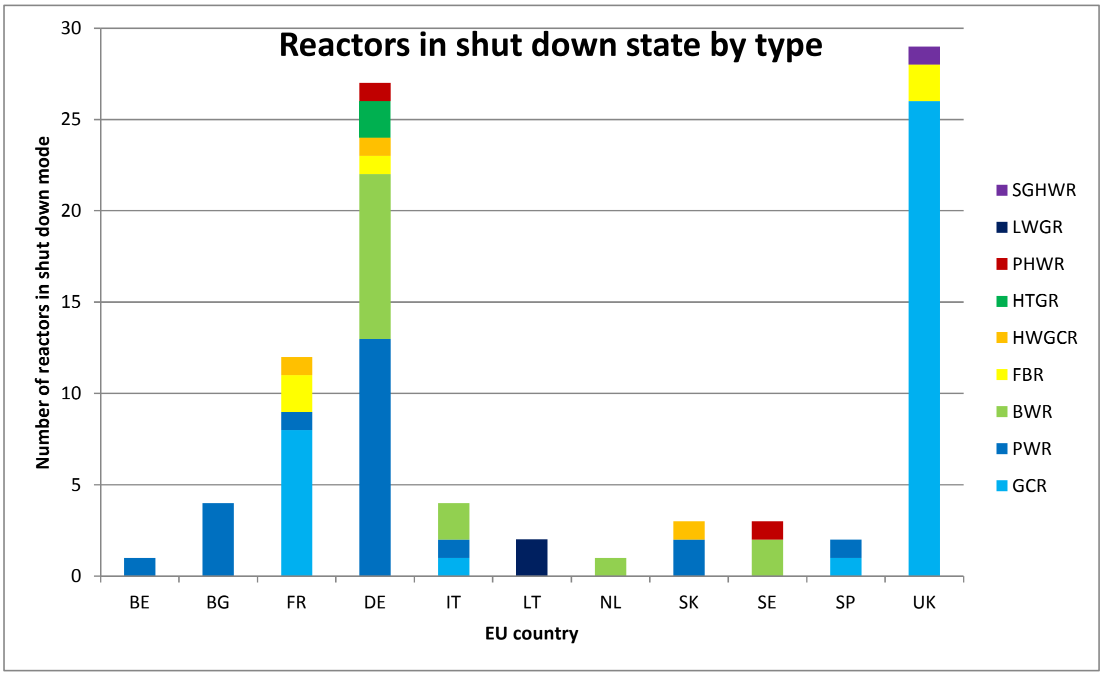
Abbrev.	Type	Moderator	Coolant
GCR	Gas cooled reactor	Graphite	CO_2, He
PWR	Pressurized water reactor	Water	Water
BWR	Boiling water reactor	Water	Water
FBR	Fast breeder	-	Sodium
HWGCR	Heavy water gas cooled reactor	D_2O	CO_2
HTGR	High temperature gas cooled reactor	Graphite	He
PHWR	Pressurized heavy water reactor	D_2O	D_2O
LWGR	Light water graphite reactor	Graphite	Water
SGHWR	Steam generating heavy water reactor	D_2O	Water

Source: Authors, data derived from the IAEA-PRIS database (PRIS 2013)

Among the reactors in shutdown mode in the EU are nine different types, with three dominating types (GCR, PWR and BWR), the other six types being represented by five reactors or fewer.

The different types and their distribution in the EU countries is shown in Figure 5.

Figure 5: Reactor type distribution of shut down reactors by country in the EU



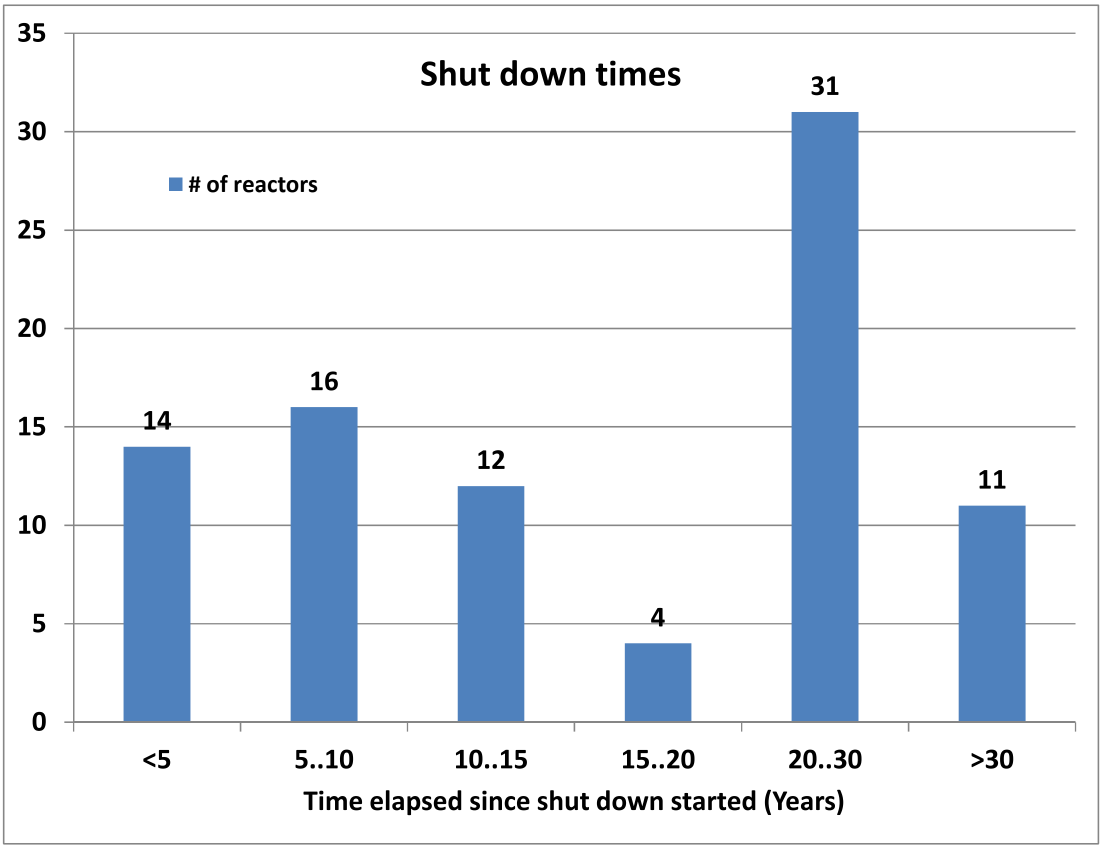
Source: Authors, data derived from the IAEA-PRIS database (PRIS 2013)

The largest type variation is found in Germany (six different types), followed by France (four types) and the UK (3 types).

Duration of shutdown states

Another interesting point is the period over which the reactors in shutdown state have remained in that state. Without going into detail into the reasons for each individual reactor, this shows on a more general scale how 'fast' or 'slow' decommissioning projects currently are. Put simply: the longer the shutdown period lasts the less priority is attributed to the decommissioning projects.

Figure 6: Times over which the current reactors in shutdown state have remained in that state



Source: Authors, data derived from the IAEA-PRIS database (PRIS 2013)

The times displayed have to be compared with the estimate that the complete decommissioning of a standard 400 MWel pressurized water reactor can be performed in less than 15 years (expert guess, no real reference).

As can be seen more than half of the reactors that are in shutdown state have been so for periods exceeding that. The majority are between 20 and 30 years in that stage, and one eighth of the projects are in that state for even longer periods. Of the 46 reactors in shutdown mode for over 15 years only 8 have currently reached their final decommissioning stage. It can be concluded that in general 'fast' decommissioning is currently not given top priority in the EU member states. Although it is known that prolonged decommissioning causes additional costs and can give rise to serious personnel recruitment shortages (in 15 to 20 years half of the workforce, in 30 to 40 years the complete workforce is exchanged once).

This general view is detailed further in later chapters.

The following general conclusions can be drawn:

- A total of 88 reactors are currently in their shutdown stage in the EU.
- The size distribution, operating time of the reactors and shutdown periods in the EU are varying widely.
- France, Germany and the UK are the most affected countries in the EU facing decommissioning projects.
- Currently only roughly 10 % of the reactors in shutdown state have reached their final decommissioning stage while the vast majority is in different stages of decommissioning. Most of the finalized projects are located in Germany.

2.2. TECHNICAL BASIS OF DECOMMISSIONING

Decommissioning a reactor takes place under controlled technical conditions and brings the facility into a state that does not require limitations any more (to a state 'below any regulatory concern' or by a complete removal) is caused by the remaining radioactive content that still is left in the facility even if the highly radioactive spent fuel has been removed. The following provides a basic understanding of the sources and types of radioactivity that play a role in decommissioning.

2.2.1. Activation and contamination of the nuclear reactor during operation

Radioactivity is generated in a nuclear reactor by two different processes: nuclear fission and neutron activation.

Nuclear reactors generate electricity by means of neutron-induced fission of fissile materials such as Uranium-235 or Plutonium-239 into fission products (such as Cesium-137) and utilize the heat generated in this process. Fission generates more neutrons than are necessary to keep the fission process steady. So a large portion of the generated neutrons are captured in materials such as:

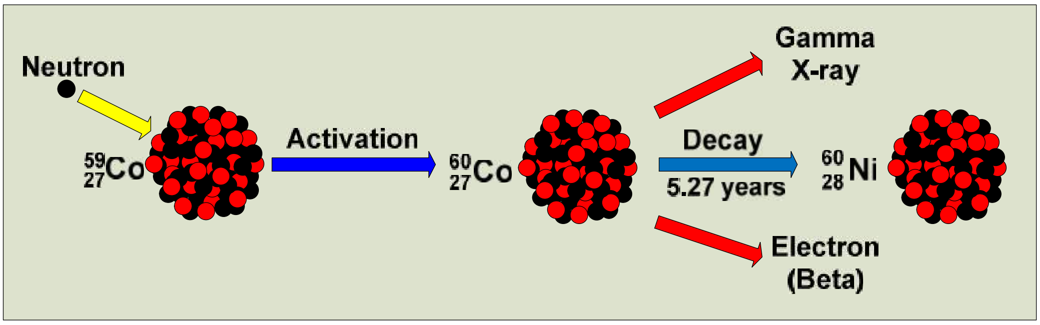
- Control rods,
- The cooling agent (such as cooling water) and neutron moderating agents (such as boric acid),
- The reactor vessel steel and the reactor vessel internals (such as the outer metal part of fuel rods, steel structural parts, measuring equipment), and into
- The bio shield[2].

[2] Bio shield: a concrete structure outside the reactor vessel that captures neutrons that leave the reactor vessel to the outside.

The effect that usually non-radioactive materials become radioactive by neutron-capturing is called activation. Activated materials are not only radioactive on their surfaces but the whole material that was exposed to the neutron flux is more or less homogenously radioactive.

Figure 7 illustrates that activation process for cobalt in steel as an example for the many other activation processes.

Figure 7: Example: the activation of cobalt in steel and subsequent decay of activated cobalt



Source: Authors

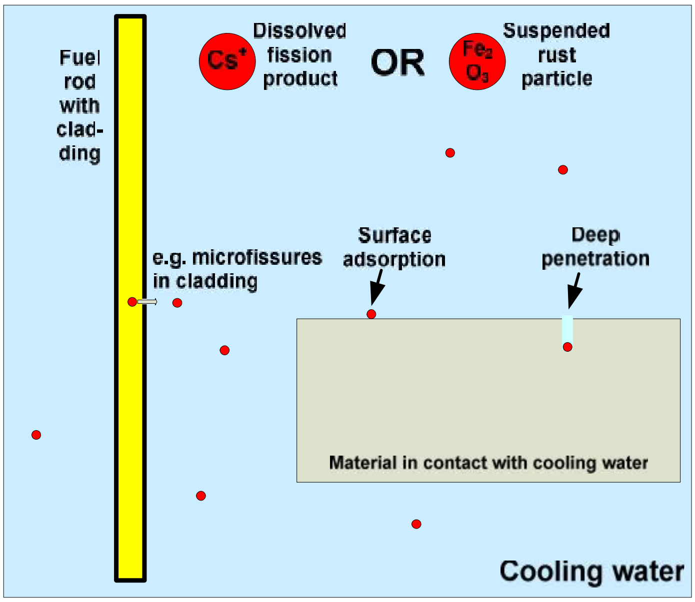
A second mechanism that spreads radioactivity to non-radioactive materials in a nuclear reactor is a contamination process.

During reactor operation certain fission products such as cesium can leave the fuel rods to a certain extent (e.g. in a gaseous form through micro fissures in the metal enclosure called cladding, during cladding failure events), dissolve in the cooling liquid and are removed by filtering and ion-exchangers. Irradiated metal surfaces corrode or are mechanically abrased. Both types, fission products as well as abrased activated particles from surfaces either dissolve or are suspended in the cooling liquid and are also removed by filters.

As a result the liquid transferring the heat (normally the cooling water) is contaminated with dissolved radioactive ions and activated particles. All surfaces with which such contaminated cooling water gets in contact (pipes, valves, heat exchangers, etc.) can adsorb dissolved and suspended contamination on their surface and so themselves become more and more contaminated. Normally the contamination remains on the surface or in the outer oxide layer. A deeper penetration can only take place in materials with a rough surface (e.g. concrete) or when the base material has surface defects (e.g. on metal surface with scratches).

Figure 8 illustrates that as a simplified example.

Figure 8: Example contamination mechanisms of materials in contact with cooling water



Source: Authors

2.2.2. The need for decommissioning of nuclear reactors

Reactors at the end of their operating time consist, in certain parts of the facility, of activated and contaminated materials, even after removal of the spent fuel. The removal of these materials is necessary because:

- People who might come into contact with contamination or come near to activated items or remove/re-use them in an uncontrolled way can receive high radioactive doses (by direct radiation, by inhalation of aerosols or dust particles, etc.) and it is impossible to ensure that, over very long time periods of hundreds of years, no one enters the facility.
- Even if thoroughly enclosed (with concrete, door locks or by other means) ageing, corrosion and erosion over a very long period degrades buildings, reactor internals and contaminated equipment with time. Over very long times of hundreds of years activated and contaminated material can thus leave the facility and could cause large doses in the vicinity.
- Any re-use of remaining buildings as well of the reactor site as a whole would not be possible because of the necessary protection measures to prevent people from entering the facility.

Like all facilities where dangerous materials are or were handled and where these materials remain as items, liquids or as contamination on equipment or their surfaces, nuclear reactors have to be decommissioned, and the activated or contaminated materials completely removed and either decontaminated or disposed under circumstances where the dangerous materials cannot re-enter the biosphere.

AF-Colenco 2008 defines decommissioning:

'Decommissioning [...] covers all of the administrative and technical actions associated with cessation of operation and withdrawal from service and it is the final phase in their lifecycle after siting, design, construction, commissioning and operation. The purpose of these actions (activities

and tasks) is to allow removal of some or all of the regulatory controls that apply to the nuclear facility while securing the long-term safety of the public and the environment, and continuing to protect the health and safety of decommissioning workers in the process.' (AF-Colenco 2008)

2.2.3. Basic strategic decision on decommissioning waste

The process of removal of all activated and contaminated equipment is called decommissioning. As most of the physical materials of a reactor were not affected by a considerable neutron flux and never got in contact with contaminated liquids (e.g. the electricity generators), the amount of non-radioactive waste is much larger than the radioactive wastes.

The further steps in the decommissioning of a facility depend to a high degree on a basic management decision for all materials from controlled areas of the reactor[3]:

1. To minimize the amount of radioactive wastes later to be disposed of in a final disposal facility with a 'high' or 'excellent' isolation potential by extended separation and decontamination efforts. Material processing is designed to release as much as possible of the non-radioactive materials by applying radiological control release procedures and to handle either the unconditionally released material via conventional waste streams (e.g. steel and concrete recycling) or as conditionally released waste for specific use or conventional surface disposal. This strategy can, generally speaking, be termed as 're-concentration': the contamination that was previously spread over larger parts of the reactor is concentrated into a smaller fraction of wastes to be disposed of later in a specific disposal facility (final disposal).

2. To separate only those activated and contaminated materials with an elevated content for later disposal in a facility with a medium or high isolation potential, to remove all materials that are obviously non-radioactive and to dispose all the rest of materials in a disposal facility with a low isolation potential. Under this mode rooms, equipment and items of the facility are simply characterized into three categories: 'no activation/contamination', 'small or scattered contamination' and 'high contamination'. Only the first category leaves the site heading for conventional waste streams, while the latter two categories are disposed of in a designated near-surface or geologic disposal facility.

It is obvious that management route no. 1 means extensive efforts in decontamination as well as measuring materials and items with small concentration levels and a sophisticated administrational scheme to prevent erroneous release of radioactive items to uncontrolled conventional material streams, while route no. 2 means the opposite and disposes large amounts of only slightly contaminated material unnecessarily as waste. The terms 'high', 'medium' and 'low' isolation potential also need clarification, because decommissioning wastes by no means consist only of 'short-lived'[4]

3 Equipment, items or buildings from areas not under radiological control can, if not needed any more, be re-used or removed in a conventional way.

4 Short-lived radionuclides have a short half life time, such as roughly 5 years for Cobalt-60 in activated or contaminated steel. In disposal, those radionuclides, if mobilized by corrosion, washout or other mechanisms, absorb on geologic layers and are decayed before any of the nuclides enter accessible surface water streams.

radionuclides which will decay within a few decades, while under route no. 1 longer-lived[5] radionuclides in the wastes do not play a relevant role.

In the EU, Germany's decommissioning framework typically stands for route no. 1 while France follows route no. 2.

2.2.4. Advanced decontamination

The surfaces of contaminated materials, especially those parts of the contaminated material where the contamination has not entered the surface to a large depth, can be removed. In doing so, the absorbed particles can be 'decontaminated' (by scrubbing, abrasive-sandblasting, chemical surface treatment, electro polishing, etc.), depending upon the penetration depth of the contamination. The bulk of the material then is handled as non-radioactive material (e.g. can be re-used or recycled), leaving behind a smaller amount of other more concentrated materials (secondary wastes: decontamination liquids, contaminated sand, contaminated sludges, etc.).

During all removal, handling and treatment of parts in a facility to be decommissioned, it needs to be borne in mind that the radioactivity must not be further spread inside the facility (to prevent further contamination of materials, 're-contamination' of already decontaminated surfaces, etc.) and the releasable non-radioactive material portion must be kept as large as possible.

The basic target of decommissioning under route no. 1 is thus the separation of radioactive and non-radioactive parts, the cleaning of contaminated items by use of advanced decontamination technology and the safe and long-term enclosure of the activated and contaminated material portions that have been concentrated in this manner.

More technical issues in decommissioning and radiologic characterization of items are discussed in IAEA 2008a.

2.2.5. Strategic decisions on performing decommissioning in stages

When decommissioning is completed, all materials of the facility are either:

- Completely removed and have finally entered radioactive and non-radioactive waste management streams ('Green field status'), or
- Parts of the buildings of the facility remain on site, but have been cleaned up in the radiological sense, so that no regulatory control over their further re-use for other purposes is necessary any more ('Brown field status').

For a systematic overview on decommissioning strategy selection see IAEA 2005. Some decommissioning projects include additional interim steps in the decommissioning scheme. These steps are designed to:

- Leave parts of the facility and materials un-removed or intact;

[5] Longer-lived radionuclides have a long half life time, such as Nickel-63 (100 years), Nickel-59 (75,000 years) or Technetium-99 (210,000 years) in activated steel. Those radionuclides do not decay under 'medium' or 'low' enclosure conditions such as in surface disposal facilities.

- Enclose them for a certain time period (e.g. the complete primary circuit in the existing and modified concrete structure, the reactor vessel or other large equipment in a specially designed and built enclosure);
- Ensure that no one can enter the structure and no activated material or contamination can leave the structure;
- Leave this structure for a certain time period;
- Foresee a final step, in which the remaining materials are removed from the structure and either released from regulatory control (if decayed to below the prescribed concentrations), or are cut, conditioned and sent to the final disposal facility.

The aims pursued by including such a step in the scheme can be manifold, as are the associated risks:

- Short-lived radionuclides decay during this period so that radiation fields (esp. gamma radiation) during the final step are less relevant. This concerns exclusively short-lived nuclides such as Cobalt-60, i.e. in activated steel structures. Other parts, mainly of the contaminated primary cooling system, are contaminated with fission products (notably Cesium-137) and for these parts decontamination has to be applied. Thus, such an aim only make sense in cases where the material can be finally released from regulatory control or when the final step(s) can be performed under considerably less complex conditions (e.g. without remote cutting) or where the decayed material becomes suitable for 'less reliably isolating' final disposal facilities). There are several risks and obstacles that can turn this aim to its opposite (e.g. materials with low concentrations of nuclides with adverse measuring properties increase necessary measuring efforts and expenses to be made, no nuclear shops able and willing to perform the final tasks are available any more, neither experienced personnel nor regulatory means are available any more, the disposal facilities and their waste acceptance criteria have changed considerably, release criteria have changed to lower and more strict concentrations).
- The costs for the final steps have to be borne at a later time. This argument is shortsighted if the previously named risks are considered. The total costs over the whole decommissioning scheme, with a long inactive enclosure period in between, can be considerably higher than those for immediate decommissioning (e.g. with extra cost factors such as for re-building personnel, expertise and regulatory administration from the very scratch, setting up specialized shops for performing the final steps, finding/building/operating/closing an extra disposal facility for the then-generated wastes).
- Similarly, the hope that money spent only years later might reduce overall costs is short-sighted:
  - Only money that is explicitly set aside (as a reserve or fund) for that purpose can generate interests over time, assuming that interest rates remain high enough over the complete time period.
  - Only if the inflation rate is continuously smaller than those interest rates, might a reduction of total costs be achieved.
  - Increases in labor costs, one of the cost factors in decommissioning, can outweigh much or all of the interest.

- Only if the money owning entity does not go bankrupt in the meantime is the money still there when later needed.

- Only if the economy does not experience massive inflation over this time may the money still be available and valuable when it is needed.

In view of these conditions, trust in such concepts is in general is misplaced.

2.2.6. Conclusions

Based on the exposé above the following conclusions can be drawn:

- Nuclear reactors have to be decommissioned because the inventory of activated and contaminated radioactive material in the facility is large and, in part, long-lived. The enclosure of this complete inventory in the existing structure cannot be guaranteed over very long times. Leakages and uncontrolled spreading of parts of this inventory can cause environmental risks, so it is necessary to remove the inventory before the facility structures can be dismantled or re-used for other purposes.

- Decommissioning is the process to allow removal of some or all of the regulatory controls that apply to the nuclear facility by e.g.:

  - Removing all activated and contaminated materials, equipment, items and surfaces from the reactor;

  - Treating selected materials to remove contamination from their surface;

  - Sorting the materials on the basis of their measured degree of activation and contamination;

  - Cutting, solidifying or compacting those materials and to package the materials.

- Basic strategic decisions, either taken on a national regulatory level or on a project-specific level, that are of relevant influence for decommissioning are:

  - Whether materials from controlled areas shall be released from regulatory control following decontamination, monitoring and control procedures or whether all slightly radioactive materials shall be disposed of in a near-surface disposal facility;

  - Whether decommissioning in steps includes (long) inactive time periods or is performed continuously without longer periods of delay.

- The risks associated with pre-planned longer time delays are considerable, the expectation to achieve cost reductions is doubtful in the extreme.

2.3. ECONOMIC BASIS OF DECOMMISSIONING PROJECTS

2.3.1. Reliability of decommissioning cost estimates

The costs for decommissioning projects can only be reliably estimated on the following basis:

- A detailed decommissioning plan that covers all work to be performed, all technologies to be applied, all necessary personnel and external services required ('Detailed decommissioning plan');
- Masses, types, activation and contamination characteristics of all materials to be removed ('Material inventory');
- The necessary treatment, decontamination, conditioning[6], packaging of all materials to be stored and later disposed or that are to be immediately disposed ('Waste management plan').

Cost estimates performed on a more generic and less precise basis can only yield raw figures, these can prove to be false when detailed data becomes available. Cost figures that are taken from a smaller or different reactor type, from a reactor with a very different operating history, etc., cannot be reliably converted to another reactor.

2.3.2. Relevant decommissioning cost factors

Decommissioning costs not only depend on the above named factors but can easily be higher by up to a factor of 1.5 or 2, e.g.

- if previous basic decisions are changed,
- if previously underestimated risks materialize,
- if the whole plan has to be restructured while decommissioning work is in progress,
- if the work in a time-critical step requires longer than estimated,
- if previously untested technologies fail and have to be re-adjusted or refitted,
- if the whole waste management schemes or the conditioning facilities have to be changed substantially, e.g. due to external factors such as major changes in acceptance criteria of the receiving storage or disposal facilities.

These factors limit the reliability of cost estimates in general, so that only facility-specific figures that are compatible with the above requirements and are regularly updated to reflect changes should be used.

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[6] Conditioning means all the measures that are necessary to bring a waste into a condition that is fully compatible with the waste acceptance criteria of the receiving storage or disposal facility.

2.3.3. Rough estimate of decommissioning costs for lightwater reactors

In order to gain a general estimate, the reserves for decommissioning costs of two large operators in Germany can be used. These figures are estimated on the basis of reactor-specific decommissioning plans, inventory data and current waste management. The estimates are updated regularly to be compatible with the state-of-the-art in decommissioning.

Table 1 lists the reserves that are set aside by RWE AG and E.ON AG for the decommissioning of their 14 reactors with a gross electric power of 16,400 MW in the years 2009 to 2012. The figures include no management and disposal costs for spent fuel. From this the specific figures in million EUR per unit and in million EUR per GW(el) are calculated. Note that all reactors to be decommissioned are of the PWR and BWR type.

Table 1: Reserves to cover decommissioning costs of two large German plant owners and derivation of specific economic characteristics

FINANCIAL YEAR	RESERVES FOR DECOMMISSIONING			SPECIFIC RESERVES	
	MILLION EUR			PER UNIT	PER GWEL
	RWE	E.ON	BOTH	MEUR/UNIT	MEUR/GW
2012	6 865	4 945	11 810	844	719
2011	6 483	4 964	11 447	818	697
2010	6 055	4 490	10 545	753	642
2009	6 444	4 626	11 070	791	674
AVERAGE	6 462	4 756	11 218	801	683

Source: Authors, data derived from various annual company reports

Under the German framework conditions (labor expenses, etc.) the total costs for decommissioning are in the range of EUR 800 million per reactor unit or roughly EUR 680 million per GW(el). As also can be seen there is no specific major trend in the million EUR/Unit and million EUR/GW(el) figures even though the cost analysis is updated on a yearly basis.

Note that converting these figures to other types and sizes of reactors yields largely unreliable numbers.

2.4. THE ORGANISATION OF DECOMMISSIONING PROJECTS

The organisation of decommissioning projects has been recognized as a central factor, e.g.:

'The reported experience demonstrates that careful planning and management is essential in ensuring that decommissioning of nuclear facilities is accomplished in a safe and cost effective

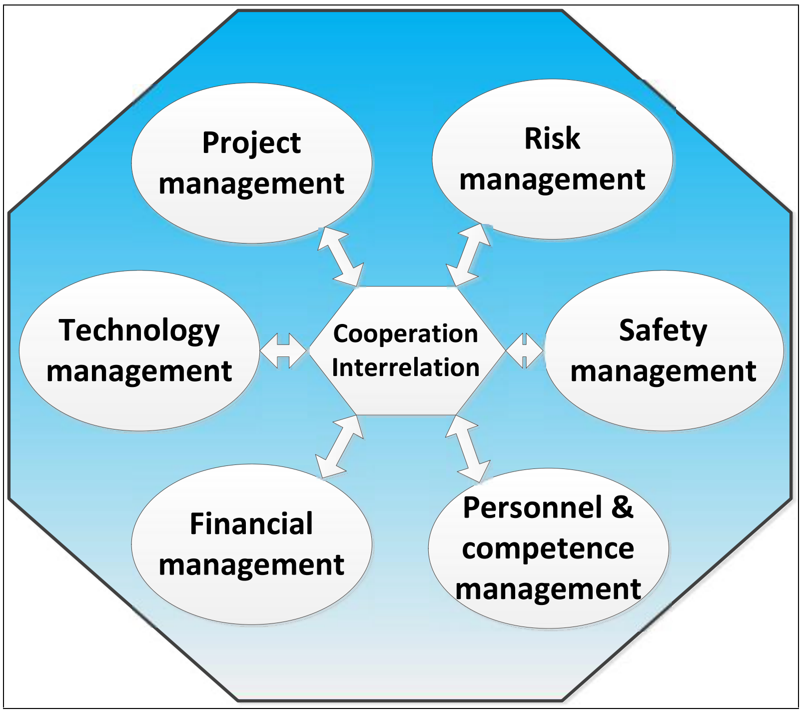
manner. On the other side it has been noted on several occasions that the major weakness in decommissioning projects is poor or inadequate planning and management, including unclear identification of roles and responsibilities.' (AF-Colenco 2008)

Decommissioning differs in organisational compared to the operational phase of the reactor. Decommissioning can in many aspects be better compared with the building of a new reactor (construction project) than with its operation. A few differences between decommissioning and new build have to be considered, e.g. decommissioning involves radiation protection and contamination prevention issues.

2.4.1. Organisational aspects

Figure 9 lists the management areas that have to be covered in a decommissioning project.

Figure 9: Relevant management areas in the decommissioning phase



Source: Authors

It is obvious from these listed management fields that the contribution of these areas to the success of a decommissioning project requires a specific approach.

Most of these management aspects change their scope, intensity and relevance during decommissioning. This change is further characterised as follows:

- Project management: The scope of project management during decommissioning covers the complete project, includes all project phases (preparation, reactor unloading, demolition, the release from regulatory control), covers all planning and work processes and provides the base for cost estimates, time schedules, identification and management of critical paths, etc.
- Risk management: During decommissioning specific risks occur. The procedures and processes applied are of a non-routine nature, many of them only applied once or in a few cases. Applied

technologies have to be adapted to facility-specific conditions. The uncertainties that are associated with these steps require thorough evaluation and plan changes, if those can cause delays, especially on critical paths, or cost increases.

The specific change is described as follows:

> *'It is extremely important to appoint a decommissioning manager and preferably to do this before the plant is shut down. This manager would have the responsibility for undertaking the development of an adequate decommissioning plan. The manager need not necessarily have direct experience in the operation and maintenance of the plant. Sometimes formulating this plan can be the responsibility of a central company headquarters department, if this exists, or undertaken by engaging specialist consultants or contractors.' (AF-Colenco 2008)*

Decommissioning differs widely from operation. In respect to typical organisational aspects Table 2 lists a few relevant ones and describes them further. As can be seen from those descriptions decommissioning is a largely unique task. Project and risk management are comparable with the new build construction phase, but knowledge and experience as well as the work organisation differs substantially. Decommissioning can in no aspect be compared with the operational phase and requires a completely different organisation, organisation structure, workforce, work planning, etc.

Table 2: Typical organisational aspects and their characterization in decommissioning/deconstruction, construction and operation of nuclear reactors

ORGANISATIONAL ASPECT	DECONSTRUCTION	CONSTRUCTION	OPERATION
Project management	**Central:** To plan far ahead, to understand complex interactions, to understand consequences, to create optimized flows, to manage experiences, to fit plans to changes, etc.		**Scarcely necessary:** except for major refitting of the facility or for outage planning and control
Risk management	**Central:** To understand all technical, organisational and financial risks in respect to their consequences for the critical flow path, risk communication culture necessary and vital		**Small relevance:** Limited scope, limited uncertainties, most risks well known, limited influence
Personnel, Knowledge and Competence management	**Central:** Complete U-turn necessary with existing personnel, requires substantial change in self-conception of management and personnel, changes considerably over time, limited attractivity, project approach habits to be learned	**External sources:** Availability and appropriateness completely task of the building company, planned and provided by external sources	**Limited relevance:** Mainly routine competence and work, well plannable ahead, nearly no relevant changes over time, high job appeal
Work organisation	**Complex:** Nearly completely project-oriented, task determines work organisation, practically no routine work and procedures, unknown and uncertain conditions require continuous re-adjustment, requires mostly interdisciplinary approaches, experience reflection and reflux on all levels necessary	**Central:** Plan-dependent work organisation, project-type work organisation, regular re-adjustment necessary to fit to work progress and delays, interdisciplinary as far as necessary, oriented mainly to experiences from past projects	**Standard:** Hierarchical command/confirm/execution structure, handbook-driven work, mostly routine, moderate influence of experiences

Source: Authors

2.4.2. Transitional issues

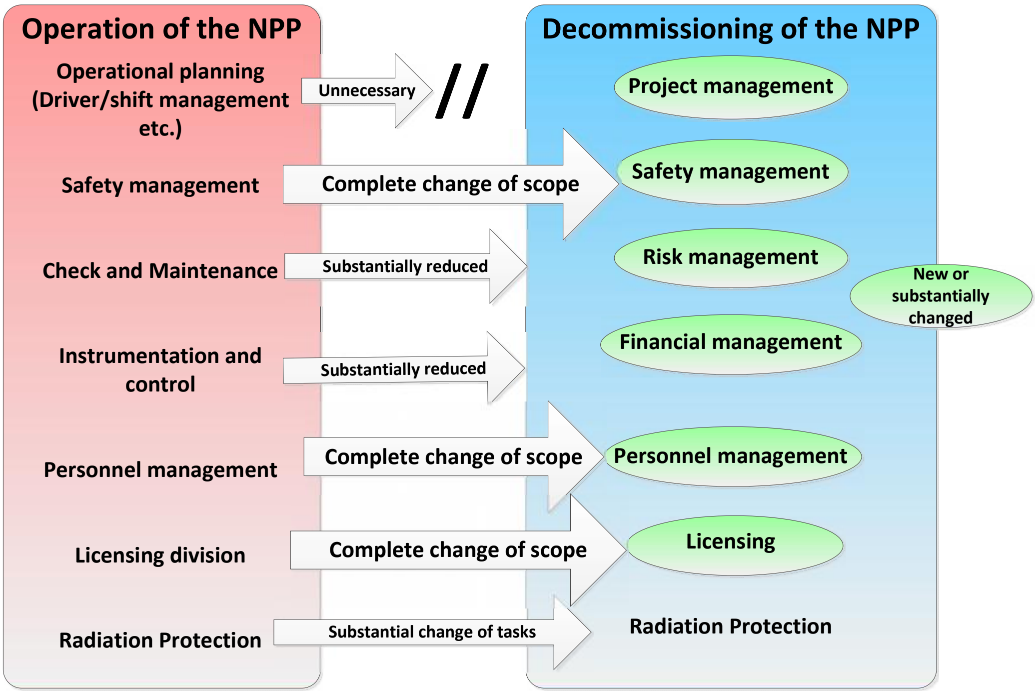
The decommissioning phase of a reactor always starts with the existing organisation, its structures, traditions, etc. On one side, this brings strong advantages, because

- Management and workforce are familiar with the facility, know all about the components, the technology, are familiar with plans, drawings and all other documentation and other knowledge sources;
- The operation history of rooms, components, items, is – normally - well known;
- The routine work includes such valuable knowledge as radiation protection procedures, quality requirements and safety culture, and all those behavioral aspects are well trained and, hopefully, in an excellent shape.

On the other side, the transition from operation to decommissioning requires a complete transition of the organisation (for transitional experiences see IAEA 2004, for a systematic overview on changes see IAEA 2008b, there especially chapter 3 and Table 1 on page 45). Within a few years most of the knowledge and experience gained in the operational phase makes no sense any more (e.g. on how to maintain quality and reliability of components, test and repair certain components) and absolutely new knowledge and experience (e.g. on how to finally remove those components, to decontaminate them, to cut them into pieces and to place them in the correct waste collection container) is required.

To support this view that operation and decommissioning require a re-organisation of the existing structures, Figure 10 provides an overview over all those changes.

Figure 10: Relevant areas of necessary changes to the organisation when shifting from operation to decommissioning



Source: Authors

As can be seen none of the well-organised and well trained areas during operation stay the same, all require at least substantial addition to their tasks (radiation protection) or substantial or complete changes of their scope.

Project management in the operational phase is required only to a rather small extent, over very limited time periods and under a rather limited complexity. Nearly no one in the management of a reactor is familiar with project management of the more complex type, as required for decommissioning, or has experience with it. So the necessary experienced persons have to be hired at the beginning of the decommissioning phase. This is the case for many other specialized knowledge and experience, too, so that the question arises in many cases if it is more effective to teach and train internal workforce or to hire experienced persons from outside the organisation. In any case this requires early planning of the necessary knowledge, experience and personnel qualification that will be required during the different phases of decommissioning ('Personnel, knowledge & qualification management plan') that fits to the overall decommissioning plan.

Learning to work in a project-oriented environment also requires new qualifications and habits. No operational handbook gives any indications on how to saw a steam generator with hundreds of small internal pipes into pieces or to cut and package graphite blocks for final disposal: this requires mechanical knowledge, knowledge and experience with – so far unknown - tools, basic material science, the associated radiation protection issues, fire prevention and protection issues, waste management basics, etc. etc., so developing those technologies and procedures and optimizing them requires a broad multidisciplinary approach that has never been developed during the operational phase. Learning multidisciplinary work so is thus a great challenge.

The transition of the organisation is one of the main factors determining time requirements and overall costs of a decommissioning project. Too slow transition can mean delays, lack of technical/safety/economical optimization, safety-related incompatibilities and failures, unnecessary blockages, and errors. Too rapid transition, on the other side, can mean overestimating learning curves, demotivating individuals and reducing the overall performance.

The main issue in the transition from operation to decommissioning is psychological, i.e. the main issue is to get rid of the operation mentality among the personnel and to create a motivated workforce although their new job is limited in time and their previous work and pride will be destroyed.

2.4.3. Strategic and operational decisions

In the previous chapters several basic decisions were described that have to be taken in an early stage of decommissioning (e.g. chapter 2.2.3 for basic strategic decisions, chapter 2.2.5 on schedule strategies). These basic decisions affect the whole decommissioning process and determine all the underlying planning and processes.

A number of management areas, some of them very specific to decommissioning, were identified (in chapter 2.4.1). In these management areas several additional strategic decisions have to be taken. Strategic decisions in this field also affect all underlying planning and processes.

Such basic decisions have to be accompanied by an even larger number of operational decisions that have to be in accordance with the overall strategic framework, but are more day-to-day decisions to implement the necessary steps.

While errors or failures in operational decisions can cause considerable losses or damages, errors or failures in strategic decisions have much larger consequences. That is why strategic decisions, as pre-planned by the management, should be subject to a decision making under control: an independent supervisory board should:

- Evaluate the proposed plans;
- Request the presentation of alternatives to those plans;
- Request a risk evaluation for the technical and financial implications of the plan(s);
- Finally decide on the plan.

The effect of double-checking strategic decisions is that all risks are better assessed and a more reasonable risk decision can be taken.

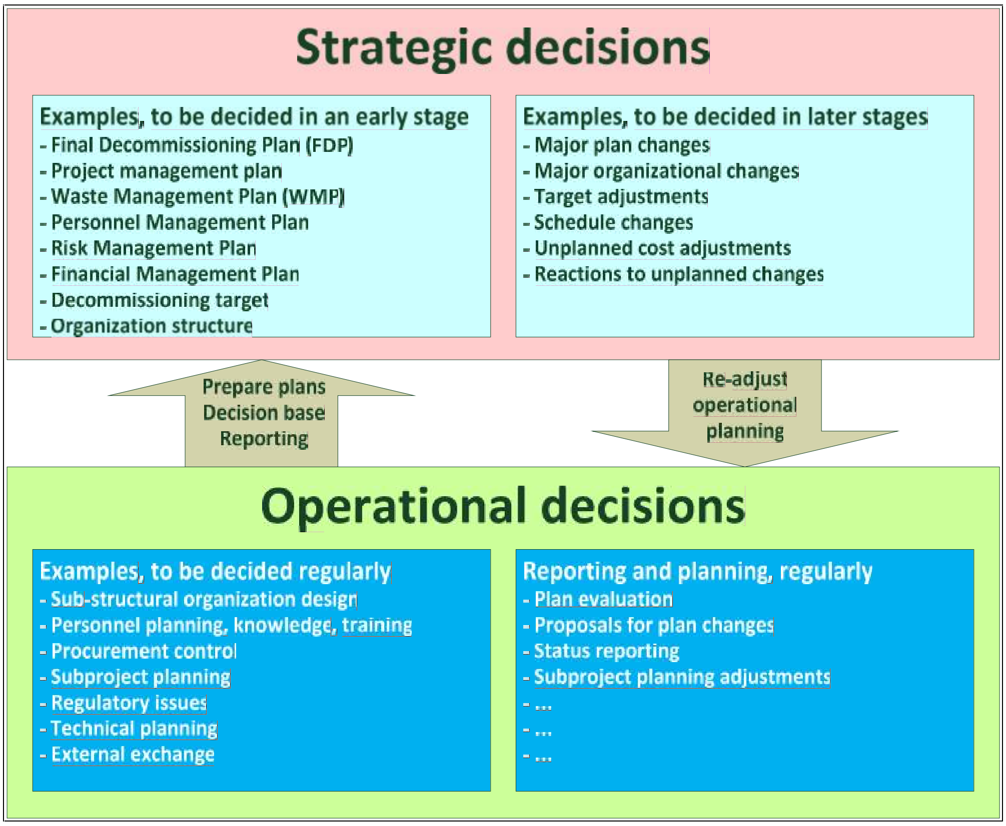
To set up an effective management and control regime, it is a central requirement to define strategic decisions to be prepared by the management and finally to be decided from the control institution, and to define operational decisions to solely be decided by the management. If this discrimination is either not clearly defined, is not respected or is unclear:

- Strategic decisions are either not taken (management waits for decisions of the control institution) or with a high risk of failure (management decides and acts on its own);
- Operational decisions are unnecessarily delayed because the control institution is unable to decide, is unwilling to take every-day-decisions or decides in a wrong way due to limited expert knowledge;
- Operational decisions are unnecessarily decided by the control institution, with the result that the management is not responsible any more, looses competency, etc.;
- The responsibility for decisions cannot be clearly assigned or is diluted between two organisations that claim that either none of them or both of them are responsible.

In all the named cases sub-optimal conditions result that can cause immense difficulties for the process.

Figure 11 lists examples of typical strategic decisions as well as operational decisions in decommissioning.

Figure 11: Strategic and operational decisions



Source: Authors

2.4.4. Conclusions

- Decommissioning requires a transition of the whole organisation towards the new task of decommissioning.
- Based on an overall plan that covers all phases of decommissioning a detailed plan for the necessary knowledge, experience and qualifications of the personnel is required.
- Based on these plans, the necessary training and the acquisition of external know-how has to be planned and implemented.
- Basic knowledge and experience on the management level in project management is a central requirement for performing a decommissioning project safely, in an economically effective manner and on schedule.
- Clear distinctions between strategic and operational decisions and a clear attribution of these decisions to the management and the control institution should be established to achieve an optimal decisional setting.

3. IDENTIFICATION AND DESCRIPTION OF BEST PRACTICES IN DECOMMISSIONING

This chapter describes project practices and experiences made in decommissioning in several western European countries. The aim is to identify current best practices in such projects. The identified best practices shall, in later chapters, be used to compare the projects in Bulgaria, Lithuania and Slovakia with these, to identify differences that can or have caused delays and cost-overruns and to identify factors that have the potential to cause disadvantageous developments in respect to costs and risks. They shall also be used to draw recommendations for improving those projects and to avoid those drawbacks in the future.

Chapter 3.1:

- Discusses criteria for identifying best practices in Europe and also names exclusion criteria;
- Selects the depth and extent to which the selected examples have to be described and evaluated, and lists aspects to be looked at in detail.

The examples from France are described and evaluated in chapter 3.2.

Selected aspects from a large decommissioning project in the UK are further described and evaluated in chapter 3.3.

Chapter 3.4 describes and evaluates the case of Energiewerke Nord (EWN) in Germany in detail.

The overall results of the best practice examples are summarized in chapter 3.5.

3.1. SELECTION CRITERIA FOR COMPARISON

The following criteria for the selection of examples are seen as relevant to ensure an as-close-as-possible comparability with the projects in Bulgaria, Lithuania and Slovakia:

1. Reactor size and type

   The size of reactor(s) to be decommissioned shall be in the range above 100 MWel in order that the complete project framework is comparable to the three countries in terms of its complexity, its management and coordination requirements, its regulatory requirements, etc.. Reactors smaller than 100 MWel - such as the pilot plant Versuchsatomkraftwerk Kahl (VAK)/Germany, even though one of the few projects that has been completely decommissioned - are substantially different in this regard and need not to be taken into account.

2. Operational phase duration

   Contamination levels, technological complexity, regulatory requirements and waste management issues are only comparable with nuclear power plants operated over periods of at least several years. Shorter term operated plants, such as Niederaichbach/Germany or Heißdampfreaktor Großwelsheim/Germany, even though decommissioning to the 'Green Field' status has been totally completed, do not yield a comparable scale due to significantly lower levels of contamination.

3. Owner type and organisation

   The basic distinction here is between private operator organisations such as private energy producing companies, and public owners on the federal or state level. As all of the three eastern European projects are public organisations, this type of organisations is better comparable. It would be scientifically interesting to discuss whether project organisation and management as well as experiences differ significantly under a private setting, but that comparison does not contribute much to the central task of this study.

4. Decommissioning stage and level

   The selected examples shall be in an advanced stage of physical decommissioning so that advantages and lessons learned from that project are already identifiable. Projects in an early stage are less usable to derive experiences from because all work is only in a preliminary stage.

Aspects to be looked at and evaluated

As all decommissioning projects in question are individually planned and implemented projects with a:

- Specific technical design and condition;
- Specific operational history, determining the type and extent of contamination in the facility;
- Specific organisational setting and owner condition;
- Specific national and regulatory framework condition

it makes no sense to compare the projects in any technical detail, with regard to specific timeframes and cost figures. The projects are rather described and evaluated with regard to the following aspects:

5. How is the decision-making and the control over the organisation's strategic decisions organised (external oversight, management control)?
6. How is the responsible organisation's internal structure designed (management, project organisation, risk management, personnel management, etc.)?
7. How is national and international funding organised?

Selecting examples

For selecting examples that fit the selection criteria described above the following criteria were applied:

- As Figure 1 (on page 32) shows that only France, Germany and the UK are among the countries having more than four reactors in shutdown mode. So coverage of the situation in these three countries yields a representative picture.
- Figure 2 (on page 33) and Figure 3 (on page 34) summarise the size distribution and the operating time of reactors in the EU that are currently under shutdown and in different phases of

decommissioning. As can be seen, enough projects fulfill both criteria, the size and the operating time duration before shutdown.

- Figure 6 (on page 36) adds information about the time elapsed after entering the shutdown state and today, Figure 1 (on page 32) adds the number of reactors under shutdown by countries. As can be seen, about half of the reactors have been in this condition for more than 15 years, so that enough examples can be found that are in an advanced stage of decommissioning.

Thus, the most promising countries for identifying examples are **France** (12 reactors, most of them twin facilities), the **UK** (29 reactors, most of them twin facilities), and **Germany** (27 reactors, mixed single and multiple facilities on one site).

In respect to the operator type of organisation

- All of the French projects are owned and decommissioned by a private operator that is majorly owned by the government;
- The projects in the UK were operated mainly by public companies and are decommissioned under the umbrella of the Nuclear Decommissioning Agency (NDA), a publicly owned and controlled entity;
- In Germany six of the projects are in federal ownership, the majority is privately owned.

With this background the following can be concluded:

- In France, EDF as the private owner of 9 nuclear power plants in shutdown state developed the general decommissioning strategy for the reactors to be decommissioned. This overall decommissioning strategy will be described and subsequently, the decommissioning of the pressurized water reactor BNI 163 (Chooz A) will be briefly presented and discussed as a selected example that fulfills the selection criteria.
- From the UK, the reactors decommissioned by Sellafield Ltd are selected. Sellafield Ltd is the Site Licence Company that manages and operates, on behalf of the NDA, the reprocessing and waste storage facilities at Sellafield and the former nuclear power stations Calder Hall and Windscale (all in West Cumbria).
- From Germany, the decommissioning of the five reactors at Greifswald is selected as most representative example for an in-depth analysis. This project fits all of the criteria best (size, owner organisation type, advanced decommissioning stage, etc.).

3.2. SELECTED EXAMPLE FROM FRANCE: EDF

The following chapters describe the EDF approach to decommissioning to identify best practices.

3.2.1. Overall framework of the decommissioning project

The following state owned companies and commercial entities are responsible for decommissioning activities in France:

- French Atomic Energy Commission (CEA) as a state research institution,
- The Waste Management Agency (ANDRA),

- The commercial nuclear energy industry (EDF, AREVA and others).

In 2006, the newly established Nuclear Safety Authority (*'Autorité de Sûreté Nucléaire – ASN'*), an independent regulatory body with five commissioners – became the regulatory authority responsible for nuclear safety and radiological protection, including decommissioning activities.

Currently, there are 58 operating nuclear power reactors operated by '*Electricité de France* (EDF)'. The majority of the 12 reactors in the shutdown stage are also owned by EDF.

EDF had previously favored a deferred decommissioning strategy with a very long period of safe enclosure in the late 1980s (Brenk 2006). It was planned that the shutdown would be followed by a safe enclosure period of 50 years. During this period, the facility would have been understood as a storage unit of the equipment left in place and kept under surveillance. The advantage of this concept was stated to be taking benefit from the Co 60 decay (see also chapter 2.2).

In 1996, the former Nuclear Installations Safety Authority - '*Direction Générale de la Sûreté Nucléaire et de la Radioprotection (DGSNR)'* - requested CEA to commission a joint study with EDF assessing the possibility to shorten the planned 50 years delay for total dismantling to find a better balance between the benefits and the drawbacks of delaying the dismantling phase. In 1999, CEA and EDF informed the authorities about the plan to prefer the immediate decommissioning. In April 2001, EDF took the decision to implement the immediate decommissioning strategy (Brenk 2006).

EDF

EDF operates 58 nuclear reactors at 19 sites in France. Additionally 9 reactors of the following types are currently under decommissioning by EDF:

- 1 pressurized water reactor (PWR),
- 1 heavy water reactor (HWR),
- 6 gas cooled and graphite moderated reactors (GCR), and
- 1 fast breeder reactor (FBR).

For all these facilities EDF developed an overall decommissioning strategy called 'decon' for total and 'immediate' dismantling. The decommissioning is seen as a technical and industrial challenge that requires an optimal time and project management. It is planned that the 9 reactors shall be decommissioned in two 'tow waves' (Brenk 2006, Laurent 2011):

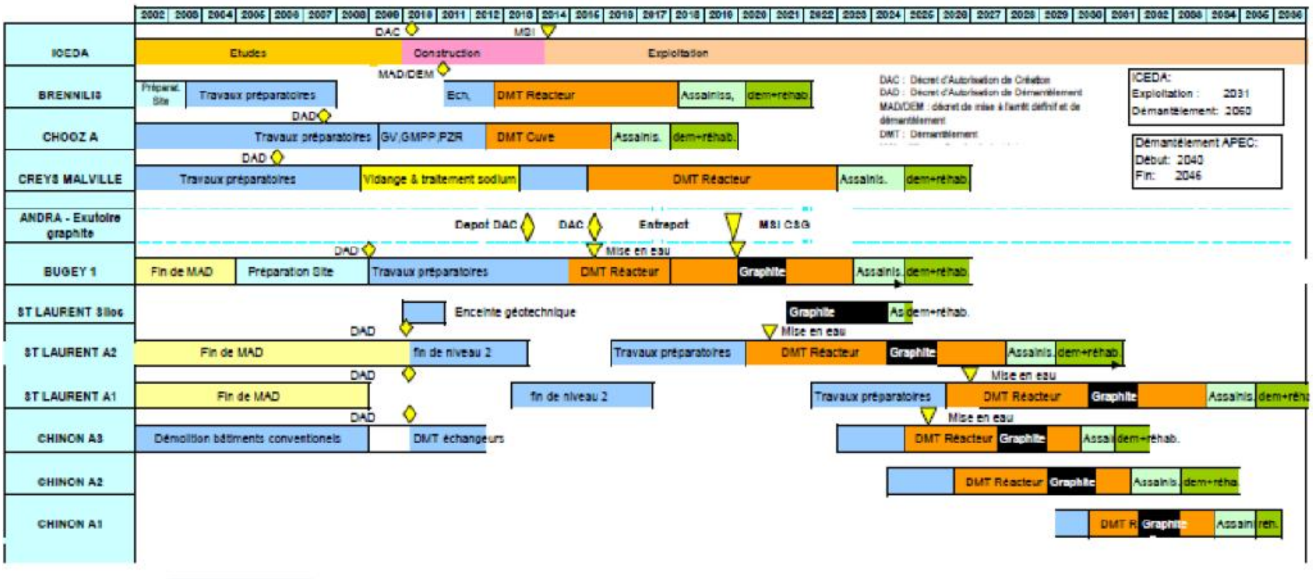
- Within the first wave, the total dismantling of the reactors at Brennilis is planned until around 2015, the dismantling of the Creys-Malville and Bugey 1 reactors for around 2025, and Chooz A before 2015/2020.
- Within the second wave, the 5 remaining gas cooled reactors Chinon A1-3 and Saint-Laurent A1-2 shall be dismantled.

The 'first wave' of the decommissioning already started in 2008 with Chooz A, being the only PWR reactor in that set. The experiences with the dismantling are seen as an important feedback source for the further decommissioning projects of reactors of that type. For the remaining 5 gas cooled reactors, a different decommissioning strategy was developed because of their specific technical and waste aspects (in relation to graphite retrieval and treatment). The decommissioning strategy for the gas cooled reactors is seen as more global so that the decommissioning projects are interconnected and linked closely to the graphite waste path (Laurent 2011).

Figure 12 shows the planned time schedule within the overall decommissioning strategy for all reactors of EDF. Note that the time scale in the figure covers the years until 2036.

As can be seen from the figure, the decommissioning of the graphite reactors is substantially delayed until 2020, with the graphite removal stage being the critical path.

Figure 12: The time schedule for overall decommissioning of all reactors with relevant milestones



Source: (Laurent 2011)

3.2.2. Organisation structure for the decommissioning

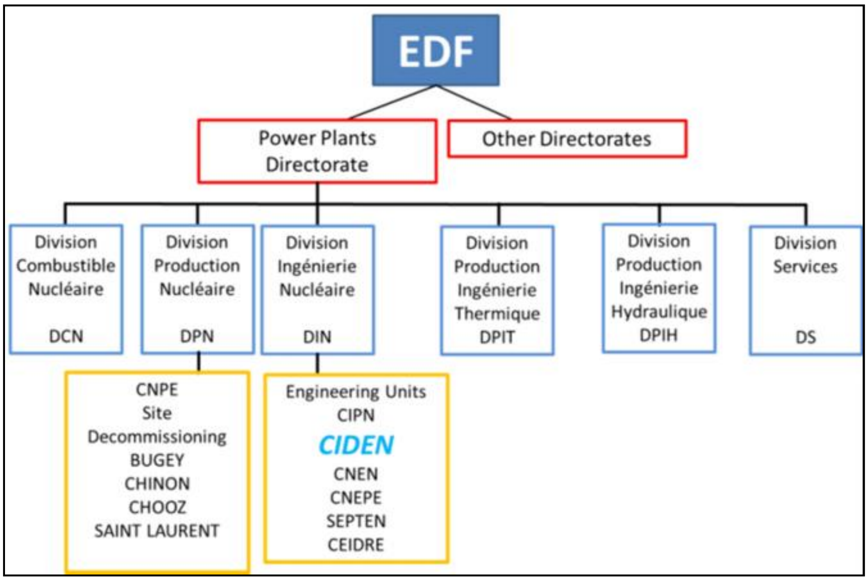
The organisation structure of EDF in respect to decommissioning is divided between two core areas: engineering services specialized in decommissioning and acting site decommissioning.

Engineering services are provided by a special unit responsible for decommissioning within EDF – the Engineering Centre for Dismantling and the Environment/'*Centre d'ingénierie de la déconstruction et de l'environnement (CIDEN)*' – which was established in 2001. It is a subdivision of the Engineering Division of EDF.

Acting site decommissioning on the different sites is headed by the production division.

Figure 13 shows the overall organisation structure of EDF and how CIDEN and the sites are located within this structure.

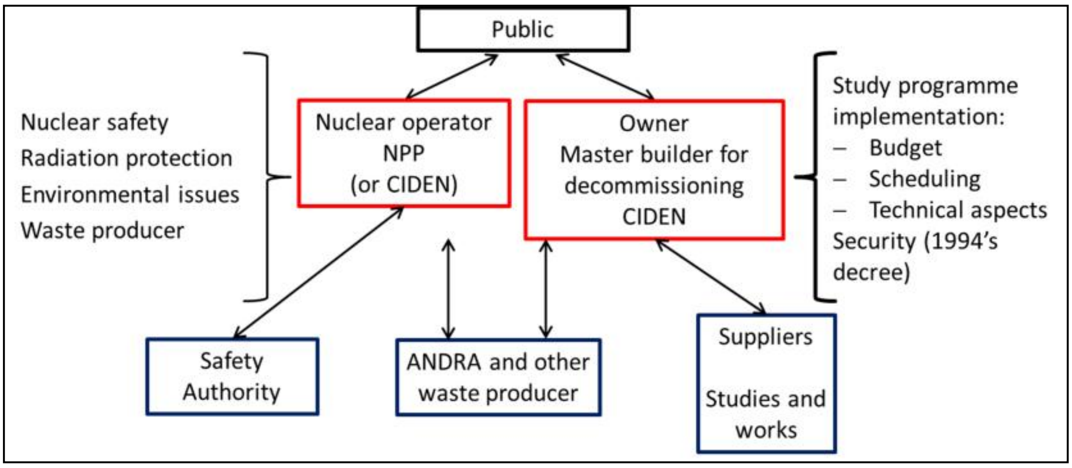
Figure 13: The involvement of CIDEN and site decommissioning within the organisational structure of EDF



Source: (Laurent 2011)

The operators of the decommissioned facilities as well as CIDEN share the responsibility for the contact with the Nuclear Safety Authority (ASN), with the waste management organisation ANDRA and also with the local and general public. The CIDEN is further responsible for the commissioning of the relevant suppliers, studies and supporting external works. These responsibilities are shown in Figure 14.

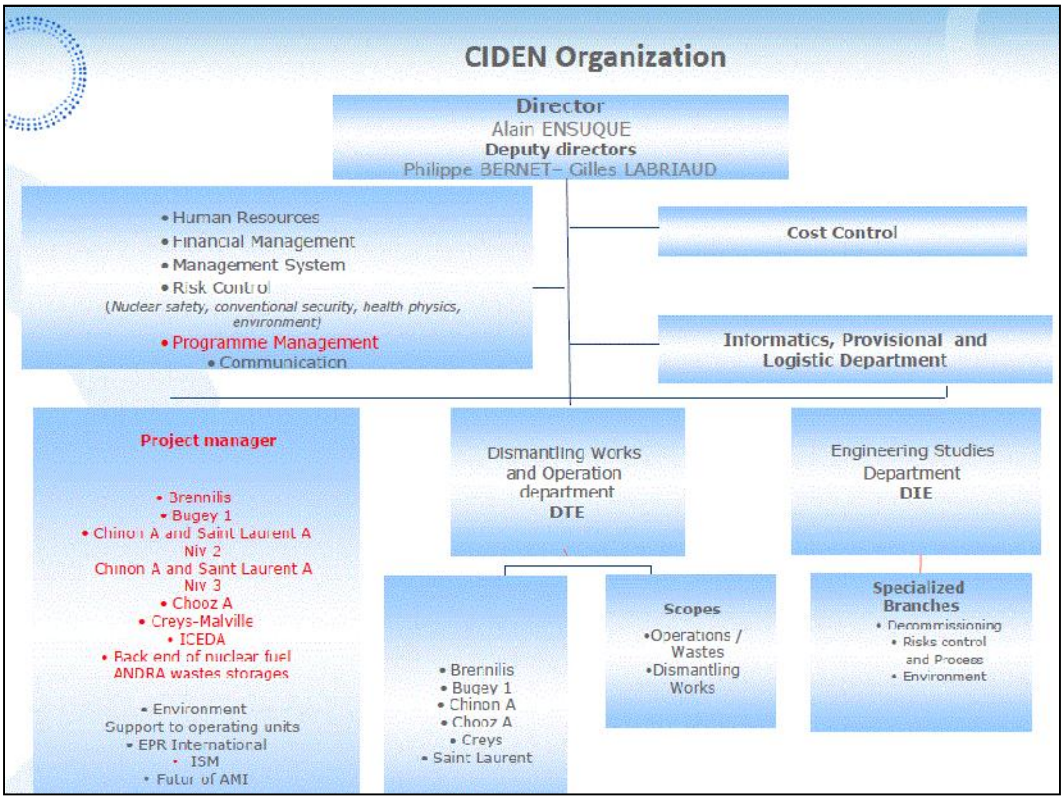
Figure 14: Decommissioning responsibilities within EDF organisation



Source: (Laurent 2011)

Figure 15 shows the internal organisation and the responsibilities within CIDEN.

Figure 15: The overall CIDEN organisation



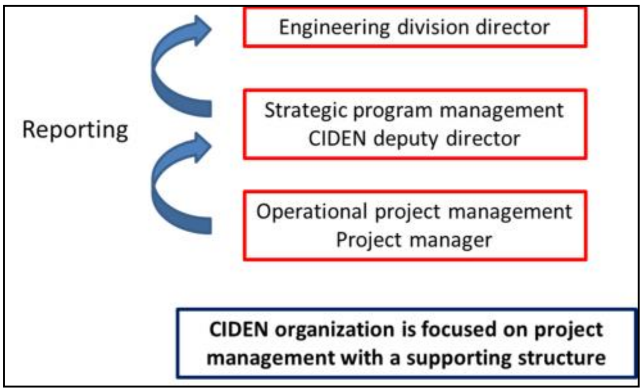
Source: (Laurent 2011)

The risk and financial control together with the financial management and overall management system are the umbrella organisational unities. At the lower level in the hierarchy the project manager is responsible for the several nuclear plants to be decommissioned.

3.2.3. Project management

In Figure 16 the project management of the decommissioning project is shown.

Figure 16: Project management by CIDEN



Source: (Laurent 2011)

The CIDEN deputy director is responsible for the strategic program management and reports to the Engineering division director (see also Figure 14 and Figure 16). As Figure 15 shows, the liability for the operational project management is located on the project manager level. The long and short term project and data management as well as the reporting are organized at several levels (Laurent 2011):

- The long term project vision is focused on the scheduling, reference costs, waste and the technical reference scenario. It is prepared by the programme manager and by the project managers (see Figure 16).
  - A data book that is updated every three years and contains: strategic scheduling, important hypothesis, expenses, engineering and operation resources, waste production by project and sub project and spreading until the end of project.
  - Risk and solution analysis etc.
- The mid-term vision (5 years) plan includes key milestones and allocated resources. It
  - Holds **global indicators** allowing to control the projects evolution and data book adequacy: working and financial progress,
  - Is consolidated by programme management, and
  - Performs a risk review.
- The annual vision 'N+1' (Annual Achievement Contract) includes annual important steps and allocated resources:
  - Project weekly meetings to coordinate short term operations,
  - Detailed work scheduling update (site, weekly basis),
  - Treatment of real time issues as far as necessary (by useful means).

The Planisware (OGOPA) software was introduced as a necessary supporting element for project planning.

3.2.4. Risk management

Risk management/risk control is located in the hierarchical structure by the umbrella organisational unities. EDF general management includes an overall risk management (EDF 2013), based on broad definition of risks. As described in the previous chapter, risk and solution analysis is included within the long term project, while risk review is included within the short term project and data management.

3.2.5. Regulatory approach

As regulatory authority, the independent administrative '*Autorité de Sûreté Nucléaire (ASN)*' - Nuclear Safety Authority - was initiated in 2006, mandated by the Nuclear Transparency and Safety law (TSN 2006). ASN is responsible for regulating nuclear safety and radiation protection.

ASN comprises the former General Directorate for Nuclear Safety and Radiological Protection with its 11 regional divisions ('*Direction Générale de la Sûreté Nucléaire et de la Radioprotection, DGSNR*') under the authority of the ministers for health, the environment and industry as well as other state departments. ASN receives technical support from '*the Institut de Radioprotection et de Sûreté Nucléaire*' - Nuclear Safety Research Institute (IRSN).

The total budget of ASN is EUR 142 million per year. This authority shall provide an efficient and credible nuclear regulation. The core tasks are:

- Regulations covering diverse activities and installations;
- Inspections;
- Information.

ASN has 8 subdivisions on national level and 11 on local level. Herein, the national subdivision - Waste Research and Fuel Cycle Facilities Department (DRC) - is responsible for decommissioning issues and coordinates the relevant local divisions.

The life of the nuclear power plant is, as defined ASN provisions, divided into 2 stages: operation and dismantling. The dismantling stage consists of two sub-phases called 'end of operation' and 'definitive shut down'. During the definitive shut down stage, the dismantling is prepared and after that performed under the framework of a new license (decree) for dismantling. The French licensing procedure foresees only one decree for the whole dismantling of the plant. This simplifies the licensing procedure, provides clarity for the safety authorities and allows less formal administration by the operator. The licensing procedure involves licensing for the dismantling itself and the overall safety license during decommissioning.

Licensing

The licensing procedure for the decommissioning stage occurs in two phases:

- End of operation phase:

  The operator has to inform the ASN in written form about the definitive shutdown 3 years in advance. The information has to include the description of the work to be performed, the modification to the organisation of the plant, the time schedule and the description of the plant in the corresponding state.

- Dismantling phase:

  An application for a license (decree) has to be delivered to the relevant ministries one year before the definitive shut down. The application consists of altogether 11 documents, the most important of which are:

  – Initial state of the plant (before definitive shutdown),
  – Main steps of dismantling,
  – Various maps,
  – Safety analysis report,

- Description of the plant premises,
- Environmental impact study,
- Operating rules for monitoring and maintenance.

Based on those documents being delivered by the operator, ASN determines whether the technical scenario, the organisation and methods adopted by the operator are sufficient to guarantee the safety of the facility in the dismantling process and workers radiation protection. ASN can set conditions in the license or add recommendations in the form of 'technical prescriptions'.

Safety license during decommissioning

ASN summarizes all the requirements in the decree for dismantling and in the technical prescript. The licensing documents have to exactly reflect the current state of the facility and must be evolved along the whole decommissioning phase. The evolutions can be done by the operator, who has then to submit them to ASN and ask for a license amendment (according to the Article 26 or 31 TSN law - TSN 2006) or ask for an internal authorization (according to the Article 27 TSN law - TSN 2006). The evolutions are indispensable before starting every significant step stated in the decree and additionally every 10 years.

EDF's internal authorisation system

EDF has established an own internal authorisation system that is based upon an independent commission on the national level and managed by the Engineering Centre in charge of all the studies for Decommissioning (CIDEN). The commission consists of EDF experts as well as non-EDF experts that are not involved in the plants' operation. The validation process of the internal authorisation system was proposed by ASN in April 2002, was subjected to a testing period of 18 months and finally approved in February 2004. The organisation is being upgraded according to the ASN requirements.

Assurance of decommissioning costs

To cover the decommissioning costs an internal company fund is required. The operator is responsible for all decommissioning costs so all the decisions are made under its own competence and to be discussed with the regulator. The regulatory body requires that the funds for decommissioning are both sufficient and available when needed.

3.2.6. Cost estimates

The total costs of the immediate decommissioning programme and the long-term changes in the estimations

The estimations for the decommissioning costs were firstly calculated within the overall decommissioning projects for all the 9 nuclear power plants to be decommissioned (first-generation fleet) plus three other additional facilities shut down, under construction or still being operated - St. Laurent silos for storage of low level radioactive wastes (LLW), the fuel storage workshop (APEC) and the activated waste conditioning and storage facility (ICEDA).

The mentioned 9 reactors are of four different types (see Table 3: Development in cost estimations for the 9 reactors (plus storage facility St. Laurent) in million EUR). Cost comparison is therefore difficult because of different technical installations etc. The last estimates showed for example that the costs for dismantling of Chooz A (PWR type) are equivalent to 68 % of the average costs for the Brennilis HWR.

The total dismantling costs for the 9 reactors with ancillary facilities were estimated at EUR 4 billion in 2010[7]. Of these total costs only EUR 1.5 billion were covered by set-aside funds, the remainder was not covered at the end of 2010 (CdC 2012).

The parameters and the approach for the costs estimation by EDF

To minimize the uncertainties in the costs estimates, the dismantling costs are calculated as estimates drawn up and regularly revised by EDF. The estimates are based on all the technical, financial and contractual data available at the time at which they were made. The operations to be carried out are listed and the costs for each operation are evaluated using parameters relating to the quantities to be processed, unit costs and completion times. Cost brackets for all these parameters are determined and a probability of occurrence is assigned to them. A subsequent sensitivity analysis of these parameter helps to identify the degree of uncertainty. From one revision to the next, information from the site where the dismantling is in progress is extrapolated appropriately. Evaluation using data gathered in the previous and current years for the engineering works, site and waste costs is subsequently carried out.

In Table 3 the developments of the cost estimations for the 9 reactors (plus the storage facility St. Laurent) to be decommissioned are listed for demonstration (in CdC 2012 according to EDF data).

[7] The total estimated amounts for dismantling of the reactors alone (without Superphénix) represents approx. 43 % of their construction costs (EUR 6.1 billion in 2010, overnight costs + interim interests during construction). See CdC 2012.

Table 3: Development in cost estimations for the 9 reactors (plus storage facility St. Laurent) in million EUR

FACILITIES	REACTOR TYPE	DISMANT-LING COMPLETED IN	2003 ESTIMATE FOR 2003	2006 ESTIMATE FOR 2006	2008 ESTIMATE FOR 2008 PRICES	2008 ESTIMATE FOR 2010 PRICES
Chinon A1 Chinon A2 Chinon A3	GCR	2035 2034 2031	649.0	586.5	810.0	820.4
St. Laurent A1 St. Laurent A2 Silos	GCR	2036 2031 2025	733.0	614.8	803.0	813.3
Bugey 1	GCR	2026	373.0	289.9	412.0	417.3
Brennilis	Heavy water	2023	260.0	265.6	373.0	377.8
Chooz A	PWR	2019*	224.0	216.5	220.0	222.9
Creys-Malville	Super-phénix	2026	952.0	912.4	943.0	955.1
TOTAL			3 191.0	2 885.7	3 561.0	3 606.8
TOTAL NORMALIZED TO 2010			3 598.4	3 074.6	3 606.8	

* According to CIDEN in Lelong 2011, the overall dismantling shall be completed between 2020 and 2025

Source: (CdC 2012)

The estimate for 2008 amounts to EUR 3 606.8 million (in 2010 prices).

Comparison of estimates between single years has to be treated with caution. For instance, the drop between the 2003 and 2006 estimates is due to the absence of charges in relation to the disposal of waste. The increase between 2006 and 2008 on a like-for-like basis for the listed facilities is 17.3 %. The changes in the costs vary considerably with the type of the reactor and are also in different cost categories (e.g. for engineering works, site and waste costs).

The variations in the estimates are mainly due to administrative reasons like finding a new site for a disposal facility that delayed the schedules for dismantling by 5 years. This resulted in a revision of the time planning, as the site selection procedure was not appropriately taken into account. In the case of Brennilis, the annulment of the authorizing decree for dismantling by the Council of State due to legal reasons caused cost increases because of postponed works and additional studies for obtaining a new decree. The other reason was of industrial nature, with the identification of significant additional costs for the works to be carried out.

The last line in Table 3: Development in cost estimations for the 9 reactors (plus storage facility St. Laurent) in million EUR normalizes the cost estimates for the reference year 2010 to make them more comparable. As can be seen from these numbers the cost estimates are fairly stable over the years and show no systematically accelerating trend.

The importance of careful and reliable costs estimation can be seen from the experiences made during the real decommissioning works. So EDF noted in its internal audit report in March 2011 that because of difficulties caused by several administrative processes (as mentioned above) the costs can increase. Further, faster use of the budget for Chooz A than expected was reported.

The main cause for the above mentioned uncertainties is seen in CdC 2012 in the fact that the approach used for the estimation by EDF consists of calculating cost brackets for all the parameters across all the facilities where a probability of occurrence is assigned (as explained above). CdC 2012 recommends the use of uncertainty margins for costs, as there is always a remaining scope of uncertainties because of lacking precedent experiences.

The cost estimation for all EDF reactors being currently in operation

The following overview of the costs estimations for the EDF fleet of 58 reactors demonstrates the importance of the proper method used for these estimations, that should be interlinked with timely preplanning of decommissioning works.

EDF defined basic characteristics influencing directly the costs estimations for the dismantling[8] of 58 reactors currently operated. All the reactors of the fleet are of the PWR type (pressurized water reactors). Here, a duration of 40 years for operation and subsequent immediate dismantling were assumed. The expenditure amounted to EUR 18,4 billion (price base 2010). This corresponds to the equivalent of 19 % of the initial construction costs for the power plants concerned (EUR 96 billion in 2010, overnight costs + interim interest (CdC 2012)).

Costs for dismantling reactors in Germany, Belgium, Japan, UK, Sweden and USA were analysed and applied to the EDF PWR fleet in operation. In Table 4, the summarization of this comparison is presented. This demonstrates how costs range across countries and as a function of different estimation methods.

[8] The stages following final shutdown of a nuclear power plant through to its decommissioning

Table 4: Extrapolation of the costs of dismantling the current fleet, 11 international references, in billion EUR in 2010

COUNTRY AND AMOUNT OF ESTIMATING METHODS	EDF	SWEDEN	BELGIUM	JAPAN	USA (3 METHODS)	UK	GERMANY (4 METHODS)
Extrapolation for 58 reactors	18.1	20	24.4	38.9	27.3 33.4 34.2	46	25.8 34.6 44 62

Source: (CdC 2012)

As can be seen the estimated fleet decommissioning costs, as compared on a relatively shallow basis and not considering a detailed analysis (facility-specific estimates, special effects, national framework conditions, etc.), are in most cases in the order of EUR 20 billion, with a variation range of a factor of two (several cases) to three (single case, maximum). The identified differences are relevant for the case they were calculated for (how large shall set-aside funds for decommissioning be), but are too shallow to yield a reliable comparison base for specific facilities in other countries, of a different size and operating history, etc.

Conclusions

The cost estimates for the decommissioning of the existing reactors that are under shut down state at EDF are made on a basis:

- Of facility-specific decommissioning plans that reflect the recent planning progress status and are detailed enough to yield reliable estimates for the purpose they are made for (evaluation of the set-aside funds within EDF's assets);
- Of a continuous update, so that the estimates reflect the current execution state and the recent knowledge/experience status of the projects;
- That yields robust results, if these are based on the same price base (reference year).

The cost analysis estimates are state-of-the-art and can be used as best-practice reference: cost analysis for decommissioning projects should not be performed with a smaller degree of detail or with less reliable methods.

The analysis for the decommissioning of EDF's complete reactor fleet under operation is less reliable as it simply up-scales figures gained from one project (Chooz A) that is currently in an early state of decommissioning to the complete reactor fleet to yield the necessary reserves of funds for this purpose. The doubts that the '*Cour des Comptes*' has raised (CdC 2012) concerning the reliability of those long-term estimates are therefore understandable. Those estimates do not contribute to the identification of best practices and are not used any further.

3.2.7. Workforce

EDF has completely restructured the decommissioning section by setting up CIDEN, for which the main functions have been described in chapter 3.2.2.

Altogether 540 persons are employed by CIDEN. 200 of them are distributed across 6 plants and 340 are working at the head office located in Lyon. The CIDEN project team directly at Chooz A involves 21 persons with clearly defined tasks.

So the relevant steps of:

- Having setup a section within the company exclusively responsible for planning and project management of the decommissioning with a complete distance to operational structures;
- Having responsible planners and workers that are familiar with the facility in effectively one dedicated organisation structure,

ensures that the structure can be optimized for the decommissioning task and that potential frictions between previous structures and the new task can be avoided.

Another decision that is not explicitly mentioned in the available documents but can be derived from the descriptions is that EDF fully uses its own workforce to perform the work and scarcely uses external consultants. With that, the knowledge and experience of employees is preserved, can be used in the planning and execution and, in the long term, can later be used in the decommissioning of reactors that are now under operation.

Conclusions

The characteristics of the EDF decommissioning projects in respect to the workforce are:

- A complete new setup of the responsible parts of the organisation;
- The preferential use of available knowledge and experience;
- Preferring the accumulation of internal know-how instead of extensive execution of tasks by external consultants.

3.2.8. Financial control

EDF is constituted like a private company (stock company), so financial control over the decommissioning project is many-fold:

- EDF management, responsible for the well-being of the whole company, has to assure that the decommissioning costs are kept as low as possible.
- The stockholders (mainly the French Government, 84.44 % as of 31.12.2012) control the company's assets.
- The French government in the form of its nuclear regulators has to ensure that the company has enough resources set aside to cover the expenses that are necessary to decommission the reactors.

Regulation of decommissioning funds

The regulator organisation ASN's opinion is that it is essential that the funds required for decommissioning nuclear installations and managing radioactive waste be both sufficient and available when needed.

Further, the national regulation in France demands dismantling cost estimates to be conservative. The reserves for dismantling and decontamination - technical decommissioning in the narrower sense - of a nuclear facility has to be fully collected already at the start of its operation. As this legislation was newly introduced, EDF was granted a transition period until 2010 to build up those funds (WICEE 2007). The securing of financing of nuclear costs is regulated in Article 20 of TSN 2006.

The securing of financing of nuclear costs is regulated in Article 20 of Programme Act 2006-739 of 28 June 2006. This article is clarified by decree no. 2007-243 of 23 February 2007 and the order of 21 March 2007 (ASN 2008).

- According to this, operators must submit a report every three years containing a cost assessment and describing calculation methods and choices made concerning assets and their management; they must also submit an annual update to the report and immediately inform the authority of any significant event in this area.
- A national committee is set up to assess the funding of basic nuclear installation decommissioning and spent fuel and radioactive waste management. It also verifies that provisions are made to cover future costs and that assets are properly managed for this purpose. The committee must submit a report to Parliament and to HCTISN, the French high committee for transparency and information on nuclear safety. EDF has to submit an assessment, describing the calculation methods and making choices concerning assets and their management; and to annually update this report. EDF has to immediately inform the authority of any significant event in this area.

EDF’s control system for decommissioning

EDF developed a controlling system which utilizes work progress and finance progress indicators for its decommissioning projects.

The work progress indicator is calculated and updated on a quarterly basis. The measurement of the work progress indicator is based on the fulfillment of representative tasks within each subproject (the lowest hierarchy level of the project) and according to the milestones. The passed milestones are recorded and compared with the programme reference - forecasted physical progress is compared with the realized physical progress. The work progress indicator is then compared with the project financial progress ratio.

Selected example EDF: Chooz A

Chooz is the only pressurized water reactor currently being dismantled in France.

Chooz A was the first commercial PWR built in Europe and the first PWR that is being decommissioned in France. Chooz A was commissioned by the Franco-Belgian Nuclear Energy Company of the Ardennes (SENA), a joint venture created in 1960 by EDF and a group of Belgian utilities.

Construction at Chooz A started in 1961 and generation commenced in 1967.

The plant was installed deep inside the bedrock of a hill in the Ardennes into two excavated caverns where the reactor and auxiliary installations were accommodated. In the building at the top of the hill were placed the emergency core cooling system and the ventilation stack. A steep, wide access gallery containing pipework connects those buildings to the reactor cavern and the nuclear auxiliary cavern 200 m below, 60 m from the side of the hill. A drainage system collects water percolating through the hillside in case of potential contamination.

Chooz A was shut down in 1991, and the responsibility for decommissioning was transferred from SENA to EDF, which had adopted a deferred dismantling strategy at that time. By December 1995, all the fuel had been removed from the facility and was dispatched to Cogema (now AREVA).

Many works were started already in 1999, the circuits had been drained, industrial waste removed and the turbine hall equipment dismantled.

EDF later set an ambitious target of completing decommissioning by 2016 (NEI 2010).

A public enquiry was carried out in 2006, and in September 2007 a decommissioning license was issued authorizing total dismantling of the plant.

Dismantling, clean up and demolition of nuclear buildings on the hillside, dismantling of service tunnel facilities (including the tunnel linking the cavern bottom to the other facilities on the site) took place before 2008.

The decommissioning schedule foresees three time periods (Lelong 2011, NEI 2010):

- 2007-2008: planning work (ventilation, waste removal, etc.);

  2008-2016: sub-steps dismantling of nuclear auxiliary cavern (2008-2012) and dismantling of reactor caverns (2012-2016). Until 2016, the equipment within the caverns will be dismantled except the apparatus needed to collect, monitor and release the drained water from within the hill;
- As of 2016: Decontamination and regeneration of the site.

The decommissioning operations are expected to be completed by 2020-2025.

After the end of the aforementioned works, the plant remains under surveillance for several years. The water from inside the caverns shall be collected and tested until the radioactivity levels are reduced (remaining radioactivity from reactor) so that the discharge can take place without tests. At the end, the components remaining in the nuclear auxiliary cavern and the waste treatment facility will be dismantled. After the finishing of these activities - planned to be completed by 2020-2025, the underground structures will be emptied of electromechanical components and their civil engineering structures will be decontaminated; subsequently, the caverns will be partially filled to avoid the subsidence (NEI 2010).

3.2.9. Overall characteristics of the example

- The time schedule

  The development of an appropriate decommissioning strategy and of the respective regulatory issues in France needed a lengthy process:

  – The evolution of the decommissioning strategy from deferred decommissioning in the late 1980s, with safe enclosure lasting 50 years, towards the immediate decommissioning concept in 1999 was a 10-year process.

  – The corresponding regulatory issues, clearly defining the responsibilities and the establishment of the relevant regulatory body (ASN) only occurred in 2006.

  – The required legal framework was set up in 2006.

  – The first decommissioning project - Chooz A – with the target of completion by 2016 (finishing of dismantling of the reactor cavern) is seen as an ambitious project. The subsequent decontamination and regeneration shall be finished in 2025 at the latest, so the complete process from shutdown in 1991 to final decommissioning will have taken 34 years.

- The experiences with the decommissioning projects

  The experiences are still seen as insufficient and will mainly be obtained during the first decommissioning projects and, hopefully, by sharing the experiences with others.

  – Chooz A is the first PWR that is being decommissioned by EDF in France.

  – EDF expects to gain expertise in terms of schedule, cost, worker exposure, safety and waste management during the decommissioning of Chooz A.

- Costs estimates and financial control

  The basic requirements as regards the costs estimates and control system were properly introduced by ASN within relevant regulatory requirements. A national controlling system with relevant liabilities was defined. A supporting framework for the operator is thus given and simultaneously the operator has the required freedom for own decision making.

  – The operator is responsible for the funds to cover the decommissioning costs.

  – As the regulatory body requires that the funds for decommissioning be both sufficient and available when needed, the operator developed long term financial planning with a corresponding controlling system and cost estimates.

  – The performed cost estimates varied within wide ranges throughout the years in which the estimations were made. This was due partly to contingencies and uncertainties of administrative and industrial nature. These should be better analyzed separately for every reactor (based on the experiences in the past) and taken up in the cost estimations together with uncertainty margins.

- The proper method for estimation plays an important role, so using several methods and comparing them to improve the accuracy of the estimation should take place.
- This should be connected with regular reviews of estimates as the project progresses.
- The experiences made within the decommissioning of one reactor is highly valuable but often specific to a given reactor type/site. There must be careful evaluation of which cost relevant experiences can be transferred to other decommissioning projects.

* Organisation, project planning and project management

  The adaptation of a new organisation within EDF with clarification of relevant responsibilities occurred in 2001. Introduction and application of project planning and project management has been started as a comprehensive project for all 9 plants to be decommissioned. The plan concretization especially for Chooz A was delayed partly because of adaptation to the changed regulatory framework.

  - A special unit with 540 persons responsible only for decommissioning, CIDEN, was established and responsibilities set out within EDF in 2001 before starting the works.
  - The CIDEN organisations with the relevant responsibilities are clearly defined; the overall management and controlling system is developed as an umbrella organisation for the decommissioning of all 9 plants.
  - A comprehensive project planning including all the 9 plants to be decommissioned was developed.
  - In 2007, a decommissioning license was issued for Chooz A.

* Regulatory framework

  An independent administrative Nuclear Safety Authority (ASN) with a special subdivision responsible for decommissioning issues was established in 2006. The licensing procedure was simplified as far as possible so that the clarity for the safety authorities is assured and licensing procedures entail less effort for operators. The license amendment procedure in the course of the project is regulated and flexible enough to cover changing needs.

  - The operator has to inform the ASN in written form about definitive shutdown 3 years in advance.
  - The licensing procedure for the dismantling stage occurs in two phases, the relevant documents with their contents to be delivered are defined.
  - Based on the delivered documents, ASN expresses conditions or recommendations in the form of technical prescriptions.
  - During the ongoing decommissioning project relevant planning documents are evaluated by the regulator. Depending from the evolution results, the operator can either ask for a license amendment or for internal authorization of the changes. This provides a flexible regulatory framework that can be adapted to the changing needs during the different phases of the decommissioning project.

– The operator has an internal authorization system on which its decisions are based, an independent internal commission and the umbrella organisation CIDEN.

3.3. SELECTED EXAMPLE FROM UK: NDA-SELLAFIELD

As part of the search for best practices, an example from UK is described in detail.

3.3.1. Overall framework of the decommissioning project

In the UK, the Nuclear Decommissioning Authority (NDA) was set up under the Energy Act 2004 (Energy Act 2004) is responsible for the decommissioning and the clean-up of 19 civil nuclear power plants. The NDA is a non-departmental body sponsored by the Department of Energy and Climate Change.

The NDA contracts out the delivery of site programmes to Site License Companies. These contracting companies are the ones who are responsible for the day-to-day operations. That means that NDA itself does not directly manage the sites. NDA and the Site License Company agree on a Management & Operations Contract for the delivery of all work in accordance with specified terms and conditions.

The Site License Companies each have a Parent Body Organisation which owns the share of the Site License Company for the duration of the contract with the NDA. The NDA and the Parent Body Organisation enter into a contractual arrangement via a Parent Body Agreement. The Parent Body Agreement specifies the obligations of the Parent Body in areas such as financing, deployment of key resources and the enhancement of performance in key areas.

In its business plan for 2013-2016 (NDA 2013a) the NDA characterizes the Sellafield site as its top priority. This is why the following descriptions are concentrated on the Sellafield site only.

Sellafield is a huge and complex nuclear site in West Cumbria, UK. It consists of the nuclear power plants Windscale and Calder Hall, the ponds and silos, reprocessing plants and other facilities which need to be safely decommissioned.

Calder Hall was the world`s first commercial nuclear power plant being operated from 1956 until 2003. Windscale comprises three reactors. Two were shut down in 1957, the third in 1981. In 1957 a fire damaged one of the reactors (Pile 1), which makes its decommissioning a 'significant challenge' (NDA 2011a).

The roles and responsibilities of the different players in charge of the decommissioning at Sellafield are described in further detail in the next chapter.

The overall decommissioning strategy and programme is described in the Sellafield Plan (NDA 2011b). A first such plan was delivered in 2007, but it was criticized as not being underpinned and credible (House of Commons 2013). Therefore a new plan was developed and published in 2011. The NDA believes that this plan is credible but uncertainties remain.

According to the NDA`s business plan for 2013-2016 (NDA 2013a) its current focus is

> *'to ensure the site remains safe and secure and to make demonstrable progress in tackling the high hazard legacy facilities on the site'.*

As stated in a White Paper of the Government (WPC 1995) decommissioning in the UK should be carried out 'as soon as reasonably practicable taking account of all relevant factors'. But the

Government recognized that 'it may also be more appropriate to delay particular operations to benefit from new or developing technologies or from further development of existing best practice, or to take advantage of radioactive decay.' The best solution should be determined on a case-by-case basis (UK Government 2004).

At Sellafield a deferred decommissioning strategy for the nuclear power plants was chosen. According to the Decommissioning plan (NDA 2011b) the Calder Hall site will enter a 'care and maintenance phase' in 2024 and Windscale Pile 1 and 2 in 2030. Between 2105 and 2115 the Calder Hall site should be finally cleared. The final site clearance is planned for 2120. The care and maintenance phase means that the reactors buildings will be made 'safe and secure and placed under a routine surveillance schedule' until the final stage of decommissioning will start after approx. 70 to 80 years. This deferred decommissioning as well as the continuous decommissioning both had been shown by the Strategic Environmental Assessment to offer long-term environmental benefits, as NDA explains in its decommissioning strategy (NDA 2011c). However, NDA acknowledged in the same paper that the continuous decommissioning potentially provides the greatest benefit. Nevertheless, NDA chose the deferred option arguing that a care and maintenance phase will take advantage of the natural radioactive decay of the nuclear materials and to allow the establishment of disposal facilities prior to the clearance phase.

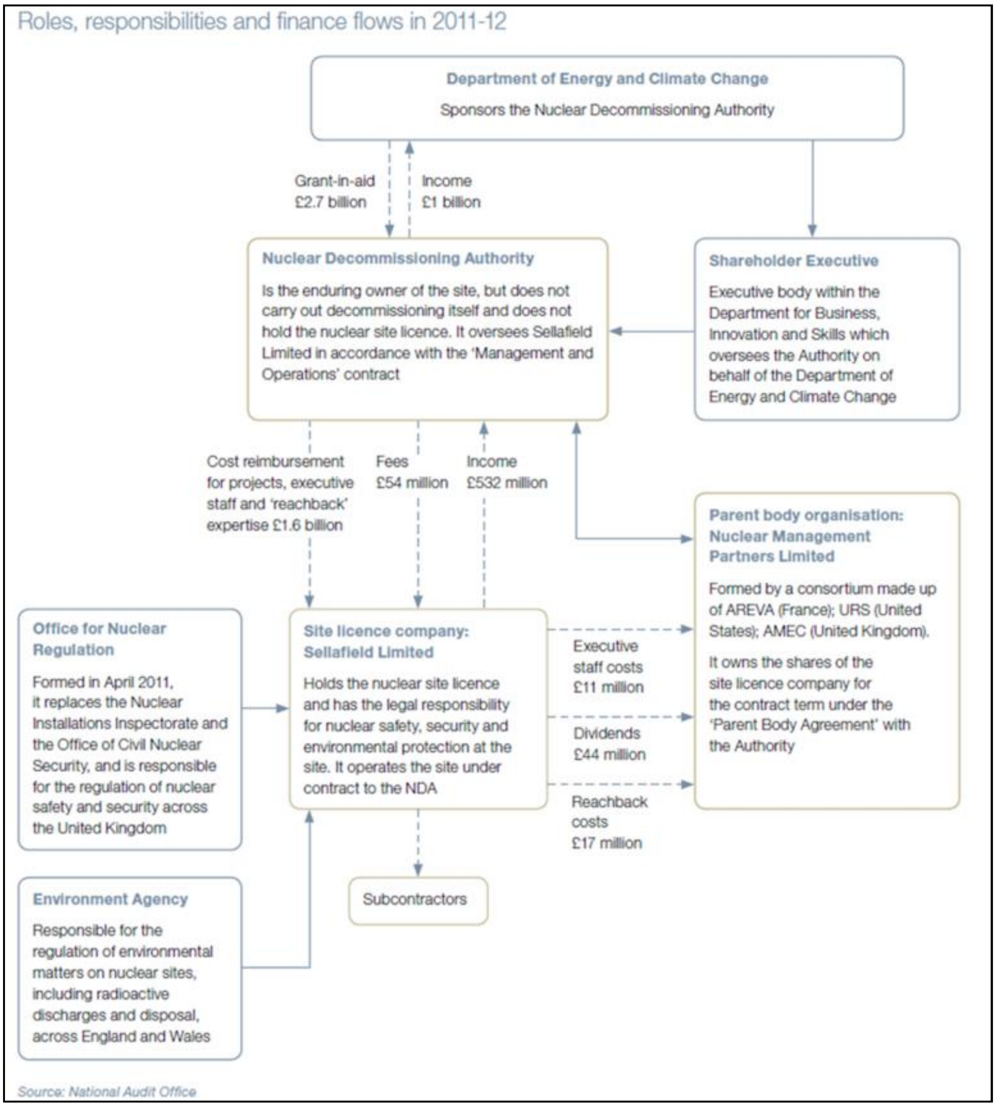
3.3.2. Organisation structure of the decommissioning

At Sellafield, the company Sellafield Ltd is the responsible Site License Company that manages and operates the decommissioning in Sellafield. NDA`s responsibility is to oversee Sellafield Ltd.

After a 2 year phase of completion, Nuclear Management Partners (NMP) was chosen on 11th July, 2008, as a new Parent Body for Sellafield Ltd. The Nuclear Managements Partners Ltd was especially created to bid for the Sellafield PBO competition. It is a consortium of the companies URS of the US, the British AMEC, and AREVA of France. The initial contract is for five years, with extension options to 17 years (NDA 2008). Every five years the process will be reviewed (NDA 2011b). The NDA and NMP entered into a contractual arrangement via a Parent Body Agreement, and the NDA and Sellafield Ltd agreed a Deed of Variation to the existing Management & Operations Contract to take account of the new Parent Body arrangements.

The roles and responsibility as well as the finance flows in 2011 and 2012 are shown in Figure 17.

Figure 17: The roles and responsibilities as well as financial flows in 2011-2012



Source: (NAO 2012)

3.3.3. Project management

According to the House of Commons failures in the project management at Sellafield caused delays and cost increase (House of Commons 2013). The concerns about the earlier management team at Sellafield were the main reason for appointing the Nuclear Management Partners as the new Parent Body Organisation.

For example great amounts of money were spent on building a plant to treat waste, but then it emerged that the facility, due to its design, could not deal with the waste safely (NAO 2012).

In 2010, Sellafield Ltd changed its approval processes in order to ensure that construction would not start until design requirements and the underpinning technology reaches an appropriate level of development. A readiness board has to review the proposals (NAO 2012).

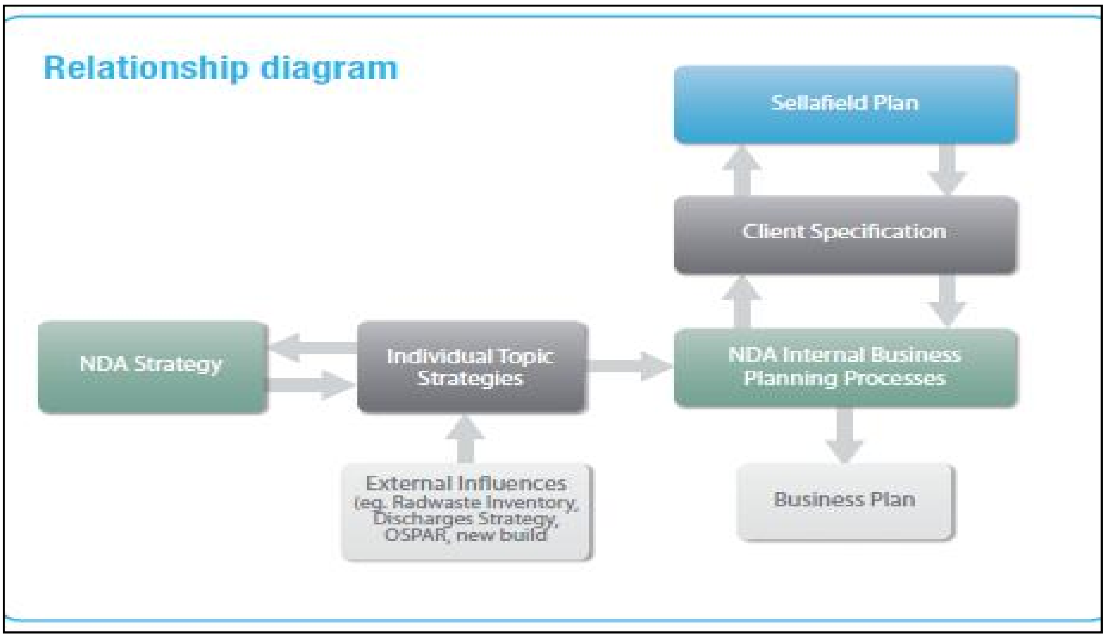
Performance in Sellafield has been improved after the appointment of Nuclear Management Partners, mainly because NMP has deployed staff short- or long-term as secondees from its parent companies

URS, AREVA and AMEC. But still the performance did not meet the planned level (NAO 2012). In total, only 3 of 14 projects are on or ahead of schedule (House of Commons 2013).

The Sellafield Plan 2011 is, according to House of Commons Office, more credible than the 2007 plan, but it is not clear yet whether it is 'sufficiently robust' (House of Commons 2013). Still, since the 2007 plan was rejected by NDA as 'undeliverable' (NAO 2012), improvements in the project management are visible. The new Parent Body Organisation Nuclear Management Partners firstly carried out an assessment of all processes across Sellafield against industry best practice in order to identify areas where changes in the management are needed (NDA 2011b). The 2011 plan identifies the key plants and projects (NDA 2011b), but uncertainties in the Sellafield plan remain. NDA revised the plan, but had no robust benchmarks to make judgments on proposed levels of performance in order to accelerate the process (NAO 2012). The NDA could also not determine whether critical paths for completing programmes and projects were correctly identified, as the Sellafield plan did not clearly show dependencies between them (HM Treasury 2013). The NDA is trying to create a benchmarking tool to be rolled out in Sellafield (NAO 2012).

The Sellafield plan is supported by other documents like e.g. the NDA strategy papers and Business Plans (see Figure 18). The NDA needs to update its decommissioning strategy every five years. In 2010 a public consultation about the new draft strategy was undertaken. According to the Energy Act 2004, the strategy has to be approved by the Secretary of State jointly with the Scottish Ministers. The first such strategy was produced in 2006 and revised in 2011 (NDA 2011c). The NDA Business plan sets out the near term objectives for a three year period.

Figure 18: Relationship between several important documents



Source: (NDA 2011a)

According to the National Audit Office NDA and Sellafield Ltd suffer gaps in information and weakness in communication between each other. NDA did not collect enough robust and timely information on projects from Sellafield Ltd until 2011. Because of this they were unable to intervene in time (NAO 2012). The National Audit Office recommended an accurate and timely reporting and monitoring to be able to identify emerging issues early on NAO 2012.

3.3.4. Risk management

The Sellafield Plan 2011 sets out measures for risk reduction for several of the Sellafield projects (NDA 2011b). According to the findings of the National Audit Office the Sellafield plan 2007

> *'did not provide sufficient information to allow NDA to understand programme-level risks fully' (NAO 2012).*

According to NDA *'the Windscale programme is not on the critical path, therefore the programme has been subject to a number of deferrals'* and the time and funds have been transferred to other projects (NDA 2013b).

In 2011, the first fuel started to be removed from Calder Hall. This was the start of a six-year programme for removal and a significant step in risk and hazard reduction (NDA 2013c). The fuel is planned to be stored elsewhere at the Sellafield site for reprocessing.

3.3.5. Regulatory approach

The Office of Nuclear Regulation, an agency of the Health and Safety Executive (HSE) formed in 2011, is responsible for the regulation of nuclear safety and security and the Environmental Agency is responsible for the regulation of environmental matters on nuclear sites including radioactive waste disposal (see NAO 2012). According to the Office of Nuclear Regulation the decommissioning is conducted normally in three stages (ONR 2013):

- Stage 1 - Post-operational clean out where the bulk of the radioactive material, such as fuel, is removed from the facility.
- Stage 2 - Initial dismantling and removal of contaminated parts or care and maintenance to allow radioactive materials to decay.
- Stage 3 - Dismantling of the facility, demolition of the structure; and remediation of land and water to meet an agreed end-state for future use.

3.3.6. Cost estimates

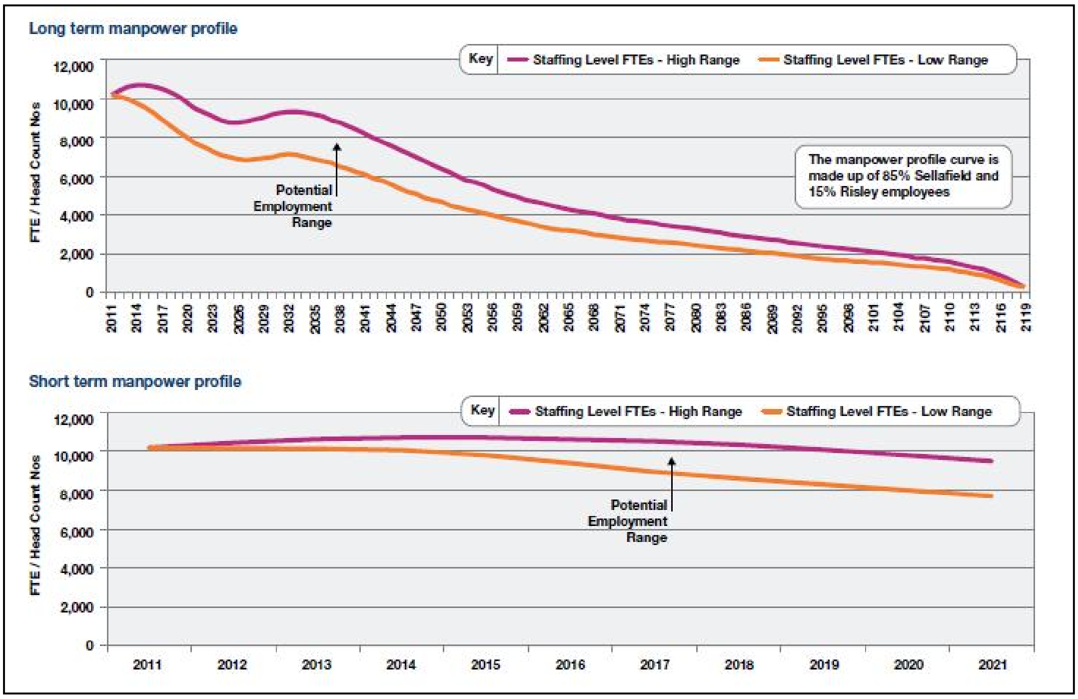
Since most of the major projects at Sellafield are complex and unique, cost estimation is difficult and uncertainties remain. The Sellafield 2011 plan includes outline estimates for costs for key projects but did not provide sufficient data for reliable estimates. In its revision, the NDA found a lack of consistency in the contingency contained within the estimates (NAO 2012).

The cost estimates in the past years have been increased on a drastic scale. In 2007 the total costs were estimated at £ 61 million, increasing in the 2013 estimate to £ 200 million (House of Commons 2013). This demonstrates the weakness of early cost estimates. The latter number is believed to be more credible than the one from 2007, but still uncertainties remain in the mid-term to 2026 as well as in the long-term to 2120 (NAO 2012).

3.3.7. Workforce

Sellafield Ltd employs approximatively 10,000 people (NDA 2011b). The development of the workforce from 2011 to 2119 is shown in Figure 19.

Figure 19: Development of work force from 2011 till 2119 and from 2011 till 2021



Source: (NAO 2012)

As can be seen from the upper figure ('Long term manpower profile') the concept that these numbers are based on cannot be called a 'safe enclosure period' strategy because of the extremely high employment rates over several decades (until the year 2119). It is unclear from those figures what these many employees shall perform over this very long period. It looks like the work is simply delayed but not structured in conformance with subprojects and work steps. An integration of the curves yields roughly 430,000 man·years in the lower case and roughly 560,000 man·years in the upper case. With an average cost figure for wages of £ 50,000/man·year over the whole period, those wages alone would add up to £ 21,500 million (EUR 26,000 million) in the lower case and £ 28,000 million (EUR 33,000 million) in the higher case. This indicates that either the cost calculation (see chapter 3.3.6) or the employment estimate here are inconsistent, differing by more than a factor of 100.

One argument for choosing the NMP as new Parent Body was that there is the chance to use the expert knowledge available at its parent companies. With this outside expertise the performance in Sellafield was intended to be improved. But critics note the extremely high costs for the external workforce (House of Commons 2013). In 2011-2012 Sellafield Ltd had 16 executives from its parent body and NDA reimbursing their salaries and other costs, e.g. relocation packages. Between November 2008 and March 2012 this summed up to £ 32 million (NAO 2012).

The parent body NMP also uses specialists known as 'reachback' for e.g. managing critical projects and programmes. NDA reimburses the costs plus an additional 10 % contribution to overheads of the parent companies. In 2011-2012 the total cost for the reachback was £ 17 million. In February 2012 the NDA identified decencies in the use of reachback resources. This resulted in the development of a reachback deployment strategy (NAO 2012). Other worries concern knowledge management over the long-term since foreign staff normally stays for only 2 to 3 years and all undocumented experience and knowledge gained is lost.

Sellafield Ltd works together with subcontractors. In 2011-2012 £ 986 million were spent on subcontractors. Of this 6 % was spent on subcontracts with the companies of the Parent body Nuclear Management Partners (NAO 2012).

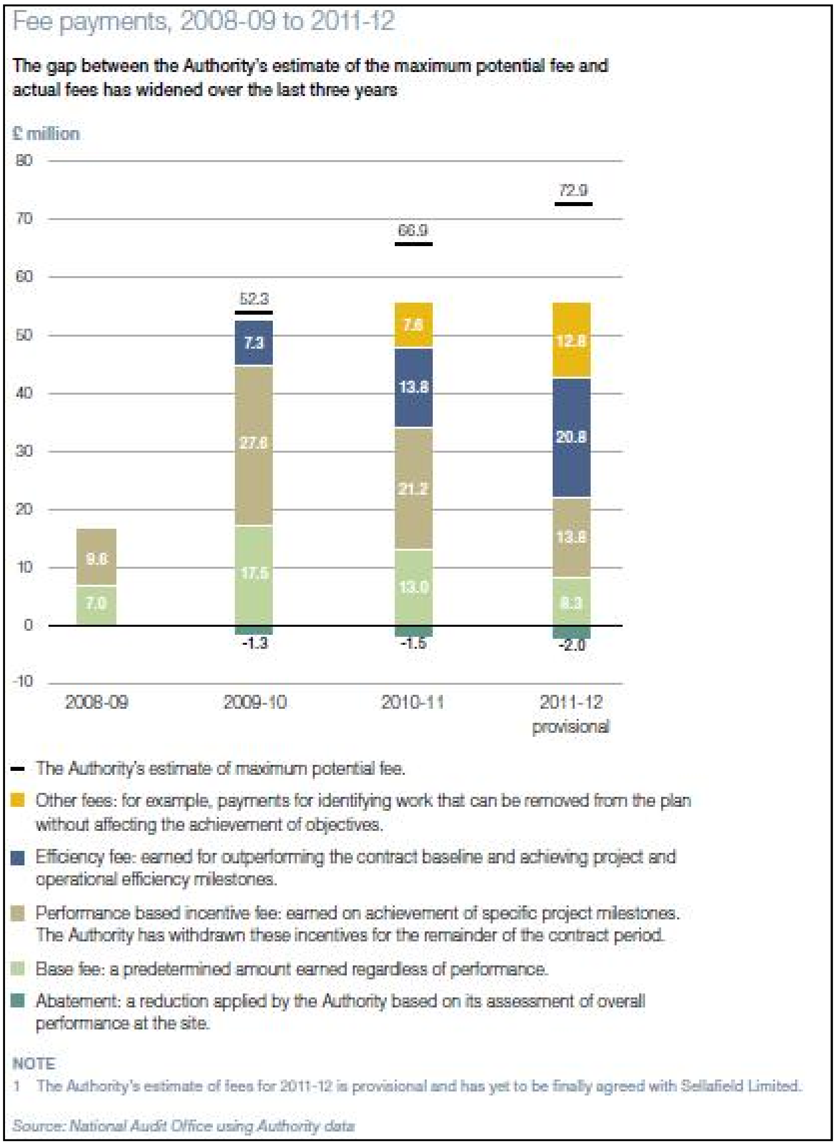
According to the National Audit Office gaps in the capability of subcontractors to undertake the required work have been identified (NAO 2012). The supply chain lacks capacity (NAO 2012). Therefore Sellafield Ltd produced a Procurement strategy in order to identify how to build up the supply chain to meet the requirements of the site (NAO 2012), e.g. waiting days should be reduced etc. Sellafield Ltd (in Sellafield Ltd 2011) now aims to prefer long term contracts with the supply chain organisations instead of the earlier usual short term contracts.

3.3.8. Financial control

The NDA receives funds from the Department of Energy and Climate Change as grant-in aid to manage the site. NDA then reimburses Sellafield Ltd for all allowable costs including the costs for the executives and 'reachback' staff from the parent body. This means Sellafield Limited does not bear risks for delay and cost increases, because the contract with NDA requires it to reimburse Sellafield Limited for all allowable costs (NAO 2012).

Additionally, NDA uses fees to incentivize efficiencies and achieve milestones which mean that NDA pays Sellafield Ltd fees according to the performance. But although the performance is less than planned, fees were still paid in the last years (NAO 2012, House of Commons 2013). The payments for fees in the period 2008-2009 until 2011-2012 are shown in Figure 20.

Figure 20: Fee payments 2008-2009 to 2011-2012



Source: (NAO 2012)

The contracts between Sellafield Ltd and subcontractors are generally reimbursement contracts, which involve very little financial risk transfer. That means Sellafield Ltd has to bear the rising costs and the impact of delays and passes this one-by-one to NDA (NAO 2012). Only some few contracts use a fixed price model or target cost contracts, involving limited risk transfer, where the subcontractor shares the saving if actual costs are lower than the target.

Incomes from Sellafield e.g. via commercial activities are paid to the Department by NDA.

The financial flow for the year 2011-2012 was already shown in NAO 2012 (on page 73).

The NDA routinely reports on performance to the Department of Energy and Climate Change, including on individual projects. It is working with the Shareholder Executive to ensure that the indicators cover the full range of issues. Most major projects require approval from the Department of Energy and Climate Change. But NDA does not report externally on the performance of its major projects (NAO 2012).

Since the Sellafield project is outside the scope of the Major Projects Authority, it is also not reviewed by that authority (NAO 2012). The Major Projects Authority aims to improve project performance for the taxpayer. It is collaboration between the Cabinet Office, HM Treasury and departments and has the fundamental aim of significantly improving the delivery success rate of major projects across central government. It was launched in 2011 (UK Government 2013).

3.3.9. Overall characteristics of the example

Several reasons for cost escalation and delays can be identified in the UK Sellafield case, e.g.:

- Weaknesses in cost and schedule estimation were identified.
- Weaknesses in planning, e.g. of waste treatment facilities, caused delays and cost increases.
- Gaps in information and weakness in communication between NDA and Sellafield Limited were identified. Until 2011 NDA did not collect enough robust and timely information on projects from Sellafield Limited to enable timely intervention.
- The decommissioning concept, with nearly continuous work at the site for more than 100 years and performed by thousands of employees, points to weaknesses in the technical concept, in the work planning as well as in the cost calculation.
- NDA does not report externally on the performance of its major projects. Projects therefore are outside the scope of the Major Projects Authority and thus are not subject to independent reviews.
- Sellafield Limited does not bear risks for delay and cost increases, because the contract with NDA requires it to reimburse Sellafield Limited for all allowable costs. The roles of management quality, work performance, excellent project management and risk control are questionable under such framework conditions.
- NDA uses fees to incentivize efficiencies and achieve milestones, but a major part of the fees are paid regardless of any project progress. The criteria for other fee contributions are intransparent and seem to fail to work properly.
- Sellafield Limited`s contracts with its subcontractors generally involve very little risk transfer. Rising costs and the impact of delays are therefore borne by Sellafield Limited and then passed to NDA and finally to the taxpayer.
- Cost effectiveness is poor, due to extensive use of costly external contractors and workforce. Experiences gained in the process are not accumulated at NDA but remain mostly with the consultants.
- Gaps in the capability of subcontractors to undertake the required work are identified. The supply chain lacks capacity.

The following conclusions can be drawn from this:

- A reliable decommissioning plan is required on which to base appropriate project management, planning and risk management and to perform reliable cost and time estimations on. Without such a reliable plan all these fields will present problems and are prone to substantial mismanagement. Escalating costs and extended delays are then likely.

- Under the current overall management structure of this project a considerable improvement of management control, work performance indicators, financial control instruments and internal timely communication is required to keep the process under control and to allow timely interventions in cases where weak performance requires this.

The overall conclusion, in respect to this study, is that neither the project management nor the organisation form nor the gained performance level in the decommissioning process at Sellafield qualifies as a best practice example.

3.4. SELECTED EXAMPLE FROM GERMANY: EWN GREIFSWALD

The former German Democratic Republic (GDR) operated six nuclear reactors (Rheinsberg, Greifswald/Lubmin units 1 to 5) in its territory, which now makes up the eastern part of the Federal Republic of Germany (FRG). Those were property of the state-owned combine 'Kombinat Kernkraftwerke Bruno-Leuschner'. When re-unification of East- and West-Germany came in 1990, this property was formally transferred to Treuhandanstalt, a privatization agency. The safety of the facilities was evaluated with the finding that major backfitting would be necessary if continued operation of the facilities was to be chosen. Talks were held in 1990 with major nuclear operating companies on a potential takeover of these facilities. These talks brought no viable result, and the property was transferred to the then-owner Bundesministerium der Finanzen (Federal ministry of Finance, BMF), the single owner since 2000. BMF became responsible to organize the decommissioning of the six reactors. This included the assumption of the associated costs because no reserves had been set aside by the previous owner to cover part or all of those expenses.

The following descriptions are based on different sources:

- The information necessary to understand organisational and control issues was received in comprehensive telephone interviews with the operator;
- On certain issues (such as project and risk management) additional descriptions and documents were provided;
- The responsible contact person at BMF provided insights concerning the perspective of the main funder and described decision-making strategic issues and the control over EWN;
- Practical experiences with the decommissioning project were derived from several visits over the past years and working as consultant on behalf of the regulator on the decommissioning of one of the facilities at EWN’s Rheinsberg nuclear power plant provided a close insight.

3.4.1. Overall framework of the decommissioning project of EWN

BMF set up a new organisation for decommissioning, Energiewerke Nord GmbH, a completely federally owned company. The formal structure is a limited liability company, with BMF as the sole owner. This organisational structure, not a state agency but acting like a privately organized company, allowed it to

- Streamline the new management level of the company;

- Define the responsibilities of the acting management;
- Re-organise the whole company structure from operation towards decommissioning.

A central accelerating factor was that after the talks on a takeover had failed it was clear for the management as well as for the workforce that re-opening energy production was not an option any more. That made clear from the beginning that re-organisation and re-structuring was unavoidable, so that this was already accepted in an early stage of the decommissioning project.

3.4.2. Responsibilities, decision making and control structures

From setting up the company under the BMF - a ministry not at all familiar with nuclear, technical or regulatory issues - it was also clear from the beginning that it was expected that the management of the newly created company be solely responsible for all routine decisions and that BMF had more the role of a classical shareholder. The classical shareholder must not necessarily be qualified to track all management decisions, but has to closely control the more strategic management decisions and to evaluate the overall performance of the management in respect to the defined targets (in that case the cost effective and timely decommissioning of the six reactors). At all events the prime responsibility rests with the management.

Among the strategic decisions of the management that had to be decided on were thus the following, many of which had to be taken in an early stage of decommissioning planning:

- To store all spent fuel and all decommissioning wastes in a single large storage facility in order to relieve the dismantling processes of any waste issues that potentially could delay the dismantling;
- To establish waste treatment and conditioning facilities at a large-enough scale;
- To remove and store large components for later cutting, treatment or conditional release;
- To release certain rooms of the facility from regulatory control in an early stage and to provide those for use by external companies;
- etc.

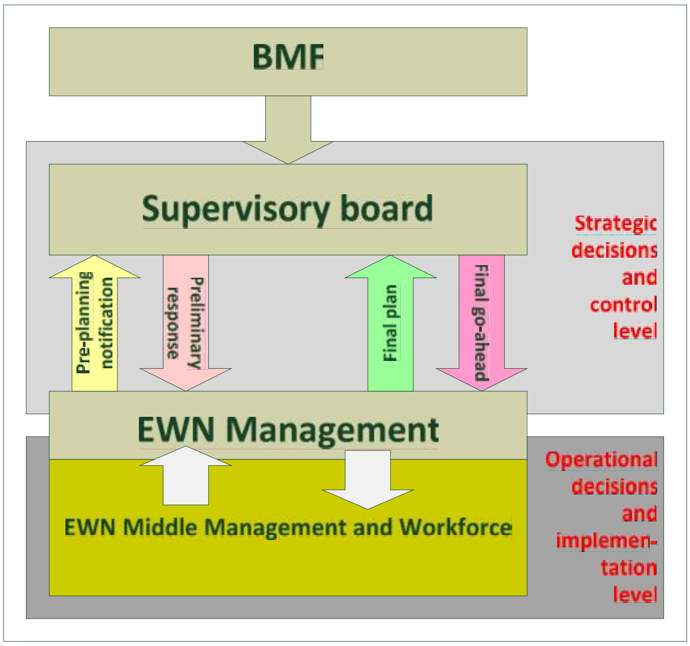
In those strategic decisions (see chapter 2.4.3) the management has to prepare drafts, calculations and pre-planning, the decision makers have to evaluate these and to give management their preliminary and final ok. Keeping control over and tracking the implementation process then is solely the task of management.

This kind of control concentrates on strategic issues and leaves the non-strategic issues with the management. It gives management the freedom but also the complete and undivided responsibility over the project. These control relationships are characterized in Figure 21.

The central control structure for strategic decisions is the Supervisory board that consists of BMF representatives. Communication on strategic decisions between management and board includes formal agreements on final plans and informal communication on plans and status of decision issues. In between the regular sessions of the board the management keeps the board informally informed about its plans and preliminary ideas at an early stage and seeks consent.

The EWN approach is thus characterized by a high degree of management responsibility, a clear distinction between strategic and operational decisions and a clear definition of control activities and issues.

Figure 21: EWN management and decision levels



Source: Authors

3.4.3. Organisation structure of decommissioning and project management organisation

Requirements

The main tasks to be fulfilled by a decommissioning project are:

- The timely removal of contamination and the enclosure of activated and contaminated components and structures in accordance with waste management practice and requirements;
- The removal of all buildings and structures that are not to be re-used;
- The release of the site from regulatory control.

As this requires resources (in the cases discussed in this study: public resources) an additional requirement is that the amount of consumed resources shall be minimized, as far as minimization does not compromise safety.

There are currently no formulated requirements in Germany on how the organisation structure and the overall management of a decommissioning project should be designed. Usual handbooks for decommissioning concentrate solely on the health and safety aspects of management. Only for this Safety Management of the operator have formal regulations been defined (compatible and in accordance with IAEA (IAEA 1999) and WENRA (WENRA 2007) requirements). As such regulation does not contribute to the question of how to best organize and control a decommissioning project, the following description does not center on the Safety Management requirements alone.

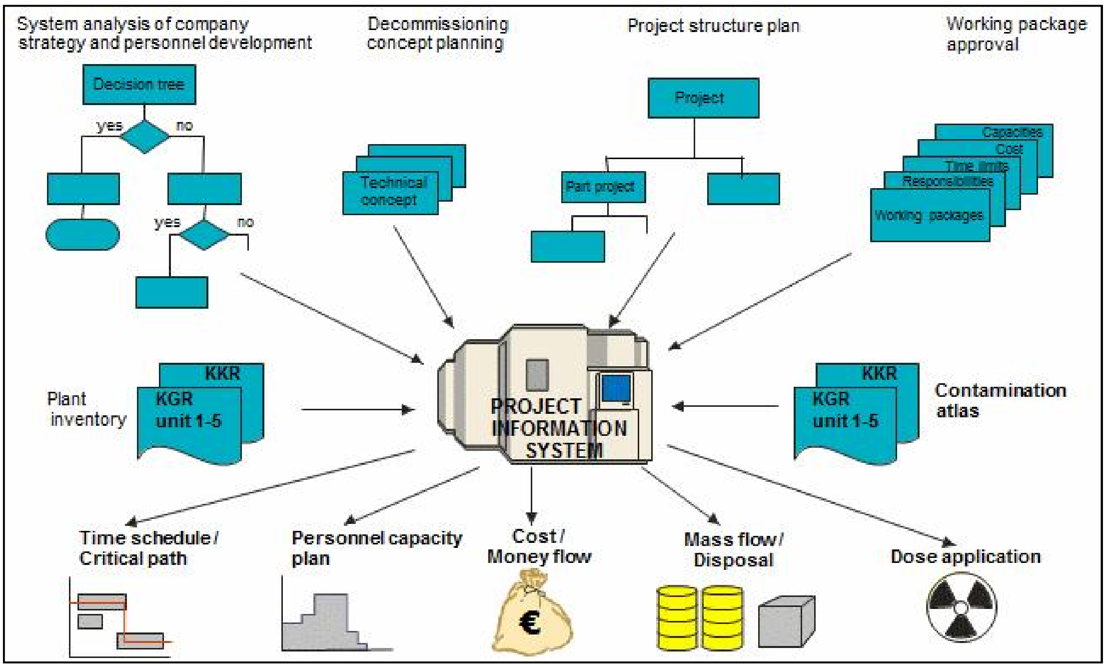
Practice

From the very outset external managers were hired who have long experiences in the project management of large and complex construction projects. With this step it was assured on the management level that favourable conditions for adapting to the very different task of decommissioning were in place. The typical methodology of project management, the tools and the very different planning and work approaches, as compared with the operational phase (see Table 2 on page 47) were thus introduced from the outset, providing a different general approach to planning and execution. This contrasts with other approaches where the adaptation of the organisation and its work approach is achieved after long periods of slow conversion.

Project management uses a set of IT planning tools and accounting methods, usually called a project information system (PMIS[9]). Such a system provides up-to-date information on the status of all relevant decisions, properties, resources, etc..

PMIS systems can be applied as an add-on, accompanying other systems, or as stand-alone systems that include all relevant aspects of a project. Figure 22 provides an overview of the issues and aspects in the PMIS at EWN.

Figure 22: Elements of project management at EWN



Source: (EWN 2013a)

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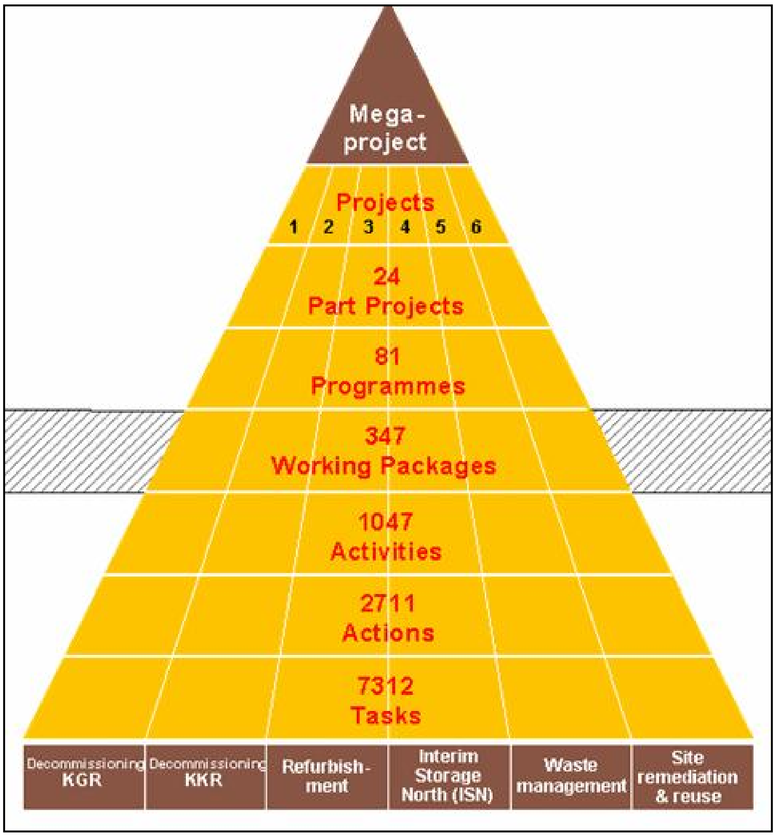
9 'A project management information system (PMIS) is the coherent organization of the information required for an organization to execute projects successfully. A PMIS is typically one or more software applications and a methodical process for collecting and using project information. These electronic systems *'help [to] plan, execute, and close project management goals'*. PMIS systems differ in scope, design and features depending upon an organisation's operational requirements.'
From: http://en.wikipedia.org/wiki/Project_management_information_system

As can be seen from the figure, the PMIS at EWN is of the stand-alone type and was tailored to the specific needs of the decommissioning process. Issues such as 'Work package approval', covering the internal approval process, and 'Mass flow/Disposal' are two aspects that play a specific role in decommissioning projects and would not be found in a traditional or conventional construction project. Another aspect included in EWN's PMIS is personnel development, relevant for decommissioning, which is not necessarily included in a standard PMIS for a construction project.

To demonstrate the complexity of such a decommissioning project the EWN project structure hierarchy is shown in Figure 23. Included are the six sub-projects:

- Deconstruction of the nuclear power plants at Rheinsberg (KKR) and Greifswald (KGR);
- Refurbishment of tools necessary for decommissioning;
- Operation of the interim waste storage facility Zwischenlager Nord (ZLN);
- Waste management (e.g. waste treatment, release from regulatory control, etc.), and
- Site remediation and re-use.

Figure 23: Hierarchical structure of the decommissioning project of EWN



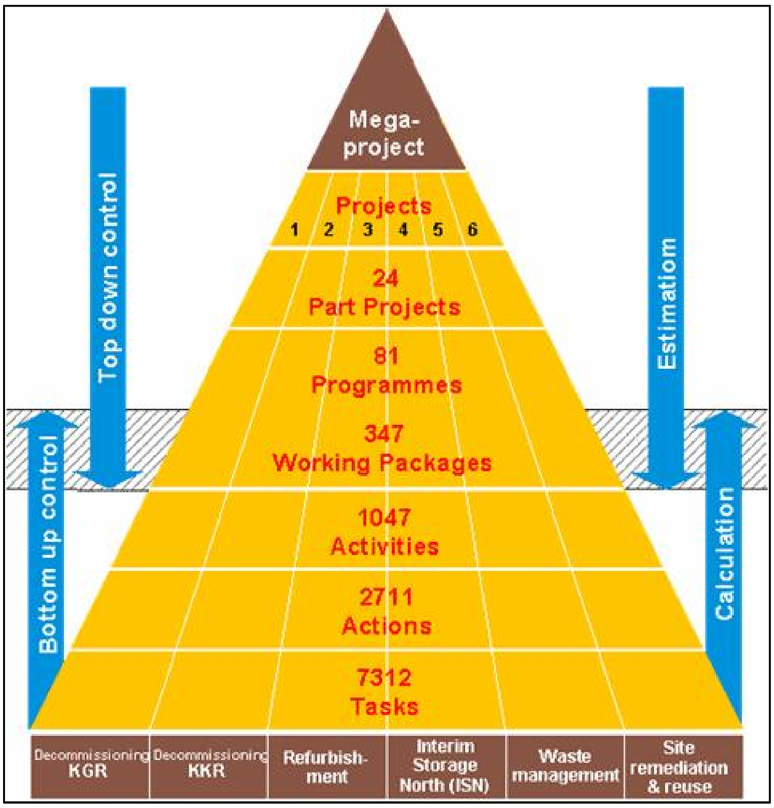
Source: (EWN 2013a)

The hierarchy of the complete projects split into 24 part projects, those into 81 programmes, etc., and reaches down into 7 312 single tasks. Some of those, on all different levels, are interrelated, some are independent. Each step requires specific resources, competences, etc.. To keep an overview and to exercise control over all those activities over the very long time that a decommissioning project lasts is the central task of project management.

As can be seen from both figures, Figure 22 and Figure 23, adding selective project management methods to a project already running in a different mode does not make much sense, because most of the necessary data is missing, data is not available or not with the necessary reliability, interfering influences can be overseen because they remain out of scope, etc.

Project management requires continued feedback of experiences made during task performance. The rationale behind that reflux is that estimates made in the planning phase of tasks require validation. Validated estimates can be used in the planning of similar tasks, thus reducing risks and uncertainties. Such reflux of experiences is highly valuable knowledge for project management purposes.

Figure 24: Control directions and reflux of experiences in EWN's project management



Source: (EWN 2013a)

This entails a different role for the workforce in a project managed environment: the workforce not only has to feed back that the planned task is performed (main role in the operational phase) but gains an additional role in controlling ('Bottom up control'), see Figure 24. Estimation from the planning phase is confronted with calculated results from the implementation phase in order to generate awareness of the original estimate's reliability. Without these corrections through experience project management would not be able to detect and correct errors.

Conclusions

It can be concluded that project management:

- As established from the beginning of the decommissioning of the EWN reactors, is one of the major factors in achieving planning reliability and cost efficiency;
- Tools tailored to the needs in this decommissioning project provide a reliable control tool to perform estimates of time and cost requirements;
- Tools make it possible to track work progress continuously and closely, to validate initial estimates and to increase overall estimate reliability;
- Is, besides general management factors, a major reason why decommissioning in Greifswald kept on track.

3.4.4. Risk management

Requirements

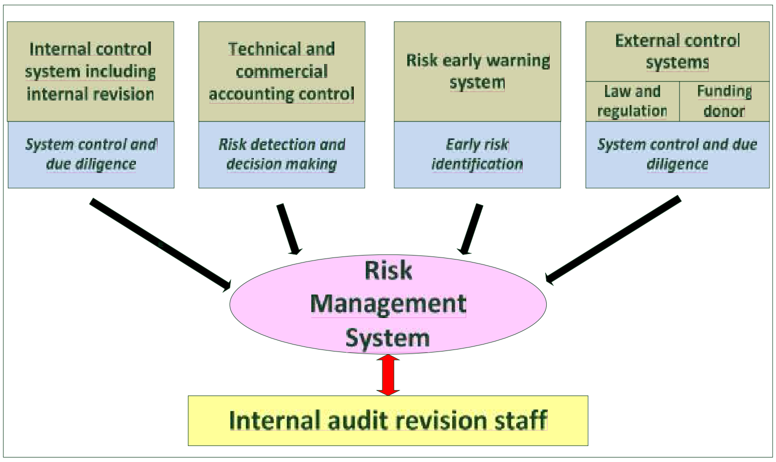
Public entities such as EWN are required by law (HGrG 2013) to apply best practice in their business accounting and to regularly check due diligence of their commercial practice. Additionally stock companies are required to install and operate an early warning risk detection system (AktG 2013)[10]. Even though not formally applicable in this case, BMF as owner and as funder required EWN to install a dedicated Risk Management System (RMS) and to concentrate all company activities that handle, evaluate and control risks within that consistent system.

Practice

Figure 25 shows the four different fields of managing risks and describes the main tasks that activities in these fields address.

[10] § 91 Aktiengesetz: „Organisation Buchführung: (1) Der Vorstand hat dafür zu sorgen, daß die erforderlichen Handelsbücher geführt werden. (2) Der Vorstand hat geeignete Maßnahmen zu treffen, insbesondere ein Überwachungssystem einzurichten, damit den Fortbestand der Gesellschaft gefährdende Entwicklungen früh erkannt werden."

Figure 25: Risk management system and its elements at EWN



Source: (EWN 2009**)**, adopted and translated by the authors

As can be seen from the different fields the term 'risk' here is interpreted in a broad sense as it includes all aspects that have the potential to negatively influence the overall task performance of the decommissioning project.

Besides the more commercial and budgetary control instruments in this RMS the management of technical risks is of specific interest here. It includes the identification of all risks that can influence the technical concept and the workflows of the work packages. Identification involves close communication between all relevant internal experts and affected workforce. All identified risks and their potential influence are evaluated, alternatives are discussed and, if necessary, measures to limit or avoid those risks are developed.

Conclusions

As decommissioning of nuclear reactors has not reached (and will never reach) the stage of a standardized procedure (such as standard construction systems for housing) and involves to a high degree very specific properties and issues of the facility, the introduction of risk management in decommissioning generally is highly recommended. Unidentified risks and their consequences can thus be reduced to an unavoidable residual level. Failures to identify obvious or hidden risks must in many cases be interpreted as bad project management.

The management of risks in the EWN project is appropriate for projects with a high commercial and technical risk potential and includes all risks that can endanger the overall performance of the decommissioning project.

3.4.5. Regulatory approach

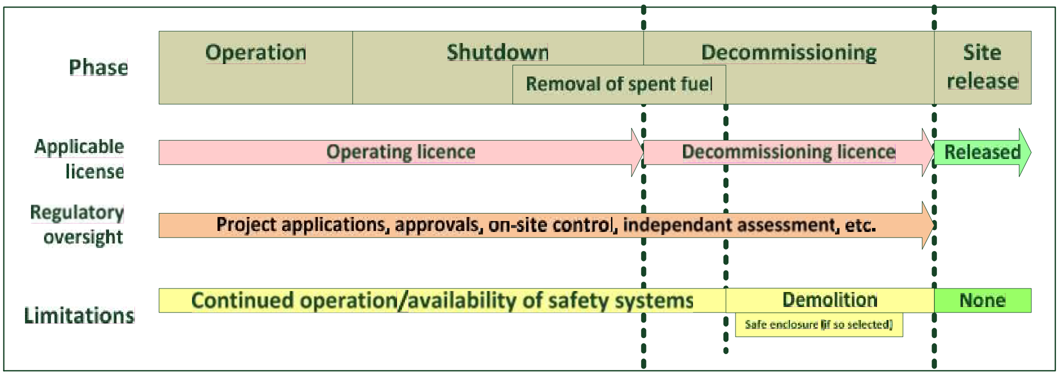
Requirements

German nuclear regulation, as applicable for the EWN project, consists of different levels. In respect to decommissioning the following framework is relevant[11]:

- The phase between shutdown and issuance of the decommissioning permit is regulated as ongoing operation (post-operational phase). Removal, deconstruction or alternative use of items that are not relevant for safety is possible and requires the consent of the supervising regulator.
- The operator's overall plan for decommissioning describes the deconstruction phases, the necessary means and tools and the measures that are foreseen to guarantee the safety of the public and of the workers. With these documents, together with the environmental impact study, the operator applies for a permit. Additional underlying documents might be necessary. If the regulator's review of these documents ends with a positive finding, the permit is granted (general decommissioning license). The decommissioning permit spans all phases of the project, usually adds further license conditions and is not time-limited.
- During decommissioning the operator designs, plans and describes sub-projects or work packages that detail and substantiate the overall plan, in accordance with its general license. Depending upon practice, the operator has to seek regulatory consent with these plans or has to apply for formal approval of the supervising agency.

The role of the (general) decommissioning license as an end to the operating license and as a basic permit to decommission the facility is illustrated in Figure 26.

Figure 26: The decommissioning license under German regulation



Source: Authors

Specific to German regulatory practice is the continued regulatory oversight. It includes sub-project applications and approvals, on-site control (e.g. expert accompanied inspections, double checking, etc.), independent assessments (e.g. independent sampling, exemplary proof by second party). The necessary approval processes can be closely adapted to the decommissioning project's phases and to their progress.

[11] For a comprehensive description of the complete German regulatory framework see: BfS 2009

The formal approval processes (general license, approval for sub-projects, etc.) require additional time and resources and are associated with additional risks (time delays, forced plan changes, etc.) to the project. Project planning has to consider the necessary time and resources for those activities. To minimize those risks the applied regulatory approach shall be to seek consent already in early planning phases.

Practice

Necessary times to apply for and to achieve regulatory consent are included in the workflow model of the PMIS tool and are regularly updated.

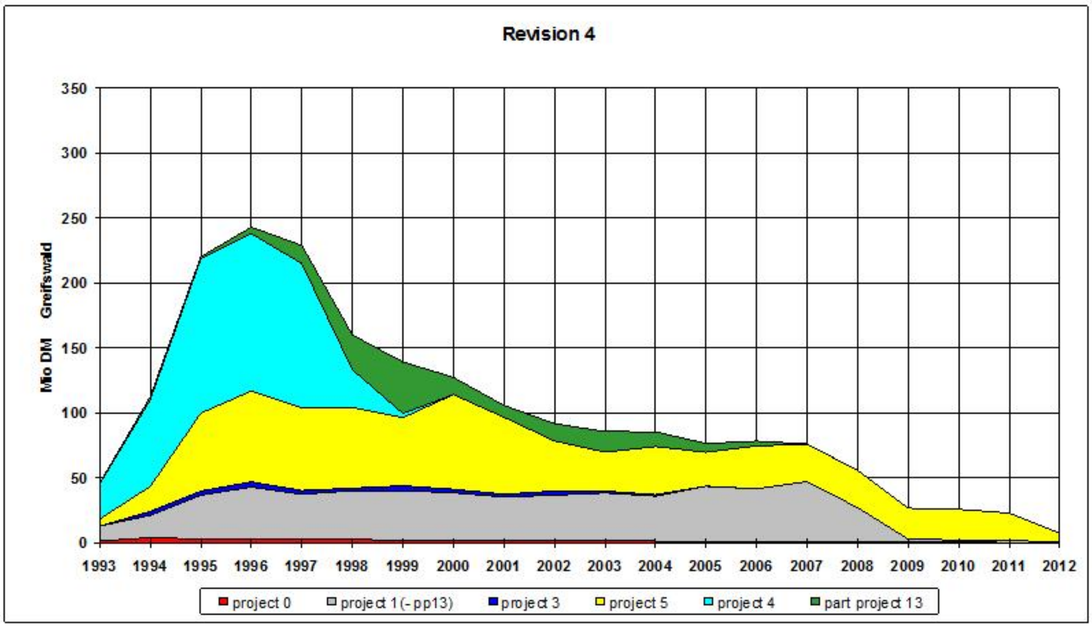
EWN seeks regulatory consent already in the conceptual stage of work package design and planning. This assures that the supervisory agency is able to voice its concerns already in an early phase and that the later approval of the agency to final plans and work packages requires no extensive times.

3.4.6. Cost estimates

All cost estimates in the EWN decommissioning project were performed by use of the project management tool described in chapter 3.4.3. From the experiences in this case the tool provides reliable estimates. By application of correction factors experiences made during the first phase estimates were integrated and reliability increased.

Figure 27 shows the overall cost development for the five Greifswald reactors.

Figure 27: Costs of decommissioning the five Greifswald reactors



Source: (EWN 2012a)

As can be seen the cost contributions from the single sub-projects are very different. It further shows that the needs are very different over time. The initial phase, where large investments have to be made for equipment, waste management treatment and storage facilities, is the most cost-intensive.

The yearly costs displayed here add up to roughly DM 2 billion or EUR 1 billion over the complete time. Compared to preliminary cost estimates performed by the nuclear operators RWE and E.ON (see chapter 2.3) for their facilities these costs are comparatively small.

3.4.7. Workforce needs and qualifications

Practice

The following decisions governed EWN's approach (EWN 2012a):

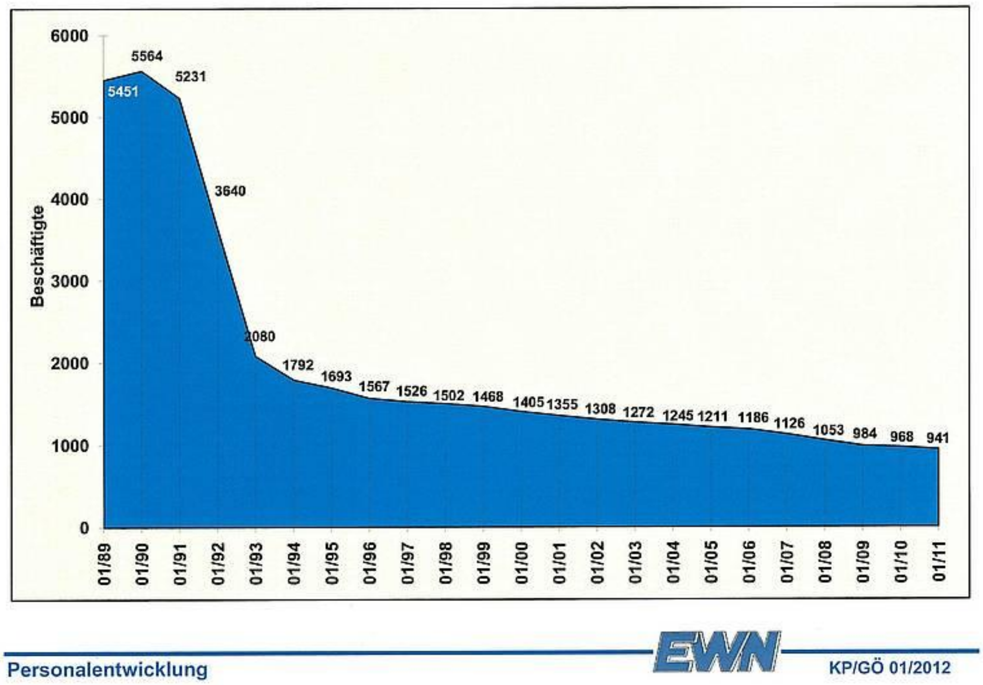
- Personnel reduction at the start of decommissioning is necessary for budget optimization; social aspects should be taken into account.
- The former operator's personnel should manage the decommissioning project and perform tasks itself, as far as possible.
- No main contractor for the overall project implementation is necessarily required – contractors only for special technical cases.
- Timely site remediation for unused areas as a precondition for future reuse.
- Creation of new projects/jobs improves personnel motivation and outlook.

EWN has established from its beginning the following basic rules:

- The project planning tool has a module that translates work steps into needs for workforce and their necessary qualifications. Amount and qualification profiles of employees were planned on that basis.
- Employees seeking continued employment had to apply for those jobs and had to complete the necessary qualification courses.
- As work scope, qualifications and job profiles change over time, the necessary extent and qualifications of the workforce must be planned ahead and qualification measures initiated in a timely manner.

Figure 28 illustrates the employed workforce at EWN over time.

Figure 28: Employed workforce at EWN over time



Source: (EWN 2012a)

As can be seen three quarters of the workforce employed during operation of the reactors were not necessary in the decommissioning phase. Note that the curve spans more than 20 years, so that at least half of the employees reached their retirement age and were replaced with newly hired and trained personnel.

3.4.8. Overall characteristics of the example

The following can be concluded in respect to current best practice of decommissioning:

- A relevant factor in this case was the fact that EWN was constituted as a company and a clear attribution of all operative responsibilities to the management was made. The funder's role (BMF) was to control the strategic decisions of the management and to keep control over commercial account management (due diligence).
- A major factor in this case was the early introduction and consistent application of project management methods and of the associated tools (PMIS). The short time needed to streamline management and organisation towards the new task was one of the most relevant factors.
- Project management was not only applied as a selective add-on with a limited applicability and scope, but all major planning aspects were integrated and covered, including aspects such as decision trees or job qualification planning.
- Managing the risks, that are associated with decommissioning projects in general, in a systematic manner and avoiding a selective, more intuitive risk identification and evaluation contributed

further. Systematic risk management, with at least the risk definition and criteria listed here, should be matter-of-course in such a large and complex project.

- Systematically managing workforce plans, necessary qualifications, etc., by means of a project management tool has several advantages as it makes planning more informed, precise and understandable.

The major key decisions of EWN, as prepared by management and finally approved by BMF, have proven to be sound:

- The decision to prioritize increased qualifications for the existing personnel rather than hiring external consultants and companies lead to a highly qualified and experienced workforce. Expertise from EWN thus has found further applications, e.g. in a number of other public decommissioning projects.
- The decision to construct and operate separate facilities to treat/condition and store wastes has relieved the dismantling process from a large number of potential conflicts and so helped to perform the decommissioning projects in a shorter time and with less complex work planning.
- The decision to remove and store large components, awaiting their treatment later on, further relieved the decommissioning project from potential bottlenecks.

3.5. BEST PRACTICES DERIVED FROM THE EXAMPLES EXAMINED

3.5.1. Best practices identified

The following best practices in decommissioning can be derived from this analysis:

- External oversight over the decommissioning process

  Any lack of external control over strategic management decisions (see chapter 2.4.3) can be costly and can cause massive time delays if strategic management decisions have to be corrected afterwards. External control over the managing organisation therefore requires a tight and close control of all its strategic decisions. Strategic decisions and their planning basis have to be carefully prepared by the managing organisation, taking all (technical, safety and workflow) risks into due account. This decision base and the risks have to be communicated clearly to the external control organisation(s). The external control organisation(s) has/have to carefully check the plans and finally to give its approval. The external organisation(s) controlling the process shall be aware that they assume full responsibility over those strategic decisions and accept the associated risks.

- Management of the decommissioning process

  The decommissioning of nuclear reactors is very different from operating a nuclear reactor in that it requires the steering of a complex process of interconnected workflows and an appropriate understanding of the (technical, safety and workflow) risks involved. The decommissioning process therefore requires a strong, well-designed, risk-awareness, flexible and self-reliant management organisation. Management has to prepare and plan all strategic decisions (see chapter 2.4.3) and is responsible for implementing those strategic decisions. Management has to decide on and is finally responsible for all operational decisions.

Management has to install and apply all necessary planning and control instruments that allow performing the decommissioning process in a safe, cost-effective, commercially correct and timely manner. The consistent re-definition of the tasks and the approach of the management level are of utmost importance for the whole decommissioning process.

- System management structure

  The decommissioning process requires thorough planning of all workflows, taking their interconnections and risks into due account. The classical management methods - applied during the operational phase - are completely contrary to this requirement. The introduction of system management structures, the implementation of the associated approaches and their consistent application in all work- and planning processes is therefore vital for the optimization of the process. System management methods should include all relevant planning processes so that all interfaces (material management, decision bases, workforce planning and skill management, etc.) are as consistent as possible.

- Risk management

  Decommissioning involves complex technical, safety, regulatory and workflow risks that have the potential to force a re-planning of complete processes, with consequences for costs and timing. In order to plan the process with the best information basis the risks need to be understood, evaluated in respect to their potential impact on workflows and costs and their potential impact limited and avoided as far as possible. Risk identification and evaluation involves the inclusion of top-down as well as bottom-up information, and so the feedback of experiences, to improve the planning.

- Workforce, qualification, knowledge and experience management

  Decommissioning requires a complete change of the workforce’s qualification, knowledge and experiences profile. Failure to adapt the quantitative and qualitative availability of trained personnel to actual needs can reduce cost effectiveness and can cause serious delays of workflow and processes. The planning of the workforce and profiles can only be performed on the basis of a detailed plan of the whole decommissioning process. Because workforce planning needs to be reliable and understandable and because qualification processes often require lengthier preparations the complete process and timescale must be managed closely.

- Management of costs and their risks

  The management of costs and their associated risks is only possible and reliable on the basis of a detailed plan of the whole decommissioning process. Absence of such a plan renders any cost estimates unusable and unreliable.

3.5.2. Basic decisions to be taken

The following decisions are vital for any decommissioning planning. Strategic decision making on these issues (see chapter 2.4.3) needs to be performed as early as possible in the process:

- Decommissioning oversight and control

  In a very early stage the control structure governing strategic decisions of the managing organisation needs to be decided upon because all subsequent issues require clear, coherent and pro-active decision-making.

- Decommissioning organisation

  Several decisions have to be prepared at the outset of decommissioning, so the design and implementation of the managing organisation should be carefully planned and decided upon.

- Decommissioning timeline

  The decommissioning plan needs to be detailed enough to allow decisions on the basic decommissioning route in an early phase. The basic decisions on whether a 'fast' or 'slow' approach is chosen or whether any inactive phases in between make sense and provide an advantage over the continuous scenario can only be based on that overall plan and its underlying cost attributions.

- Decommissioning target

  The decommissioning target ('end state') needs to be clear from an early stage because several planning variables depend upon it. To be decided on are 'Advanced decontamination', 'Regulatory release', 'Green/brown/red field status' and 'Long term target of the organisation's life time'.

- Decommissioning risks

  Identification, assessment and methods to limit risks needs to be implemented from the outset because a consistent decommissioning plan cannot be setup without this and because the approach of the management level and the workforce requires training to achieve an appropriate risk management.

- Decommissioning workforce

  From the outset a decision is necessary whether the project will work with the existing workforce or will be based on extensive external contributions. If the latter will be the preferred strategy, then strong controls have to be setup to ensure that the managing organisation is able to control all processes, that an appropriate risk balance is achieved, etc.

- Decommissioning costs

  Cost figures are necessary from the outset because they are a criterion determining all decisions early on. Updates need to be made regularly, identifying relevant contributions.

4. DECOMMISSIONING IN BULGARIA, LITHUANIA AND SLOVAKIA

4.1. REACTOR SHUTDOWN AND GENERAL PREPAREDNESS FOR THE DECOMMISSIONING PHASE

Within their accession to the **EU** the three member states Bulgaria, Lithuania and Slovakia committed themselves to shut down eight reactors earlier than per design life planning (see Figure 29).

Figure 29: Reactors having been shut down in Bulgaria, Lithuania and Slovakia and early closure data

Nuclear power plant	Reactor unit *(and type)*	Start of commercial operation	Theoretical closure date *(as per design)*	Actual closure date *(in line with agreement)*	End of decommissioning *(current forecast)*
Kozloduy (Bulgaria)	Unit 1 *(VVER 440 / 230)*	1974	2004	2002	2035
	Unit 2 *(VVER 440 / 230)*	1975	2005	2002	2035
	Unit 3 *(VVER 440 / 230)*	1981	2011	2006	2035
	Unit 4 *(VVER 440 / 230)*	1982	2011	2006	2035
Ignalina (Lithuania)	Unit 1 *(RBMK 1500)*	1984	2013	2004	2029
	Unit 2 *(RBMK 1500)*	1987	2017	2009	2029
Bohunice V1 (Slovakia)	Unit 1 *(VVER 440 / 230)*	1980	2008	2006	2025
	Unit 2 *(VVER 440 / 230)*	1981	2010	2008	2025

Source: (ECoA 2011)

None of the affected countries was prepared for that closure, even though this early preparedness was a common safety principle well addressed in international Safety Guides:

- Financial arrangements for the decommissioning of those reactors were not available, thereby not implementing applicable international safety standards, e.g. the Safety Guide (IAEA 1999) that went into effect five years before the first plant shut down. It requires explicitly the establishment of dedicated funds for decommissioning[12], and requires that those are immediately (!) set up for already existing and operating reactors[13].
- No conceptual planning for their later decommissioning had previously been established, even though international safety standards explicitly required that (IAEA 1999)[14], and called for this planning, including for existing reactors[15] 'without undue delay'.
- The reactors were of the older Soviet **PWR** and **RBMK** types and not designed having their later decommissioning as a layout criteria in mind, which should be a basic design criteria nowadays (IAEA 1999).

The requirement to have enough resources at hand to decommission a facility, whenever this is needed, can also be derived from the Fundamental Safety Principle 7 ('Protection of present and future generations'):

> *'Where effects could span generations, subsequent generations have to be adequately protected without any need for them to take significant protective actions.' (IAEA 2006)*

As a consequence of this failure to implement these international principles and recommendations, the operators and the three member states were majorly unprepared for the shutdown of these installations[16]. Neither were financial means nor were the necessary procedural steps, organisational

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[12] The Decommissioning Safety Guide (IAEA 1999) requires the following: *'5.24. In order to provide the necessary confidence that the resources will be available to maintain radiation and environmental protection during decommissioning, provision for allocating resources should be established early in the planning of the nuclear power plant design. According to the legal framework, such a mechanism should be established before operation in order to secure the funds needed for decommissioning. The mechanism should be sufficiently robust to provide for decommissioning needs in the event of premature shutdown of the reactor installation. Irrespective of the type of financial mechanisms used, provision for premature decommissioning should be in place, should it be needed.'*

[13] Decommissioning Safety Guide (IAEA 1999): *'5.25. For existing reactor installations with no financial assurance mechanism for decommissioning, such a mechanism should be established without undue delay.'*

[14] Decommissioning Safety Guide (IAEA 1999): *'5.6. An initial plan for decommissioning should be prepared and submitted by the operating organization in support of the license application for the construction of a new reactor. Although the level of detail in the initial plan will necessarily be lower than that in the final decommissioning plan, many of the aspects listed in para. 5.11 should be considered in a conceptual fashion. A generic study showing the feasibility of decommissioning may suffice for this plan, particularly in standardized installations. Depending on applicable regulations, the plan should address the costs and the means of financing the decommissioning work.'*

[15] Decommissioning Safety Guide (IAEA 1999): *'5.7. In cases where an operational plant does not have an initial plan for decommissioning, a decommissioning plan reflecting the operational status of the installation should be prepared without undue delay.'*

[16] Only Slovakia had, at that time, encountered a reactor under shutdown, Bohunice A1, see ANNEX 1 of this study, and had limited experiences with its decommissioning.

and technical know-how (not even on a conceptual basis) or the administrative framework (administrative rules, legislation, regulation, etc.) available and ready for this new situation.

Moreover, the management and the administrative control instruments were unfamiliar with the situation. Facing a complete new set of problems to be resolved quickly, whilst still in a familiar and well-understood operational state caused internal resistance and the generation of numerous internal barriers against adaptation to the new task. The opportunities presented by this situation – e.g. developing excellence in dismantling, the organisation of well-designed processes, to solve waste management challenges - were not seen behind all the unresolved problems. In this phase it was a decisive contribution that the neighbouring countries were willing to assist the affected countries.

Towards assistance

Prior to and during the negotiation stage of the accession to the European Union (EU), older reactors of Soviet design were operated in several former East-European countries (including East Germany). In Bulgaria and Slovakia pressurized water reactors **WWER**-440/230 were in operation and the water-cooled graphite reactor type **RBMK**-1500 in Lithuania.

In 1992, the **G7** summit in Munich concluded that these reactors did not comply with the required safety standards and cannot be economically upgraded. The summit therefore recommended that these reactors should be decommissioned before reaching their originally foreseen end of lifetime.

This recommendation became a part of the accession negotiations with the former East-European countries and fixed closure dates were defined. The premature shutdown – as compared with the originally planned lifetime – was seen by the **EU** as a significant economic burden. Moreover, the earlier failure to comply with international standards in combination with the shortened lifetime did not allow sufficient financial resources to be accumulated within the funds for covering the decommissioning costs. The Acts of Accession have foreseen a financial assistance for this reason.

It was clear from the beginning that the assistance should not cover the full costs of decommissioning but should be designed to express solidarity between the **EU** and the affected member states. The effort needed from the relevant countries to decommission as well as to resolve the social consequences and the resulting gaps in the energy sector was to be supported. The assistance was implemented in three periods: 1999-2003, 2004-2006 and 2007-2013 (EU 2011a, EU 2011b).

4.2. FUND ESTABLISHMENT AND CONTROL

The following description is based on the descriptions in a special report of the European Court of Auditors (ECoA 2011) and the statement of the European Bank of Reconstruction and Development (**EBRD**), as documented in ANNEX 8.

As a blueprint for the organisation of the assistance in decommissioning the profile of the Chernobyl shelter fund was chosen:

- Countries willing to contribute to the fund ('donors') were searched for. Motivation should be the commitment to support international nuclear safety issues and the solidarity with the affected countries.
- The fund members contributing at least EUR 1.5 million and the affected country constitute a fund:
  - **IIDSF** (Ignalina International Decommissioning Support Fund) for Ignalina/Lithuania 17 members;
  - **KIDSF** for Kozloduy/Bulgaria 12 members;
  - **BIDSF** for Bohunice 10 members.
- Fund members constitute a donor's assembly for the respective fund as the highest decision-making body. The assembly decides on projects and funds. The receiving country is a non-voting member.
- The **EBRD** acts as

  a) A secretariat for the donor's assembly, communicating and presenting projects for decisions to be made;

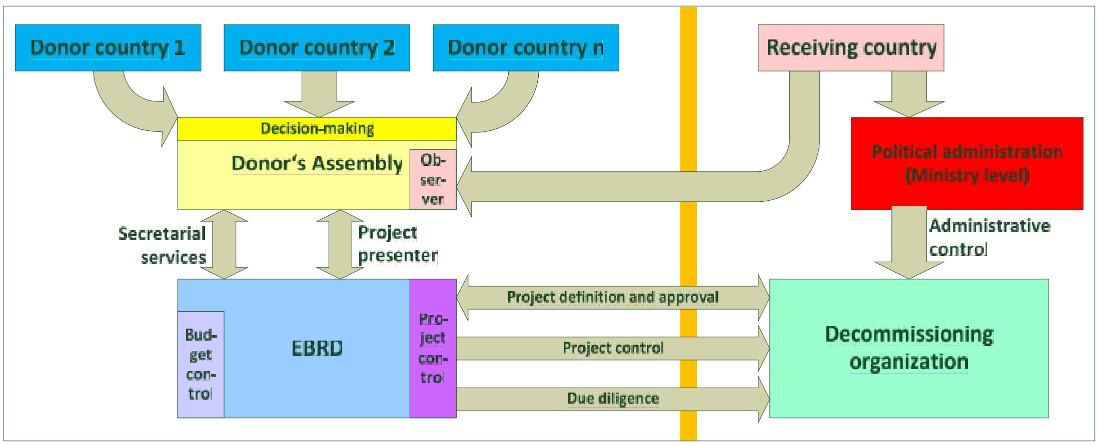
  b) A fund manager, it collects money from the donors, spends money for the projects, and administers money that was not spent;

  c) A financial controller checks and controls money spending;

  d) A procurement and implementation controller.

The structure is illustrated in Figure 30.

Figure 30: Major roles and relationships between donors (left) and fund-receiving country (right)



Source: Authors

Note that in Figure 30 substructures between the receiving country and **EBRD** have been omitted. These are discussed in more detail in later chapters (see chapters 4.3 and 4.4).

This shows that according to the structural arrangements **EBRD** has immense and diverse responsibilities. It has a considerable power over funding generally as well as over the decision and implementation process. EBRD, not the Decommissioning organisation, prepares the projects to be decided (project presenter), and so acts as a filter between the implementer and the decision maker.

Fund volumes and **EU** contribution

The following countries were contributors to these funds: Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Luxembourg, the Netherlands, Austria, Poland, Finland, Sweden, the United Kingdom, Norway and Switzerland. Their contribution amounted to EUR 60 million. From 2004 the **EU** is the only contributor (ECoA 2011), but fund management arrangements were not changed.

The complete volume of EU-funded assistance is given in Figure 31.

Figure 31: EU contribution from 1999 to 2013 and their share

Programme	EU contribution *(million euro)*	Percentage of the total
Kozloduy	870	30,5 %
Ignalina	1 367	48,0 %
Bohunice	613	21,5 %
Total	**2 850**	**100 %**

Source: (ECoA 2011)

The **EU** contribution totals at EUR 2 850 million in 2013, with different shares among the three receiving countries (Ignalina/Lithuania received about half of the total contributions).

4.3. THE ORGANISATIONAL FRAMEWORK OF DECOMMISSIONING IN BULGARIA, LITHUANIA AND SLOVAKIA

As described in chapter 4.1, all three countries were, to a more or less high degree, unprepared and practically had not established national structures to organize and administer the decommissioning phase of their nuclear power plants.

4.3.1. Establishment of national organisational structures

Bulgaria

After having closed Kozloduy Unit 1 and 2 before 2003, based on a memorandum between Bulgaria and the EC in 1999, Bulgaria committed to the closure of Unit 3 and 4 in 2005 (Accession 2005)[17] and shut down these two units on the 31st of December 2006.

The decommissioning activities (fuel unloading etc.) started under control of the former operator organisation of the plant.

In 2004, the state-owned organisation **DP RAO** (or **SE RAW**) was constituted by law (Act 2011a, Section II - Radioactive Waste State-Owned Company, Effective 1.01.2004) and put in charge of managing all activities concerning nuclear waste. The responsibility to decommission Units 1 and 2 were later transferred to this organisation in 2008, Units 3 and 4 followed in 2012.

DP RAO is under administrative control of the Ministry for Economy and Energy (MEE 2013).

In 2003, Bulgaria established a fund which aimed to cover the decommissioning costs (Act 2011a, Section V - Nuclear Facilities Decommissioning Fund - Effective 1.01.2003). The main contributor to the fund is the State of Bulgaria and, since the amendment of 2010, the state-owned operating company of Kozloduy NPP Units 5 and 6. The control of the fund is performed by a Management board comprised of Ministries, the operator of the nuclear power plants and others (Article 52 in Act 2011a).

Lithuania

In 2003 Lithuania committed to close its **RBMK** Units 1 and 2 of the nuclear power plant in Ignalina (Accession 2003a)[18].

Decommissioning preparations for Unit 1 were already earlier initiated by law (Act 2000), but the terms of this law remain very general. Article 4 of the law calls for a decommissioning plan, for which the operator of the Ignalina nuclear power plant (**INPP**) is mandated. Article 5 sets up a fund, but remains very general about the size, the sources and the administration rules of this fund. Article 10 requires the government to draft a fund law. This law (Act 2001) names as sources for the funds mainly deductions from sold electricity from **INPP**, foreign contributions and the sale of property.

INPP is formally administered by the Minister of Energy (ME 2013). The structure is shown in Figure 32.

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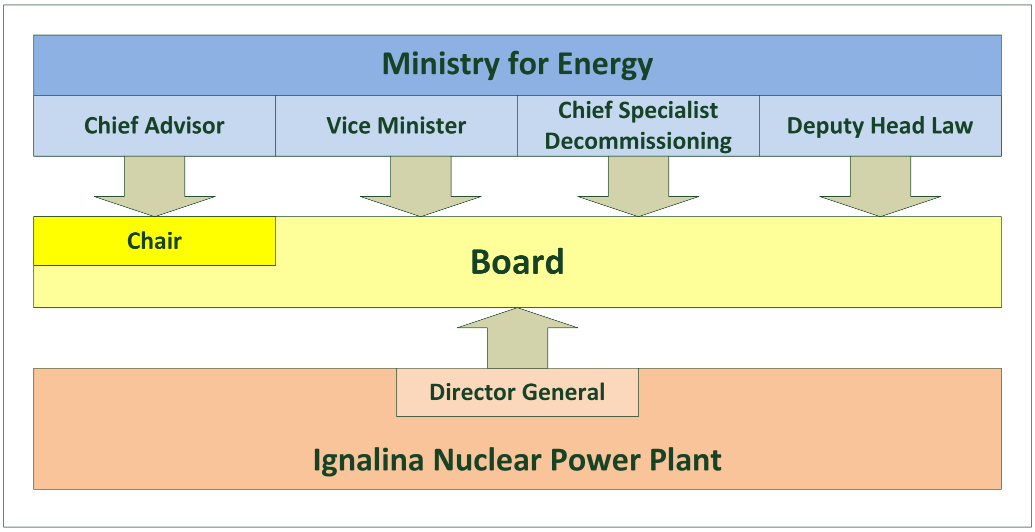
[17] Accession 2005: Article 30: '*1. Bulgaria, having closed - in line with its commitments - definitively for subsequent decommissioning Unit 1 and Unit 2 of the Kozloduy Nuclear Power Plant before the year 2003, commits to the definitive closure of Unit 3 and Unit 4 of this plant in 2006 and to subsequent decommissioning of these units.*'

[18] Accession 2003a: Article 1: '*Acknowledging the readiness of the Union to provide adequate additional Community assistance to the efforts by Lithuania to decommission the Ignalina Nuclear Power Plant and highlighting this expression of solidarity, Lithuania commits to the closure of Unit 1 of the Ignalina Nuclear Power Plant before 2005 and of Unit 2 of this plant by 31 December 2009 at the latest and to the subsequent decommissioning of these units.*'

Figure 32: Control structure for decommissioning in Lithuania



Source: Authors

As can be seen from this structure the Ministry for Energy is the sole controller of the decommissioning and is responsible for all decision-making.

Slovakia

According to the condition of accession to the European Union, both **WWER** units U 1 and U 2 of the nuclear power plant in Bohunice V1 were closed in 2006 and 2008 respectively[19] (Accession 2003b, Decree 1999).

Since 2006 the organisation **JAVYS** is responsible for the decommissioning of V1 and radioactive waste management in the Jaslovské Bohunice nuclear power plant. The company's single shareholder is the Ministry of Economy of the Slovak republic.

The activities of **JAVYS** are performed according to a Government Resolution titled '*Strategy of the Back End Cycle of the Peaceful Use of Nuclear Energy in the Slovak Republic*' (Government 2008).

A *'National Nuclear Fund for Decommissioning of Nuclear Facilities and Management of Spent Nuclear Fuel and Radioactive Waste (**NNF**)'* was established in 2006 according to the Act No. 238/2006 Coll. (Act 2006)[20]. It was supplemented by the Government Decree 312/2007 (Decree 2007) in which details of the collection and payment of obligatory contributions to the **NNF** are defined.

The Slovak Government introduced in 2010 the Act No. 426/2010 on Tax from Electricity Sales Collection coming in to force in 2011 (Act 2011b). According to the Act in total EUR 70 million needs to be collected yearly for decommissioning of nuclear facilities in Slovakia.

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[19] Accession 2003a: Article 1: *'Slovakia commits to the closure of Unit 1 of the Bohunice V1 Nuclear Power Plant by 31 December 2006 and Unit 2 of this plant by 31 December 2008 at the latest and to subsequent decommissioning of these units.'*

[20] Act 2006: Zákon č. 238/2006 Z. z. o Národnom jadrovom fonde na vyraďovanie jadrových zariadení a na nakladanie s vyhoretým jadrovým palivom a rádioaktívnymi odpadmi

The Government of the Slovak Republic notified a draft act amending article 7(4) and (5) of the Act 2006 in 2012. According to these draft amendments from 2013 onwards the operator needs to pay the levy to the Ministry of Economy. The Ministry of Economy oversees and coordinates the fund in the Slovak Republic (Aid 2013).

4.3.2. Comparison and evaluation of the national organisational structures with best practice

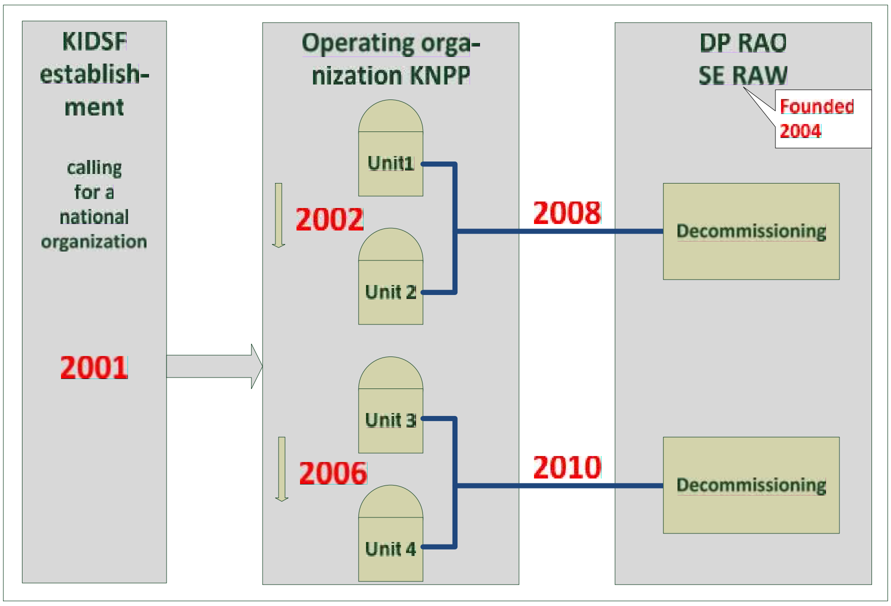
In all three countries Bulgaria, Lithuania and Slovakia the national structures are clear, straight-forward and transparent.

Based on our findings in chapter 3 a major difference between **EWN** and the three countries was that in the case of **EWN** the German Finance Ministry as the sole financial contributor took over the complete control over the activities of the company. The basic structure of the management level at **EWN** was already changed from the start to better fit to the decommissioning project needs. And **EWN** was, from the beginning, tightly controlled by the supervisory board, in which the Ministry acted. All strategic decisions of the company's management were intensely discussed and approved in that way.

The administering of the implementing organisation by the responsible Ministries in case of Bulgaria, Lithuania and Slovakia was not as close as it was at **EWN**. First of all, the powerful operating organisations kept their traditional role, resisting against any external influence to change their approach. Secondly, a possible reason for the different role of the national control organisation in the three cases was that the external control institutions (Donor Assembly, **EBRD** as fund manager and project presenter) were more expected to take over that role, just because these controlled the major part of the resources. The design of the national implementation organisation, its internal structure, the configuration of its management level, its self-confidence and the quality and performance of work on this decisional level was to be defined and controlled by the national authority supervising the organisation. But this task was not adopted by the responsible Ministries: there were neither any incentives nor any requirements to take over that new role. Their focus was rather on achieving the necessary resources to finance the decommissioning than on finding the mode of changing management, planning, project and work structures.

The fact of not identifying, finding and taking their role in setting up an organisational framework in the early phase of decommissioning to adapt their national setting to the new decommissioning task delayed the process further. In the view of the national administrations it was rather expected from the external control institutions to take this responsibility. But as those external institutions were objectively not responsible to control the inner design of the decommissioning organisation, substantial delays in the setup of the responsible organisations were characteristic. So it took several years until the national structures reached today's more appropriate state. As an example the establishment of the managing organisation in Bulgaria is shown in Figure 33.

Figure 33: Timeline establishing the managing organisation in Bulgaria



Source: Authors

As can be seen it took nine years to establish **DP RAO** to its current structure.

The external funds, as controlled by the Donor Assembly and administered by the **EBRD**, did not require the receiving countries to adjust their national organisational setting. The importance of substantial changes to the whole national framework regime was not identified[21] and no requirements were derived from that. The definition of minimum managing requirements in the Framework Agreements concentrated on management requirements within the national organisation:

> *'(a) The implementation of each Project shall be managed, coordinated and monitored, by a Project Management Unit (herein called the 'PMU') established by the Recipient. The PMU shall establish adequate organisational structures to perform specific engineering, procurement or other services. The PMU shall be staffed with consultants engaged in accordance with the applicable procedures of the Bank and the Fund and with suitably qualified specialists provided by the Recipient. The relevant Grant Agreement shall contain the specific provisions relating to the responsibilities, establishment and operation of the PMU.' (Agreement 2001)*

So the role of the supervising national body, to oversee the managing organisation and to supervise their strategic decisions, remained undefined. The consequence was that the governments were not getting aware of their role as:

a) A strategic decision maker;

b) A reviewer of plans of the managing organisation in an early stage;

c) The responsible institution to supervise management's activity,

21 It could have been known if lessons learned from the EWN case would have been drawn in an early stage: at the time of **IDSF** set up this case was already ten years old.

d) The counterpart of reporting requirements of the management.

In the two best case examples, decommissioning by **EDF** in France (see chapter 3.2.2) and in Germany at **EWN** (see chapter 3.4.2) the driving factor for achieving consistent and well-controlled organisation structures was in the economic as well as the political self-interest of the responsible organisations: to reduce the costs by effective re-structuring and by achieving a well-balanced accord between decommissioning targets and effective cost control (EDF: on behalf of its shareholders; EWN: on behalf of the taxpayers). In the cases of **EDF** and of **EWN** the achieved cost optimization had direct advantages for these organisations.

Another difference between the best cases and the decision-making in the Bulgarian, Lithuanian and Slovakian cases is the quality of supervision imposed on the managing organisation. It is neither directly required to report on its performance nor to achieve consent for their projects in the Donor Assembly, because **EBRD** acts on behalf of them. If delays or excess costs have to be reported it is not the managing organisation that has to take over responsibility. Supervision by the Donor Assembly is not imposed on the management organisation but on **EBRD**. Thus, the continuous supervision imposed by **BMF** on **EWN**'s management cannot be compared with the much less rigorous practice in this case.

Over the past years the national structures to steer and supervise the managing organisations have progressed in all three countries but never reached intensity and tightness like in the two described best cases. One reason for that might be that the vast majority of the spent resources stems from external sources so that cost optimization has a much smaller advantageous effect for those countries.

4.3.3. Development of a proposal to strengthen the national framework

In this current situation, opportunities to strengthen the role of the national administering and supervising agencies could be to

a) Principally co-share the decommissioning projects, and to

b) Implement a joint supervision over the managing organisation.

The following develops a proposal on how these structures could be improved.

Co-financing the decommissioning costs would increase the country's interest in controlling the managing organisation's strategic decisions towards increased cost effectiveness. In the co-financed projects both institutions financing the activity (EC and National Administration) should equally and in a co-directed manner oversee their effectiveness. The share should be defined at a fixed level, but allowing the EC's contribution to be lowered when projects are only in part related to decommissioning. The fixed level should be depending upon the country's abilities, but should not be below certain thresholds to achieve the desired goal. Shared financing is a well-known **EU** instrument, e.g. with structural funds in regional policy to improve development in needy regions (EU 2013).

Strengthening the overall control over the management's organisation could in parallel be achieved by implementing a joint control institution, following **BMF**'s approach at **EWN**. In the case of **EWN**, **BMF** was the only supervising agency, so the design of control structures was easier than in Bulgaria, Lithuania and Slovakia. As there are two institutions co-financing the decommissioning – the EC and the national control organisation -, a joint control instrument is appropriate in this instance of co-shared financing. The joint control should be limited to

- Strategic decisions (see chapter 2.4.3), leaving operational decisions with the management of the implementing organisation,
- Those parts of the organisation that relate directly to decommissioning.

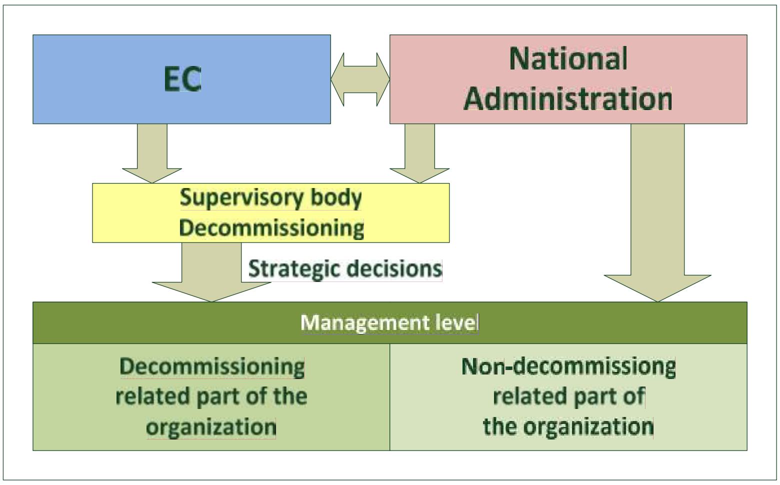
The latter is relevant for Bulgaria and Slovakia. There, the managing organisation has additional tasks beyond decommissioning (such as radiation protection, planning and operating interim storages or final waste disposal facilities, etc.), so that a large part of the organisation's tasks are not related to funded decommissioning projects.

As a result, the persons in the Supervisory Body to oversee the decommissioning process must meet specific criteria and expectations:

- It should be continuous in terms of nominated persons. As the decommissioning process is a long-term undertaking it is absolutely essential to strive for high continuity.
- The nominated persons have to be closely familiar with the subject, the technical plans, their cost implications and the organisational framework, because the supervised management organisation can only act in a responsible manner if it has a highly qualified counterpart.
- The nominated persons should be and act independent from the managing organisation, the funding sources and the fund administration, so that their central interest in achieving a consistent management approach is not biased by contradicting aspects and interests.
- As working successful in the supervisory board envisages close communication with the national supervisor, close knowledge of the national framework as well as high-level communication skills are required.
- Where not (yet) appropriately qualified, the supervisory board should engage external experts of its own choice to evaluate the management's plans and proposals.

The following structure (Figure 34) would result from that setting. Single sided arrows mean 'sent representatives to' and 'having control over', the double sided arrow means 'exchange' and 'co-ordination'.

Figure 34: Possible structure of a joint control over the decommissioning part of the managing organisation



Source: Authors

The EC was selected in this proposal as the steering organisation because:

- The controller should be on the same decision level as the national administrator of the organisation;
- The task has a considerable political component, for which a technical or financial institution (such as e.g. **EBRD**) would not be appropriate;
- Both contributors of funds should be on the same decision level and should represent their interest;
- The proportions in which certain projects are financed have to be decided on the same level and by the same institutions, the controlling institution should be directly involved in the strategic decisions and take responsibility.

Such a change to the current regime would also increase the role and importance of the managing organisation because all strategic decisions have to be prepared, while operational decisions are the sole responsibility of the managing organisation.

4.3.4. Recommendations

The introduction of EU/member state shared projects and a joint steering of the strategic decisions of the organisation that is responsible for implementing decommissioning is recommended in order to strengthen the role of the national controlling administrator and to increase the cost effectiveness.

The EU support of the decommissioning should be re-organized as co-sharing projects. Co-sharing of the costs would increase the country's interest in controlling the managing organisation's strategic decisions towards increased cost effectiveness. In the co-financed and co-directed projects both institutions financing the activity should equally control their effectiveness. The share should be defined with a fixed level, but allowing to lower the EC's contribution in case of projects that are only in part related to decommissioning. The fixed level should be depending from the country's abilities, but shall not be below certain thresholds to achieve the desired goal.

4.4. THE MANAGEMENT ORGANISATIONS FOR DECOMMISSIONING IN BULGARIA, LITHUANIA AND SLOVAKIA

4.4.1. Establishment of national organisations

Bulgaria

In the first years prior to and after shutdown, up to the end of 2002, the operating organisation of the nuclear power plants was also responsible for preparing and implementing decommissioning. But considering that two further reactors remained in operation, no substantial changes to the organisation were made regarding this new task. Even the creation of the state-owned organisation **DP RAO** in 2004, which is responsible for waste management issues, did not change this setting.

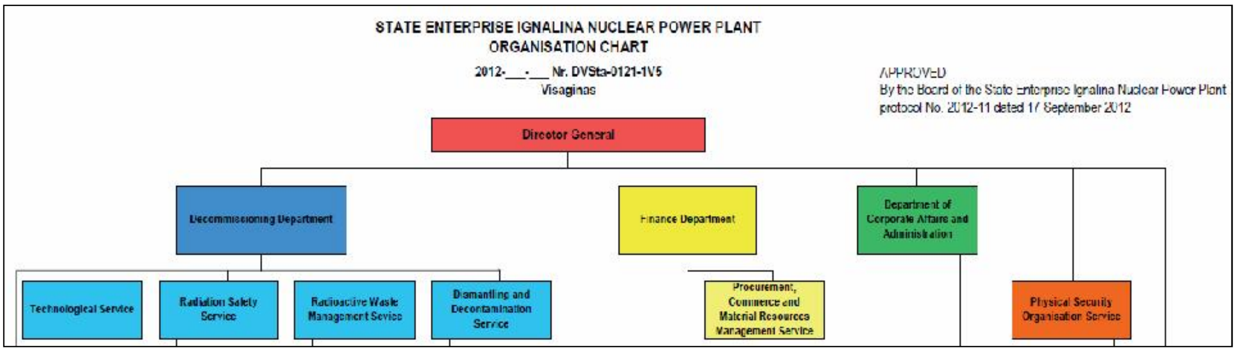
Only at the end of 2008 (SE RAW 2013) was the responsibility for decommissioning the first two units transferred to this institution. One of its divisions, the Decommissioning Directorate, is currently in charge of decommissioning Kozloduy nuclear power plant Unit 1 and 2.

Between 2009 and 2010 twenty persons at **DP RAO** prepared the license application for the decommissioning of the two units, which was granted on October 18, 2010. Also in this year (2010) around 100 employees changed from the unit's operation division to **DP RAO** and the dismantling work of the generator started in June 2011, after nine years in shutdown mode. In December 2012 responsibilities for Units 3 and 4 were transferred to **DP RAO**, so that **DP RAO** is now responsible for all decommissioning activities in Bulgaria.

Lithuania

At Ignalina, the organisation responsible for decommissioning was founded in 2000 as a subdivision of the operating organisation of the power plant (INPP 2013a). Following the shutdown of Unit 2 in 2009 the organisation structure was further streamlined to decommissioning. The current structure of the upper management level of **INPP** is displayed in Figure 35.

Figure 35: Upper level management structure at INPP



Source: Excerpted from INPP 2013c

As can be seen in Figure 35, the structure does not include a project management unit explicitly coordinating project management activities. Such a unit was formerly externally established as a separate unit called Project Management Unit (**PMU**), but these project management activities are now integrated in the Decommissioning Department of **INPP** (Tractebel 2013).

All in all the change process to the internal organisation structure took roughly eleven years, with frustratingly long learning and adaptation phases, and is still in progress (see ANNEX 4).

Slovakia

The establishing of **JAVYS** is connected with the generally complicated and not always transparent privatization process in the Slovak Republic that was started in the late nineties. Slovenské elektrárne company (SE), a state enterprise company, was originally responsible for the operation. Part of the company was privatized by the ENEL Company - a multinational group based in Italy (ENEL 2013). Selected nuclear assets of **SE** in which ENEL was not interested were detached. For this reason, **SE** formed the subsidiary **GovCo** company (**GovCo** a.s.) in 2005. **GovCo** was owned by the government that was represented by the Ministry of Economy of the Slovak Republic. Subsequently, **SE** assured as much as possible smooth transfer of administration and operation of these assets towards **GovCo**.

Based on a decision by the government of the Slovak Republic the resolution on the privatization of Slovak Power Plants went into power in April 2006. At that time it was assumed that **GovCo** will be stock company. It would have been responsible for the operation of the V1 Nuclear Power Plant, the decommissioning of nuclear facilities and the treatment of radioactive waste and spent nuclear fuel as well as for the decommissioning of the A1 **NPP**[22]. The shareholder Ministry of Economy of Slovak Republic later initiated changing of the company's name to **JAVYS** (Jadrová a vyraďovacia spoločnosť, **JAVYS** - Nuclear and Decommissioning Company).

The first organisational structure of the decommissioning company was introduced within the framework agreement between the Slovak Republic and the **EBRD** that was signed in 2001 – before **GovCo** was established. The activities of the Bohunice International Decommissioning Support Fund (**BIDSF**) were fixed in the agreement. In this context the Project Management Unit (**PMU**) was established which was responsible for preparation and implementation of decommissioning projects. The **PMU** was composed of **JAVYS** experts and international consultant staff (see ANNEX 5).

The Decommissioning License was issued in July, 2011 (**NRA SR** Resolution No. 400/2011) by **UJD SR** (Nuclear Regulatory Authority of the Slovak Republic - Úrad jadrového dozoru Slovenskej republiky). The license issuing was based on the application of **JAVYS** in December 2010.

Organisational requirements to obtain the license included the change of the organisational structure, reduction of personnel responsible for operation, change of personnel portfolio and mix of operational staff with new project-oriented personnel and personnel trainings.

In January 2012, **JAVYS** had 897 employees; 382 people of them were employed by the V1 Decommissioning Division and the Project Management Unit division (CPD 2012).

[22] Bohunice A1 is situated on the Jaslovské Bohunice site and was shut-downed after an accident in 1977. It is currently is undergoing a decommissioning and cleanup process. The Federal Government of the CSSR resolution No. 135/1979 put a definitive end to the operation of the A1 nuclear power plant in 1979 at that time, ordering it to be prepared for gradual decommissioning. [Link]

4.4.2. Comparison and evaluation of the national organisations with best practice

The change processes in the two best practice examples **EWN** and **EDF** were very different. The organisation and processes at **EWN** were changed rapidly because it was already clear at an early stage that decommissioning was the only option and that this requires a completely different approach (project management). The setup process at **EDF** only started after the basic decision for decommissioning was taken, but then was consistent and complete.

Compared to these two examples, the change processes in Bulgaria, Lithuania and Slovakia were considerably slower, required more interim steps and in some aspects are still not sufficiently effective. Several reasons played a role in the past:

- The decision to shut the plants down was seen as possibly reversible. That kept responsible management and workforce from adopting the task early and with the necessary rigor.
- Decommissioning was not seen as an ambitious task but much less demanding than operation of the facility. The complexity of this undertaking was generally underestimated.
- In the first phase the management of the reactors had no experiences at all with the new situation and tried to manage the changed situation with some additions or 'add-ons' to their organisation until this, years later, proved to be inadequate.
- In this phase nearly no exchange between the three countries was established so that learning from more advanced countries (e.g. Slovakia) or a systematic, planned and well-organized experience exchange with the other affected countries and/or with countries having advanced experiences in decommissioning did not occur.
- Organisational issues were in general underestimated so that continuity in the established structures was chosen and kept as long as possible.

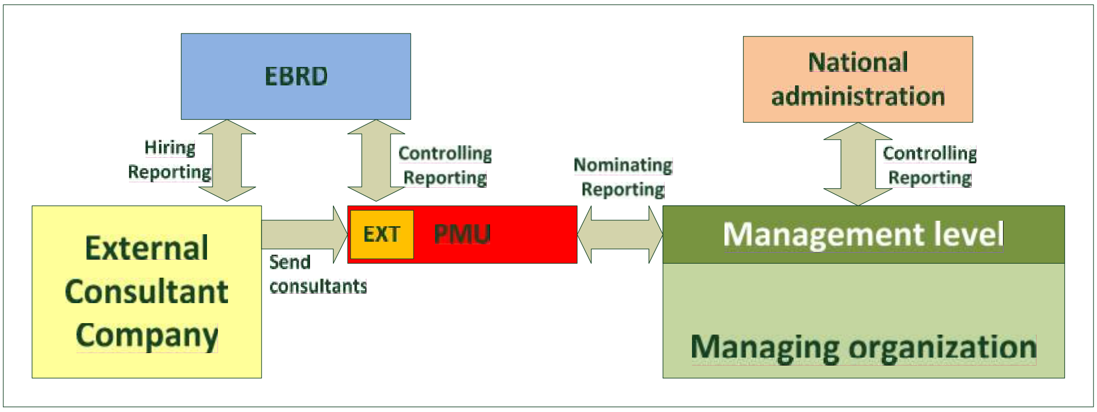
These aspects do not play a role any more. From our interviews, site visits and from the answers to our questionnaire we evaluate today’s internal structures, the self-confidence of the management and the awareness about the necessary changes are well-established in all three countries.

Another aspect that was over long periods very different from **EWN** and **EDF**’s principal practices was that the main managing and planning instrument, the **PMU**, was constructed outside the managing organisation. The **PMU** unit consisted of two different member categories:

- Experts as employed by, nominated by, reporting to and under full control of the managing organisation;
- External consultants, as selected, controlled and fully administered by EBRD.

This construction was not in line with the framework agreement between the countries and **EBRD**, which defined the task to establish **PMU**s as part of the managing organisation and under national control (see the respective text of such an agreement on page 103). Decision-making, not only on operational but also in strategic issues (see chapter 2.4.3), previously a task between the internal **PMU** and its controlling ministry, was shifted towards the external **PMU** and **EBRD**. This **PMU** design is shown in Figure 36.

Figure 36: External PMU design and its roles



Source: Authors

That brought the managing institutions into a complex and intransparent situation and limited their sense of responsibility:

- The national administration, controlling the managing organisation, had no complete control over the **PMU**'s activities, as part of the **PMU** was controlled by **EBRD**.
- The consultant company did not bear responsibility for the decisions prepared by the **PMU** (strategic decisions, to be decided by a control institution) and taken (operational decisions, to be made by the management level of the managing organisation) or for those being in any way adequate, correct or appropriate. The only risk taken over was that the contract with EBRD failed, was delayed or the customer (**EBRD**) was not satisfied with the work provided. None of these risks has to do with the success or failure of the decommissioning process and the decisions to be taken and their risk.
- The external experts in the **PMU** had no obligation to report to the national administration and no formal right to do so, even if requested, because their (and the external consultant company) was formally a consultant for **EBRD**, and had no mandate from, obligations in respect to or reporting requirements towards the managing organisation or its control institution.
- In this structure responsibilities for management decisions, be they of a strategic or an operative character (see chapter 2.4.3), were
  - In-transparently attributed (who prepares proposals for projects or strategic decisions to be taken, who decides on those proposals and on which legitimation basis, with which quality and reliability are those to be prepared and decided, etc.);
  - Completely mixed (the difference between strategic and operational decisions got lost, the awareness of responsibilities is unclear, for insiders as well as for outsiders);
  - In-transparently deployed over five different institutions, all responsible or not for selective parts of the whole process.

The decision to install those units on this unclear basis neither strengthened the national administration's nor the managing organisation's sense of responsibility. This was even further weakened by the fact that for most of the strategic (see chapter 2.4.3) and as well for all operational decisions the formal approval of the **EBRD** was required. So the national controller and the managing organisation as such were only required for usual routine work, their role was not of any importance for the final decisions and for their success or failure.

The European Court of Auditors has, in its section on 'Programme Accountability and Management Organisation', named *'Weak accountability of Programme's performance'* a relevant point:

> *'Effective management requires the definition of clear lines of responsibility for the use of programmes' resources and the achievement of their objectives. Whatever the management method, the Commission should be in a position to exercise its ultimate responsibility for the implementation of the programmes and be held accountable for the use of the funds.' (ECoA 2011, # 30., page 23 of the PDF version)*

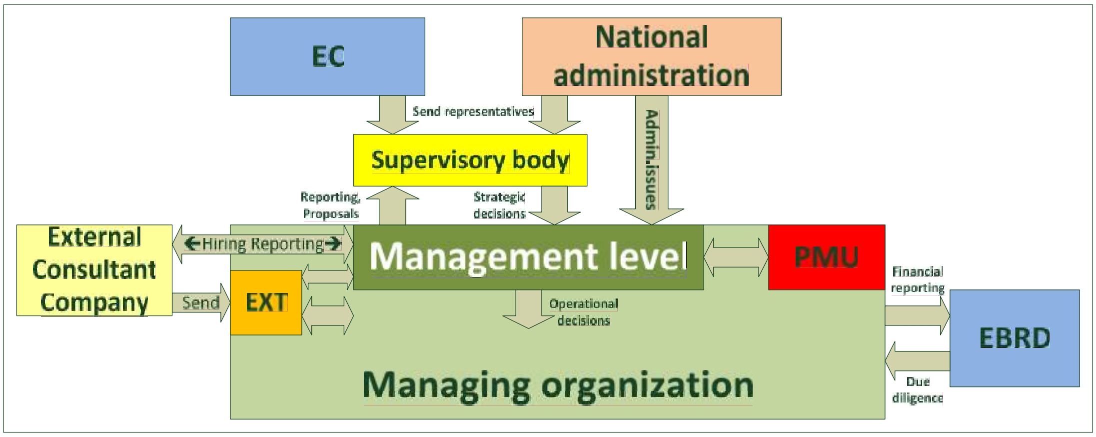
It should be a clear consequence of this to:

- Strengthen the roles of the managing organisation;
- Remove all external **PMU** construction elements from the management structures;
- Clearly define the management's responsibilities;
- Establish clear management and supervising structures.

4.4.3. Recommendations

It is recommended to aim for a more clear attribution of responsibilities in respect to strategic decisions (see chapter 4.3.3). In accordance with this proposed re-organisation and under consideration of the specific conditions in this case (e.g. co-financing, shared control) a possible advanced structure of the management organisation in accordance with the identified best practice is recommended. This structure is presented in Figure 37.

Figure 37: Proposal for an improved structure of the management organisation



Source: Author

All management and control functions are clearly defined:

- The supervisory body controls strategic decisions, to be prepared by the management of the managing organisation (see chapter 2.4.3).

- The management selects and controls external consultants that send their experts to work with the managing organisation (either with the management or the work level, whatever appropriate for the task).
- The **PMU** is fully integrated into the managing organisation level, defined and controlled by its management.
- The managing organisation's budget control issues are a task of the national administration (source 1, the institution responsible for national fund control) as well as of **EBRD** (source 2, control on behalf of the EC budget contribution) and serves as control of the due diligence.

Improvements of the management in the three countries are still possible. This involves on the one side to strengthen the management's role as a planner of strategic decisions (see chapter 2.4.3), but on the other side also to hold management responsible for any failures, for perceiving/evaluating/communicating risks and for consistently controlling work planning and work progress.

In order to strengthen the role of the management a clear definition of its tasks should be established. One of the tasks should involve the complete internal control of the work progress, to be reported using meaningful and significant indicators to the supervising organisations.

The management and its control institutions, not any outside institutions, should be held responsible for all aspects that involve control over the decommissioning process.

4.5. PROJECT AND RISK MANAGEMENT

As described in chapters 3.4.3 and 3.4.4 project and risk management should govern the whole planning process of the decommissioning project.

This chapter identifies the approaches in the three countries and compares them with the best practice.

4.5.1. Project and risk management approach in the decommissioning projects

Bulgaria

ANNEX 3, page 150, lists several examples of projects and their delay. Among them are well foreseeable reasons for delays that can well be expected and should be detected with a functioning systematic project and risk management approach.

E.g. the time that was required for unloading the pools was underestimated by the consultant group. The described reasons (delay in finishing the external storage facility through detection of unsuitable underground conditions and delayed cask delivery) point to underestimated risks that were not correctly evaluated. The condition of the underground of a site for a facility must well be known if the planning involves state-of-the-art foundation ground examination as part of the site identification, site selection and evaluation process. So risks of this kind are foreseeable, if the planning is following rules that allow for early risk identification.

The example shows that project and risk management are still to be vastly improved. The responsible decommissioning organisation has to take control over all relevant issues and has to have the capability and the necessary skills to independently check the work of consultants, namely that of external members of the **PMU**. It points to a deficient management understanding to uncritically take over inadequate estimates that an external consultant provides (see chapters 4.4.2 and 4.4.3).

Lithuania

The necessity to introduce project and risk management at **INPP** has been recognized (see ANNEX 4, page 159). The stepwise introduction of respective project management tools and their later extension to manage risks are foreseen, but still require time and support.

Slovakia

The overall project planning did not take place within the first years of decommissioning project. Several 'small' projects were planned without any long term project concept that would include risk management.

The originally introduced decision making process has spread the decommissioning in many subprojects and is more complicated and more demanding in comparison with the aforementioned decommissioning of the other **NPP** under **JAVYS** management, meaning **NPP** A1. The reason is the financial model set by the Bohunice International Decommissioning Support Fund **BIDSF**, where many stakeholders are involved into the decision making, but the responsibilities and hierarchies are not clearly defined. The involved stakeholders are: European Commission, European Bank for Reconstruction and Development (**EBRD**), Ministry of Economy and a specific **PMU** (involving external consultants). The process is time consuming and needs a lot of staff (see ANNEX 5).

The decision making about the financing of several projects has been organized in the following way (JAVYS 2013).

An evaluation procedure was introduced that was based on **EBRD** Procurement policies, FIDIC international standards and World Bank Procurement Guidelines.as well as **JAVYS**. Firstly, the cheapest tenders have been considered:

- This approach allows to contract a company which offered a price lower than the allocated Grant from the **BIDSF** resources.
- Saved funds are transferred back to **BIDSF** and are used again for awaiting decommissioning projects.
- By saving money from **BIDSF** resources **JAVYS** effectively and responsibly takes an advantage of **EU** financial assistance.
- Each decision taken by **JAVYS** in the field of procurement and contract management must be approved by **EBRD** through its 'No-Objection'.

As the license **NRA SR** defined organisational requirements to obtain the license, the first steps towards implementing an overall long term decommissioning plan with project and risk management were started.

Within the aforementioned organisational requirements to obtain the license (in 2011), personnel trainings had to be introduced. For this reason, off-site trainings took place that also involved a risk management training in Lyon and risk analysis training offered by **EDF-CIDEN** respectively took place.

The first step towards more comprehensive decommissioning planning was taken in 2007 when the so called *'Conceptual decommissioning plan'* (in further text *'decommissioning plan'*) was developed that comprises of two main decommissioning stages. According that, the decommissioning activities should be completed in 2025 (ANNEX 5).

The 1st stage of the decommissioning was started in 2011 and the 2nd stage shall start in 2015 according to the decommissioning plan. Subsequently, as described in *'Combined Programming Document – Bohunice Programme'* (CPD 2012) (also see ANNEX 5), several tasks/projects and their objectives were defined that are co-financed within the **EU** assistance. According to the status in 2012, the project *'Management and preparation of decommissioning activities'* has been implemented. The objective is to ensure the effective project management in compliance with western management methodologies. Among other things, the international standards in the quality management, risk management, interface management, scheduling and costs calculation should be implemented.

As support it was proposed to contract a consultant to provide **JAVYS** with expertise or to cooperate with **JAVYS**.

4.5.2. Comparison and evaluation of the project and risk management with best practice

All three investigated cases point to serious deficiencies in the understanding of management, responsibilities and decision processes.

A consultant group or an external **PMU** consultant can never take over responsibilities for failures or mal-planning of processes, because his work has principally to be independently checked by the management of the managing organisation, corrected or upgraded if necessary, and finally adopted by the finally responsible management (and its control institution). It then is the management's (and its control institutions) failure to accept inadequate planning or consultant work. This misperception in the current understanding of management duties and responsibilities and their control has already been discussed in chapter 4.4.3.

Project management which is performed isolated in a **PMU** unit instead of being integrated into the whole organisation cannot work properly. **INPP** has clearly recognized that and now tries to integrate this as a holistic approach. Compared to best practice this has to be evaluated as being in an *'early stage of implementation'*. Bulgaria and Slovakia are on that way, too, but *'responsibility sharing'* between the management, its national administration institution, external consultants and EBRD still is an issue.

4.5.3. Recommendations for project and risk management

A complete and adequate project and risk management, including the respective task-tailored IT tools (**PMIS**), for the decommissioning project has to be considered a state-of-the-art requirement. Improving, completing and fully implementing project and risk management should be given highest priority. Management should set up respective work methods and tools, the controlling institutions should supervise their design and timely implementation in the managing process.

4.6. REGULATORY APPROACH

The identification of best practices has shown that decommissioning requires:

- An overall permit procedure on a more general base;
- Close supervision and regulatory procedures to decide on the sub-project level;
- Close communication of plans in early stages;
- Integration of licensing milestones and regulatory approval times in the overall project plan.

Failures to achieve these objectives can cause serious delays and additional costs.

4.6.1. Regulatory approach in the decommissioning projects

Bulgaria

Bulgaria's regulatory agency BNRA has regulated the safety aspects of decommissioning already in 2004, mainly dealing with the issue of still needed safety systems (BNRA 2004). The requirements for achieving a decommissioning license were later regulated, as Safety Guide (BNRA 2010). **DP RAO** applied in 2012 for this license:

> *'In June 2012 SD RAW submitted applications to NRA for issuance of licenses for decommissioning of Unit 1 and Unit 2 of Kozloduy NPP. As a result of the review of the enclosed documents, it was assessed that a part of the presented documents need further development, in order to satisfy the legislative requirements for justification of main activities upon decommissioning.' (BNRA 2012)*

Also still pending is the regulation for wastes and for releasing wastes from regulatory control (ANNEX 3, page 156).

The relationships between the operator and the regulatory body are described in ANNEX 3 as *'clear, well regulated'* and *'based on mutual confidence'*.

Lithuania

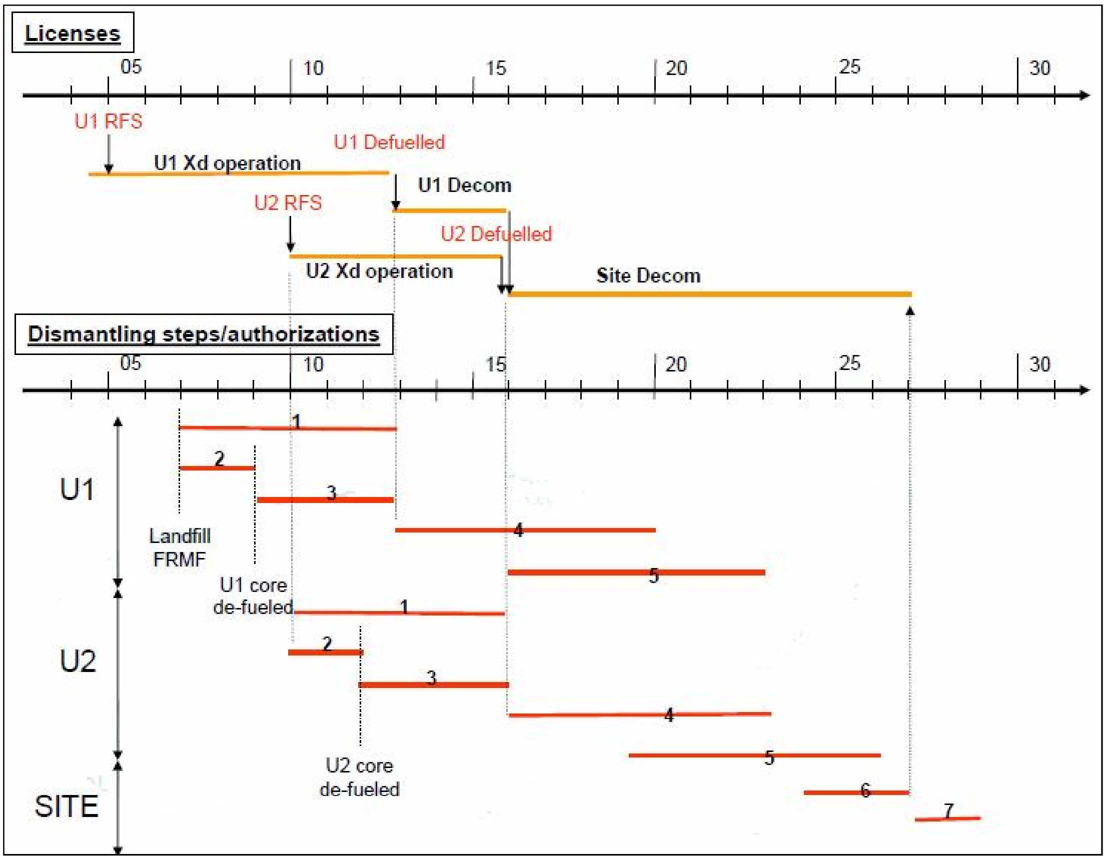
The Lithuanian regulatory body **VATESI** has issued its regulation on decommissioning in 1999 (VATESI 1999). In accordance with respective international safety requirements in IAEA 1999 this regulation called for a decommissioning plan for the facility, to be updated every three years.

The current plan was provided for regulatory approval last year:

> *'In 2012, the updated Final Decommissioning Plan of Ignalina NPP was submitted for review by VATESI. Ignalina NPP is planning to revise the plan and to resubmit it for review by VATESI in 2013.' (VATESI 2012)*

The regulatory framework of the decommissioning project is seen by the regulatory body in a seven stage process, completely depending from the fuel unloading process, see Figure 38.

Figure 38: Licensing process in the decommissioning process



Source: (Paulikas 2011)

During the visit **INPP** declared its relationship with the regulatory body as close and reported about regular communication with its representatives.

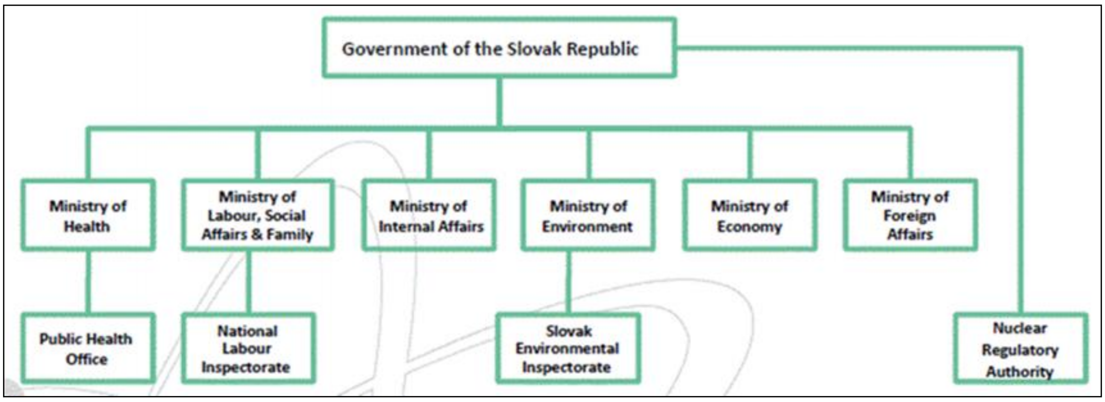
Slovakia

The structure of the regulatory bodies in the context of the decommissioning licensing process is clearly defined. The Slovak Republic (**SR**) has established nuclear regulation according to the **EU** legislative framework.

The supervisory bodies of **JAVYS** are: the Public Health Authority of the SR, Ministry of Environment of the SR, the Technological Inspection of the SR, the National Labour Inspectorate, the Regulatory Office for Network Industries and the Nuclear Regulatory Authority of the **SR** (JAVYS 2013).

The overall structure of the Slovak regulatory bodies is shown in the Figure 39. According to that, the Nuclear Regulatory Authority **UJD SR** is situated directly under the Government. As aforementioned, the Ministry of Economy is the single shareholder of **JAVYS**.

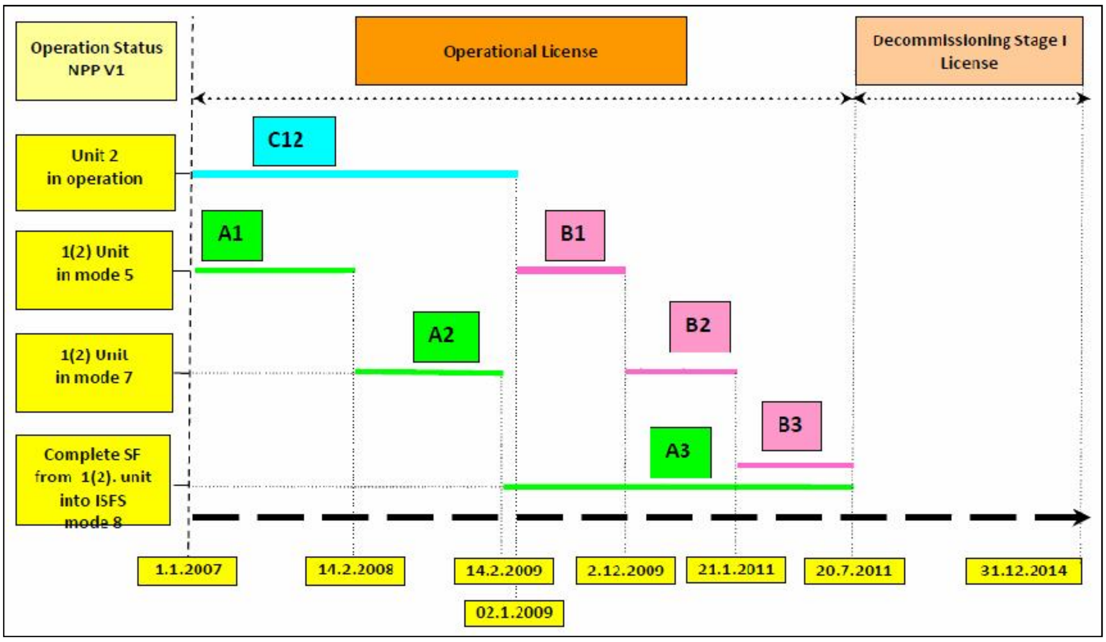
Figure 39: Structure of the Slovak Regulatory Bodies – Decommissioning Licensing process



Source: (JAVYS 2013)

The permit application process in Slovakia is divided into stages. The license for stage 1, as issued in 2011, followed different stages of the operation license, as can be seen from Figure 40.

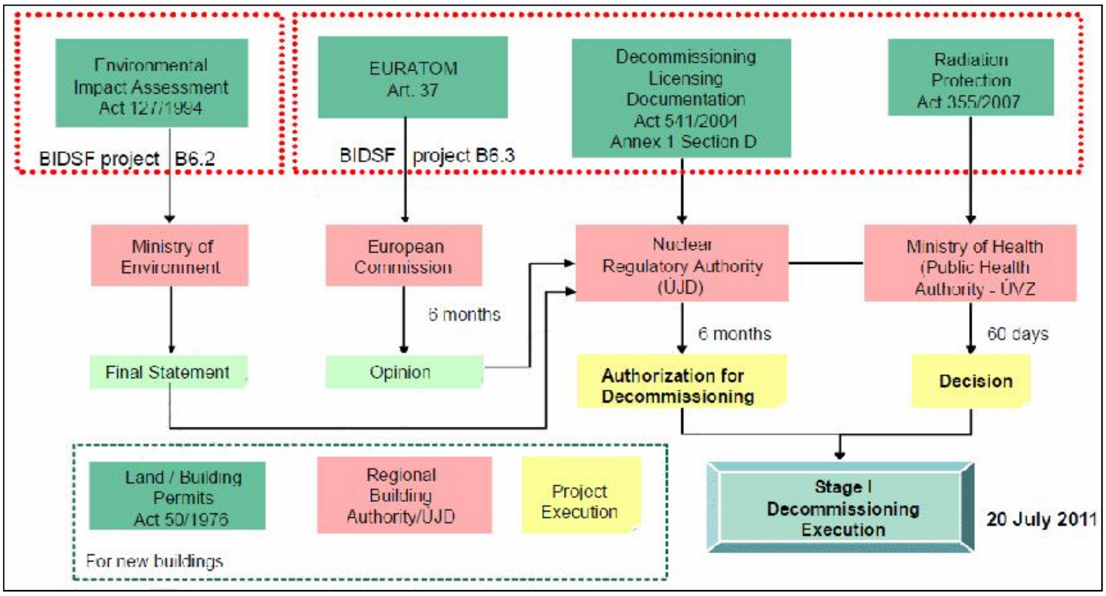
Figure 40: Licensing processes prior to stage 1 in Slovakia



Source: (JAVYS 2013)

As can already be seen the licensing stages in the operational phase were numerous and their duration was very limited in time. This also applies that the license for step 1: it is time-limited until 31.12.2014, a duration of 3½ years. Figure 41 shows the time that was required to achieve the license.

Figure 41: Process for achieving the license for stage I in Slovakia



Source: (JAVYS 2013)

The listed durations were comparatively short, which lets assume that the process is well-designed and the bilateral understanding is good.

On the other side, the splitting of licenses in such short periods includes the risk that the process might require longer periods than previously expected. This might be especially the case with later stages because those include work in radiologically controlled areas, the handling of materials under elevated doses, the decision over materials with higher contamination and more sophisticated waste management decisions.

In short, the experiences made with the regulatory approach were good, but the staged process in the future bears risks so that caution should be included to address possible bottlenecks.

4.6.2. Comparison and evaluation of the regulatory approach

In the two best practices the regulatory approach was recognized as central. The necessary permit applications require time as well as a mutual consent between the operator and the regulatory body.

It has to be seen here that the relevant guiding documents, governing requirements for decommissioning and waste acceptance, still are in progress or are only recently issued. The staged processes with time-limited duration of licenses have risks that the necessary licensing of the next stage may interfere with a smooth and continuous decommissioning. That has to be accounted for in the risk assessment.

All three countries describe their relationship with the regulatory body as 'good' and based on continuous discussions already in the pre-planning stage.

4.6.3. Recommendations for the regulatory approach

Licensing issues should be carefully considered within the risk assessment and should not be underestimated, because failures and delays in this field can have major consequences for the decommissioning process. The good practice identified so far should be continued and upgraded to match to the upcoming more sensitive worksteps.

4.7. COST ESTIMATES

Cost planning is a fundamental requirement for any project. Without a transparent and as detailed as possible (at a certain project stage) cost planning it is not possible to obtain financing of a decommissioning project. And without secured financing it is not possible to perform a project. At the same time the cost planning is the basis for the cost controlling of the project. Cost planning is only reliable if it is based on:

- A detailed planning, identifying all steps to be made;
- Inventory data for masses and contamination;
- A thorough risk evaluation.

4.7.1. Cost estimates of the decommissioning projects

Bulgaria

Bulgaria performs cost estimates on the basis of (see ANNEX 3)

- A detailed work plan (work breakdown structure);
- Underlying sub-tasks on the second level;
- Estimated labor costs; investment costs; operating costs and incidental costs for those activities.

Bulgaria applies the cost estimation standards as recommended in (NEA 2013), which are based on an explicit project management approach.

38 % of the total costs are labor costs (ANNEX 3). The most influence on changes to the cost estimates are seen with adjustments of the work schedule.

The differences between previous cost estimates and the actual costs are seen as follows:

> *'The main reasons for the divergence in the forecast cost appraisals and the real ones are due to the changes made in the initial schedule and in the terms for implementation of the main activities, ensuring the implementation of the Decommissioning plan for Units 1-4.' (ANNEX 3, page 151)*

This has to be seen on the background of the delays in four projects for waste treatment facilities (ANNEX 3, page 150). The risk that further delays occur, delaying work on critical pathes, can increase costs further. This points to the already discussed weaknesses of the project management organisation (see chapters 4.5.2 and 4.5.3).

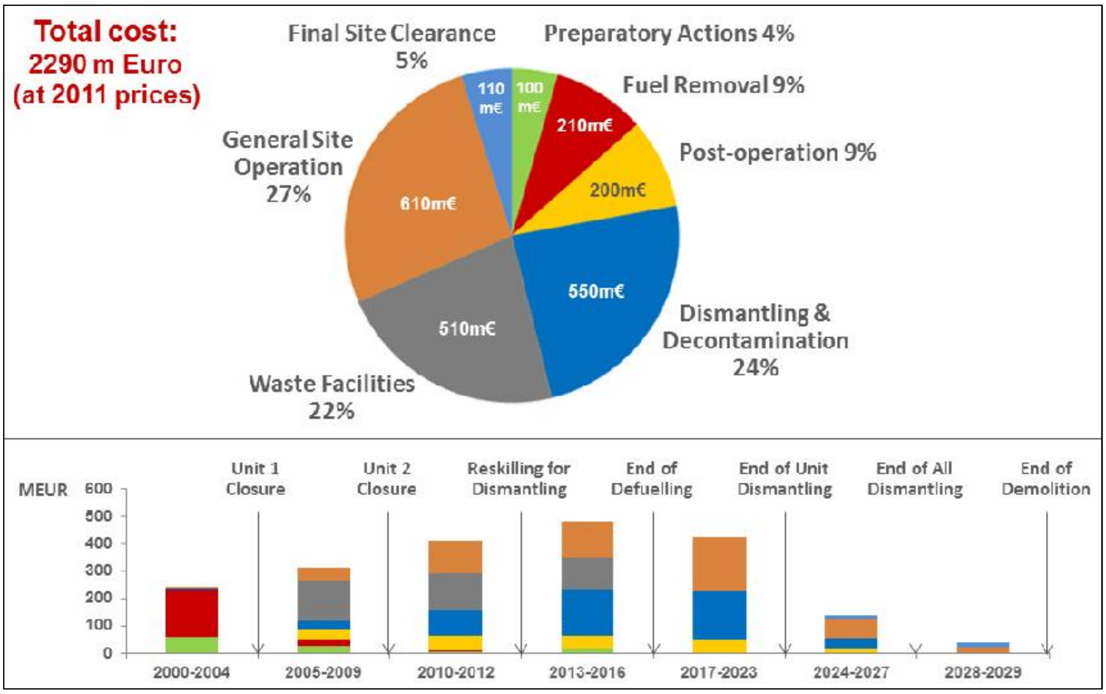
Lithuania

Cost estimation of the decommissioning at Ignalina is in detail described in Harrison 2012. The estimate is based on:

- The Final Decommissioning Plan;
- A simplified model of the project, but including all project stages and cost-relevant factors;
- Greifswald data;
- 2011 prices, 2029 macroeconomic adjustment and cost escalation of technical risks.

Figure 42 shows the main results of the estimate by action type (upper part) and over the time periods (lower part).

Figure 42: Cost structure by activity and by phase



Source: (Harrison 2012)

The results are well compatible with EWN analysis.

According to Harrison 2012 this latest estimate differs only insignificantly from previous estimates.

All in all, the recent cost estimate is state-of-the-art.

Slovakia

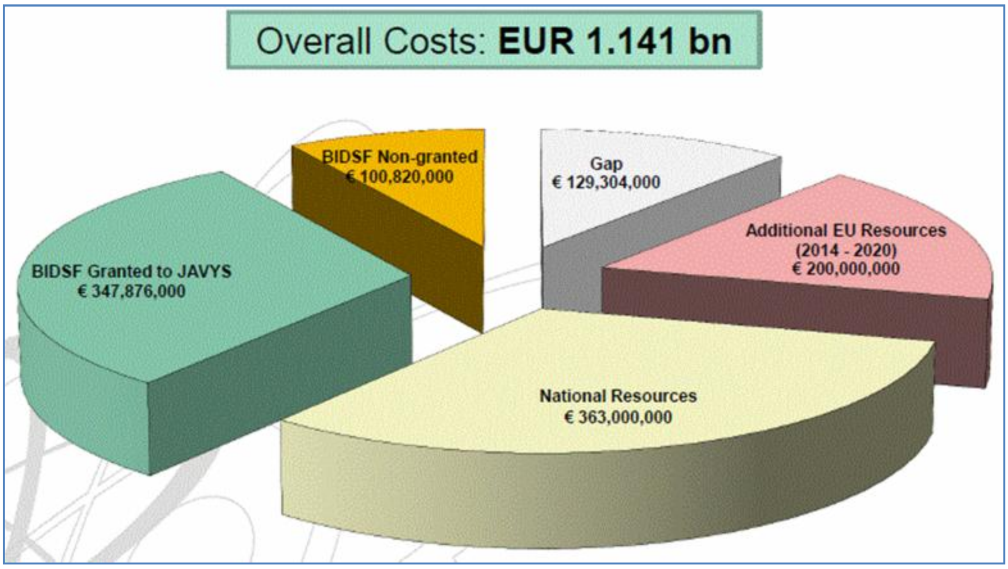
In 2006, at the beginning of the decommissioning project a long term costs analysis was developed. A more comprehensive cost analyses was later prepared and reviewed by external bodies. The Bohunice V1 **NPP** Decommissioning Cost Analysis that identified the costs needed was developed in 2011 (Aid 2013). The analysis was based on the key documentation *'Conceptual decommissioning plan'*, as performed in cooperation with **EWN** (see ANNEX 5). This analysis identified that there is a substantial need for further funding of EUR 300 million of the V1 **NPP** Bohunice decommissioning process at that time.

The most recent cost analysis estimated the total costs for the decommissioning from 2003 until 2025 to be EUR 1 141 million (including the spent fuel wet storage costs).The direct decommissioning costs sum up to EUR 868 million and the costs incurred due to premature shutdown to EUR 273 million respectively (JAVYS 2013).

The costs due to premature shutdown were calculated as follows (JAVYS 2013): The V1 nuclear power plant (which is made of two units) should normally have remained in operation until 2015. But as mentioned earlier the Unit 1 was shut down in December 2006 and the Unit 2 in December 2008 respectively. A National Nuclear Fund for Decommissioning (**NNF**) was established in 2006 according to the Act No. 238/2006 Coll. (Act 2006, see also chapter 4.3.1). So the operator paid contributions to the **NNF** until to December 2006 for the operation of the two blocks and only for the remaining block until December 2008.

The overall estimated costs and their share to different resources are shown in Figure 43. The **EU** pays the decommissioning costs firstly to the Bohunice International Decommissioning Support Fund (**BIDSF**) which is administrated by **EBRD**. This total financial support is about EUR 348 million. The **BIDSF** further covers the costs of EUR 100 million which are not granted.

Figure 43: The overall costs divided according to the financial resources and taking into account the expenses being still not covered



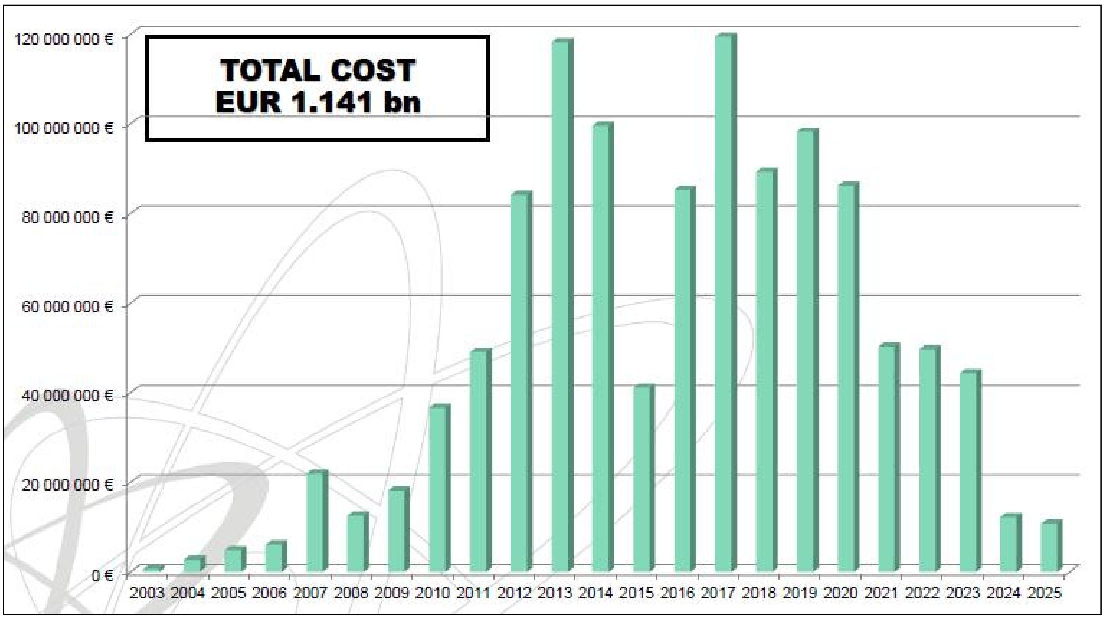
Source: (JAVYS 2013)

National resources need to cover the costs of EUR 363 million. Additionally about EUR 200 million will be supported by **EU** from 2014 until 2020. A remaining gap of EUR 129 million is still not covered. Due to development of several strategies how to cover the costs and/or due to a more accurate cost estimation the aforementioned estimated remaining gap of EUR 300 million was reduced.

According to JAVYS 2013 the relation between the costs covered by **BIDSF** and **NNF** shifted from 54 %/46 % (**BIDSF**/**NNF**) in 2011 towards 42 %/59 % (**BIDSF**/**NNF**) in 2012.

An analysis of cost development is shown in the Figure 44. The operator expects an increase of costs for the period 2016-2020 which is comparable to all expenses spent until 2014 (see Figure 44).

Figure 44: The time development of the total costs



Source: (JAVYS 2013)

4.7.2. Comparison and evaluation of cost estimates

The listed cost estimates for all three countries are performed with state-of-the-art methodology. They are all based on the recent decommissioning plan, on project management plans and underlying material and work structures. They are state-of-the-art and comparable to the methodology used in the two identified best practices.

Two issues are best addressed in the Lithuania example:

- Cost escalation is calculated, like identified as important in the EDF case;
- Risks are accounted for and their influence on total costs is estimated.

4.7.3. Recommendations on cost estimates

Cost estimates are based on state-of-the-art. To further increase their reliability and usefulness, cost escalation and risks should be included in future estimates.

4.8. WORKFORCE

As identified in the two best practice examples, the issues concerning the workforce have to be included in an assessment because of the influence of psychological factors, the long-term perspective and the issues of knowledge and skills management.

4.8.1. Workforce aspects in the decommissioning projects

In respect to workforce issues, the best practice is to:

- Work as much as possible with own experienced persons that have insider knowledge on the facility and its operating history;
- Overcome inner barriers and manage changes in the perspective of those;
- Increase and train knowledge and skills of those towards decommissioning.

Bulgaria

Bulgaria chose a different way to restructure the workforce needed for decommissioning. After transferring the ownership of Unit 1 and 2 in 2008 to the organisation **DP RAO** (see chapter 4.4.1) the respective unit in this organisation was set up. The staff at that time was very small and did not include workforce personnel.

Only after the Kozloduy Units 1 and 2 received the license as installations for the management of radioactive wastes in 2010, around 100 'specialists', former employees of the **NPP**, were also transferred to **DP RAO** (DP RAO 2013). According to different insiders, at that time most of the employees did not see this as an attractive future opportunity and **DP RAO** not as an attractive employer so that the risk of losing knowledge and experience was very high.

Only after the transfer of Units 3 and 4 followed in 2012 the situation improved. In ANNEX 3 the more technical aspects are described (in answering to the aspects '*acceptance of the new targets, job satisfaction, self-complacency, expert excellence*' in question), so that the respective aspects cannot be evaluated.

The named training courses in ANNEX 3 show that it has been recognized what re-qualification means and how valuable improved skills and knowledge is.

Lithuania

The minutes of the meeting (as documented in ANNEX 4) report about a very long period that it took to overcome previous structures, to adapt to the new tasks and to see decommissioning as a new challenge. This process is described as 'still ongoing', but majorly settled. In the meantime new personnel, that is not familiar with the operating habits, is employed and contributes to progress in this field.

About 5 000 employees were employed during operation (ANNEX 4), while 2 053 employees worked at **INPP** on 2 January 2013 (INPP 2013b). Most of today's employees stem from the operational phase.

Remarkably are the efforts to adapt a set of safety culture indicators, which were already developed and implemented in the operational phase, to the specific needs and conditions in the decommissioning phase.

Slovakia

As of the end of 2008, altogether 1 242 people were employed at **JAVYS**, of which the V1 **NPP** division had 382 employees. The amount of the employees was reduced in several steps of changing the organisational structure of **JAVYS** according to the pre-decommissioning and the 1st decommissioning stage (as defined in the license requirements). In January 2012, **JAVYS** had 897 employees; 382 people of them were employed at the V1 Decommissioning Division and the Project Management Unit division (CPD 2012).

After 2006, an intensive communication with and training programs for those, who were previously operational personnel, was required in order to achieve a general acceptance of the new profession.

JAVYS also hired external workforce for several activities in reasonable cases and where an economic benefit for the company was expected (ANNEX 5).

4.8.2. Comparison and evaluation of workforce aspects

In accordance with the best practices identified at **EDF** and **EWN** all three countries have either directly (Lithuania) or indirectly, via a change in the managing institution (Bulgaria, Slovakia), decided to use knowledge and skills of existing personnel in the **NPP**s. While the change at **EWN** took only short time, it took a longer phase in the similar Lithuanian case to establish new structures and a different understanding. This points to a possible previous underestimation that the conversion will in any way be necessary and unavoidable by the previous management, or to an unwillingness to change the approach as rapidly as necessary.

Bulgaria and Slovakia, which took a more indirect way of installing new substructures in their managing organisations, are more comparable to **EDF**s approach (establishing **CIDEN** as managing organisation, see chapter 3.2.2). In these cases the conversion ran faster and in a more strict form, but was associated with a higher risk for fundamental frictions and failures (Bulgaria).

4.8.3. Recommendations

The relevance of workforce issues, such as conversion management and training, is well recognized in all three countries. Explicit training, e.g. in the less technical and more soft skill areas of project management, risk communication and knowledge management is recommendable.

4.9. EXAMPLE OF DISTRIBUTED RESPONSIBILITY: THE PLASMA OVEN AT KOZLODUY NUCLEAR POWER PLANT

In order to understand decision distribution and its weaknesses better, the plasma oven facility at Kozloduy **NPP** is selected as an example. It shows how difficult it is to identify responsible persons and organisations for a certain decision in a distributed responsibility environment.

4.9.1. First failure to identify responsible decision makers

The European Court of Auditors described this example as follows:

> *'In Bulgaria, an experimental plasma melting technology was selected in Kozloduy without proper demonstration of its effectiveness and without due consideration of the design and construction costs (some 30 million euro compared to one fifth for traditional technologies).' (ECoA 2011)*

In its answer in the same document the European Commission did not address the named arguments (experimental technology, high investment costs), but explained, without going into details, on the potential purposes of the selected technology:

> *'The plasma melting technology was the market response to the procurement process and was approved by the relevant safety authorities. The project is co-financed from national resources. Plasma melting technology can potentially serve many more purposes than traditional technologies.' (ECoA 2011)*

The answer says, in a simplified form:

- The 'procurement process' and the 'market' decided over which technology to prefer for that purpose.
- The regulatory agency decides on the technology to use, this agency's compliance decision is supporting the technology selection.
- It is in no way the managing organisation (in this case **DP RAO**) and its national control institutions (in this case **MEE**) that are finally responsible for this strategic decision.

In order to understand this decision process additional background seems necessary.

4.9.2. The basics: project rationale

The project of installing a plasma oven at the Kozloduy **NPP** to treat LAW, which was in part generated during the operational phase and, in part, stems from decommissioning, is rationalized by the missing space for storing wastes at the site (EWN 2013b). Alternatives to this technology are not at all discussed nor evaluated in EWN 2013b.

Waste treatment technologies

During the operational phase of nuclear power plants operational wastes are generated and, if not treated, accumulate over the lifetime of the reactor. These wastes are of very different types:

- Evaporation waste, majorly dissolved/crystallized contaminated boric acid from the partial evaporation of cooling water;
- Spent resins, organic plastic pellets with adsorbed contamination suspended in water;
- Decontamination liquids and cleaning tools;
- Contaminated filters, protective clothes and other materials;
- Removed/exchanged metal parts such as valves or pipes.

If not treated, those wastes are stored at the facility in tanks (liquids), barrels or containers (e.g. metal parts or filters) or vaults (reactor internal or externally added).

During decommissioning the so accumulated raw wastes have to be treated, packaged and later disposed. Depending from the material several treatment methods are applicable:

- Drying (for liquid or wet waste);
- Compaction or super-compaction (for resins, filters, metal scrap or other materials);
- Cutting (for metals);
- Cementation (for metals);
- Incineration (for combustible wastes).

For a brief overview on widely applied treatment methods (see WNA 2013). Treatment goals are: volume reduction, limiting chemical gas generation, reducing microbial activity associated with gas generation, immobilization (avoiding of losses of contaminated liquids or release of contaminated dust particles) and inner-package corrosion prevention (e.g. drying).

Those technical methods are simple and robust. However, incompatibilities between the waste and a potential matrix have to be avoided, e.g. cementation of evaporation wastes, resins or incineration ashes due to chemical reactions of concrete with these materials.

Characteristics of plasma technology

A very special technology, rather expensive and very rarely applied is to heat the wastes in a plasma oven to extremely high temperatures of several 1 000 C, so that carbon and organics are destroyed and released as **CO2**. Metals are molten to yield metal and slag. The method was applied for combustible conventional wastes, e.g. at Karlsruhe/Germany ('Thermoselect/Sinerga') with a typically high energy input (electricity), high specific operating costs and technical difficulties, so that the operation of the mentioned facility has been stopped by the operator. A facility for treating operational **LLW** nuclear wastes at Würenlingen/Switzerland required enormous technical backfitting to achieve the designed throughput. A pilot plant in the nuclear research center in Mol/Belgium was operated in the 1980ies without positive results.

With nuclear wastes the high temperature of the plasma oven evaporates a considerable number of radionuclides that are common constituents in operational wastes, such as Tritium (H-3, mainly as tritiated water), Cesium-137 and Carbon-14. To limit doses received in the vicinity of the facility the off-gas has to be cooled down and filtered (e.g. for Cesium-137). C-14 cannot be filtered without enormous additional efforts (as it requires the removal of the complete carbon dioxide from the discharged gas stream and its later disposal as radioactive waste) and so generating large quantities of secondary wastes. Emitted C-14 dominates the doses in the vicinity of such plants by far and, due to its long half-life time and its high mobility, circulates in the environment ('carbon cycle') and causes high collective doses. The condensate from the off-gas cooling stage concentrates all evaporated tritiated water and can have considerably higher concentrations (requiring additional treatment of the condensate if it exceeds release criteria) (Nachtrodt 2013).

The products of the plasma oven and secondary waste produced have to be disposed as radioactive waste. Elevated (i) investment costs; (ii) operating costs (electricity); and (iii) technological sensitivity and risks, are only balanced by the high volume reduction factor if packaging and disposal of the waste is extraordinarily expensive.

As Bulgaria is currently following a concept to dispose these waste categories in a surface near disposal facility, the volume-specific disposal costs are low to moderate compared to other disposal methods. The advanced volume reduction of 6 to 7 : 1 (Shuey 2006) is less relevant, e.g. compared with the less cost intensive and technically more robust (high-pressure) compaction methods that achieve a reduction factor of up to 5 : 1 (WNA 2013).

4.9.3. Second failure to identify decision makers

We have asked different communication partners to better understand how this decision was actually taken. Our respective question to EBRD was (see ANNEX 7):

> *'How could it happen, and what was EBRD's responsibility in that case, that a completely inadequate plasma oven was ordered and built as part of the decommissioning project, while there is no technical and economic benefit at all from that facility? How was the plan technically and economically evaluated, and on which grounds, if this contributes anything to the decommissioning progress? What were the check mechanisms in that case? What failed here and why did it fail?' (ANNEX 7)*

EBRD's answer to these questions was:

> *'The decommissioning strategy for Kozloduy Units 1-4 foresees the conditioning of solid radioactive wastes with a high volume reduction factor. The technical specification issued for tender did not prescribe any specific technology. The market response to an open competitive tender resulted in proposals using plasma melting technology – not only by the winning bidder. During project implementation, no particular risks were identified with regard to plasma melting and its associated technologies. The technical design, the detailed design and Intermediate Safety Analysis Report (ISAR) have been approved by Kozloduy NPP. The ISAR went through independent verification review and received a positive conclusion. The technical design and ISAR are currently under final review by the nuclear regulator, which includes review by international experts funded from the KIDSF. The Environmental Impact Assessment Report was approved by the Ministry of Environment and Water on 30 May 2013 and public hearings are planned for July-August.' (ANNEX 8)*

Even though explicitly asked, the 'thorough reviews' are not named. The 'approvals' mentioned include only institutions that are not responsible for technology selections but solely for radiological and environmental issues.

The exact definition of 'high volume reduction factor', which in this case is prescriptive, limits and practically determines applicable technologies, again was neither explained further nor reasoned.

The risk that an experimental technology can fail and result in delays or requires time-consuming backfittings was not identified by EBRD:

> *'During project implementation, no particular risks were identified with regard to plasma melting and its associated technologies.' (ANNEX 8)*

This, as well as the other characteristic aspects named above, is not sufficiently treated in the EIS (EWN 2013b). Neither the relevant storage space and conditions (in the section on alternatives) nor the radioactive emissions from the plant (emissions over air and water in the section on environmental impacts from operation) are described in the necessary detail to be understood correctly.

4.9.4. Conclusions

Project status

According to DP RAO the plasma melting facility is already 2½ years behind schedule (see ANNEX 3) and this clearly contradicts that the facility is on track (see ANNEX 8).

This, and the potential further delays, result in a considerable risk that the decommissioning steps, that require and depending upon a working waste treatment and conditioning facility will also be delayed.

Attribution in a dispersed responsibility environment

Neither from the answers provided nor from our talks with very different persons in Bulgaria, who are or were at very different decision levels (from consultants all the way up to the Ministry level), we did not find a single person who could tell us exactly how the decision was taken to build a plasma oven for that purpose.

It can be seen from this example that in an organisation and decision form with a strongly dispersed responsibility even such large portions of budget like EUR 30 million can lack any identifiable decision maker.

4.9.5. Recommendations

In any future setting clear, unambiguous and transparent responsibilities have to be defined and implemented to avoid any dilution and dispersion of responsibilities over several institutions and to avoid unclear and uncommunicated attributions.

The national supervising institution and the EC should be jointly attributed the full responsibility for controlling the national managing organisation's strategic decisions. They should have the right and as well the obligation to completely oversee the whole performance of the decommissioning project and to steer and control the management.

The managing organisation has to be attributed the sole, undivided and unambiguous responsibility to a) prepare the proposals and the complete background for the strategic decisions and b) for any operational decisions. This includes all overseeing, steering and supervision of internal and external processes, including procurement-, cost- and time-control.

To control the due diligence of all financial transactions, the managing organisation should define, set up, implement and regularly audit an adequate internal control system. The national controlling institution or an equivalent (e.g. the Ministry for Finance) as well as the EC should have the right and the obligation to oversee and make exemplary checks on the adequacy of the management's measures to keep control over its financial transactions.

If, in the case of Bulgaria and Slovakia, the interferences of the constitution of the managing organisation's with its non-decommissioning obligations is too complicated and may reduce the effectiveness of the management level's ability to act, an institutional separation of the decommissioning project part should be considered.

5. COUNTRY PROFILES, RISKS AND POTENTIAL IMPROVEMENTS

The following derives, in a short and condensed form, the findings in chapter 4 and points to relevant risks and potential improvements.

Chapters 5.1, 5.2 and 5.3 provide major evaluation results for the three countries. The overall evaluation of the risk profiles in a short form are elaborated in chapter 5.4.

5.1. BULGARIA

The following applies to Bulgaria:

- The **national framework** is incomplete in respect to the funds required for decommissioning. The main reason for that is that during operation of the reactors no build-up of funds was established and that this gap was not adequately filled in the years from at least 1999[23] (IAEA 1999) on until their shutdown in 2002 resp. 2006. Further external support to assist Bulgaria in filling that gap is necessary and recommendable.

  The established national structures to control and steer the managing organisation are weak and need urgently to be strengthened. Bulgaria needs to understand that it is in its own interest to have strong control structures established to achieve optimal results and effectivity for its own invested funds. The full control over the management and all strategic decisions is necessary, otherwise the decommissioning process as a whole is at risk. Bulgaria and the EC should establish a common understanding on those bilateral supervision and steering structures.

- In respect to the **managing organisation** their restructuring towards decommissioning is still to be established. Dividing management and PMU into separate organisations is not an optimal solution as it diverts responsibilities. The PMU should be completely integrated into the responsible organisation, their work should be completely under control of the management so that the management can be held responsible for all its operational decisions. Management then has to be fully aware and has to evaluate all risks associated with those decisions.

- The same effect of inadequately and ineffectively dispersed responsibilities applies both to **project and risk management**.

- The **regulatory regime** should be more fitted to the needs of decommissioning. The stepwise permitting process, with time-limited licenses instead of project-adequate approvals, does not support the awareness that all relevant steps in decommissioning are more or less interconnected and require early planning to fit together. The model of a general decommissioning license regulating the whole general approach, associated with a more project-oriented approval to projects and sub-projects, is seen as more adequate for decommissioning. This also establishes the necessity to intensely communicate with regulators in early planning stages.

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[23] 'At least' means that the final version of the document was released in 1999. Years before such a final version of such a Safety Guide is released the member states of the IAEA receive draft versions so that they can comment on it. The requirements in their draft form are well known earlier and member states can already start to prepare for their adaptation.

- The **cost estimates** are based on a sufficient understanding of the whole process. An estimate for potential consequences of risks can be added to be aware of and better understand their economic influence.

- The role of the **workforce**, the psychological barriers, understanding of the tasks to be done and the self-sufficiency should be better understood and addressed. The priority to use available experience and knowledge can be better communicated. The training programs on technical experience are adequate.

5.2. LITHUANIA

The following applies to Lithuania:

- The **national framework** is incomplete in respect to the funds required for decommissioning. The main reason for that is that during operation of the reactors no build-up of funds was established and that this gap was not adequately filled in the years from at least 1999[23] (IAEA 1999) on until their shutdown in 2004 resp. 2009. Further external support to assist Lithuania in filling that gap is necessary and recommendable.

  The established national structures to design, control and steer the managing organisation are weak and need urgently to be strengthened. The established national funding base still is very weak. It should be mandatory to bear at least a considerable portion of the total costs from own sources, so that the national interest to achieve a cost-effective decommissioning and to install a solid and functioning management- and control-system is strong enough.

  Lithuania needs to understand that it is in its own interest to have strong control structures established to achieve optimal results and effectiveness for its own invested funds. The full control over the management and over all its strategic decisions is necessary to be gained, otherwise the decommissioning process as a whole is at risk. Lithuania and the EC should establish a common understanding on those bilateral supervision and steering structures.

- In respect to the **managing organisation** their restructuring towards decommissioning is still underway and unfinished. Integrating the former external PMU into the managing organisation is a consistent step should be fostered by additional integration steps to achieve that the work of the PMU is completely under control of the management. The management should be held completely responsible for all its operational decisions. Management then has to be fully aware and has to evaluate all risks associated with those decisions.

- In respect to **project and risk management** establishing the necessary changes in the planning and management process, as well as the necessary tools, is still underway in Lithuania. Management is aware of the necessary changes and has initiated them, but the slow implementation process, nearly ten years after shutting down the first unit, lets expect that this requires further acceleration. All involved parties – middle management, workforce, national administration, the EC – should assist the management's efforts to implement those changes. The final structure should be well-designed and implementation targets for the staged processes should be clearly set (e.g. less than three years).

- The **regulatory process** in Lithuania is described as being of no risk. No significant barriers have been identified. The regular updates of the FDP every three years, to be approved by the regulator, should be accompanied by a project-oriented approval procedure more oriented on the necessary steps and their planning and execution process and a close regulatory supervision by site inspector(s) during execution.

- In respect of the quality of **cost estimates** major improvements of the applied methodology are achieved. The recent cost estimates are state-of-the-art and reflect best available knowledge, cost escalation as well as a risk estimate.

- **Workforce** issues are well recognized in Lithuania. The re-structuring is well advanced, but not finalized. The trend to use as much as possible own workforce, accompanied by training, is positive, but still requires additional efforts to cover not only the more 'non- or low radioactive' work steps.

5.3. SLOVAKIA

The following applies to Slovakia:

- The **national framework** is partially incomplete in respect to the funds required for decommissioning. The currently allocated funds, including the BIDSF support, cover the decommissioning costs only partially. The main reason for that is that during operation of the reactors no build-up of funds was established and a fund arrangement was only established in 2006. Prior to that, during the reactor's operating time, no arrangement was made even though required from at least 1999[23] (IAEA 1999) on until their shutdown in 2006 resp. 2008. Further external support to assist Slovakia in filling that gap is necessary and recommendable, but should not exceed limits where Slovakia's own efforts are reduced.

  The established national structures to design, control and steer the managing organisation are strong, but weakened by the external PMU organisational design. In order to strengthen those national control structures Slovakia should integrate the PMU into its responsible managing organisation and should negotiate with the EC on a joint supervision over the decommissioning section of its managing organisation.

- The **managing organisation**'s responsibilities for operational decisions is well developed but can still be strengthened by the integration of the PMU unit into the decommissioning section of the responsible managing organisation. The managing organisation is already structured and self-sufficient enough to handle this additional responsibility so that such a step is associated with only a small risk for failures.

- In respect to **project and risk management** the managing organisation is far developed and seeks close interaction with advanced organisations. These efforts can be further strengthened by integration of the PMU to get a full integration of all operational issues.

- The **regulatory approach** of the managing organisation is successful; it already received its decommissioning license for stage 1. Potential improvements are to integrate the following stages by a general license, covering all following stages, accompanied by project-oriented approval procedures for sub-projects.

- The **cost estimates** performed are based on advanced methodology and a thorough project based approach. Possible improvements that can be made are cost escalations and the consideration of risks.
- In respect to **workforce** issues Slovakia builds dominantly on experienced workers familiar with the facility. From an early stage on task communication and training was headed towards decommissioning. Training programs can be expanded and should include management training.

5.4. OVERALL EVALUATION

In this chapter the results of the relevant issues are summarized using a qualitative evaluation scale from 0 ... 5, whereby

0 - means that none of the evaluated aspects was correctly identified, taken into account and implemented in planning and practice ('Nil').

1 - means that the evaluated aspects were identified, were only in small parts taken into account and implemented, fundamental improvements are necessary ('Rudimentary').

2 - means that the evaluated aspects were identified, less than half was taken into account and implemented, large improvements are necessary ('Widely incomplete').

3 - means that the evaluated aspects were identified, half of them were taken into account and implemented and further improvements are necessary ('Half way through').

4 - means that all evaluated aspects were identified, were in most cases adequately taken into account and successfully implemented, but further improvements are still possible ('Nearly perfect').

5 - means that all evaluated aspects were identified, were in all cases adequately taken into account and were successfully implemented ('Ideal', 'Perfect').

Even though numbers are used, the evaluation results are not quantitative and are not a matter of calculation but of an overall judgment.

Table 5 shows the six aspects, displays in brief the aspects that were evaluated and summarizes the results for the three countries with that scale.

Table 5: Evaluation results on a scale from 0 to 5

AREA	ASPECTS EVALUATED	BG	LT	SV
National framework	• Availability and management of national funds • National control over the managing organisation's strategic decisions	**2**	**1**	**3**
Management organisation	• Consistent structuring of the organisation towards decommissioning • Internal PMU under complete control of the management	**1**	**2**	**3**
Project and risk management	• Project management system established, complete and applied • Risk management under full control of the managing organisation	**1**	**2**	**4**
Regulatory approach	• Regulation matched to decommissioning needs • Early and timely communication of plans towards regulatory agency	**3**	**3**	**4**
Cost planning	• Estimates based on detailed project work plan break down • Cost estimate under full awareness of all influencing risks	**4**	**5**	**4**
Workforce	• Role of own workforce well defined and communicated • Priority for own workforce and establishment of training programs	**2**	**3**	**5**

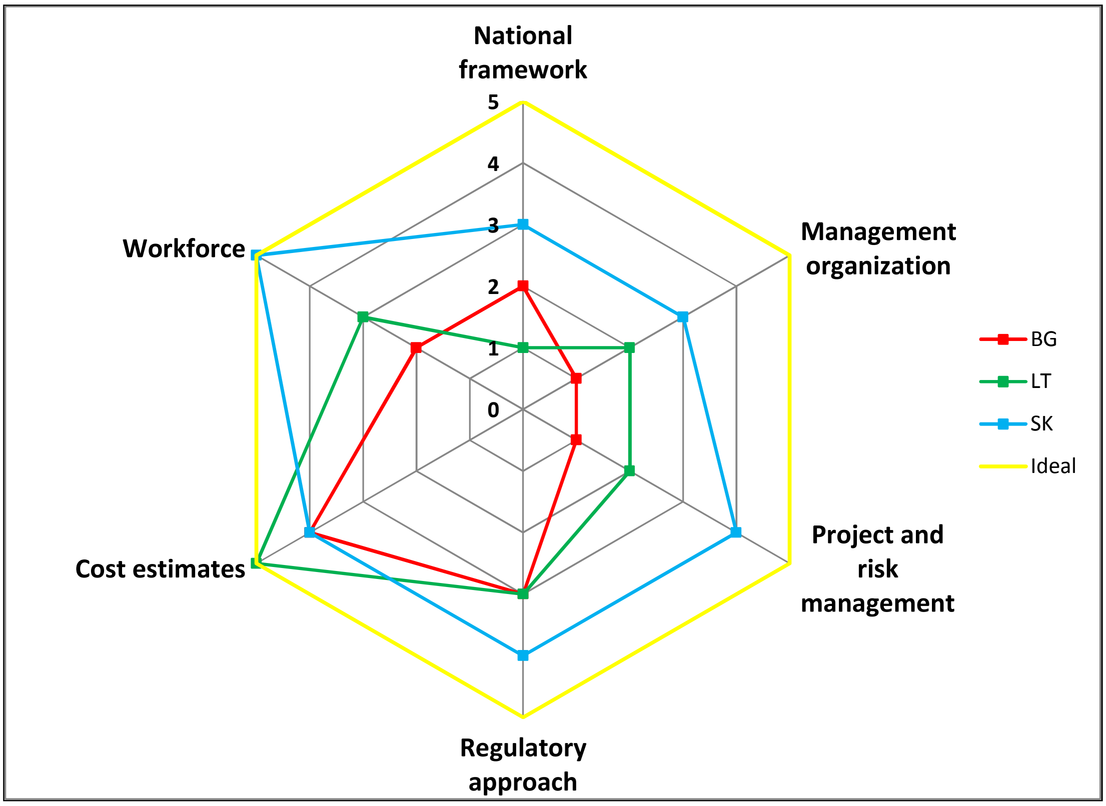
Country evaluation: see scale explanation

Source: Authors

The table shows the areas where future improvements are necessary (1..3), where further improvements are still possible (4) and where the situation is in our view optimal (5).

To draw further conclusions these results are displayed in Figure 45.

Figure 45: Overall visualization of evaluations results



Source: Authors

As can be seen from the figure the areas of the National framework and of the Management organisation are generally far from best practice. Improvements in this field are and should be primarily the task of the respective countries.

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ANNEX 1 - REACTORS IN THE SHUTDOWN STAGE IN THE EU

Table A1-1a: Reactors in the shutdown stage in the EU, compiled after (PRIS 2013)

Ctry	Facility	Location	MWel	Start	Shutdown	Type
BE	BE-3	Mol	10	10.10.62	30.06.87	PWR
BG	Kozloduy-1	Vratza	408	28.10.74	31.12.02	PWR
	Kozloduy-2	Vratza	408	10.11.75	31.12.02	PWR
	Kozloduy-3	Vratza	408	20.01.81	31.12.06	PWR
	Kozloduy-4	Vratza	408	20.06.82	31.12.06	PWR
FR	Bugey-1	St.Vulbas	555	01.07.72	27.05.94	GCR
	Chinon-A2	Avoine	230	24.02.65	14.06.85	GCR
	Chinon-A1	Avoine	80	14.06.63	16.04.73	GCR
	Chinon-A3	Avoine	480	04.08.66	15.06.90	GCR
	Chooz-A	Charleville	320	15.04.67	30.10.91	PWR
	Super-Phenix	Creys-Malville	1242	01.12.86	31.12.98	FBR
	G-3	Marcoule	43	04.04.60	20.06.84	GCR
	G-2	Marcoule	43	22.04.59	02.02.80	GCR
	EL-4	Brennilis	75	01.06.68	31.07.85	HWGCR
	Phenix	Marcoule	142	14.07.74	01.02.10	FBR
	St.Laurent-A1	St.Laurent des Eaux	500	01.06.69	18.04.90	GCR
	St.Laurent-A2	St.Laurent des Eaux	530	01.11.71	27.05.92	GCR
DE	AVR Juelich	Juelich	15	19.05.69	31.12.88	HTGR
	Biblis-A	Biblis	1225	26.02.75	06.08.11	PWR
	Biblis-B	Biblis	1300	31.01.77	06.08.11	PWR
	Brunsbuettel	Brunsbuettel	806	09.02.77	06.08.11	BWR
	Greifswald-1	Greifswald	440	12.07.74	14.02.90	PWR
	Greifswald-2	Greifswald	440	16.04.75	14.02.90	PWR
	Greifswald-3	Greifswald	440	01.05.78	28.02.90	PWR
	Greifswald-4	Greifswald	440	01.11.79	22.07.90	PWR
	Greifswald-5	Greifswald	440	01.11.89	24.11.89	PWR
	Gundremmingen-A	Gundremmingen	250	12.04.67	13.01.77	BWR
	HDR Grosswelshein	Karlstein	27	02.08.70	20.04.71	BWR
	Isar-1	Essenbach	912	21.03.79	06.08.11	BWR
	KNK II	Eggenstein	21	03.03.79	23.08.91	FBR
	Kruemmel	Geesthacht	1402	28.03.84	06.08.11	BWR
	Lingen	Lingen	268	01.10.68	05.01.77	BWR
	Muelheim-Kaerlich	Muelheim-Kaerlich	1302	18.08.87	09.09.88	PWR
	MZFR	Karlsruhe	57	19.12.66	03.05.84	PHWR
	Neckarwestheim-1	Neckarwestheim	840	01.12.76	06.08.11	PWR
	Niederaichbach	Niederaichbach	106	01.01.73	31.07.74	HWGCR
	Obrigheim	Obrigheim	357	31.03.69	11.05.05	PWR
	Philippsburg-1	Phillipsburg	926	26.03.80	06.08.11	BWR
	Rheinsberg	Gransee	70	11.10.66	01.06.90	PWR
	Stade	Stade	672	19.05.72	14.11.03	PWR
	THTR-300	Hamm-Uentrop	308	01.06.87	29.09.88	HTGR
	Unterweser	Stadland	1410	06.09.79	06.08.11	PWR
	VAK Kahl	Kahl	16	01.02.62	25.11.85	BWR
	Wuergassen	Wuergassen	670	11.11.75	26.08.94	BWR

Table A1-1b:Reactors in the shutdown stage in the EU, compiled after (PRIS 2013) (cont.)

Ctry	Facility	Location	MWel	Start	Shutdown	Type
IT	Caorso	Caorso	882	01.12.81	01.07.90	BWR
	Enrico Fermi	Trino Vercellese	270	01.01.65	01.07.90	PWR
	Garigliano	Sessa Aurunea	160	01.06.64	01.03.82	BWR
	Latina	Borgo Sabotino	160	01.01.64	01.12.87	GCR
LT	Ignalina-1	Visaginas	1300	01.05.85	31.12.04	LWGR
	Ignalina-2	Visaginas	1300	01.12.87	31.12.09	LWGR
NL	Dodeward	Dodeward	60	26.03.69	26.03.97	BWR
SK	Bohunice A1	Jaslovské Bohunice	143	25.12.72	22.02.77	HWGCR
	Bohunice-1	Jaslovské Bohunice	440	01.04.80	31.12.06	PWR
	Bohunice-2	Jaslovské Bohunice	440	01.01.81	31.12.08	PWR
SP	Jose Cabrera-1	Almonacid de Zorita	150	13.08.69	30.04.06	PWR
	Vandellos-1	Vandellos	500	02.08.72	21.07.90	GCR
SE	Agesta	Agesta	12	01.05.64	02.06.74	PHWR
	Barseback-1	Barseback	615	01.07.75	30.11.99	BWR
	Barseback-2	Barseback	615	01.07.77	31.05.05	BWR
UK	Berkeley 1	River Severn	166	12.06.62	31.03.89	GCR
	Berkeley 2	River Severn	166	20.10.62	26.10.88	GCR
	Bradwell 1	Blackwater Estuary	146	01.07.62	31.03.02	GCR
	Bradwell 2	Blackwater Estuary	146	12.11.62	30.03.02	GCR
	Calder Hall 1	Seascale	60	01.10.56	31.03.03	GCR
	Calder Hall 2	Seascale	60	01.02.57	31.03.03	GCR
	Calder Hall 3	Seascale	60	01.05.58	31.03.03	GCR
	Calder Hall 4	Seascale	60	01.04.59	31.03.03	GCR
	Chapelcross 1	Annan	60	01.03.59	29.06.04	GCR
	Chapelcross 2	Annan	60	01.08.59	29.06.04	GCR
	Chapelcross 3	Annan	60	01.12.59	29.06.04	GCR
	Chapelcross 4	Annan	60	01.03.60	29.06.04	GCR
	Dounreay DFR	Dounreay Caithness	15	01.10.62	01.03.77	FBR
	Dungeness-A1	Romney Marsh	230	28.10.65	31.12.06	GCR
	Dungeness-A2	Romney Marsh	230	30.12.65	31.12.06	GCR
	Hinkley Point-A1	Hinkley Point	267	30.03.65	23.05.00	GCR
	Hinkley Point-A2	Hinkley Point	267	05.05.65	23.05.00	GCR
	Hunterston-A1	Hunterston	173	05.02.64	30.03.90	GCR
	Hunterston-A2	Hunterston	173	01.07.64	31.12.89	GCR
	Oldbury-A1	Oldbury on Severn	230	31.12.67	29.02.12	GCR
	Oldbury-A2	Oldbury on Severn	230	30.09.68	30.06.11	GCR
	Dounreay PFR	Dounreay	250	01.07.76	31.03.94	FBR
	Sizewell-A1	Sizewell	245	25.03.66	31.12.06	GCR
	Sizewell-A2	Sizewell	245	15.09.66	31.12.06	GCR
	Trawsfynydd 1	Merionethshire	235	24.03.65	06.02.91	GCR
	Trawsfynydd 2	Merionethshire	235	24.03.65	04.02.91	GCR
	Windscale AGR	Windscale	36	01.03.63	03.04.81	GCR
	Winfrith SGHWR	Dorchester	100	01.01.68	11.09.90	SGHWR
	Wylfa 2	Anglesey	540	03.01.72	25.04.12	GCR

ANNEX 2 - MEETING AGENDA FOR BULGARIA, LITHUANIA AND SLOVAKIA

The following meeting agenda resp. questionnaire was sent to the member states.

Meeting agenda

Main task of the meeting

Öko-Institute – as research and consultancy institution in the field of nuclear engineering - was commissioned by the Budgetary Control Committee of the European Parliament (EP) with a study analysing the management of costs and risks in the decommissioning of nuclear power plants (see attached file *'Intro Letter Study on Nuclear decommissioning Öko'*). The management of several of those projects in other EU member states shall be compared with the management in the decommissioning of costs and risks in Bulgaria, Slovakia and Lithuania and recommendations shall be made that have the potential to improve that management, to reduce future costs and to avoid technical and economic risks.

Meeting agenda

The main method to understand your approach to manage the decommissioning project is by identifying any publications and by interviewing you as a responsible person. The interview shall discuss all relevant aspects within two or three hours time. If it seems appropriate, additional experts might participate in the meeting. In this interview we would like to discuss the following issues with you:

- The conceptual planning within the project:
  - The overall plan of the project, it's major packages, it's serial flow, etc.
  - The identified decision breakpoints in that plan (technical, regulatory and financial dependencies, decision base, etc.)
  - The time planning in that concept (What were the major set-backs in the time plans so far? What measures were taken to remove obstacles? Etc.)
- The financial planning within the project:
  - How and on which knowledge/estimate base are financial plans set up and updated?
  - How is, from the view of the operator, the decision process organized (internal and external process, structure of checks, approvals, past experiences with the decision process)?
  - Which experiences were made with financial risks (What were the reasons for serious underestimates in the past? What influences your cost structure mostly (personnel costs, external cost factors, etc.)?

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- The personnel and competence management/responsibilities (personnel planning)
  - How was the personnel made familiar with the new task of decommissioning (training, task communication, etc.)?
  - Which continuous measures has been introduced and set up (training on the job, internal and external courses, etc.), which measures proved to be advantageous/disadvantageous?
  - Has the personnel majorly adopted their changed tasks (acceptance of the new targets, job satisfaction, self-complacency, expert excellence)?
  - Do you see or encounter difficulties between internal and external workforce (with consultants, with construction companies, on competencies, etc.)?
- Administrational aspects
  - Was it necessary to majorly change the internal administrational structure to adapt it to the new task?
  - Did you encounter frictions in that change process?
  - Are major administrational changes ahead to improve the structures?
- Technical aspects
  - Which safety status has the facility reached? What has to be done technically to reduce safety risks further?
  - Which technical challenges were encountered so far in the project? How did those influence costs and time frame?
  - Have lessons been learned by technical challenges so far?
  - Which technical challenges do you see currently and in the near future? How are you preparing for those?
- Waste management aspects
  - Waste management is a necessary prerequisite for a smooth decommissioning. Do you have enough means to store, treat and dispose the wastes from decommissioning internally or externally?
  - Did missing waste management means delay or obstruct your technical or regulatory timeframe?
  - If you see current or future difficulties with your long-term waste management, what will be the measures you see as promising to answer to that expectations?

(Continued)

(Continued)

- Regulatory aspects
  - Have you encountered difficulties caused by regulatory action so far in your project (major delays, necessary re-planning caused by regulation, difficulties in finding common understanding)? If so: what were the reasons for that in your view (incompetence, unwillingness, misunderstandings, etc.)
  - Are the different roles of you as the operator and the regulatory body clear for you (does the regulatory body remain in its own role, would you expect more assistance, etc.)?
  - In which fields could the regulatory body ease your planning, technical and financial structures (should there be more detailed regulation, should there be more written regulation, etc.)?
  - Is it difficult for you to understand the regulatory issues?
  - How would you evaluate your relationship with the regulatory body (cautious, trustfully, distantly, frustrating)?

ANNEX 3 - WRITTEN ANSWERS FROM BULGARIA

• Conceptual planning within the project:	
– The overall plan of the project, it's major packages, it's serial flow etc.	The content of the Plan for the decommissioning of Units 1 and 2 of Kozloduy NPP is developed in accordance with: – The requirements of Art. 59 of the Regulation for the procedure for issuing licenses and permits for safe use of nuclear energy; – The requirements of the BNRA in the Manual PP-2/2010; – The IAEA instructions, in 'Standard Format and Content for Safety Related Decommissioning Documents', SRS No 45. The Plan contains 24 chapters. The Work Breakdown Structure for the preparation and the implementation of the decommissioning process contains the main structural components of the transition from units operation to their decommissioning and dismantling. It is developed according to 'International Structure for Decommissioning Costing (ISDC) of Nuclear Installations (NEA7088, OECD 2012)'. The first level of the Work Breakdown Structure includes the following key phases: 01 Preparation for decommissioning activities; 02 End of operation activities; 03 Supply of equipment and materials; 04 Dismantling activities; 05 RAM and RAW treatment and disposal; 06 Site management and maintenance; 07 Project management and engineering; 08 SF and nuclear material management.

	For each of the key phases sub-tasks of second level are defined (work packages) as well as their sequence of implementation. Third and lower level activities are defined, as well as the time and the terms of their implementation. A detailed schedule is developed. Analysis of the necessary human resources and expenditures has been done. According to the Work Breakdown Structure, dismantling activities start in the 'observed area' (OA) and end in the 'controlled area' (CA). The international experience to start the dismantling from the non-contaminated systems and equipment is followed. The dismantling of systems by category of contamination follows the next sequence: category I, category II, category III. Due to the accepted acceleration of the decommissioning process the dismantling of the activated equipment will be implemented in parallel with the III category equipment dismantling in the CA. <u>Dismantling in the OA:</u> In early 2004 the Nuclear regulatory Agency (NRA) issued to Kozloduy NPP a license series E, № 00613 for Unit 2 and license series E № 00707 for Unit 1 operation in operational status E of the reactor – without production of energy. This reactor status is characterized by absence of fuel in the core and storage of the fuel in the at-reactor pools. In the beginning of December 2006 NRA introduced changes in the operational licenses of Units 1 and 2, **thus permitting dismantling of systems and equipment, not related to the safety and not containing radioactive substances over the regulatory clearance levels.** Kozloduy NPP developed and started to implement a 'Dismantling program', which scope is the dismantling of constructions and system's components *конструкциите* of Units 1 and 2, characterized as III-d category for decommissioning (unnecessary systems that may be isolated and/or dismantled). Since October 2010 NRA issued to SERAW licenses for operation of Units 1 and 2 as radioactive waste management facilities, subject to decommissioning. The licenses include activities for **dismantling and regulatory clearance of materials**. In 2011-2013 SERAW has dismantled large-dimension equipment in Units 1 and 2 Turbine hall, amounting to over 3000 tons from critical groups by Radiological inventory: I – clean materials without potential contamination and II – clean material with potential contamination, for which clearance criteria are met based on approved by NRA radionuclide vector. <u>Dismantling in the CA</u>: The dismantling in the CA will start after obtaining a license for decommissioning of Units 1 and 2. The development of a project for dismantling of the equipment and systems in the CA is forthcoming. The project will include reactor vessels and other internal equipment dismantling as well.

– The identified decision breakpoints in that plan (technical, regulatory and financial dependencies, decision base etc.)	The planning of the main decommissioning activities on Units 1 and 2 has the following aims: Final aim of the decommissioning activities: Removal from the site of the sources of ionizing radiation and its clearance from regulatory control. Decommissioning activities frame: until 2030 Quantities of materials, subject to dismantling during decommissioning: About 30 000 tons, 20 0000 tons of them - metals Operational RAW, stored in AB-1, to be treated: About 2000 m^3 solid phase in ECT About 347 m^3 sorbents About 540 m^3 solid RAW etc. The 'Technical Design for the Decommissioning of KOZLODUY Units 1 and 2 (PHARE Contract BG 9608-01-01-L001)', determines the technical, regulatory and financial aspects of the decommissioning, and the main approaches for their solution.
– The time planning in that concept (What were the major set-backs in the time plans so far? What measures were taken to remove obstacles? Etc.)	On 14 April 2011 Bulgaria has presented to the EC its position on the continuation of the financial support of the EU for 2014-2020 in relation with the earlier shutdown for decommissioning of Units 1-4 of Kozloduy NPP, including conceptual linear schedule for the decommissioning of Units 1-4. According to the schedule the decommissioning is accelerated and is foreseen to be finished in 2030 (5 years earlier than according to the initial plan). The necessary prerequisites for the implementation of the accelerated decommissioning are: Decommissioning license for Units 1 and 2 – by end 2013; Timely implementation of the projects of the decommissioning programme for Units 1-4 of Kozloduy NPP (financed mainly from KIDSF): o Commissioning of the facility for measurement and clearance of materials - September 2016; o Commissioning of the Workshop for defragmentation and decontamination of materials – Contactor: Consortium ONET Technologies Nuclear International and Risk Engineering OOD. It is expected to be implemented in July 2015;

	o Commissioning of all liquid RAW treatment facilities by the end of 2015. The facilities are supplied from different contractors, and some of the projects have a significant delay: ▪ Facility for treatment of low-level liquid waste – Supplier: Atomstroyexport. The project was finished in 2012 with 4 years of delay, ▪ Facility for retrieval and treatment of spent ion-exchange resins - Supplier: ENSA (Italy). After interruption the work on the project is restarted in June 2012. It is expected to be finished in 2017 against in October 2007 as it was initially scheduled; ▪ Plasma melting facility – Supplier: Consortium Iberdrolla Ingeneria and Belgoprocess. It is expected to be finished in November 2015 against in July 2013 as it was initially scheduled; ▪ Facility for retrieval and treatment of the solid phase of evaporator concentrate tanks – Supplier: ONET Technologies Nuclear International. It is expected to be finished in January 2016 against in September 2012 as it was initially scheduled. Commissioning of the National disposal facility for LILW – 2015. The significant delays in the implementation of some of the projects for supply of RAW treatment facilities, as well as in the implementation of projects of the decommissioning support programme for Units 1-4 of Kozloduy NPP, may compromise the accepted and declared to EC terms for acceleration of the decommissioning process of Units 1-2. To overcome the problems working meetings are organized on regular basis between the Supplier, the Client and the Consultant of D-R PMU. In the time planning the main limitation is the initial preparatory period of 5 years for release of the Units from spent fuel. The initially foreseen period was of 8 years, 3 years of them for storage of the assemblies in the at-reactor ponds and 5 years for preparatory decommissioning activities. The Consortium 'BELGATOM - EWN – ENERGOPROEKT' reduced the period from 8 to 5 years. Afterwards it was realized that the period is unrealistically shortened. The main delay in the spent fuel removal from at-reactor ponds was due to the delay in Project 1 – Dry Spent Fuel Storage Facility (DSFSF). The project was completed with some years of delay, due to different technical difficulties, encountered during foundation of the loess cushion under the facility and during the supply of storage casks for the spent fuel assemblies from Units 1-4 of the NPP. The problems were resolved in October 2010. Licenses for Units 1 and 2 as Radioactive waste management facilities were issued to SERAW. The preparatory decommissioning activities and the conditions for their implementation are part of the scope of the license and are defined by the Bulgarian regulatory body – the NRA.

• The financial planning within the project:	
– How and on which knowledge/estimate base are financial plans set up and updated?	For Units 1-4 of KNPP decommissioning cost appraisals the Work Breakdown Structure approach has been used. From the standardized list of activities in the 'International Structure for Decommissioning Costing (ISDC) of Nuclear Installations, NEA7088, OECD 2012' 8 main groups of activities have been chosen and Units 1-4 decommissioning activities are grouped in them. For each main group of activities the following groups of costs are discussed and evaluated: Labor costs; Investment costs; Operating costs; Incidental costs.
– How is, from the view of the operator, the decision process organized (internal and external process, structure of checks, approvals, past experiences with the decision process)?	With Grand Agreement 038/June 1, 2012 the Units 1-4 decommissioning projects with the respective KIDSF financing were transferred to SERAW as. The necessary co-financing for some projects is ensured by RAW Fund, within the annual general budget of SERAW. The financing process from the RAW Fund follows the state budget structuring procedure and according to the requirements of the ASUNE and the respective Regulations on RAW and Decommissioning Funds accumulation and expenditure. The salaries of the personnel directly involved in the decommissioning activities are financed by KIDSF under Grant Agreement 016 E.
– Which experiences were made with financial risks (What were the reasons for serious underestimates in the past? What influences your cost structure mostly (personnel costs, external cost factors, etc.)	The main reasons for the divergence in the forecast cost appraisals and the real ones are due to the changes made in the initial schedule and in the terms for implementation of the main activities, ensuring the implementation of the Decommissioning plan for Units 1-4. The highest costs from the 4 groups (38 %) are labor costs. Labor costs are predictable and within the estimated values.
• The personnel and competence management/responsibilities (personnel planning):	
– How was the personnel made familiar with the new task of decommissioning (training, task communication, etc.)?	Project 27 (KIDSF financed) had as main aim the acknowledgment and the initial training of Kozloduy NPP personnel in the area of decommissioning of nuclear units. The project is accomplished in 3 main directions: – Training courses following a programme developed and approved by Kozloduy NPP; – Training in external organizations, specialized in decommissioning; – Training in EU member states' facilities, where decommissioning is implemented, including Greifswald.

	The decommissioning personnel of Kozloduy NPP is the same one, that operated the units before. The good policy and strategy of the IAEA is observed to keep trained and well qualified personnel with knowledge on the technical status of the nuclear facility. The change in the operator of the Units didn't change the personnel's' qualification and its competencies. The specialists in the area of nuclear energy, physics and chemistry developed a number of documents, such as: Decommissioning plans, Safety Analysis Reports, different programs for dismantling of separate elements of systems, whole systems, as well as large dimensions equipment, instructions etc. All sections, units and groups in the Decommissioning Directorate participate in the development of the necessary documents, required from the regulator, observe strictly the license conditions and monitor and observe all safety aspects of their activities.
– Which continuous measures have been introduced and set up (training on the job, internal and external courses, etc.). Which measures proved to be advantageous / disadvantageous?	According to the plan for training and maintenance of the qualification, in relation with the decommissioning the Office for Preparation and Educational and Training Center of Kozloduy NPP undertook series of training courses with different syllabus (depending on the qualification) on the following main decommissioning activities: – Safe radioactive waste management activities – 89 workers for 1 hour course, 122 workers for 2 hours course, 86 workers for 3 hours course, 126 workers for 5 hours course, 36 workers for 6 hours course, 11 workers for a longer training; – Decontamination – 15 workers for 4 hours course, 20 workers for 6 hours, 47 workers for 3 hours, 67 workers for 7 hours; – Decommissioning – 40 workers for 1 hour, 337 workers for 2 hours, 42 workers for 4 hours, 26 workers for 5 hours, 59 workers for 7 hours; – Environment protection – 34 workers for 2 hours, 217 for 3 hours; – Treatment and conditioning of RAW – 5 workers for 2 hours, 33 workers for 5 hours; – Modes of operation in status 'E' – 234 workers for 1 hour, 75 workers for 2 hours, 14 workers for 3 hours, 70 workers for 5 hours, 14 workers for 7 hours; – SF storage – 44 workers for 5 hours, 5 workers for 7 hours;

	– Storage and disposal of RAW – 41 workers for 2 hours; – Decommissioning technologies for nuclear facilities – 226 workers for 1 hour, 100 workers for 2 hours, 200 workers for 3 hours, 105 workers for 4 hours, 19 workers for 5 hours, 11 workers for 6 hours, 40 workers for 7 hours; – Decommissioning management of nuclear facilities – 2 workers for 4 hours ; – Materials management – 33 workers for 2 hours. At the moment this personnel is accomplishing decommissioning activities on Units 1-4 and the results of the personnel's activities show that these courses for enhancement of the qualification are very useful. On-the-job training is a continuously practiced measure. There is a continuous process of enhancement of the competencies and the qualification of the personnel, using IAEA training courses, forums organized by countries well ahead in the decommissioning etc. As a very useful may be noted the exchange of experience with German representatives from KKW Nord – NPP Greiswald. All the levels of the training passed are certified by the regulatory bodies.
– Has the personnel majorly adopted their changed tasks (acceptance of the new targets, job satisfaction, self-complacency, expert excellence)?	The personnel adopted their new aims and the tasks for their completion. The tasks posed by the National Strategy for SF and RAW management are adopted, as well as the conditions and prescriptions in the new edited regulatory documents.
– Do you see or encounter difficulties between internal and external workforce (with consultants, with construction companies, on competencies, etc.)?	There are no conflicts and difficulties in the communication between workers and external contactors/consultants in SERAW.

• Administrational aspects:	
–Was it necessary to majorly change the internal administrational structure to adapt it to the new task?	Yes, the administrative structure was changed to be adapted to the new tasks, to be implemented in the nuclear facility. A totally new directorate – Decommissioning was established and the structure of the enterprise was changed respectively, as well as its Rules of procedure, internal rules of the specialized divisions, instructions, programs, methodologies etc.
–Did you encounter frictions in that change process?	No difficulties met by now.
–Are major administrational changes ahead to improve the structures?	No significant administrative changes are foreseen. In case it is necessary for the improvement of the work, administrative changes might be done.
• Technical aspects:	
–Which safety status has the facility reached? What has to be done technically to reduce safety risks further?	After the removal of the spent fuel the facility is kept in a safe status for a long period of time. Radiological monitoring and radiological survey of the contaminated structures and materials are implemented. Environmental monitoring is implemented according to the regulator's requirements. To decrease the risk and to maintain the concept of defense in depth, it is necessary to carry out decontamination of first circuit, of the assembly storage pool and after that to drain them.
–Which technical challenges were encountered so far in the project? How did those influence costs and time frame?	The challenges are entirely in the area of early planning and its contradiction with the subsequent phases of the projects. The projects, as a whole, during their management from KNPP accumulated delays of several years. As of today, during last 2012 year, the majority of the projects were transferred for management from Kozloduy PMU to International Projects Division of SERAW. SERAW, as decommissioning and RAW management operator is highly motivated to finalize and timely complete the decommissioning projects. Thus no delays in the projects transferred are observed.
–Have lessons been learned by technical challenges so far?	It is a continuous process there the technical challenges overcome help to increase the competence level of decision making and executive teams, involved in the decommissioning activities.

– Which technical challenges do you see currently and in the near future? How are you preparing for those?	As new technical challenges are identified: • Completion of the radiological inventory of Units 3 and 4 – Turbine hall and Reactor hall; • Verification of the radiological inventory for Reactor hall of Units 1 and 2; • Completion of the projects such as: Decontamination and Defragmentation Workshop, sites for temporary storage of RAM and RAS and upgrade of the facility for regulatory control clearance; • Completion of the projects for removal of historical RAW, ion-exchange resins and boron concentrate from ECT.
• Waste management aspects:	
– Waste management is a necessary prerequisite for a smooth decommissioning. Do you have enough means to store, treat and dispose the wastes from decommissioning internally or externally?	As a result of the decommissioning non-radioactive materials (scrub) are expected to be generated, as well as radioactive materials (RAM), radioactive waste (RAW) and non-radioactive waste. Four open sites are planned to be built for the storage of radioactive and non-radioactive materials. RAM will be stored in 20'ISO containers, and non-radioactive materials – in skip containers. RAM treatment aiming regulatory clearance is planned to be done in the Decontamination and Defragmentation Workshop. Treatment of the decommissioning RAW will be implemented in the existing RAW Treatment Workshop, situated on the Kozloduy NPP site. New depot for storage of non-radioactive household and industrial waste is planned to be built. At the moment the construction of Decontamination and Defragmentation Workshop is at technical design elaboration level. After its commissioning the enterprise will be able to accomplish all the activities related to collection, treatment, conditioning and storage of RAW at the respective sites. In the near future - in 2015 the commissioning of National Disposal Facility for LILW is foreseen and the biggest part of the RAW generated from the decommissioning and dismantling activities on Units 1-4 , will be disposed in it. In this way all the RAW management process will be considered as closed.
– Did missing waste management means delay or obstruct your technical or regulatory timeframe?	Non-radioactive and radioactive waste management is a prerequisite for the good planning of the decommissioning process. The delay in the construction of whatever facility, included in the waste management process will lead to delay in the decommissioning process. The lapse of some of the facilities needed will lead to impeding of the decommissioning process and non-adherence to the planned terms of implementation.

– If you see current or future difficulties with your long-term waste management, what will be the measures you see as promising to answer to that expectations?	The long term RAW management is well founded in the national legislation and in the National strategy for RAW and SF management until 2030. Measures: Fast and adequate decision making for construction of facilities, needed for the management of radioactive and non-radioactive waste. Joint monitoring with EBRD on the implementation of contacts for supply, of the facilities at modern technical level.
• Regulatory aspects:	
– Have you encountered difficulties caused by regulatory action so far in your project (major delays, necessary re-planning caused by regulation, difficulties in finding common understanding)/ If so: what were the reasons for that in your view (incompetence, unwillingness, misunderstandings etc.)?	Decommissioning plans are in accordance with the legislation in force and with the restrictions imposed by it, as well as with the recommendations of the NRA.
– Are the different roles of you as the operator and the regulatory body clear for you (does the regulatory body remain in its own role, would you expect more assistance, etc.)?	The relationships between the Operator and the independent Regulatory body are clear and well regulated.
– B In which fields could the regulatory body ease your planning, technical and financial structures (should there be more	The Regulatory body may contribute for easing the processes in several ways. In 2001 the first version of the Decommissioning regulation has been elaborated, in 2002 - the Act for the Safe Use of Nuclear Energy and a number of secondary legal acts, easing the decommissioning activities – in 2004. At the moment there is a need for elaboration of Guides on the application of the *'по прилагане на'* Regulation for the safe management of RAW

detailed regulation, should there be more written regulation, etc.)?	and the Regulation on BSS-2012, which regulate the management, conditioning, intermediate storage, disposal of RAW and materials clearance. Part of these Guides are under development but still are not in use.
– Is it difficult for you to understand the regulatory issues?	No
– How would you evaluate your relationship with the regulatory body (cautious, trustfully, distantly, frustrating)?	The relationships with the independent Regulatory body are based on mutual confidence.

ANNEX 4 - MINUTES OF THE MEETING AT IGNALINA NPP, LITHUANIA

Finalized after consultation with the participants of the meeting

Minutes of the meeting in Ignalina nuclear power plant on 19 July 2013

Participants:

- Ignalina NPP: Director General Darius Janulevičius, Head of Communications Natalija Survila, additional responsible persons from the divisions on technical planning, personnel management, financial department, etc.
- Öko-Institute: Veronika Ustohalova, Gerhard Schmidt

The agenda of the meeting was sent ahead of the meeting. Cited text portions in these minutes are formatted *in italic*.

Passages formatted in **bold** characters indicate additional documents that will be provided to Öko-Institute for further reference.

<u>Underlined</u> text has been copied in from other sources. Please check if this information is correct and complete. If inappropriate please preferably delete this text as it is not exactly a result of the meeting.

The conceptual planning within the project

the overall plan of the project, it's major packages, it's serial flow, etc.

the identified decision breakpoints in that plan (technical, regulatory and financial dependencies, decision base, etc.)

the time planning in that concept (What were the major set-backs in the time plans so far? What measures were taken to remove obstacles? Etc.)

…………………………………………………………………………………………………

Presently, the revision of planning system is being performed at the INPP. It includes enhancement of planning procedures, revision of decommissioning schedule for its synchronization with the decommissioning projects management system. This system also is being enhanced at the moment (all INPP decommissioning projects are integrated into one 'Megaproject'). It is planned that the whole complex of activities will be accomplished until the end of 2013.

For the purpose of planning of the decommissioning process the following levels of planning are identified at the INPP:

Strategic planning is intended for the entire decommissioning period. According to the existing current version of Final Decommissioning Plan (FDP), the decommissioning should be finished until 2029 and ends with a brown field (buildings assigned for later re-use still existing).

Perspective planning is intended for specific 7-year periods pursuant to the decommissioning activity financing perspectives provided by the European Union (2000-2006, 2007-2013, 2014-2020, etc.) and for 3-year periods with annual review of the Megaproject schedule for subsequent 3 years;

Annual planning is intended for the upcoming year;

Day-to-day production planning is intended for a month, week, day, shift.

The adopted structure of the Megaproject:

- 1st level Projects programs;
- 2nd level Projects subprograms;
- 3rd level Projects;
- 4th level Project WBS;
- 5th level Project work packages;
- 6th level Separate works of the project work packages;
- 7th level Operations.

The projects within the Megaproject are grouped according to the project programs:

- P.0 – The Programme related to the organizing of the enterprise activity (general types of activity).
- P.1-The Programme related to preparation for the decommissioning.
- P.2 – The Programme related to dismantling/demolition of facilities and the site restoration.
- P.3 – The Programme related to handling of the spent nuclear fuel (hereafter referred to as SNF).
- P.4 – The Programme related to the waste management (except for initial solid radioactive waste treatment).
- P.5 – The Programme related to the post-operation.

These programmes are divided into sub-programs.

The systematic analysis and schedule revision is performed taking into account the current status of decommissioning and taken decisions for the future periods, considering provided financial resources.

A more detailed planning level covers the upcoming three years. These schedules are updated every year for the next year. In this way the previous experiences are taken into account within the planning for the next year. The most detailed planning level is updated weekly.

The time planning is linked with all the programs within the whole decommissioning project.

To control quality and assess performance a project structure for each part of the project will be developed. A project control tool for this purpose is planned to be introduced in I/2014. The addressed levels of the structure planning work packages are:

- Project Management
- Preparation
- Implementation of works
- Project closure

The tool provides information on:

- the performance of the work packages,
- the completion of the project or program,
- the personnel involved,
- the cost calculation (derived from the personnel),
- other sources necessary,
- subcontracts,
- services provided,
- procurement,
- energy consumption,
- taxes,
- etc.

The tool is based on Oracle's Primavera software. This tool includes the respective module for risk management. The risk management system should be developed in close relation to the project management program. This is a new field and the operator currently has no experiences. For this reason, additional support by introducing the risk management system as well as education and training are needed. Courses are planned within the program 'Risk management'.

This overall project control with that tool will be introduced step by step and experiences shall be used to optimize its application and to customize the tool for application in the decommissioning project. The control system is currently in the process to be introduced.

The description on how the planning tool and the risk management system are incorporated into the decision making process will be provided to Öko-Institute.

The financial planning within the project

How and on which knowledge/estimate base are financial plans set up and updated?

How is, from the view of the operator, the decision process organized (internal and external process, structure of checks, approvals, past experiences with the decision process)?

Which experiences were made with financial risks (What were the reasons for serious underestimates in the past? What influences your cost structure mostly (personnel costs, external cost factors, etc.)?

Preliminary Decommissioning plan (FDP) was elaborated by a consortium NIS/SGN/SKB in 1999 under the PHARE project. The waste management issues were not included in this plan. From 2001 to 2004 the Final Decommissioning Plan FDP was elaborated. In 2006 a cost calculation covering the time period from 2007 to 2014 was added, to be updated in 2014. From 2010 to 2011 the 'Global Decommissioning Plan' GDP was developed and the complete perspective for 2020 and 2029 was elaborated.

The first financial support in 1999 was provided by European Commission for preparation the above mentioned FDP, Ignalina International Decommissioning Fund was established in 2000. Since 1995 a national decommissioning fund was established by a national decree. Since 2002, the decommissioning is co-financed from both national as well as international sources. The current financial state is:

EUR 2 900 million Total cost estimate for Ignalina decommissioning up to 2000-2029.

EUR 1 130 million Already allocated EU financial support until 2014.

The internal decision process, is currently seen as an inflexible system. The procurement must be in full compliance with all the requirements. This involves a close interaction between the decision making and planning and of the supporting organizations/funds. Having the responsibility for the decision-making and acknowledgement process split between several organizations, and in cases where additional national institutions have to be involved even more organisations, hinders the flexibility. Incompatibilities so delay decisions.

The available resources must be carefully integrated into the planning that in return depends on the financial restrictions. The involvement of the three different financing institutions is difficult and it is often unclear what can be financed via IIDF IP (EU) or via the national fund must be closer specified.

It is additionally asked which share costs for personnel have in the complete decommissioning process. A 'total costs scheme', as designed and updated by the operator gives an overview on the cost distribution between the several sectors. A rough estimate is that 1/3 accounts for personnel, 1/3 for utilities/resources and 1/3 for the decommissioning projects including contracted companies, but excludes costs for waste management and final storage. **More detailed information on cost shares will be provided to Öko-Institute.**

The personnel and competence management/responsibilities (personnel planning)

How was the personnel made familiar with the new task of decommissioning (training, task communication, etc.)?

Which continuous measures has been introduced and set up (training on the job, internal and external courses, etc.), which measures proved to be advantageous/disadvantageous?

Has the personnel majorly adopted their changed tasks (acceptance of the new targets, job satisfaction, self-complacency, expert excellence)?

Do you see or encounter difficulties between internal and external workforce (with consultants, with construction companies, on competencies, etc.)?

……………………………

The reactor unit 1 was shut down in 2004, unit 2 in 2009, and the activities changed from the operation towards the decommissioning. The work force had to be reorganized, the personnel had to start decommissioning activities, for this reason, the new additional tasks regarding decommissioning activities were delivered to the training division.

The first activities towards reorganization were started in 2000 – when the Decommissioning service – a separate unit – was set-up.

Part of the staff is still involved into operational activities. Simultaneously the decommissioning work occurred and required an adaption to the new skills by personnel. A general safety policy was established in 2010 where the strategy of the decommissioning works is described.

The training programs were modified towards decommissioning works and the composition of the work force was adapted. The training of dismantling staff is partly carried out by internal forces and partly executed by external forces. The training for the staff in the training centres involves both 'hardware' - technical as well as soft skills training.

The adaptation to the decommissioning task also involved psychological aspects. The first decommissioning activities started in 2001. The reorganization occurred only later in 2010-2011. The first phase can be characterized as a 'frustration period', among the staff but as well among the whole region around Ignalina being economically and socially strongly depending from the nuclear power plants. The task of decommissioning had to be established over this period. Meanwhile, the work force and the region accepted the decommissioning as their prime task.

Another factor is that decommissioning requires a very different organization structure and job understanding than in the operational phase. The original top down hierarchy of the operation phase, more driven by handbooks, guidelines and well-established routine work, has to be exchanged by a more project-oriented approach, non-routine work governs the process and problem-solving capabilities are required instead. The adaption process is still under development and new and old structures still exist, but are more and more exchanged.

About 5 000 people were employed in the time of the operation. Currently, about 2 000 employees are involved into the decommissioning – with about 95 % the same personnel. New experts are employed if they are needed.

Safety culture indicators – quantitative and qualitative – had already been developed and implemented in the operation phase and are now adapted for the decommissioning phase. The long continuity behind those indicators is seen as a clear advantage. A regularly bench marking of the safety culture takes place.

Administrational aspects

Was it necessary to majorly change the internal administrational structure to adapt it to the new task?

Did you encounter frictions in that change process?

Are major administrational changes ahead to improve the structures?

Technical aspects

Which safety status has the facility reached? What has to be done technically to reduce safety risks further?

Which technical challenges were encountered so far in the project? How did those influence costs and time frame?

Have lessons been learned by technical challenges so far?

Which technical challenges do you see currently and in the near future? How are you preparing for those?

……………………………

The new structure has been established over the past 13 years when the decommissioning unit was integrated. The change of the organization and the incorporation of the decision making process into the decommissioning work is seen as a long process. Many decisions are discussed before the decision is finally made; in other cases the top down approach is used. The original "handling according to hand book" within the operation has been adapted towards the decision finding process within the decommissioning.

Waste management aspects

Waste management is a necessary prerequisite for a smooth decommissioning. Do you have enough means to store, treat and dispose the wastes from decommissioning internally or externally?

Did missing waste management means delay or obstruct your technical or regulatory timeframe?

If you see current or future difficulties with your long-term waste management, what will be the measures you see as promising to answer to that expectations?

………………………………………….

The radioactive waste management is incorporated into the legal framework and binding. The implementation of the radioactive waste management is – of course – confronted with several difficulties that have to be addressed. The radioactive waste management strategy is still under development and has to be continuously adapted.

Pool storage facilities have been operated already during the time of the operation. Defueling of the reactor to the storage pool has been completed in unit 1 and is currently on-going in unit 2. In parallel, the project to take the new interim dry storage in operation is in the implementation phase.

The construction of the new storage facilities is delayed. The interim storage of all fuel in the reactors and the pools should be finished until 2016 according to the current planning.

It is further planned that the storage for the medium radioactive wastes should be constructed on site.

Free Release facility and buffer storage for low level radioactive wastes have been constructed on site, Non-radioactive and low-radioactive equipment such as central heating facility, turbines, etc. now can be decommissioned.

Regulatory aspects

Have you encountered difficulties caused by regulatory action so far in your project (major delays, necessary re-planning caused by regulation, difficulties in finding common understanding)? If so: what were the reasons for that in your view (incompetence, unwillingness, misunderstandings, etc.)

Are the different roles of you as the operator and the regulatory body clear for you (does the regulatory body remain in its own role, would you expect more assistance, etc.)?

In which fields could the regulatory body ease your planning, technical and financial structures (should there be more detailed regulation, should there be more written regulation, etc.)?

Is it difficult for you to understand the regulatory issues?

How would you evaluate your relationship with the regulatory body (cautious, trustfully, distantly, frustrating)?

……………………………………………..

The cooperation with the regulatory body has continued over the past 20 years and is described as very good. It is a professional but open relationship with close and regular face to face exchange. Several project phases and problems connected with the planning can be openly discussed. The contents of the discussions of the meetings are documented in minutes. The regulator is not obliged to organize these meetings; the meetings are voluntary. The operator has the opportunity to talk open about the difficulties within the project; agreements can be made already in the early stage of the relevant project phases.

ANNEX 5 - WRITTEN ANSWERS FROM JAVYS, SLOVAKIA

(Underlined text refers to the questionnaire)

The conceptual planning within the Project

The overall plan of the Project, it's major work packages, it's ordering and serial flow, etc.

It is mandatory for all Slovak nuclear power plants to prepare and periodically update Conceptual decommissioning plans already during construction and operation of the power plant. This was also the case of strategic preparedness of V1 NPP for its due decommissioning. These conceptual documents were later replaced by detailed 1st Stage Decommissioning licence documentation and overall V1 NPP Decommissioning Strategy.

Conceptual Plan:

Conceptual Planning of Bohunice NPP V1 decommissioning was commenced in frame of the project titled 'Conceptual Planning'.

The mentioned project was completed in 2007. Multicriterial analysis resulted in selection of the Immediate Decommissioning Option ('IDO') out of 4 analysed alternatives. This option assumes 2 decommissioning stages of Bohunice NPP V1 and decommissioning activities completion by 2025.

The project was followed by consecutive activities:

1) The Environmental Impact Assessment Report of V1 NPP Decommissioning,
2) The V1 NPP Decommissioning 1st Stage Plan & Other Documentation, and
3) Decommissioning Database

Later on, the outputs from abovementioned projects were used for development of the Bohunice V1 NPP Decommissioning Strategy Report (2010), later replaced by updated and renamed version called Strategy of Bohunice V1 NPP Decommissioning (described in detail below).

Based on the abovementioned projects were identified and defined single decommissioning projects packets as follows:

Packet of decommissioning projects (sorted by criterion: Types of activities):

"A" block: Projects related to NPP modification for decommissioning activities and development of comprehensive documentation

"B" block: Projects related to decommissioning licencing

"C" block: Projects related to wastes and RAW management

"D" block: Projects related to systems dismantling & buildings demolition (i.e. decommissioning)

Packets of decommissioning projects (sorted by criterion: Implementation time frame):

- Projects to be implemented in Stage 1 of Bohunice NPP V1 decommissioning (2011-2014),
- Projects to be implemented in Stage 2 of Bohunice NPP V1 decommissioning (2015-2025),

Comprehensive document: 'Strategy of Bohunice V1 NPP Decommissioning':

Was based on older document *'Bohunice V1 NPP Decommissioning Strategy Report' (2010).* This 'Report' defined all steps necessary for successful end of decommissioning works in 2025 even before issuance 1st stage decommissioning licence.

New document 'Strategy of Bohunice V1 NPP Decommissioning' was elaborated and approved in 2012 and it provided a substantial improvement and enlargement of the previous 'Bohunice V1 NPP Decommissioning Strategy Report'. The document provided mainly:

- comprehensive 'roadmap' of all decommissioning activities;
- database of all decommissioning projects till 2025 (decommissioning completion);
- logistic scheme of all projects split up according to:
  i) types of activities,
  ii) respective decommissioning phase;
- logistic scheme including interfaces among projects;
- identification of BIDSF projects eligible for grant allocation together with time schedule of projects` granting;
- identification of 'KPI' (key performance indicators) for decommissioning projects;
- chart depicting implementation phases of all projects

IPBTS ('Integral Project Baseline Time Schedule'):

Managerial Tool (based on 'MS Project' application) with complete database of all decommissioning projects, their time schedule (including preparatory phase, tender preparatory phase, tender phase and implementation phase). IPBTS is being updated on weekly basis.

<u>The identified decision breakpoints in that plan (technical, regulatory and financial dependencies, decision base, etc.)</u>

Main decision break-points:

a) The first decision break point was early decision of Slovak republic to construct and operate the nuclear back-end cycle infrastructure, took in 1980’s and 1990’s. JAVYS thus already operates all facilities necessary for successful and complex decommissioning activities:
   - Interim Spent Fuel Storage,
   - RAW Treatment Centre, and
   - National repository of radioactive waste
b) The second main breakpoint was establishment of National Nuclear Fund already in in 1995, which was set up to continuously collect funds for later decommissioning purposes (according to planned lifetime of nuclear powerplants).
c) Selection of decommissioning alternative. Outcomes of BIDSF projects B6.1 (The V1 NPP Conceptual Decommissioning Plan) and B6.2 (The Environmental Impact Assessment Report of V1 NPP Decommissioning) resulted in selection of the 'Immediate Dismantling Option' (IDO) consisting of Decommissioning Phase 1 (2011-2014) and Phase 2 (2015-2025).

d) Speed up cooling down and transport of the spent nuclear fuel out of the facility. Calculations for early transport were thus conducted. Based on the outcomes of the calculation, transport facility container was re-licenced, which allowed earlier removal of the spent fuel.

The transport of spent fuel thus took place in advance of the original schedule.

e) Early strategy for treatment of future radioactive waste was prepared during shut-down of reactors, so that capacity of existing facilities was assessed.

f) Feasibility study on dismantling of the Primary Circuit's large components was performed in order to maximise effectiveness of decontamination, fragmentation and disposal process of the most critical equipment.

g) Other decision break-points (criteria used for decommissioning plan elaboration):
   - to finalize the decommissioning process by 2025;
   - not to exceed cost estimate for overall decommissioning;
   - RAW minimalization and minimalization of the impact on the environment (resulting in modernization of existing and procurement of new Fragmentation & Decontamination facilities, selection of proper D & D methods, etc. ...);
   - minimalization of number of external contractors in NPP Controlled area;

<u>The time planning in that concept (What were the major set-backs in the time plans so far? What measures were taken to remove obstacles? Etc.)</u>

The major experienced set-back was lack of necessary decommissioning funding due to premature shut-down of NPP, when compared to decommissioning funding system's set up in Slovakia and external factors (like change of legislation and following increase of mandatory steps)

Apart from so far accrued resources in the Nuclear Decommissioning Fund, additional funds had to be found and established through:

- BIDSF fund
- additional levy on the price of electricity sold in Slovakia
- V1 NPP operator's (JAVYS') own resources

The second external factor influencing the original time schedule for implementation of decommissioning activities came in the form of new Act on Environmental Impact Assessment (the so-called EIA Act) in 2006. The new act unified Slovak legislation with our international obligations resulting from Aarhus and Espoo conventions and it provided opportunity for deeper involvement of the public into the assessment process.

Next to factors stated above, the decommissioning process has not been seriously endangered by any technical set-backs and JAVYS was granted Stage 1 Decommissioning licence in July 2011, as originally scheduled.

In addition, all usual set-backs caused by missing necessary nuclear back-end cycle infrastructure were not the case of V1 NPP decommissioning. This is due to long-ahead planning of Slovak Republic in terms of nuclear decommissioning. Slovakia owns and operates (through company JAVYS) the necessary nuclear back-end cycle infrastructure – RAW treatment facilities, Interims Spent Fuel Storage facility, National Repository for RAW.

After issuance of decommissioning licence (and consecutive start of dismantling works) it is not possible from the legal and technical point of view to return to operation of the NPP. No organisational or political decision thus cannot further hinder the process, as there are strict deadlines imposed on JAVYS in the decommissioning licence and the NPP already lacks many essential components preventing its re-start.

The financial planning within the project

How and on which knowledge/estimate base are financial plans set up and updated?

The cost estimates were always part of the relevant studies and/or decommissioning plans that have been prepared or reviewed by external competent bodies. JAVYS' requirement was always to have them set based on the latest international experience and respective internationally accepted methodologies. The key documentation 'Conceptual decommissioning plan' was a result of the study performed by German-based Energiewerke Nord that had a long experience in decommissioning of similar power plant in Greifswald. The latter Decommissioning strategy was based on the Yellow book methodology and its latest revision is based on the latest fine-tuned Yellow book update - the International Structure of Decommissioning Costing that is a methodology prepared jointly by EC, IAEA and OECD- NEA (issued in 2012).

The financial plan was based:

- On estimated flow and contamination of material from similar Greifswald NPP. After Decommissioning database of the NPP V1 was elaborated, new tailor made figures were able to be introduced;
- Decommissioning as a labour intensive industry was based on price level of salaries at the time of elaboration of the document, significant changes in the national political and economic system resulted in an update, increase of the respective cost estimate of decommissioning works.

How is, from the view of the licence holder, the decision process organized (internal and external process, structure of checks, approvals, past experiences with the decision process)?

The overall decision making process is much more complicated and more demanding than for example the decommissioning of the other NPP under JAVYS management, meaning NPP A1. The reason is the financial model set by the BIDSF fund's administrator – the European Bank for Reconstruction and Development – and involvement of more stakeholders – European Commission, European Bank for Reconstruction and Development, Ministry of Economy and specific Project Management Unit (involving external Consultants). The process is more time consuming, needing more staff devoted to the management of the overall process and reporting tasks.

In compliance with the Framework Agreement (Section 3) signed between the Slovak Government and the EBRD in 2001, Slovenské Elektrárne, a.s. and later JAVYS established the Project Management Unit ('PMU'). The PMU is composed of JAVYS experts and international Consultant staff. PMU is currently represented by internal organizational unit titled 'Division of Decommissioning and PMU', chaired by the vice-chairman of JAVYS' Board of Directors. In order to manage the preparatory works and implementation phase of BIDSF projects, project teams for implementation of respective BIDSF projects were established within JAVYS.

BIDSF funding of projects requires that internal approval processes have to encompass also the roles of PMU Consultant and the EBRD. The role of the PMU Consultant is to elaborate certain technical documents and/or authorise technical (and tender) documents elaborated by JAVYS staff according to the Framework Agreement between EBRD and Slovak Republic. The role of the EBRD is, among other, to approve of technical and tender procedures by providing its 'no-objection' for all activities during respective phases of BIDSF projects` implementation.

The decommissioning management system is focused on speed up and effectiveness of all activities, for which it uses:

- daily meetings of project managers,
- Integral Project Base Time Schedule 'IPBTS' (updated on weekly basis based on outcomes from the Weekly Internal meetings),
- Weekly Internal meetings (attendees: JAVYS project managers, PMU Consultant, the EBRD representative),
- Monthly Progress meeting (attendees: JAVYS management, PMU Consultant, the EBRD representative, representatives of Ministry of Economy and National Nuclear Fund),
- Quarterly reports on status of BIDSF projects implementation (submitted to the General Directors` Meeting)

External bodies in decommissioning decision making:

a) Semi-annual on-site visits of EC (DG ENER) representatives in JAVYS (JAVYS reports on status of progress in BIDSF projects implementation),
b) The Joint Committee Meeting submitting new BIDSF projects for granting (participants: the Ministry of Economy, the EBRD, the National Nuclear Fund, the Nuclear Regulatory Authority),
c) The Assembly of Contributors of BIDSF fund approving grants for new BIDSF projects (participants: EC, donor states, EBRD, Ministry of Economy),
d) Annual Nuclear Decommissioning Assistance Programme Meeting (organized by Energy section of the European Commission; held in Luxembourg)

Experience with decision processes:

Documents prepared by JAVYS are being submitted to external bodies for their approval according to Slovak legislation. The authorities are bound to issue their licences and/or approvals within time limits set up in the Slovak legislation and JAVYS conservatively schedules the longest possible deliberation time period into its projects' time schedule. Any necessity to provide further responses to possible additional queries by the authorities is also included in the time schedule.

JAVYS also informs external bodies in advance before the final requests are submitted by JAVYS to these authorities for their final approval.

Apart from legislation-bound approvals, there exists also second group of documents that are being approved (non-objected) by the EBRD, as the administrator of the BIDSF fund. Since the EBRD is not bound by any time limits for issuing their non-objection, this aspect represents external uncertainty in planning of decommissioning activities.

Which experiences were made with financial risks (What were the reasons for serious underestimates in the past? What influences your cost structure mostly (personnel costs, external cost factors, etc.)?

In all performed cost estimations, main risk factors were considered those that were applicable according to the methodology chosen for the given cost estimate.

However, all knowledge gathered from our discussions at international forums or publications issued by IAEA, OECD-NEA or EC were reflected.

Thus, JAVYS was able to avoid any significant **systematic** underestimates. The main identified reason for increase in cost estimation throughout the time is general continuous improvement of costing methodologies through their deeper specification, based on the world-wide increase of understanding the decommissioning needs and definition.

This is why the first cost estimate was prepared by Energiewerke Nord – a German company known for its decommissioning experience and it provided a basic general comparison between assessed decommissioning options, necessary for responsible selection of one.

Current cost estimate has been calculated based on most recent International Structure of Decommissioning Costing, jointly issued by IAEA, OECD-NEA and EC and the calculated costs for both units of V1 NPP are well in limits set by different calculations ('EON and RWE estimate individual projects may cost as much as 750 million euros to 1 billion euros' per unit (Nicola 2013)), or direct experience (e.g. NPP Greifswald).

Another general factor raising the overall decommissioning cost estimate is also the fact that JAVYS decommissions only two VVER type reactors, which are both included in one decommissioning project (V1 NPP). This is the result of basic economic rule – doing a one-time only work is more expensive if compared to large scale industrial approach.

The main factor causing not an underestimation of a cost estimate, but a system failure to gather sufficient future decommissioning financing was premature shut down of V1 NPP. This decision lead to shortage of planned decommissioning resources accumulated in the National nuclear fund at the moment of V1 NPP shut down.

After necessary system's adjustments on national and international level, the decommissioning financing is now secured through:

1) Existing Slovak resources:
   - National Nuclear Fund
   - JAVYS' own resources
2) BIDSF fund, established as solidary fund of EU in respect of remediation for its previous requirement for shut down of V1 NPP,
3) Systematic approach of Slovak legislation imposing a special levy on price of electricity sold in Slovakia (EUR 3 per 1 MWh) that is being collected from all end-users since 2011 to make up for shortage in decommissioning funding due to premature shutdown.

The personnel and competence management/responsibilities (personnel planning)

How was the personnel made familiar with the new task of decommissioning (training, task communication, etc.)?

JAVYS has been continuously providing extensive trainings for its decommissioning personnel by both on-site and off-site trainings long before issuance of the Decommissioning licence.

The most important base stone training for decommissioning was extensive 12 weeks mandatory training, required by law for all decommissioning personnel. The training was conducted under licence of Slovak Nuclear Regulatory Authority and essential part was final exam and thesis.

In addition to this mandatory training, JAVYS voluntarily provided more focused specialised trainings for designated specialists in their respective fields of expertise:

- multiple trainings at Greifswald NPP (Germany)
- multiple trainings in Enresa (Spain)
- multiple trainings in Argonne National Laboratory (USA)
- training in Marcoule facility (France)
- scheduling training in Iberdrola (Spain)
- FIDIC course for project managers (provided by Iberdrola)
- EPRI seminar (provided by US company)
- Law of Contracts (provided by EBRD)
- multiple Procurement trainings provided by (EBRD)
- multiple MS Projects scheduling training (provided by Iberdrola)
- multiple Project management (provided by Slovak Technical University)
- Cooperation with technical university in Slovakia (Slovak Technical University) on continuous university education in decommissioning:
    i) annual Summer University on Decommissioning
    ii) annual Post-graduate study on Decommissioning

Continuous education is also ensured via permanent participation in international projects and forums:

- International Atomic Energy Agency (IAEA) – International Decommissioning Network (IDN),
- Organisation for Economic Co-operation and Development, Nuclear Energy Agency (OECD-NEA) – Working Party on Management of Materials from Decommissioning and Dismantling (WPDD)
- Organisation for Economic Co-operation and Development, Nuclear Energy Agency (OECD-NEA) – Decommissioning Cost Estimation Group (DCEG)
- Cooperation through Agreement for the Exchange of Scientific and Technical Information on Nuclear Installation Decommissioning Projects – Cooperative Program on Decommissioning (CPD)
- participation on Nuclear Decommissioning Assistance Program and Decommissioning Funding Group meetings

The training of personnel is further planned and managed in systematic manner on the annual basis reflecting current and future status of decommissioning and personnel needs.

All these forms of re-training personnel, along with permanent internal discussions and interviews conducted continually since 2006 resulted in general acceptance of new profession by former operation employees who now work full time on decommissioning tasks.

Which continuous measures has been introduced and set up (training on the job, internal and external courses, etc.), which measures proved to be advantageous/disadvantageous?

JAVYS has combined both forms of trainings – both internal and external.

Internally, JAVYS is focusing on continuous improvement of the technical education (for new employees) and managerial skills. During the first years of decommissioning preparation, focused was given to acceptance of transition from operation to decommissioning and the implementation and organisation challenges it will bring.

Externally, JAVYS provides opportunity, as well as actively arranges transfer of international experience and know-how to its employees through taking part in international seminars. Many of the events require mutual sharing of information, which provides JAVYS with high opinion feedback. Annual postgraduate study course for decommissioning organised by the Slovak Technical University in Bratislava is also regularly attended.

Has the personnel majorly adopted their changed tasks (acceptance of the new targets, job satisfaction, self-complacency, expert excellence)?

Yes, it is possible to state now, that the operation personnel have changed their acceptance and attitude towards decommissioning. However, successful implementation of the change took several years and required day-to-day communication with the staff, as its motivation is a complex task. Important milestones were making operation employees recognize their own importance even during the decommissioning stages, based on their acquired knowledge of systems, professional attitude in the work, as well as job stability for the next decade.

Also, mixture of the original experienced staff (still forming about 70 % of decommissioning staff) with young and enthusiastic people has brought a strong synergy effect.

Do you see or encounter difficulties between internal and external workforce (with consultants, with construction companies, on competencies, etc.)?

It is normal to experience some day-to-day difficulties when working with external companies, but these frictions are well within the limits of common managerial difficulties that can be solved as they come into attention. Most of them come from different point of view of the internal and external workforce (contractors):

- Internal workforce sees the global objective and adapts the particular tasks to this objective, must be and is more flexible in solving imminent problems.
- External workforce is more oriented only on achieving the goal of their specific task, the overall objective is not their concern.

JAVYS company is hiring external workforce for those activities where is a reasonable ground and economic benefit for the company. The reasons might be:

- JAVYS does not need their performance for the whole decommissioning stage/proces, so it hires external employees for implementation of short-term works or projects.
- it is more effective (from the point of duration, profession, costs,…) to be performed by external company when compared to JAVYS' internal possibilities.

The cooperation works under normal conditions - as a client-supplier relationship with a normal commercial tensions.

Administrational aspects

Was it necessary to majorly change the internal administrational structure to adapt it to the new task?

Definitely yes. The operation of the nuclear power plant is generally a routine work desiring the workforce to follow procedures and not to 'invent' new approaches as their tasks are defined in the operational procedures and manuals. The decommissioning process is however a creative work solving new and unique issues on a daily basis.

The management thus had to shift from line organization into more project oriented organization. The new managerial and financial scheme has demanded JAVYS to adapt to its new responsibilities and tasks and to train people for new competences and responsibilities. JAVYS had to slightly change the portfolio of employees and mix operational staff with the new project-oriented people.

Did you encounter frictions in that change process?

Yes, certain frictions existed and are considered normal. Any change in company culture and company tasks is accompanied with certain refusal of change that is common to the human behaviour. This change had to be therefore accompanied by continuous training, explanation of new tasks and responsibilities. New employees with different background and knowledge have been hired and used for the creation of teams consisting of the old operational staff and new project oriented staff. This enabled JAVYS to keep the company memory and at the same time to adapt to new tasks.

Are major administrational changes ahead to improve the structures?

Yes, JAVYS is continuously trying to adapt and learn from lessons learned from abroad and from similar power plants or worldwide accepted methodologies. JAVYS has introduced the major changes when there was a major change (shift from operation into operation termination period, shift into decommissioning/after obtaining the license, and so on). All of these changes have been later analysed and tuned to optimal working conditions.

Technical aspects

Which safety status has the facility reached? What has to be done technically to reduce safety risks further?

Bohunice NPP V1 has reached its decommissioning status under the decommissioning licence issued on 19th July, 2011.

Based on the international classification of steps decreasing safety risk (i.e. 1) shutdown of the reactor, 2) cooling down of spent fuel, 3) transport of spent fuel out of the facility, 4) processing of operational radioactive waste, 5) systems' reduction and shutting down), V1 NPP has reached stages 4) and 5). All spent nuclear fuel has been transported out of the facility, only the selected support systems are in operation in accordance with operational regulations valid for Stage 1 of decommissioning. Other obsolete systems are dismantled and operational radioactive waste is being processed according to conditions set in the Decommissioning Licence.

In order to further reduce risks (which are thus narrowed mainly to conventional labour protection and radiation protection) the following decisions have been made:

- all personnel entrances into & works in V1 NPP are minimised to lowest possible extent required by the nature of the decommissioning works and/or legislation in order to minimise movement of personnel and thus to minimise the probability of safety incident,
- pre-dismantling decontamination of systems is being done in order to lower the dose rates to workers,
- continuous constant radiological monitoring of all work areas and at radiological borders
- precise planning of dismantling works.

Which technical challenges were encountered so far in the project? How did those influence costs and time frame?

JAVYS has not experienced any major unexpected technical challenges during pre-decommissioning and decommissioning projects' implementation so far.

It is natural that some minor obstacles had been encountered in some of the already implemented decommissioning projects, however, these obstacles had no serious impacts on overall scheduled project costs or time frame.

Concerning BIDSF projects to be implemented in the future: In order to prevent occurrence of unexpected obstacles during later decommissioning projects and to further allow preparation of as detailed as possible scheduling of activities within 2nd stage decommissioning projects, JAVYS conducted the key background study – the Feasibility Study for the Management of V1 NPP Primary Circuit Components. Based on selected alternative for handling, dismantling and disposal of Primary Circuit Components JAVYS will further elaborate consecutive projects for dismantling in the Controlled Area.

Have lessons been learned by technical challenges so far?

In order to apply lessons learned by companies worldwide JAVYS set up an extensive system of national and international trainings in order to avoid mistakes already encountered in other decommissioning projects. One of the most important sources of information has become attending meetings of Technical Advisory Group within the Cooperative Program for Decommissioning, where exactly such cases are being discussed.

Based on the gained knowledge and in compliance with the V1 NPP decommissioning strategy JAVYS thus proceeds from less complicated dismantling projects (non-contaminated environment of the Secondary circuit) to more sophisticated dismantling activities (contaminated systems' dismantling within Controlled area) in order to personally gather the necessary experience.

So far major lesson learnt was in connection of thermal insulation removal in the Turbine hall.

The project showed that dust control and spreading prevention is a major issue that will need to be approached during insulation dismantling in Controlled area. JAVYS therefore prepares to eliminate this problem during implementation of consecutive decommissioning projects in Controlled area since it is expected that latter project will be much more demanding in terms of possible contaminated insulation and thus dust outlets. Therefore mobile shielding tents over equipment and facilities shall be inevitable to be erected.

Another lesson learned is that despite FIDIC rules allow for broader definition of procured works, JAVYS is of the opinion that it is better if tender documentation (mainly technical specification) is prepared in a straightforward and clear manner. Such approach helps to minimize the risk of potential changes in projects` scope after contract with supplier is signed.

Which technical challenges do you see currently and in the near future? How are you preparing for those?

Main pending challenge will be to safely demolish V1 NPP's cooling towers located in the imminent vicinity of the cooling towers of operational NPP V2.

Next technical challenge will be thorough decontamination of the Primary Circuit in order to decrease dose rates for workers during its later dismantling. Another challenge will be safe manipulation (both in terms of regular labour protection, as well as radioactive protection) with Primary circuit's large components during their removal, fragmentation, decontamination and storage.

A general technical challenge will be minimalization of RAW during decommissioning. RAW treatment facilities have been therefore reconstructed or are planned to be installed.

Waste management aspects

Waste management is a necessary prerequisite for a smooth decommissioning. Do you have enough means to store, treat and dispose the wastes from decommissioning internally or externally?

The Slovak Republic had been aware of its responsibility for the back-end nuclear cycle on national level long before the decision to shut-down Bohunice NPP V1 was taken. Accordingly, the Slovak Republic has erected necessary RAW treatment and disposal facilities in the territory of the Slovak Republic:

a) Bohunice Radioactive Waste Treatment Centre
b) Facilities for Final Processing of Liquid Radioactive Waste
c) Interim Spent Fuel Storage
d) National Radioactive Waste Repository in Mochovce

Establishment of all these facilities was financed exclusively from national financial sources.

Premature shut-down of V1 NPP made necessary to re-evaluate current capacities for RAW treatment and storing. Thus it becomes necessary to construct new double-row at the National Repository in advance to original back-end cycle strategy of the Slovak Republic. In addition, very low level waste repository and Interim Storage facility are planned to be erected in order to ensure smooth waste flow and its adequate treatment.

Additional smaller-scale facilities, storages and projects for management of increased volumes of materials are being implemented, or the current ones are being reconstructed, so they will be in operation during the respective phase of decommissioning

Did missing waste management means delay or obstruct your technical or regulatory timeframe?

This point is addressed above. We do not expect any serious set-backs or delays in dismantling & demolition projects implementation compared to time schedule set up in the Strategy of Bohunice V1 NPP Decommissioning. JAVYS has already built, or is building the necessary infrastructure. The latter projects shall represent supplementing of already existing RAW processing, storage and disposal infrastructure so that overall infrastructure is available before decommissioning projects producing waste are launched.

If you see current or future difficulties with your long-term waste management, what will be the measures you see as promising to answer to that expectations?

With respect to long-term Spent Nuclear Fuel management we share the same difficulties as other EU countries: no common policy has been passed on the European level on disposal of spent fuel in deep-geological repository.

Slovak Republic has nevertheless elaborated feasibility studies for deep-geological repository to be located in the Slovak Republic and several potential locations have been identified. JAVYS perceives that only an official and unified policy on the erection of deep-geological repositories adopted at the European level would promote the European countries to erect these facilities on their territories.

RAW coming from V1 NPP decommissioning and not immediately acceptable for disposal in the National Repository in Mochovce is planned to be stored in the Interim Storage at Jaslovske Bohunice nuclear site. Start of operation of Interim Storage is planned in 2016 and apart from storing middle level RAW, it will serve also as a decay storage in order to ensure maximum volumes of free released materials in next decades.

Slovak Republic also operates a National Repository for low level waste and JAVYS has currently overcome major administrative obstacles for its enlargement for the purposes of decommissioning waste disposal, as well as erection of a very low level waste repository.

Regulatory aspects

Have you encountered difficulties caused by regulatory action so far in your project (major delays, necessary re-planning caused by regulation, difficulties in finding common understanding)? If so: what were the reasons for that in your view (incompetence, unwillingness, misunderstandings, etc.)

In general, Slovakia has well drafted, long established and EU harmonised nuclear legislation which makes any nuclear licencing well predictable.

The same applies also for the applications for decommissioning licence – although the scope and details of documents submitted were significant, the necessary documentation definition has been clearly written in the Atomic Law and its corresponding Decrees, issued by the Nuclear Regulatory Authority.

Harmonisation with EU legislation (EURATOM Treaty, EC Directives) is maintained continuously – even latest Council Directive 2011/70/EURATOM for responsible and safe management of spent fuel and radioactive waste has been already fully incorporated into Slovak legislation.

Regulatory bodies understand the complexity and the nature of NPP decommissioning. Their actions lead to finding solutions supporting successful continuance of decommissioning activities implementation in particular projects in accordance with all legal requirements.

The only misunderstanding JAVYS has experienced is application of provisions from the Environmental Impact Assessment (made in 2007) in discussions with the Ministry of Environment of the Slovak Republic. Therefore, to transparently cover the environmental issues, JAVYS has decided to prepare a new full-scale EIA (due in 2014) for all the works necessary for successful decommissioning and site remediation (instead of preparing numerous small one-purpose individual EIAs).

Any and all EIAs are prepared according to EBRD's Environmental and Social Policies and under EBRD supervision, too.

Are the different roles of you as the operator and the regulatory body clear for you (does the regulatory body remain in its own role, would you expect more assistance, etc.)?

Roles and responsibilities of both, the operator and the regulatory bodies are clearly defined and set by relevant legislation. Relationship and interactions between JAVYS and regulatory bodies are transparent, cooperation and assistance on daily basis is correct and functional.

In which fields could the regulatory body ease your planning, technical and financial structures (should there be more detailed regulation, should there be more written regulation, etc.)?

Legislation frame for decommissioning is well determined and clear, as well as fully in compliance with EU legislation and EURATOM.

Is it difficult for you to understand the regulatory issues?

Regulatory issues are defined well and clear and they can be supported by interpretations if necessary. JAVYS is used to deal with the legislation for already a long time and it respects the needs and expectations of the regulatory bodies. This can be seen on the results of audits performed by the regulatory bodies - having no major findings. Moreover, JAVYS actively participates on legislation elaboration by means of active cooperation during their preparation or review of these documents before their final issue and adoption.

How would you evaluate your relationship with the regulatory body (cautious, trustfully, distantly, frustrating)?

On the basis of abovementioned, we can summarize that relations with regulatory bodies are professional and respecting principles of correct and open communication. The regulators are officially and regularly informed about the status of V1 NPP decommissioning projects on quarterly basis, as well as on ad hoc working meetings when needed.

Thus, through the mechanisms of constant communication via various permanent meetings, or through cooperation with NRA's locality inspector, permanently present on site, JAVYS has established a solid and effective lines of communication and thus of high-level trustful mutual relationship with the Nuclear Regulatory Authority in Slovakia.

This approach allows Nuclear Regulatory Authority and JAVYS to remain independent in their activities (which is a state both parties are cautious to maintain), yet it helps them to communicate clear decisions and/or standpoints necessary for each other's work.

ANNEX 6 - ADDITIONAL QUESTIONS TO JAVYS, SLOVAKIA, AND ANSWERS

The following additional questions were asked to JAVYS (29.07.13, by email):

- How large is your organisation, what structure has it, which divisions are actively involved in decommissioning work?
- Which work structure and which software tools for project management, risk management, project progress and financial management accounting are in use?
- Can you describe skill and knowledge management in your organisation?
- Can we have a look into the Final Decommissioning Plan?

(The following answers were given by JAVYS to the additional questions, attachments omitted)

How large is your organisation, what structure has it, which divisions are actively involved in decommissioning work?

JAVYS currently employs 850 people.

In addition to operation of V1 NPP, JAVYS operates 5 more nuclear facilities:

- A1 NPP,
- Radioactive Waste Treatment Centre,
- Facility for final processing of liquid radioactive waste,
- National Radioactive Waste Repository,
- Interim Spent Fuel Storage, and
- Production operation of certified RAW packaging forms for the National RAW Repository.

In addition, JAVYS is preparing to build and operate other nuclear installations in the near future such as:

- Interim storage of RAW,
- Final disposal for very low radioactive waste,
- Institutional radioactive waste final disposal.

V1 NPP decommissioning thus represents only one of many activities, belonging to the responsibility of JAVYS, which was entrusted by the Slovak Government to provide comprehensive back end activities of nuclear power in Slovakia for all producers of radioactive waste and nuclear spent fuel.

In addition, JAVYS is responsible for:

- management of all types of radioactive waste, caught at the territory of the Slovak Republic, respectively entering the territory of the Slovak Republic, and
- Management of institutional radioactive waste from all other areas of human activity.

For the purpose of exercising these functions, JAVYS is internally divided into five basic divisions:

- Management and Human Resources Section (41 employees)
- RAW and SNF Management (240 employees)
- Decommissioning and PMU Division (202 employees)

- Business and Trade Division (149 employees)
- Safety and Investments Division (204 employees)

(The structure is provided in Annex no. 1 at the end of this document)

V1 NPP decommissioning involves JAVYS employees of several departments, some only partially, by the proportional working time.

System tools for monitoring and reporting is the procedure 'Process of planning, declaration and invoicing of the progress in the frame of BIDSF project D0', which makes it possible to accurately determine the number of employees participating on V1 NPP decommissioning each month:

Working full time at V1 NPP decommissioning:

- Decommissioning and PMU Division 120 employees
- Business and Trade Division 13 employees
- Safety and Investments Division 26 employees

The proportional working time at V1 NPP decommissioning:

- Department of General Director 5 employees, on average 38 % of their working time;
- Management and Human Resources Section 27 employees, on average 18 % of their working time;
- RAW and SNF Management Division 46 employees, on average 12 % of their working time;
- Business and Trade Division 75 employees, on average 13 % of their working time;
- Safety and Investments Division 109 employees, on average 42 % of their working time

The V1 NPP decommissioning project activities generally involve approximately 420 employees of JAVYS (about 50 % of all employees)

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Which work structure and which software tools for project management, risk management, project progress and financial management accounting are in use?

JAVYS has established the process model of an Integrated Management System and map processes, including the procedure documentation management. This system is certified as a whole in accordance with standards ISO 9001 'Quality Management Systems'; ISO 14001 'Environmental Management Systems' and OHSAS 18001 'Occupational health and safety management'. In addition to these systems, the company JAVYS has certified system in accordance with the standard ISO/IEC 20000-1:2011 'Information technology Service Management'.

The work structure system and management system is processed in the procedure documentation. The main procedures relating to the V1 NPP decommissioning, project management, risk management, project progress and financial and accounting management are:

Identification	Document title
OG/OR/ZSM	Organization Management
OG/DP/SM-01	Organizational Order
OG/DP/ZSM	Authorisation delegation management
VZ/BI/ZSM	Preparation and management of V1 decommissioning
VZ/BI/SM-07	Management of BIDSF projects
RP/PK/SM-03	Management of investment projects at the stage of pre-project and project preparation
RP/PK/ZSM	Pre-project and project preparation of investment projects
RP/RR/ZSM	Management of investment projects implementation
VZ/BI/SM-04	Schedules of BIDSF projects
VZ/BI/SM-01	Management of technical documentation and technical records on PMU
VZ/PV/ZSM	Support and operation of V1 safety decommissioning
VZ/BI/SM-02	Management of input data on PMU
VZ/BI/SM-03	Management of meetings on PMU
VZ/BI/SM-05	Management of interfaces on PMU
VZ/BI/SM-06	Procurement manual of BIDSF projects
VZ/BI/SM-09	Process of RAW declaration from V1 decommissioning in the frame of BIDSF projects implementation
VZ/BI/SM-10	Management of the flow of the non-active materials from the V1 NPP decommissioning
RS/IR/ZSM	Identification and risk management
RS/RD/ZSM	Management of management documentation
EO/PC/ZSM	Planning a controlling
EO/PC/SM-01	Planning
EO/PC/SM-02	Controlling
EO/CR/ZSM	Making calculations, prices and budgets
EO/UF/ZSM	Accounting and finances
EO/UF/SM-01	Accounting
EO/UF/NA-01-06	Financial Statements
EO/UF/SM-02	Finances
EO/UF/SM-03	Taxes and fees

The procedure documentation describes the processes, responsibilities and authorisations.

Identified processes within the company are verified by audits. The focus is mainly on the area of nuclear safety, radiation protection, health and safety at work, environmental protection so as to respect graded approach to quality assurance and to ensure assessment of the effectiveness and efficiency of the integrated management system.

Areas of your interest that you have defined as:

- Project management,
- Risk management,

- Projects progress
- Financial and accounting management

can be described in a simplified form as follows:

Tools for project management, used in JAVYS

In the process of project management, JAVYS uses the following basic levels of management: Project Manager, Project Engineer, Steering Committee, and Board of Directors:

- The project manager is a full-time employee of JAVYS and personally manages one or several decommissioning sub-projects and leads appointed project team(s), consisting of experts from different fields. The project has appointed professional guarantor (being a relevant division director), who directs the strategic concept and the main direction of the project.
- Project Engineer is responsible for overall project management of V1 NPP decommissioning set by the project management system and he is the representative of the operational project management (and in the case of the supply model he is also representative to the contractor in accordance with the applied rules and contractual FIDIC conditions).
- The Steering Committee consists of the Head of PMU (Project Management Unit) and of representatives of other JAVYS' divisions involved in the V1 NPP decommissioning project activities. They address the interfaces with other JAVYS' projects, as well as other business activities in JAVYS.
- The Board of Directors represents the highest governing body addressing the fundamental questions of project scope, management and the budget.

Project management in addition to internal meetings is also performed on the monthly progress meeting of V1 NPP decommissioning project, involving the representatives of the European Bank for Reconstruction and Development (EBRD) and PMU Consultant (Project Management Unit).

Project management process continues in the external environment of JAVYS company, through the Ministry of Economy as the sole JAVYS' shareholder and decommissioning coordinator at the national level. The next level of management is through so-called The Joint Committee of the Slovak Republic and the EBRD, in which operate, in addition to the above-mentioned entities, also relevant Slovak authorities, including the State Nuclear Regulatory Authority, the National Nuclear Fund, Ministry of Finance, Office of the Government, etc. Information about decommissioning is presented also to the Slovak Government every year.

This management structure is fully functional for escalation and subsequent decisions making in managing of questions, problems and risks in risk and changes management.

Risk management

Within the document *'Bohunice V1 NPP Decommissioning Strategy Report'* a conceptual risk management for the overall V1 NPP decommissioning project has been developed. Risk management for the overall V1 NPP decommissioning project identifies risk categories (from very low to very high, probability criteria and impact criteria) with 6 major risks defined. Each major risk includes the type, definition, risk factor with assigned probability of occurrence and potential impact on the decommissioning project.

Based on the classification and risk assessment a risk matrix has been developed and were proposed measures for identified set of risks in order to avoid the risks or minimize their impact. The proposed measures, as well as permanent monitoring of new risks are constantly monitored and implemented. The actual implementation and its monitoring is conducted on multiple levels and divisions of JAVYS' organisation chart which results from the nature of the proposed measure (e.g. management risk of critical projects, or risk of other projects provides decommissioning division, but the management of risk of the assets and related measures is the responsibility of the Business and Trade Division).

The risk analysis shows that the most risky area forms so-called critical projects, to which is devoted the maximum attentions at all levels of JAVYS management. Monitoring of critical projects is implemented continuously by project manager and project teams, as well as by head of the relevant department and section director. Evaluation of the critical projects is carried out on a weekly internal meeting, on monthly progress meeting of V1 NPP decommissioning project, as well as on monthly meetings of the individual projects.

Each quarter is presented to General Director meeting an 'update' of the state of V1 NPP decommissioning for the relevant period. In the event of unforeseen circumstances, these problems are solved immediately (i.e. after identification, all parties are informed, the meeting is organised with an objective to find a solution – and consequently, an immediate corrective measure is applied).

Risk management is also an essential and integral part of the management of each individual project. Risk management matrix included in the Inception Report for each project (i.e. group of similar subject-matter/system tasks) is developed at the beginning of the project. This risk management matrix includes all foreseen risks as well as tools to address and minimize the impact of the risks not foreseen at that time.

Risk control, solving and management is carried out without any interruption during the whole duration of the project, with regular monthly monitoring at monthly meetings of project management and usually recorded in the minutes of the monthly meetings. Project Manager, where appropriate, in case of risk solutions escalation, immediately notifies the Project Engineer (and, if necessary, the Steering Committee and Board of Directors) and the risk is jointly addressed on the weekly or monthly management meetings.

To manage the risk management system JAVYS uses the standard MS Office tools, providing communication, recording and visualization interfaces and MS Project program for monitoring of the interrelationship and correlations.

Progress of projects

Project progress is monitored by tool called Integrated Project Baseline Time Schedule in MS Project application based on Gant diagram. Progress is evaluated weekly by comparison with the so-called Baseline and on the basis of the variations, appropriate corrective measures are taken. As a base for weekly updates of schedules and projects progresses are used outputs from project meeting.

Once a month, Monthly progress meeting is implemented with the participation of the main stakeholders (Ministry of Economy, European Bank for Reconstruction and Development). Quarterly, the progress of projects is submitted to the senior management of the company, where the possible corrective measures and individual projects interfaces are discussed mutually along with other company activities.

Each project has its Progress Report, which is generated at least once a month on the basis of monthly meetings of the project team or as needed with the participation of the contractor if it is by the contractor implemented project.

Financial and Management Accounting

Financial Management (FM) is understood as a comprehensive financial management of processes in JAVYS, including financial planning and financial controlling.

V1 NPP Financial Planning is based on the overall plan of V1 NPP decommissioning, which includes the costs of activities, personnel costs and investment plan. The financial plan for V1 NPP decommissioning is part of the business plan and JAVYS' financial budget, which is presented each year for approval through the executive authorities to the General Assembly of JAVYS of which rights are performed by Ministry of Economy of the Slovak Republic as the sole shareholder.

Part of the financial management is also control, which assesses the degree of achievement of financial targets in previous periods (ex post) and analyses the development of the next financial activities during V1 NPP decommissioning (ex-ante).

Software tools for project management, risk management, project progress and financial and accounting management?

In the performance and V1 NPP project management administration JAVYS uses standard software tools for communication and management. The main control system in the company is management program SAP and its sub-modules, including modules for financial planning and costs monitoring of decommissioning projects, including financial management and accounting.

The subject, time and financial recording of V1 NPP projects is implemented in software module SAP PS (Project System). The system provides data for comparison of planned and actual values for the individual V1 NPP projects.

The actual financial transactions are recorded in the company's accounts in SAP FI module (Financial Accounting) and fixed investment assets in accounting module in SAP FI-AA (Asset Accounting).

For planning are used SAP ERP (Enterprise Resource Planning), Controlling module and SAP BPC (SAP Business Objects Planning and Consolidation).

For various subtasks are used advanced extensions SAP BO BI (SAP Business Objects Business Intelligence), SAP BPC (SAP Business Objects Planning and Consolidation), SAP WEBI (Web Intelligence) and SAP CR (Crystal Reports), operating above the central data warehouse.

The main system for communication, progress control of activities, tracking and reporting of tasks, approval and monitoring of billing is IBM Lotus Notes.

Main program for planning is MS Project, used for planning of the decommissioning project (from the most general top-up tasks to the detailed particular steps for the project or groups of tasks).

Program ARSOZ is used for monitoring of physical and radiological state of material database of nuclear facilities, as well as for issuing of Work Orders in controlled areas and for work with contaminated materials.

Oracle database is used for Work Orders, information administration and documentation. Last but not least, MS Office programs are actively used for routine administrative and support work.

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Can you describe skill and knowledge management in your organisation?

Development of professional skills and knowledge of JAVYS' our employees in decommissioning industry represents another strategic aspect of further company's existence. Therefore, the needs of knowledge development are analysed in detail from multiple angles and upon that the process of increasing the quality of knowledge and experience of the employees is set, whose own work performance form JAVYS activities.

Development and knowledge management of employees is implemented on the basis of obtained ISO certificates rules (see above), as well as subsequent internal procedures for continuing education of employees, respectively the transfer of specific know-how and experience:

Identification	**Document title**
ĽZ/VP/SM-01	Employee professional training system
ĽZ/VP/SM-02	Professional, managerial, language training of staff
ĽZ/VP/SM-03	Training on BOZP, OPP, ISM (SMK, EMS, SMBOZP), FO, HPP and RO for employees, contractors and cooperating persons
ĽZ/VP/ZSM	Education and training of staff
VZ/BI/SM-03	Management of meetings on PMU
VZ/BI/SM-04	Schedules of BIDSF projects
VZ/BI/SM-05	Management of interfaces on PMU
KO/EK/SM-04	Exchange of information on events at nuclear facility
RS/IR/ZSM	Identification and risk management
RS/NE/ZSM	Management of non-compliances, corrective and preventive actions, improvement
BZ/JB/SM-02	Safety Culture
OS/HD/ZSM	Evaluation of contractors
RP/RR/SM-01	Acceptance and evaluation of completed investment projects

The actual process of general and individual training of employees is being implemented, on the basis of the established system by several fundamental ways, namely by:

1) Joining of old experience and new approaches

Decommissioning is an activity that has a challenging demand for human capital, which knows in detail the technical infrastructure of the nuclear facility from the operation period and, at the same time, has also a creative approach to the approaches of complex dismantling of the systems.

For this purpose, working groups were created consisting of former operating personnel, maintaining the continuity of historical experience with the equipment and its operation and new people from outside, with current and extensive expertise in project management in engineering and construction.

Their mixing and subsequent interaction gave rise to project oriented reality when JAVYS takes the advantage of the knowledge and approach of both team components (knowledge of equipment and innovative solutions) while eliminating the individual shortcomings, which would bear otherwise both groups separately (old-fashioned practices and ignorance of the plant's systems/technical environment).

2) Institutional system training of employees

The Slovak legislation has created a system of compulsory continual additional education of employees working in the relevant field of nuclear energy - in operation, as well as in decommissioning.

This continuous educational process is required by law and is subject to direct nuclear regulatory body - Nuclear Regulatory Authority of the Slovak Republic, which is responsible for the management and control of all aspects of safety of nuclear energy in the Slovak Republic. Graduation of personnel in the relevant training types was a lawful condition before issuing licence for V1 NPP decommissioning.

After electricity production has been completed, JAVYS thus had to ensure, prior to obtaining decommissioning licence, retraining of all relevant staff (at that time it was 241 employees) for activities during decommissioning of nuclear installations, respectively comprehensive training of new employees (22 employees, training time represents 40 working days). The theoretical part of the training has been divided into a general section on nuclear energy and the specialised section on decommissioning.

After completion of the theoretical training is then required direct training in situ for the respective job position and performance of the relevant decommissioning activities.

Training is completed by final thesis and a state examination before the Examining Board - only then a certificate of achievement can be issued on gaining the prescribed level of knowledge and skills by the employee.

Our company and individual employees are obligated to sustain this statutory training every three years.

3) Maintaining and developing of institutional memory

In planning of its further development, JAVYS gives special attention to personal and professional development of knowledge and experience of key personnel and provide them with specialized trainings in their respective areas of specialization far beyond the minimum extent required by law, described in the preceding paragraph.

For example, in order to acquire and subsequent distribute current worldwide best practice in the decommissioning sector, employees participated in:

- multiple trainings in NPP Greifswald (Germany)
- multiple trainings in Enresa (Spain)
- multiple trainings in Argonne National Laboratory (USA)
- training in facility Marcoule (France)
- multiple trainings to development and administration of schedules in MS Project (Iberdrola, Spain)
- FIDIC Trainings for project managers
- Training EPRI
- Training for FIDIC contractual law (provided by EBRD)
- multiple trainings on public procurement/tendering (EBRD)
- multiple trainings on project management (Slovak Technical University)
- cooperation with the Slovak Technical University in continuous university education in decommissioning:
  i) annual summer decommissioning university
  ii) annual university postgraduate decommissioning course

Continuing education has been also provided through a permanent participation in international projects and forums, e.g.:

- International Atomic Energy Agency (IAEA) – International Decommissioning Network (IDN),
- Organisation for Economic Co-operation and Development, Nuclear Energy Agency (OECD-NEA)
- Organisation for Economic Cooperation and Development, Nuclear Energy Agency – Working Party for Decommissioning and Dismantling (WPDD)
- Organisation for Economic Co-operation and Development, Nuclear Energy Agency (OECD-NEA) – Group to determine the costs of decommissioning (DCEG)
- Cooperation in the framework of the exchange of scientific and technical information on nuclear decommissioning projects-Cooperative Programme on Decommissioning (CPD)

In that deepening qualifications of personnel, the company uses standard tools of human resources policy to ensure the longest possible maintenance of the employee's acquired know-how in the company (e.g. through agreements on minimum consecutive working period in the company following the deepening of qualification), respectively the widest possible transfer of knowledge and experience also to other colleagues through personal leadership in the workplace, meetings, training, etc.

JAVYS currently finalises an additional training plan of employees working in the field of nuclear decommissioning that is beyond the minimum extent of training required by ISO certificates and internal policies.

4) By general hand-over of the individual knowledge

The main sources of knowledge obtained are:

- Own solutions/designs, applied in the decommissioning processes,
- External trainings (domestic and foreign),
- Continuous representation in international projects,
- Participation in symposiums and conferences.

General and personal transfer of experience is at working level implemented by:

- Regular meetings of project teams,
- Publishing information on lessons learned on the company intranet,
- Personal knowledge presentation by conference participants for all employees,
- Meetings of individual departments, when required,
- Weekly and monthly meetings of project managers and executives, often with the participation of Nuclear Regulatory Authority representatives, Ministry of Economy, external consultants and a representative of the EBRD.

Transfer of obtained individual know-how and information is therefore implemented in standardized procedure from top to bottom, and bottom to top for all involved departments and at all levels of management.

The whole system of knowledge management in the company is systematically controlled via relevant ISM quality procedures and the relevant department of human resources management.

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Can we have a look into the Final Decommissioning Plan?

Bohunice V1 NPP Decommissioning Strategy Report partially contains industrial security confidential information, as well as part of JAVYS' trade secret. Therefore, only summary form for consultation and discussion can be presented during the meeting.

However, there will be available a detailed plan for the first phase of V1 NPP decommissioning prepared on the basis of this strategy and related documentation.

ANNEX 7 - QUESTIONS ASKED TO EBRD

Questions to the EBRD concerning the decommissioning projects in Bulgaria, Lithuania and Slovakia

(Please note that our scope is only on the decommissioning projects in those countries and does not include other measures or projects in conjunction with the early closure of reactors. As part of the questions touch not only EBRD responsibilities but also others, such as the Commission or the national decommissioning organization, the EBRD-related portion is meant.)

Project organisation at EBRD

- How is the EBRD organised in this task, which responsibilities are defined for the EBRD headquarter and the national EBRD offices?
- On which level of the EBRD organisation are which decisions a) prepared and b) drawn?
- Where can detailed information be found on those decision processes and on the basis of those decisions?
- Which specific organisational measures have been initiated at EBRD specifically to cope with the decommissioning projects?

Decision base at EBRD

- What level of detail is required for EBRD's approval to applications in respect to project management, to the overall project design and plan, to the risk management and risk identification/evaluation prior to and during the project, to the appropriateness of the organisation's structure and to the qualification of its personnel?
- Is EBRD generally evaluating the applicants organisation structure in respect to its appropriateness to the work to be done, its ability to organise projects, to control and manage those projects closely, to evaluate the quality of work, to supervise project execution and to react to adverse differences to the planned execution. Are those abilities thoroughly evaluated and are minimum requirements set, implemented and respected?
- To what extend does the EBRD include external managerial and technical expertise to evaluate project applications?
- As an example for mismanagement: How could it happen, and what was EBRD's responsibility in that case, that a completely inadequate plasma oven was ordered and built as part of the decommissioning project, while there is no technical and economic benefit at all from that facility? How was the plan technically and economically evaluated, and on which grounds, if this contributes anything to the decommissioning progress? What were the check mechanisms in that case? What failed here and why did it fail?

Interface to the Commission

- How are responsibilities between EBRD and the Commission defined, which shared responsibilities are established and which consultation processes between the two organisations are foreseen?

- Do you see any areas of responsibilities that are currently not appropriately defined, but should be clearly defined in future so that unallocated responsibilities with adverse consequences can be avoided?

Interface to the involved Countries

- Does the EBRD feel that the usual order- and instruction-manual based organisation form, as usually applied during the operational phase of an NPP, is an appropriate form to manage decommissioning projects? Have structural changes been initiated by EBRD?
- Does EBRD negotiate upon the necessary organisational structures and set requirements for the responsible decommissioning organisations?
- How is assured that the management level of decommissioning organisations is appropriately qualified to manage decommissioning projects?
- Has EBRD defined and implemented quality control measures to evaluate its own and the responsible organisation's performance?
- Which national shares are required, on the general and on the project level, to qualify for a shared undertaking? Which factual shares have been reached in the decommissioning projects so far and which shares are planned for the future? How is guaranteed that only factual contributions to decommissioning projects are counted as shares? Is the effectiveness, the factual contribution to the decommissioning projects, evaluated and included in the calculation of those shares?

Decommissioning plan

- Have all key decisions been adequately analyzed and resolved, so that the overall path of decommission is clear?
- Is a decommissioning plan available for each of the facilities? Does this plan identify all necessary technical steps, does it qualify and evaluate all the risks involved, does it identify sub-projects and critical pathways, missing technical means and development necessities, time span estimates, mass/volume-related balances, inventory-related information and if-then-relations for key decisive issues (break points, etc.)? In which interval are these plans re-evaluated and updated?
- If not: on which basis have decisions (under #15) been established and estimates on costs, shares, disposal volumes, etc., been made? Which requirements will EBRD set to establish such decommissioning plans as a basis of its decisions?

Financial control measures

- Is the project contribution and the project progress mirrored on the complete overall decommissioning plan (see #16) or which evaluation criteria are applied by EBRD?
- How does reporting towards EBRD work? How detailed are those reports (can we have an example to gain an own sight?)?

- How is assured that project progress adequately corresponds to the spent financial resources? What reactions are established if this is not the case and indications for cost-overruns are evolving? What typical time delay between this indication and the reaction were encountered so far?

Upgrade(s) addressing the concerns of the Auditors

- What has been changed at EBRD to address the Auditor's critique on
  - missing decommissioning plan (paragraphs 19 and 20),
  - diffused responsibilities (paragraphs 35, 36 and 41),
  - the slow progress and unclear/insufficient progress indications (paragraph 40).

ANNEX 8 - ANSWERS PROVIDED BY EBRD

EBRD Response of 30 July 2013 to Öko-Institute Questions of 18 June 2013

Introduction

The questions asked by Öko-Institute focus on details of the management of three International Decommissioning Support Funds administrated by the European Bank for Reconstruction and Development. It was felt that replies to these questions can only be provided by describing the framework for the Bank's activities in the nuclear safety area. Without this context, answers to the questions would be isolated and insufficient to provide an understanding of the entire process.

The Bank has therefore chosen to provide information covering all questions in seven themes:

- The Bank and Nuclear Safety
- Fund Governance
- The Bank as Fund Manager
- Relations between EC and EBRD
- EBRD's approach to program management
- Project Implementation
- Court of Auditors report

The Bank and Nuclear Safety

The EBRD was founded in 1991 with a mandate to assist countries of Eastern Europe and the former Soviet Union in their transition to democracy and market economy. It has been involved in international assistance in the area of nuclear safety from its inception as many of its countries of operation inherited a burdensome nuclear legacy from Soviet times.

In the context of the G7 Action Plan to improve nuclear safety in the countries of the Soviet bloc, presented at the 1992 summit in Munich, the Bank was asked to establish an efficient delivery mechanism for large nuclear safety assistance programs. The first Fund, established in response to this appeal, is the Nuclear Safety Account (NSA), which started operation in 1993. The NSA has funded nuclear safety projects in Lithuania, Bulgaria, Russia and Ukraine. Currently it finances projects required for the decommissioning of Chernobyl NPP Units 1-3. Modeled on the NSA, and again at the request of the International Community led by the G7, the Bank set up a second Fund – the Chernobyl Shelter Fund - in 1997 to fund a program to bring Chernobyl NPP Unit 4 into a safe state.

A very similar approach was taken to funding the assistance programs that are the topic of this questionnaire: the International Decommissioning Support Funds for Bohunice (BIDSF), Ignalina (IIDSF) and Kozloduy (KIDSF). Recognizing the economic burden on the three accession countries posed by the decision to close their first generation Soviet-designed nuclear power plants (NPPs) ahead of the expiry of their intended lifetime, the EC requested the Bank to set up three Funds to finance projects related to the decommissioning of these units as well as to measures in the energy sector for assisting in overcoming the consequences of the loss of generating capacity. The purpose of these Funds was never to cover all costs associated with the decommissioning of the plants to be closed, as these NPPs would have to be decommissioned at some point in time anyway.

The Funds support decommissioning in recognition of the burden of early closure. They became operational in 2001.

In addition, the Bank manages a Fund – the Northern Dimension Environmental Partnership (NDEP) Nuclear Window - which deals with the legacy issues stemming from the operation of the Soviet Northern Fleet.

One of the key priorities of international nuclear safety assistance has been to achieve the closure of reactors of Soviet design (RBMK reactors as well as VVER 440-230) where there has been a consensus that these are not upgradeable to acceptable safety levels. EBRD-managed Funds have contributed to achieving this aim in Chernobyl 1-3, Bohunice V1, Ignalina 1 and 2 and Kozloduy 1-4.

The EBRD retains the necessary expertise to manage these specialized Funds as well as to advise on nuclear safety projects financed from the Bank's ordinary capital in line with its Energy Policy. The Bank's Nuclear Safety Department has 23 full-time employees. The majority of the 14 senior managers have a technical background and most have worked in the nuclear industry or nuclear regulatory agencies. Other functions in the team cover procurement, financial control and administration. Five staff work out of EBRD's Resident Offices in Kiev and Moscow. The Nuclear Safety Department draws on all of those services of the Bank needed to fulfill its task, such as services from the Environment and Social Department, the Procurement Department, Energy Efficiency Department, Legal Department, and relevant finance departments.

Fund Governance

The three International Decommissioning Support Funds are multilateral Donor Funds. Donors contributing at least 1.5 million EUR become full members with representation in the Assembly of Contributors, which is the highest decision-making body in each of the Funds.

IIDSF has 17 members, KIDSF has 12 members, and BIDSF has 10 members[24].

Bulgaria, Lithuania and the Slovak Republic are members without any obligation to make a cash contribution[25] to their respective Funds.

The operation of the Funds is governed by Fund Rules which are approved by the Assembly and the EBRD's Board of Directors. The Fund Rules set out roles and responsibilities, in particular: the purpose of the Fund; membership of the Assemblies; the duties of the Fund Manager and the privileges of the Assembly; and logistical arrangements (chairmanship, number of meetings etc).

The Assembly of Contributors is the top decision-making body for each of the Funds. It takes decisions by consensus. It elects its chairman (as proposed by the largest donor) and approves strategic decisions as well as the regular financial reports and work programs produced by the Fund Manager. Its most important role is the approval of funding for individual projects or programs. Projects are presented to the Assembly at several stages, first for information and then for approval. Typically it is first presented early on after a candidate project has been identified in the decommissioning strategy, plan or a relevant study. When the development of a project has matured sufficiently to provide cost and schedule information, it is submitted in the form of a Project

[24] Switzerland is a contributor to all three funds but has ceased its participation in the Assemblies

[25] They are included in the number of members

Information Sheet. The Bank can only enter into a Grant Agreement with the recipient once the Assembly has approved the allocation of funds for the purpose. Any material change to scope or cost also requires Assembly approval.

The Assemblies typically meet twice a year but can be convened whenever required.

The Bank as Fund Manager

The Bank serves as Secretariat to the Assemblies. In this function it provides: information on project progress, project proposals and action plans in the Work Programs; financial information in the Annual Financial Report; and information on the Bank's Administrative Budget. In addition, the Bank presents all relevant information at the Assembly meetings, and minutes its deliberations. It also informs the Assembly about relevant developments via ad hoc communications to the Assembly.

The other part of the Fund Manager's responsibilities concerns the overseeing of program and project implementation described below.

The Bank accepted to manage the three Funds as a service to major shareholders to the Bank led by the EC and to the Bank's countries of operation, recognizing that the safe and secure decommissioning of their first-generation nuclear plants and associated challenges to their energy sectors represented significant transitional challenges in line with the Bank's mandate.

The Bank provides its services at cost. It does not charge any fees and makes no profit. Each year, the Assembly approves the administrative budget for the following year, although only costs actually incurred are charged to the Funds. Administrative costs of some 23 million EUR for the three Funds, since their inception, represent around 1 % of available funds (contributions plus interest income). Cash held by the Bank which is not immediately required for project purposes is placed in the Bank's deposits on the basis of guidelines approved by the Assembly. Interest income from these placements is paid back to the Funds in full. Cumulative income on liquid assets amounts to almost 100 million EUR. Net income, minus administrative costs, is therefore in the order of 75 million EUR.

The operations of the Bank as Fund Manager have been the subject of a number of external performance and financial audits, as well as an internal audit, none of which found any serious performance, system or quality control deficiencies.

Relations between EC and EBRD

The EC and the EBRD have been working closely together since the inception of the Funds during the accession negotiations with Bulgaria, Lithuania and the Slovak Republic. The EC, as by far the largest donor, has chaired the Assembly from the beginning. The Secretariat obviously has a particular close working relationship with the Chairmen and their staff. In addition, the Bank recognizes the particular role of the EC in these Funds, to which it provides significant contributions (overall more than 2 billion EUR to date) representing more than 95 % of all contributions.

Bilateral co-operation ranges from informal day-to-day exchanges of information to formal meetings of the Joint Steering Committees. The Bank keeps the EC informed of any relevant developments in the programs, supports the EC in its missions to the recipient countries, and supports any specific requirements the EC may have (reports to the European Parliament, audits by the European Court of Auditors, OLAF and others). The EC and the EBRD hold regular meetings ahead of Assembly meetings to discuss any issues that may arise. The Bank accommodates its schedules to allow for documents to be distributed to the EC's member state consultation body (NDAP). The Bank participates in NDAP meetings and, where relevant, in monitoring meetings of the Lithuanian projects implemented through the national channel.

The EC, EBRD and Governments of the recipient countries have established a Joint Steering Committee (JSC) for each of the Decommissioning Programs. The JSCs provide a forum to discuss at a high level any issues affecting the programs and to coordinate actions on various levels.

Other donors, by now all EU member states, made contributions at the beginning of the programs. Only the EC has been making continuous payments. This may justify a review of governance structures which may lead to transfer to the EC of the Assembly's role in the formal decision making process while keeping other donors involved either through Assemblies or through the NDAP mechanism.

EBRD's approach to program management

While it is important to stress that recipients (NPPs, Decommissioning Agencies and other entities) have full ownership and responsibility for the decommissioning programs and individual projects, it is also true that the Bank oversees these in a very hands-on way to ensure that donor funds are spent efficiently for the intended purpose.

A key element in the overseeing of these donor programs is close co-operation with the authorities in the recipient countries. Governments are important partners, as they have made the relevant political commitments - including for the closure of the old NPPs - for the creation of the necessary institutional framework, typically as owners of the recipient organizations and as partners in co-financing agreements.

Co-operation with authorities is based on Framework Agreements which the Bank has signed with the three recipient countries. These are international treaties which set out the ground rules for implementation of the decommissioning support programs, such as provisions for tax exemption and indemnification, but also undertakings for the government to support project implementation. Framework Agreements establish the principle that projects will be funded on the basis of Grant Agreements between Bank and recipient and that projects will be managed by a dedicated Project Management Unit (PMU). Framework Agreements also stipulate that the Bank and the Recipient country establish a mechanism to regularly review at a senior level progress and solutions to possible obstacles. This can be done through regular contacts and the formal establishment of Joint Committees. In the case of Bulgaria and Lithuania, the Bank and the respective governments have had an understanding that formal meetings were not required as the regular contacts served the purpose.

Grant Agreements with recipient organizations set out the purpose and the conditions on which grant funds can be made available. They also detail the obligations and resources to be provided by the recipient and reiterate the obligations in the Framework Agreement (such as the requirement to employ a PMU) and from the Fund Rules (such as the obligation to follow the Bank's Procurement Policies and Rules[3]).

Project Management Units for the decommissioning programs are intended to be an integral part of the recipient's organization and should be composed of recipient personnel and of staff provided by an international consultant. The PMU is responsible for all aspects of program and project management from planning and engineering to procurement, contract management and invoice control. It draws on expertise from other departments in the recipient's organization and advises the recipient's management on strategic issues. The PMU liaises with the Bank on all aspects of project implementation through regular reviews and the formal 'non objection process' (see *project implementation*).

The services of the international consultant are procured through open tender. The scope and structure of the consultant's involvement can vary significantly, essentially depending on the resources and competencies available in the recipient organization. The consultant should complement the recipient's skills and provide, in particular, state-of-the-art technical, procurement and project management expertise.

The Bank works in partnership with the recipients, and initially it is for the recipient to identify the areas in which support is required. The Bank reviews specifications for these consultancy services as diligently as for any other project. The Bank does however carry out capacity assessments, in particular with regard to procurement capabilities (which covers a broad range from the preparation of technical and commercial documents for tendering to contract management) and it may employ external experts to assess project management arrangements when necessary. PMU organisational structures and interfaces with the recipient are constantly under review and are periodically amended to introduce improvements based on the analysis of past experience, in order to adapt to different requirements at different stages of the decommissioning process and to take into account the transfer of knowledge from consultant to recipient.

To date, all three recipient organizations have undergone significant organizational changes during implementation of the decommissioning programs. All three started as operating organizations and were at times responsible for shutdown and operating units. In Kozloduy and Bohunice, organizations responsible for closed units have been separated from operating utilities (something that is not required in Ignalina where all units are closed). The necessary changes are, of course, a responsibility of the organizations and national authorities concerned. However, the Bank, as manager of the decommissioning support funds, takes an active interest in any changes that may impact the implementation of programs financed from the PP&R[26] apply with the limitation that tenders are open only to companies from donor countries (in this case including all member countries of the European Union) or the Bank's countries of operation IDSFs. In cases where the recipient's organization changes, the Bank engages in discussions with the recipient to assess whether the organization still fulfills all requirements, and encourages both the use of experience from international best practice and input from the PMU Consultant to ensure that efficient decommissioning management structures are being put in place and maintained. The Funds also finance training programs for recipient's staff in project management, procurement and other relevant disciplines, with a particular emphasis on decommissioning.

The recipient enters into contracts with suppliers on the basis of the Grant Agreement with the Bank. The Bank is not a party to these contracts and the recipient is fully responsible. The PMU processes invoices, certifies that all contractual requirements are fulfilled and requests the Bank to pay. The Bank reviews invoices against contracts and against the, provisions of the Grant Agreement (and in

[26] PP&R apply with the limitation that tenders are open only to companies from donor countries (in this case including all member countries of the European Union) or the Bank's countries of operation

some cases other conditions imposed by the Assembly of Contributors) and disburses directly to the contractor. Grant Agreements can be suspended and terminated if the recipient fails to comply with its provisions.

The Bank obliges the recipient to adhere strictly to the Bank's Environmental and Social Policy.

The Bank appraises each potential project on its merits before it presents it to the Assembly but always attaches great importance to the availability of a coherent strategic framework in which individual projects have a logical place. This is true for energy sector projects but even more so for a complex decades-long process such as the decommissioning of a nuclear power plant. In all three countries significant work has been done on decommissioning strategies and regulatory requirements for decommissioning planning. It was a high priority for the Bank to assist the recipients in developing high quality decommissioning plans. The Bank has supported involvement of PMU consultants and external experts using funding from the Funds to achieve this goal. Detailed decommissioning plans, approved by the respective regulatory authorities, are now available for all three NPPs. These define sequences, projects and schedule and take into account the most recent inventory of radioactive materials.

It is true that decommissioning plans should ideally be available ahead of closure and some aspects of decommissioning should already be taken into account in the design of the plant. However, the three recipients did not find themselves in an ideal situation. In Soviet times, early planning for decommissioning was underdeveloped in most countries. The decision to close the plants early further reduced the preparatory time available, and reluctance to close (at some political, management and workforce levels) was not conducive to thorough and genuine decommissioning planning.

The Bank has created technical advisory bodies for all its funds. These are comprised of independent experts nominated on the merit of their expertise. These groups have provided high level technical guidance on strategic topics and were particularly helpful in the early phase of the programs when strategic decisions on the direction of the program and on individual urgent projects had to be taken in the absence of fully developed decommissioning plans.

Project Implementation

Project implementation is primarily a task for the recipient and its PMU. The Bank is, however, closely involved. The Bank employs a senior program manager for each Fund, dedicated to overseeing work one of that Fund. He (she) follows projects on a day-to-day basis and typically spends about half his time at project sites for project review meetings and in depth analysis of project and procurement documents. Project review includes all project and contract management areas, including the PMU's quality assurance and risk management approaches, and any technical or commercial issues impacting progress.

The Bank is entitled to receive any project-related documentation. It receives detailed monthly reports from the PMUs. One example of a monthly report (BIDSF) is attached as requested.

The recipient and its PMU develop technical specifications and cost and schedule estimates for projects to be funded from the Fund. Occasionally, the recipient may propose a project which may also be used for a purpose other than that of the decommissioning fund. It may, for instance, make sense to design a waste facility so that it can be used for the treatment of historic waste, as well as for waste stemming from decommissioning and from current operating plants. Another example is the physical protection facilities shared between operating plants and plants to be decommissioned. Such projects may qualify for co-funding from the Funds, provided that the recipient can conclusively justify which part of the costs is attributable to the decommissioning program. The Bank assesses such proposals as part of its due diligence review, to ensure that the cost-sharing logic is sound and based on an as accurate as possible a factual basis.

Procurement is key in the project implementation process. It is the recipient's responsibility to carry the process out to a high professional standard and in line with the Bank's procurement policies and rules. The Bank follows the process closely, and the Bank's formal 'no-objection' is required at important milestones. This means that the process foresees time for a detailed review by the Bank of, for instance, tender documents and evaluation reports. The review typically includes the Bank's Procurement Department. The Bank may also engage external technical expertise if required. The process can only continue once the Bank confirms that it has no reason to object. This process often leads to clarifications and amendments to documents. The Bank's procurement complaint mechanism is available to any bidders in procurement processes undertaken within the framework of the decommissioning programs.

The Bank's close involvement in project implementation is designed to give the Bank the best possible chance of picking up as early as possible on project issues which could potentially cause schedule delays and cost increases. As far as appropriate, the Bank facilitates efficient co-operation between recipient and contractors and resolution of issues, recovery of delays and joint commitment to cost efficiency.

The Bank exercises very thorough financial controls over activities of the international decommissioning support funds. In addition to the controls and mechanisms provided by the Bank in line with requirements in its Banking operations, the Nuclear Safety Department keeps separate track of all contract information and disbursement data. The financial statements for each of the Funds are externally audited annually, as are all of the Bank's accounts. The three international decommissioning support funds have all recently been the subject of financial audits by Moore Stephens approved by the Assemblies. The three audits confirm that appropriate financial controls are in place.

Plasma Melting Facility in Kozloduy

The Bank categorically rejects the unfounded statement that this project is an example of mismanagement. The project was developed in line with the processes described above and has been subject to thorough reviews. It has received all the necessary approvals and is on track to successful completion.

The decommissioning strategy for Kozloduy Units 1-4 foresees the conditioning of solid radioactive wastes with a high volume reduction factor. The technical specification issued for tender did not prescribe any specific technology. The market response to an open competitive tender resulted in proposals using plasma melting technology – not only by the winning bidder. During project implementation, no particular risks were identified with regard to plasma melting and its associated technologies. The technical design, the detailed design and Intermediate Safety Analysis Report (ISAR) have been approved by Kozloduy NPP. The ISAR went through independent verification review and received a positive conclusion. The technical design and ISAR are currently under final review by the nuclear regulator, which includes review by international experts funded from the KIDSF. The Environmental Impact Assessment Report was approved by the Ministry of Environment and Water on 30 May 2013 and public hearings are planned for July-August.

Manufacturing of equipment began in May 2012 and Factory Acceptance Tests (FATs) of the main equipment (primary treatment chamber, melt collecting chamber, feeding and shredding system and exhaust gases system) were successfully completed in Spain, Belgium and the Netherlands in June 2013. Delivery of the main equipment to Kozloduy NPP is expected in August-September 2013.

Court of Auditors report

EBRD has contributed to and shares the comments provided by the EC as published in the annex to the Court of Auditors report.

The topic of Decommissioning Plans has been addressed above. Preparation of the plans is an iterative process and all three recipients have been updating the plans since the time of the report. The plans define projects and sequences as well as cost and schedule estimates.

As outlined above, there is agreement between the EC and the EBRD that there is no uncertainty about responsibilities. There will, however, be discussions on adjustments to the governance arrangements and formalization of the role that the EC de facto already holds.

All three programs have had instances in which progress was slower than anticipated. Whenever delays have occurred, the reasons have been thoroughly assessed. To date, all cases have been attributable to project-specific circumstances (often legacy issues such as uncertainties in the historic data on nuclear fuel and waste) or external circumstances (such as reluctance to close the NPPs) and not to systemic failures.

Testimony to that are the vast majority of projects which have been implemented efficiently in line with schedule and cost estimates.

It is important to note that closure of the plants did not occur upon inception of the Funds, but over a period of time afterwards (Kozluduy 2002-2006, Ignalina 2004-2009, Bohunice 2006-2008), which had a significant impact on the course of the three decommissioning programmes.

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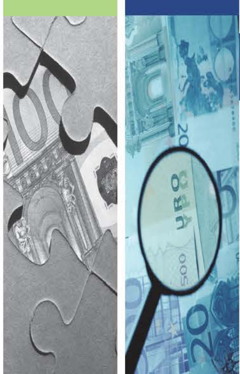

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