strategy&

NRG Historical Waste

Final document

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pwc

Ministerie van Economische Zaken

Transmittal / Cover letter

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Ministerie van Economische Zaken
For attention of B. Heijs and H. Sleiderink
Bezuidenhoutseweg 73
2594 AC Den Haag
Netherlands

Subject: Project NRG and historical waste

Dear Madame, Sir

We report on NRG (the "Company") in accordance with our proposal dated January 19th 2017, and your confirmation of this proposal by the tender decision dated January 26th 2017. This report has been prepared to provide insight into costs of the (historical) radioactive waste and the uncertainties involved, possibilities for a more cost-effective processing and disposal, arguments pro/con a potential disentanglement of NRG's nuclear activities and the (historical) radioactive waste and possible scenarios for disentanglement and cost-effective processing and disposal.

This report is addressed to the Ministery of Eocnomic Affairs and is prepared solely for their benefit for the purpose of furthering their insights on NRG and the historical waste dossier. This report is not to be relied on by any other person or for any (other) purpose. Consequently, PricewaterhouseCoopers Advisory N.V. does not accept or assume and denies any responsibility, liability or duty of care towards any party other than the addressee[s] (e.g. the Ministery) of the report. The Ministery remains at all times fully responsible for any decision made on the basis of this report.

If you have any questions please contact me at your convenience.

Yours faithfully
PricewaterhouseCoopers Advisory N.V.

Paul Nillesen
Partner Strategy&
Part of the PWC network

Our scope and process

Our scope

Limited **Extensive**

This project was subject to a limited timeframe while having a broad and complex topic of study. During this project we maintained focus on the main drivers of costs and uncertainty of the different waste streams. We have looked at all waste streams in RWMP, and have especially investigated and detailed the uncertainties of the main waste streams RAP and RAP Alfa (80% of projected costs). In addition, we examined operational and organizational improvement possibilities which were expected to have the largest impact. We have not quantified the effects of the different improvement scenarios, due to the amount of uncertainty and lack of quantified input from the relevant experts at both involved operators NRG and COVRA.

Access to management

None **Good**

In general we have had good access to management and were pro-actively aided in our understanding of the drivers and uncertainties of the costs of the radioactive waste management program. That being said, due to the timeframe of the assignment, and the limited availability of the NRG operational staff, we mainly interacted with NRG's senior management and had limited interactions with employees in the line organization. Not all ECN/NRG senior management staff could be present at key workshops.

Access to information

Limited **Extensive**

Overall, the information provided by NRG has given us a good basis to analyze the significant drivers and issues of RWMP. Other information such as supporting business cases, growth plans, legal basis for the ownership issue or disentanglement advantages, which were identified as key required inputs in our proposal, were not (yet) available at ECN/NRG, nor based on supporting data. Information was supplied in an online environment. Additional requests for information were granted timely.

Clarity of information

Poor **Good**

The information provided, together with our access to management, has allowed us to gain a good understanding of the RWMP. It should be noted that earlier cost projections have been subject to reevaluation. The most current estimation is not considered finite, as it does not include uncertainty buffers and will be periodically revised and updated. ECN/NRG has indicated that current estimates remain uncertain and should not be relied on for any purpose due to unquantifiable uncertainties. However, no evidence has been provided that any risks with unlimited uncertainties exist. ECN/NRG's current cost projection represents the best knowledge of the cost and uncertainty of the RWMP available at this moment. Cost remain uncertain until completion.

Important scope comments and guidelines for use of this report

Definitions and meaning of PwC qualifications used throughout the report are explained in the Glossary. This is still a draft report, final comments from the client are outstanding.

** = We assume factual correctness of all information provided to us by ECN. However, it was not part of our scope to confirm that all information (incl. that of third parties) is free of material error or omission*

We have interviewed the different stakeholders to get a 360 perspective

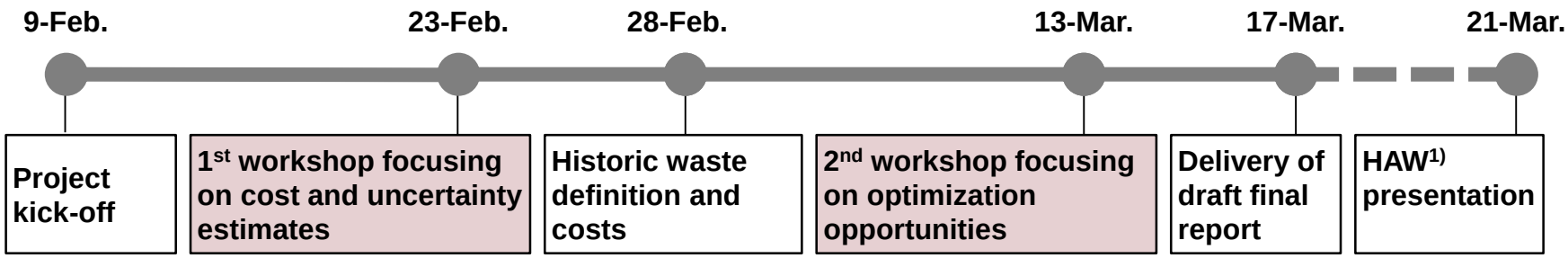
Involved NRG staff	Other stakeholders
RWMP team	**EZ project team**
ECN / NRG staff and management	**ANVS project team**
Selected legacy NRG RWMP staff	**Ministry of Finance**
External provider to NRG (for RWMP cost estimates)	**COVRA**
Names can be provided upon request	

Key reports and data sources

- **General information ECN/NRG**: Annual reports, RWMP report (2015) & update (2017), RAP(-alpha) reports (2015/2016), decommissioning report (1998) & update (2007), NRG Pamflet (2017), NRG nuclear permit (2001) and accounting information on RWMP provision / cost estimates
- **General information COVRA**: Annual reports, 'Oranje Boekje' (2017), COVRA case exploration report (2017)
- **External studies:** Turkenburg, Berenschot & Holtkamp report as well as international nuclear waste cost estimation reports, PWC's risk contingency management
- **Public information:** ECN / NRG / COVRA websites

During the process, we ensured active contributions from all stakeholders and drove alignment in key working sessions

Status of the project



1) Hoog Ambtelijke Werkgroep
Source: Strategy&

ECN/NRG face increasing and uncertain cost projections from the obligation to relocate radioactive waste to Zeeland

Brief introduction of the case

- Since the commissioning of High & Low Flux Reactors (HFR, LFR) in the 1960s, **radioactive waste from nuclear activities was stored at waste storage facility** (WSF) at Onderzoeks Locatie Petten (OLP) **in the interim before final disposal** (which does not yet exist)
- In 1984, the Dutch government decided that all radioactive waste is to be collected and stored for the interim period until final disposal by a single organization (COVRA) – following the relocation of COVRA in the 1990s, it was decided that **all radioactive waste** from Petten (new and stored) **needs to be transferred to Zeeland**
- NRG's radioactive waste is categorized into three main categories:
  - **Operational waste**: waste from current or recent activities of which the composition is precisely known and disposal route is defined and agreed with COVRA (to be transferred to COVRA within 2 to 5 years after production)
  - **Stored historical waste**: waste from historical activities of which the composition and/or disposal route is uncertain or not yet agreed with COVRA (to be transferred to COVRA as soon as possible)
  - **Decommissioning waste**: waste that will largely be produced in the next 15 years from bringing ~10 facilities to sufficiently low radioactivity level or greenfield state after operational life time (LFR decommissioning is in progress)
- To manage the waste transfer from Petten to Zeeland, ECN/NRG set-up a **radioactive waste management program (RWMP)** which is operated by license holder NRG and funded by ECN which carries the liability on its balance sheet
- RWMP costs related to stored and decommissioning waste are **inherently uncertain and difficult to predict** due to:
  - **Many different waste streams** (85) each with **specific characteristics**, **processing and disposal requirements**
  - **Contents** of various waste streams and canisters is **not yet exactly known and also complex to determine**
  - Disposal process requires **specific expertise**, **unique solutions**, **tailor made equipment** and **special tools**
- **Over time, RWMP provision cost projections increased by a factor 9 (+€176Mn to €198Mn vs. €22Mn in 2000) and €82Mn has been spent –** at the end of 2016, ECN maintained a provision of €116Mn for the total RWMP
- Since 2000, the **government contributed €58Mn to RWMP costs plus a €40Mn loan in 2016** for general purposes – **ECN/NRG contributed €93Mn** (no information available on costs and funding prior to 2000)

ECN/NRG's requests that the State should take over RWMP costs and liability

ECN/NRG request

- "The business case for isotope and consultancy activities is positive, but this business cannot carry costs for historical waste disposal – nor is it meant to, as there is no link between commercial activities and the cost for historical and decom waste"
- "The burden of historical waste jeopardizes the financial viability of ECN/NRG and thereby threatens unnecessary the supply of medical isotopes to 25.000 patients per day, as the costs of historical waste will not disappear when NRG is not viable"
- "The obligation to have enough revenues from medical isotopes to support the costs of historical waste puts a risky pressure on the safety required for nuclear processing. Also when NRG is for too long time under a financial pressure, this could lead to unsafe situations"
- "The burden of historical waste poses a key risk to the success of Pallas as it deters investors"
- "ECN/NRG is not responsible for the historical waste nor decommissioning costs, as both have their origins in the time before the creation of ECN/NRG; thus the Dutch Government carries this responsibility"
- "The waste treatment process lacks a party responsible for the overall cost control; all parties are fully or partially owned by Dutch government and their incentives are driven by reducing only their own risk – ECN/NRG is at the top of this chain and is forced to absorb all cost of other parties and/or the cost implications of their decisions"

STRATEGY& OBSERVATION INCLUDED IN APPENDIX

Note: ECN/NRG arguments are not well documented in any level of detail and are not substantiated by facts and analyses (e.g., legal or financial underpinning is not available), previous recommendation to create a clear benefits case for liability take-over by the State have not been executed
Source: NRG Management

Since 2000, EZ contributed on an ad-hoc basis to ECN/NRG continuity and is now studying more structural solutions

Brief introduction of the case

- In September 2016, the Ministry of Economic Affairs supported ECN's conclusion that **costs related to historical radioactive waste disposal are inherently uncertain**, **cannot be avoided** and **cannot be fully absorbed by ECN/NRG**'s current nuclear activities (nuclear energy and medicine research, consultancy and isotopes production)
- **ECN/NRG plays a key role** in the Dutch and international energy **and nuclear research** sector, the global **supply of medical isotopes** (for which the business case is positive), and contributes to **regional employment** and to the **potential success of the Pallas** project
- A **discontinuation scenario is less attractive than investing** and to **ensure long-term continuity** of ECN/NRG the Ministry of Economic Affaris granted **further financial support in terms of a loan and reduced interest rate**
- In addition, the Ministry of Economic Affairs decided to pursue **further structural solutions** and investigate:
  - **Carve-outs of ECN's Duurzaam** activities and merger with TNO to create unified Energy Research Center and **independent policy advice activities** ("Rekenmeester Functie") to Planbureau voor de Leefomgeving (PBL)
  - Options for **effective and cost-efficient disposal of NRG's historical radioactive waste** and **considerations for the potential take-over of related activities, costs and liabilities** by other parties (scope of this report)

In this context, EZ requested insight into costs & bandwidths, cost-efficient solutions and potential separation scenario's

Main objective

Evaluate cost-effective optimization options and considerations for potential take-over of costs and liabilities related to ECN/NRG historical radioactive waste

Sub-objectives

I. *Provide insight into historical radioactive waste **disposal costs and potential bandwidth** including **underlying uncertainties and drivers** and clarity on **historical waste definition***

II. *Identify **opportunities for more cost-effective processing and disposal** of the historical radioactive waste*

III. *Evaluate **potential scenarios for separating NRG's historical radioactive waste activities***

IV. *Evaluate **(substantiated) benefits and drawbacks** of potentially **separating NRG's** historical radioactive waste activities, costs and **financial liabilities***

ECN/NRG recently completed an RWMP cost review, which confirms the limited maturity level and high cost uncertainty

I Costs insights and bandwidth

- At the end of 2016, **ECN maintained a €116Mn provision for RWMP,** of which **€67Mn for historical stored waste**, **€37Mn for decommissioning waste** and **€13Mn for operational waste** – these reported costs do not include any contingency for unknown uncertainties and do not fully reflect inherent uncertainties
- Recently**, NRG completed an in-depth review of its RWMP cost estimates** – including an **initial assessment of potential cost bandwidths,** based on identified drivers and uncertainties
- NRG **cost projections appear to be fairly robust, yet remain difficult to predict as:**
  - **Several waste streams are highly complex** and require unique solutions, equipment and tools
  - **Disposal plans are still immature** for stored waste, as well as for decommissioning waste
  - **Key NRG resources are also deployed for other activities,** which limits execution speed and success
  - **Collaboration with stakeholders** (COVRA, ANVS) **is not optimal**, driving re-work/over-specification
- **Full scope of risks and uncertainties is not covered** (e.g. changes in regulation and acceptance levels) and therefore not accurately reflected in current reported RWMP costs

I Stored waste

- Whilst actual total **costs will ultimately only be known after disposal is fully completed,** we believe that applying **NRG bandwidths for stored waste provides a fair indication of potential ranges** – given the maturity level and information available today and limitations for relying on the potential use of these ranges
- NRG **stored waste disposal plans and cost projections are most advanced for RAP families, but further detailing is required across all waste streams** – The current high case **estimation for cost related to stored waste disposal is €113Mn** (+68% vs €67Mn), but this is not an absolute maximum cap

I Decommis-sioning waste

- NRG **decommissioning plans are still fairly early stage** and cost projections remain **uncertain due to complexity of selected facilities, lack of (international) comparisons and long time horizon, and NRG applies an uncertainty bandwidth for decommissioning costs of between 30% and 100%**
- A **more differentiated approach per facility**, taking into account maturity stage and complexity level confirms that decommissioning costs could **exceed €71Mn** (+92% vs. €37Mn) – decommissioning the HCL could have a higher exposure than currently anticipated whilst other facilities are within or below NRG range

There are clear opportunities to enhance program mgmt. and to realize cost efficient solutions across the value chain

I

Cost insight & reporting improvement options

- Currently, **NRG has a strong technical focus on managing costs related to the RWMP program**, and adequately leverages internal and external expertise, multi-functional teams and international peers to develop and evaluate effective and cost-efficient solutions
- We believe there are **three improvement areas for further improving the robustness of NRG's RWMP cost estimates, program management and reporting**:
  - Develop **holistic approach** in identifying cost optimization opportunities **across the waste value chain** – involving COVRA, ANVS knowledge & other 3rd parties early on to develop plans and validate assumptions
  - Enhance **program management capabilities** and drive plans through a **structured stage-gate-process and maturity funnel with clearly defined criteria and KPIs for completing each maturity phase**
  - **Report** costs regularly with **probability levels for achieving cost projections** and **differentiate between stored** (short-term priority) **and decommissioning waste** (longer-term horizon) and review provision level

II

Cost-efficiency improvement options

- There are **two boundary conditions** that need to be considered **when identifying cost-improvements**:
  - All waste needs to be **characterized before it can be transported** – requiring specialized work at OLP
  - Furthermore, all waste needs to be **characterized for intermediate storage** and **final disposal**
  - As a result, all waste streams needs to be transferred to COVRA and **cannot remain unsorted at OLP**
- Within these boundaries there are **opportunities for cost-optimization** by making four **key economic trade-offs across the value chain**:
  - **What activities are done or how:** make trade-offs between technological solutions with different costs
  - **When activities are done:** optimize workload over time, leveraging potential technological advancements
  - **Where activities are done:** concentrating investments in one location, leveraging volume consolidation
  - **Who the activities do**: leveraging different suppliers for make-or-buy decisions
- Going forward, NRG and COVRA should **jointly identify and evaluate optimal disposal route for each waste stream** – as a result of this project, **several concrete opportunities were identified**
- **Focus and first priority is for stored waste streams** – decommissioning waste has a longer time horizon

Waste organization, collaboration and financial support should be improved first before considering liability take-over

III **Alternative organis-ational options**

- **Realizing economic benefits across the waste disposal value chain requires better collaboration between NRG and stakeholders – for which we have identified three organizational alternatives:**
  - Short term option, of the current situation with carve-out a dedicated waste team from NRG, improved cross value-chain operational collaboration and expert input from ANVS & COVRA and others to develop and evaluate more cost efficiency solutions within set (safety) regulation
  - Second option, with a further holistic value-chain approach, COVRA taking over and integrates all operational activities, and a steering committee approving the program budget, planning & investments (safeguarding the financer's interests) can be considered in mid-term in case tangible benefits are proved
  - Third option, optimization on national level under decommissioning authority, requires policy, ownership, financial and governance changes and can only be justified in case of scale benefits and synergies from joint disposal optimization – e.g., large decommissioning programs from different sources and companies

IV **Financial liability solutions**

- **Current situation of repeated credit crises, lack of transparency and grip on costs is not sustainable**
  - ECN/NRG's current profit generating activities cannot fully absorb RWMP costs and uncertainties
  - Current situation of repeated credit crisis situations causes a distraction for all stakeholders involve and does not contribute to safe, quick and cost-efficient disposal
  - Government de-facto already provides financial back-stops to absorb cost increases and has few instruments to increase grip on costs and influence RWMP execution
  - Situation is likely to continue as RWMP provision does not include contingencies despite high uncertainty
- **More structural credit solutions are possible in the current set-up without it being a blank check and a risk of providing state-aid, and ECN/NRG incurring high-costs and/or risk premiums**
  - There are instruments for more structural support, such as credit guarantees or state fund
  - There seems to be legal basis to further support stored waste removal without non-compatible state aid penalties, but exact terms and amounts are still under investigation by government
  - Terms of State support could be used as a vehicle to driver cost and operational excellence
  - Take-over of the liability introduces additional risks, costs and change which ECN/NRG cannot absorb
- **State take-over of RWMP liability as requested by ECN/NRG remains not yet substantiated; Critical opportunities for improvement of the current situation need to be investigated first**

We see a number of key first steps that should be taken in order to start improving the current situation

Key next steps

1. **Strengthen dedicated waste management organization** (separate from NRG's nuclear activities) **with clearly defined and agreed operational KPIs** to drive operational focus – and develop transition roadmap for greater cross-value chain collaboration (model 1)

2. **Improve NRG's RWMP program management capabilities** and implement a **structured stage gate process** with clear **milestones and KPIs**, and **regular communication** of **program progress** against agreed timeline and **probability linked cost estimates**

3. **Finalize identification of cost-optimization opportunities across the value chain (NRG, COVRA and ANVS),** quantify high-level synergy potential, align different incentives amongst the three stakeholders and identify required enablers

4. **Investigate short-term options for more structural (government) credit support within current organizational and governance set-up** and develop charter with terms and incentives and KPIs aligned to government objectives (safe, quick, and cost effective disposal safeguarding the "polluter pays" principle and contributions from ECN/NRG)

5. **Further investigate legal, organization and financial considerations for longer-term optimization opportunities (i.e., alternative models 2 and 3)** only once organization model 1 is fully implemented and has reached a steady state

Context & main conclusions

Appendix 1: Introduction

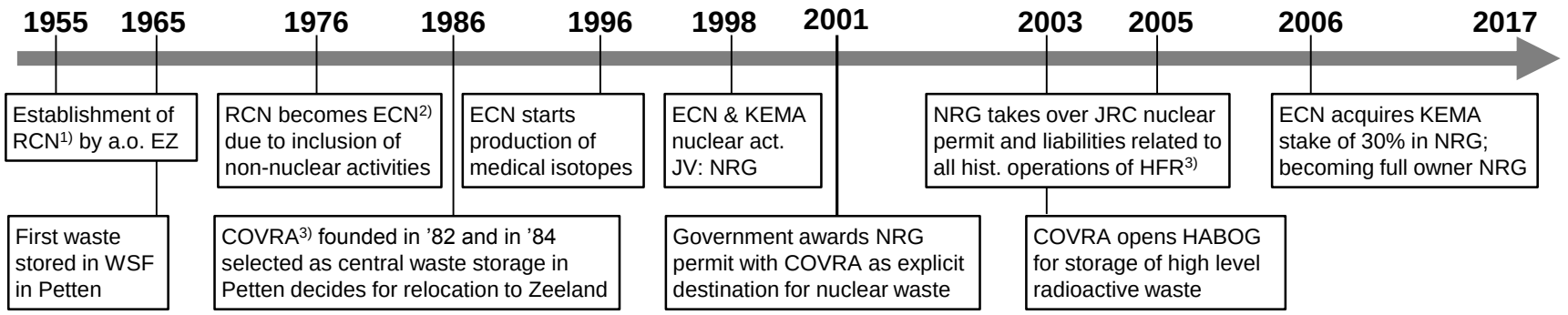
Appendix 2: Cost & uncertainties

Appendix 3: Operational improvements

Appendix 4: Organizational & financial improvements

NRG was formed out of the ECN and KEMA nuclear joint venture, but activities started in 1955 as RCN

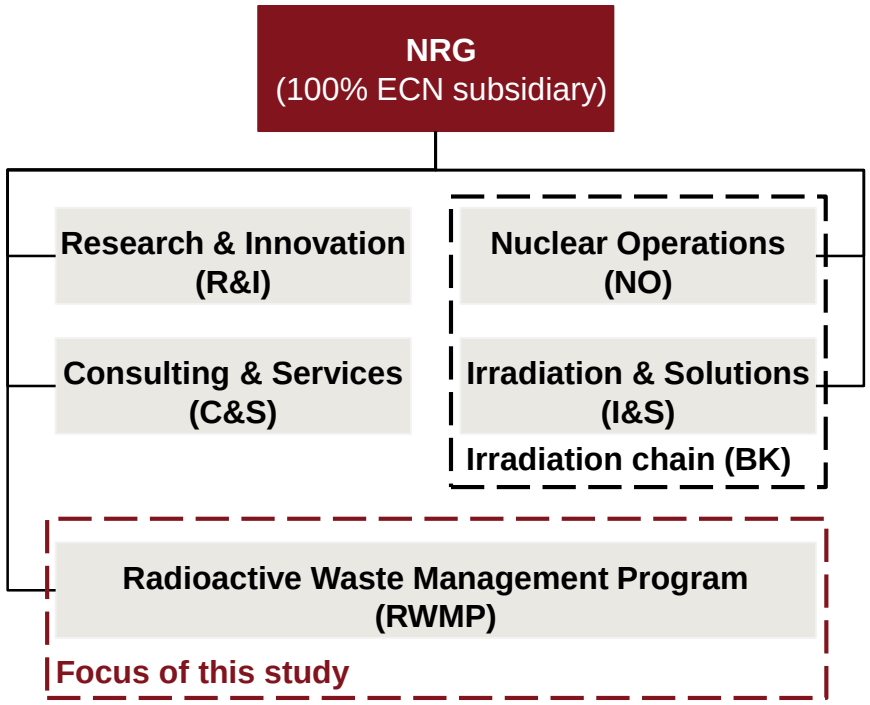
ECN/NRG timeline with key milestones



1) Reactor Centrum Nederland Stichting, 2) Energieonderzoek Centrum Nederland Stichting, 3) Centrale Organisatie Voor Radioactief Afval NV
Sources: Strategy& analysis, COVRA, www.nrg.eu, www.ecn.nl, 'Update kostenraming RWMP 2016', 'Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG (2007)', 'Kostenraming Decommissioning Nucleaire faciliteiten ECN-terrain & afvoer radioactief afval (1998)', Onderbouwing update DECOM kostenraming voorz ult 2016.xlsx, 'update voorziening RWMP ult 2016.xlsx',

NRG is a nuclear services provider and producer of medical isotopes based in Petten, and is a full subsidiary of ECN

NRG's activities



Comments

NRG

- NRG is the **operator of the High Flux Reactor** (HFR) in Petten and provider of nuclear research and consultancy services
- Main source of revenue is irradiation, production and **sale of medical and industrial isotopes**
- Isotopes have a **history of pricing below full-cost levels,** making it challenging to run business sustainably

Radioactive Waste Mgmt. Program (RWMP)

- RWMP is the program of **processing and transporting all radioactive waste** and the main focus of this study
- The challenge for this program is the **high uncertainty about future costs** with respect to historical stored and decommissioning waste

Sources: Strategy& analysis, NRG

RWMP consists of stored historical and decommissioning waste, plus operational waste

RWMP — **Processing and transport of all radioactive waste to COVRA**

Stored historical waste

- Mainly canisters with historical radioactive waste produced by experiments, of which the exact composition is largely unknown
- Also includes waste resulting from operating and maintaining the HFR that cannot be directly moved off the site

Decom-missioning waste

- Radioactive waste resulting from decommissioning and clean-up of all structures (LFR, HFR, HCL, etc.)
- Part of this waste to be created only at facility end-life (until ~2030)

Operational waste (out of scope)

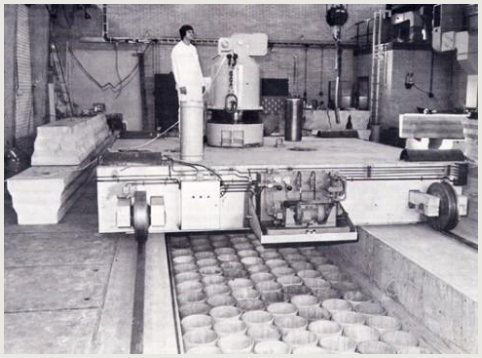
- (Current) waste from operation of the OLP plants, primarily from research activities and Mo-99 production
- Normally moved off the site within between two and five years (from OLP to COVRA) as a matter of routine through an open waste disposal flow
- Incurred waste treatment costs included in integral product cost calculation

Source: NRG

Radioactive waste was intended to stay in Petten until disposal but changes in regulation requires relocation to Zeeland

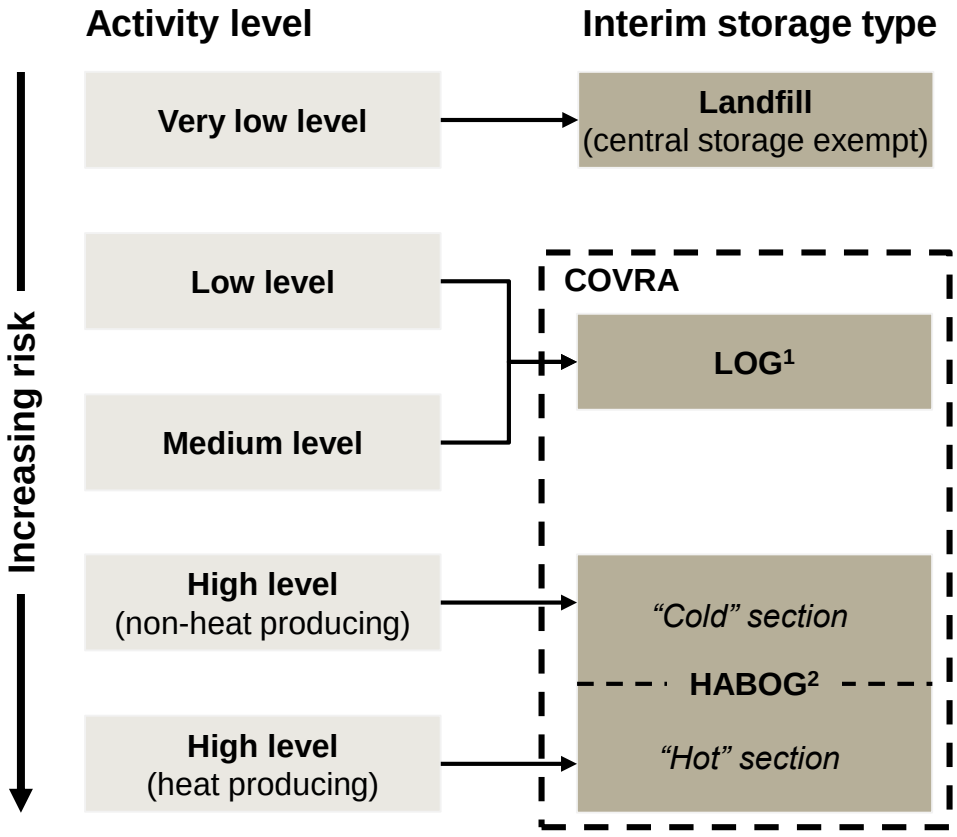
Nuclear waste storage

Current ECN/NRG storage



- Since 1960s, radioactive waste from nuclear activities was stored at waste storage facility (WSF) at Onderzoeks Locatie Petten (OLP) in the interim before final disposal
- In 1984, the Dutch government decided that all radioactive waste is to be collected and stored for the interim period until final disposal by a single organization (COVRA)
- Following the relocation of COVRA in the 1990s, it was decided that all radioactive waste from Petten (new and stored) needs to be transferred to Zeeland

Current nuclear waste storage policy



1) Laag- en middelradioactief afval Opslag Gebouw 2) Hoogradioactief Afval Behandelings- en Opslag Gebouw; Sources: Strategy& analysis, COVRA

This transfer of radioactive waste is done in 7 key steps involving four organizations

General process chain of RWMP

Involved organizations

- **NRG** — Operator of the HFR and responsible for all waste at Petten
- **COVRA** — Charged with collecting and disposing all nuclear waste in NL
- **BELG PROCESS** — Service provider that conditions nuclear waste (e.g. RAP from NRG)

Key auditing organization

- ANVS is the policy advisor, licensing authority and inspectorate for all nuclear activity in NL

Process steps	Description	Location
Lift/ decommission	• Waste is retrieved, either by lifting waste from storage facilities or by decommissioning buildings	NRG
Process (e.g. cut, sort)	• Waste undergoes necessary processes, ranging from cutting up into smaller parts and sorting waste according to level of radiation	NRG
Characterize	• All nuclides and radiation types residing in the waste are mapped to create required documentation for transport, storage and disposal	NRG
Repackage (for transport)	• Waste is transferred to transportable containers	NRG
Condition	• Waste is compressed to minimize physical footprint • Waste is encapsulated in concrete	BELG PROCESS *or* COVRA
Store	• Waste is stored in secure facilities for 100 years	COVRA
Dispose	• After 100 years, waste is permanently moved to an underground geological disposal (end-storage)	COVRA

Different types of radioactive waste have historically been stored in Petten – each requiring a customized disposal route

Overview of Stored Waste streams

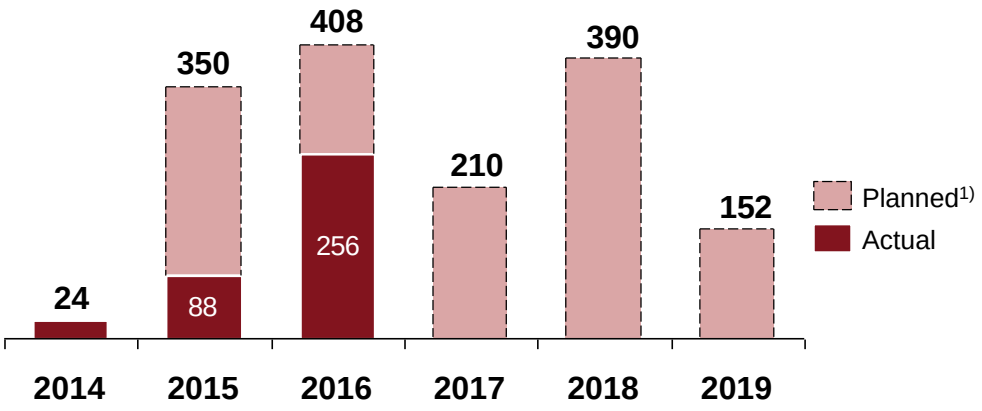
		Description
	RAP (~80% of exp. costs)	• 1120 canisters non-alpha-emitting waste from historical experiments • Characterization, sorting and repackaging of waste has started and first canisters have been relocated
	RAP alfa	• 527 canisters with alpha-emitting waste from historical experiments • Will be initiated upon completion of RAP; a customized alpha-proof hot cell needs to be developed
	Resin canisters ("harsvaten")	• 338 large canisters with radioactive resin: operational waste from replacing the reactor's cooling water • Process for analyzing activity levels in development; will be disposed via service provider in future
"Other Waste Streams"	Large parts ("grote delen")	• Components of radiation tubes removed from the HFR when replacing the reactor vessel in 1984 • Disposing of these parts is a process similar to decommissioning of the OLP plants
	Irradiated fission material waste	• 101 canisters of highly radioactive heat-producing waste from experiments with fission materials • Disposal route is currently still highly uncertain due to complexity of handling this specific waste
	Irradiated fuel rods	• ~30 highly radioactive irradiated fuel rods from the HFR • Rods are currently stored in the basin of the Hot Cell Laboratories, potential disposal route is identified
	Unirradiated fission material	• Several restricted non-radioactive materials used for experiments to be relocated to COVRA • Materials do not emit radiation and therefore do not need sophisticated treatment before transport
	Beryllium	• Highly radioactive and poisonous waste, generated when replacing certain components of the HFR • Disposal route highly uncertain, also due to COVRA not having a process for storing beryllium
	Several other waste streams[1)]	• Relatively small amounts of waste produced by historical experiments • Require customized but relatively straightforward disposal routes

1) Sodium-bearing waste, Cesium-bearing waste, radiation sources, Tritium filters, Plutonium jars and sanitizing of "Pluggennest" ; Source: Strategy& analysis, NRG discussions, Update RWMP kostenraming (2017)

Whilst disposal of RAP canisters is in progress disposal of other waste streams has not yet started

Stored waste disposal progress

Processed RAP canisters, in # of canisters



Processed stored waste progress

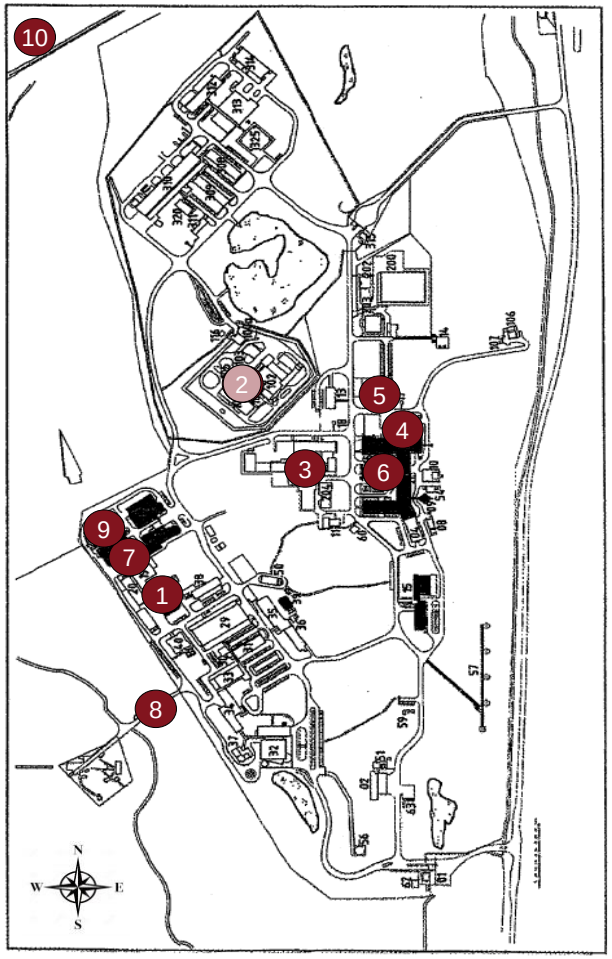
Waste stream	Status	Progress (in % of total)	Planned completion
RAP	In progress	33%	2019
RAP-alpha	Not yet started	n.a.	2022
Resin	Not yet started	n.a.	Unknown

Comments

- **RAP is the first** waste stream for which the disposal has started and is **planned to be completed in 2019**
- At the end of 2016, **33% of the RAP canisters had been sorted**
- Currently, **only low-level waste can be relocated to COVRA** as higher-level waste requires the usage of the not yet completed Waste Transfer Unit
- Only the **low-level contents of 18 original RAP canisters have been relocated to COVRA**, as other low-level waste has been rejected due to **new developments in characterization requirements**
- **RAP-alpha is the next waste** stream for which the disposal is planned to start in 2019 and is planned to be **completed at latest in 2022**
- For all other waste streams **no formal disposal planning has been made**

1) Planned number of processed at barrels at start of each year
Source: Strategy& analysis, RWMP Voorziening, management interviews

Decommissioning at OLP involves bringing ~10 facilities to sufficiently low levels of radioactivity or greenfield state



Facilities on ECN/NRG site in scope of investigation:	
Reactor / production	1 Low Flux Reactor (LFR) 2 High Flux Reactor (HFR) 3 Molybdeen Production Facility (MPF)
Research	4 Hot Cell Laboratories (HCL) 5 Jaap Goedkoop Lab (JGL) 6 Chemical/material science building no. 5 & 6
Treatment	7 Decontamination & Waste Treatment (DWT) 8 Sea drainage pipe
Storage	9 Waste Storage Facility (WSF) 10 Underground channel system

Need to be decommissioned to:

I. Regulatory restoration to sufficiently low levels of radioactivity

And *possibly* to:

II. Restoration of landscape to original 'greenfield' state

Regulations and internal planning determine adherent requirements, which form a basis of cost calculation

Sources: Strategy& analysis, www.nrg.eu, 'Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG (2007)', 'Kostenraming Decommissioning Nucleaire faciliteiten ECN-terrein & afvoer radioactief afval (1998)', 'Update RWMP Kostenraming (2017), 'Onderbouwing update DECOM kostenraming voorz ult 2016.xlsx,', 'update voorziening RWMP ult 2016.xlsx'

Facilities were built over various periods of time and used for training, storage, research and production purposes

Overview of facilities with share in the provision as of end-of-year 2016

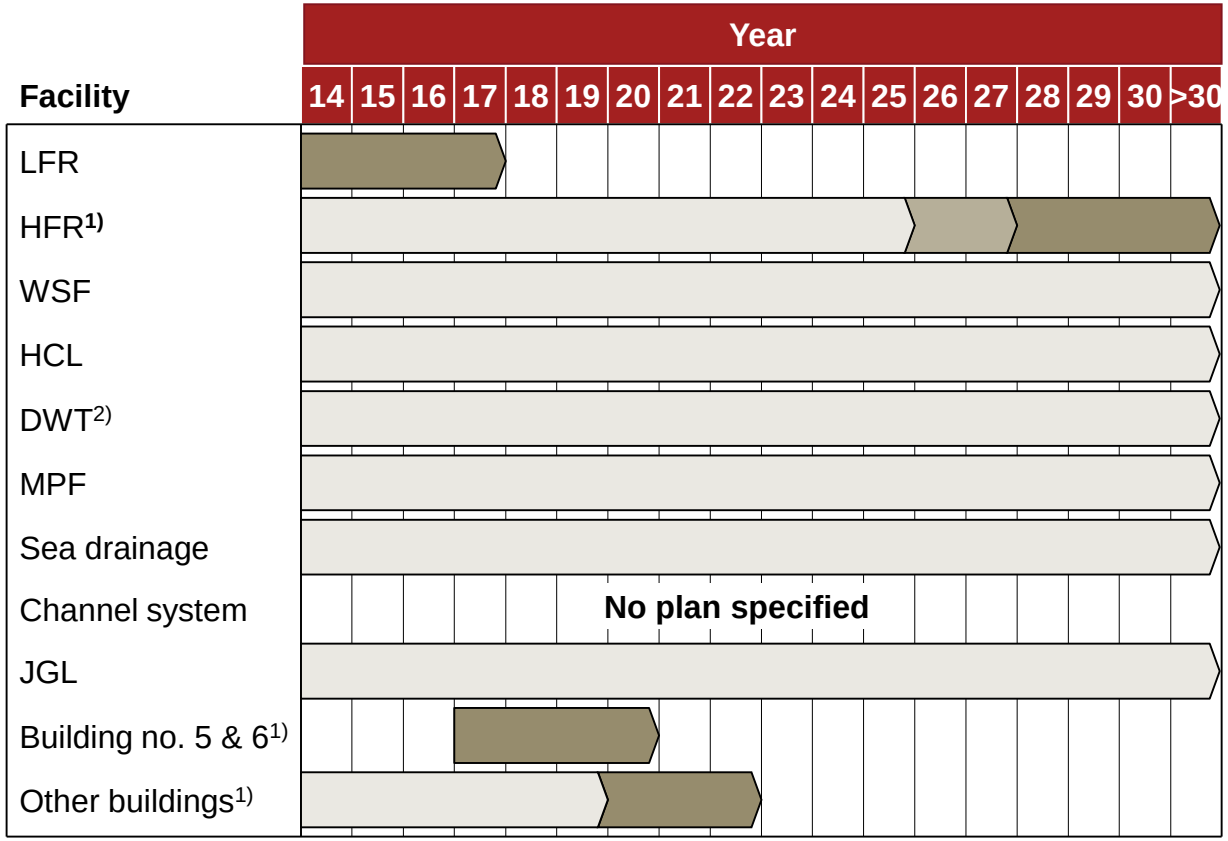
Facility	Start of use	Purpose	Description
LFR	1960	Reactor	• **Low Flux Reactor**; for training personnel and facilitating nuclear experiments. Decommissioning currently in process
WSF	1962	Waste storage	• **Waste Storage Facility**; long-term storage facility where historical radioactive waste is stored
HCL	1964	Sorting & research	• **Hot Cell Laboratories**; for sorting RW & experiments with HFR[3] output for research / production
DWT	1960	Waste treatment	• **Decontamination and Waste Treatment**; to separate, sanitize and transport radioactive waste
MPF	1996	Isotope production	• **Molybdeen Production Facility**; preparing radiated Molybdeen (isotopes) for transport
Sea drainage	196x	Waste drainage	• **4.4 km long channel** to transport conditioned radioactive water from DWT to sea
Channel system	196x	On-site transport	• **Underground channel system** for transport of substances (possibly RA) between facilities
JGL	2007	Research	• **Jaap Goedkoop Lab**; for researching new isotopes and improving radioactive waste management
Building no. 5 & 6	196x	Research	• **Buildings for radiological research**; no. 5 for spectometrics and no. 6 for material sciences
Other buildings	Various	Numerous purposes	• Includes buildings no. 15, 28 & 39 and other unspecified facilities with **limited impact on costs**
Total			

Sources: Strategy& analysis, www.nrg.eu, 'Update … raming' (2017), 'Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG (2007)', 'Kostenraming Decommissioning Nucleaire faciliteiten ECN-terrein & afvoer radioactief afval (1998)', 'Update RWMP Kostenraming (2017), 'Onderbouwing update DECOM kostenraming voorz ult 2016.xlsx,', 'update voorziening RWMP ult 2016.xlsx'.

Decommission work has a longer time horizon than stored waste, as most buildings will be in use until ~2027/2030

Decommissioning plan

Activity: In use | Cooling off | Decommission



Comments

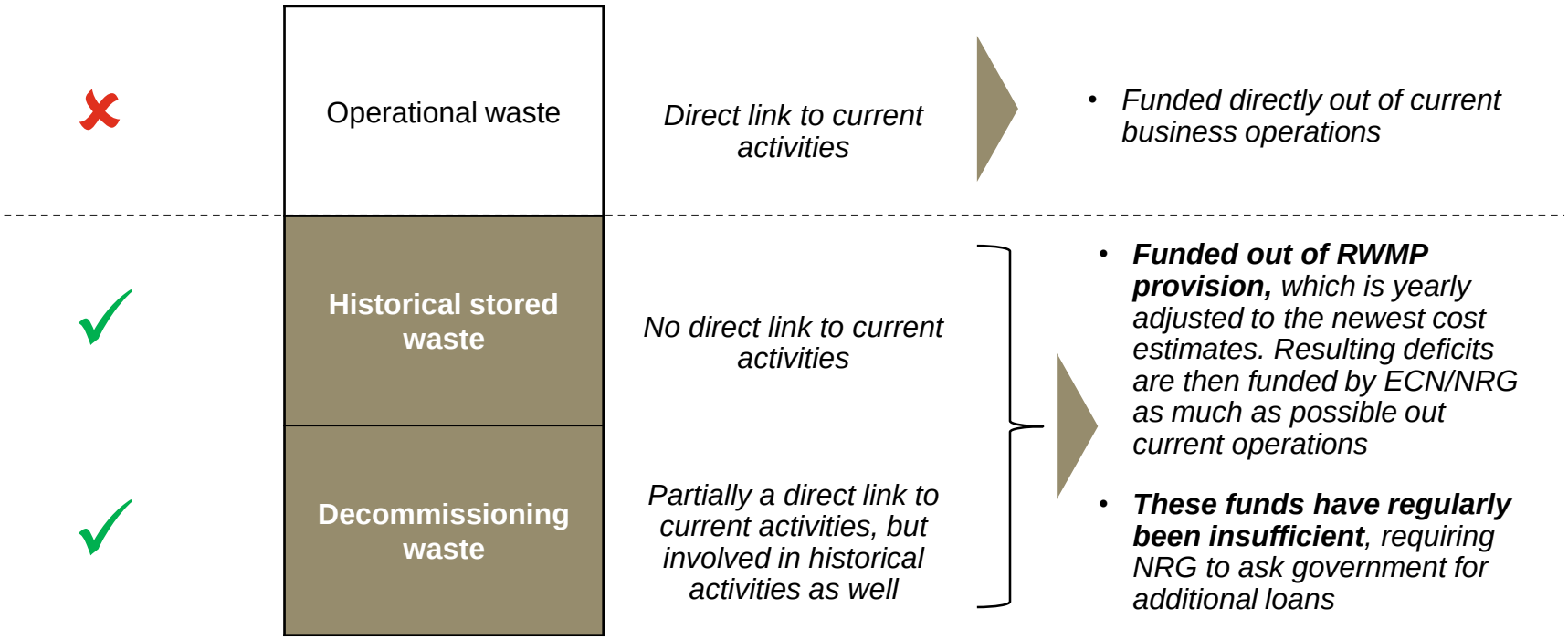
- Decommissioning planning currently has less priority than the disposal of stored waste
  - Some facilities are still planned to be in use beyond 2030 as they will be used during the decommissioning activities (e.g., DWT)
  - Most attention now to bring stored waste as soon as possible to COVRA
- Still, planning can be made on how and when to bring planning per building to next maturity phase

1) Preliminary plans await finalization of plans for HFR succession; 2) Building no. 24 is part of the DWT and has the same planning except for sanitation work in 2014
Source: Strategy& analysis, NRG "herziene geactualiseerde PvA RWMP augustus 2015"

Historical waste costs are a part of the RWMP not directly linked to current income from research & isotopes activities

Funding of waste categories – operational vs. historical waste

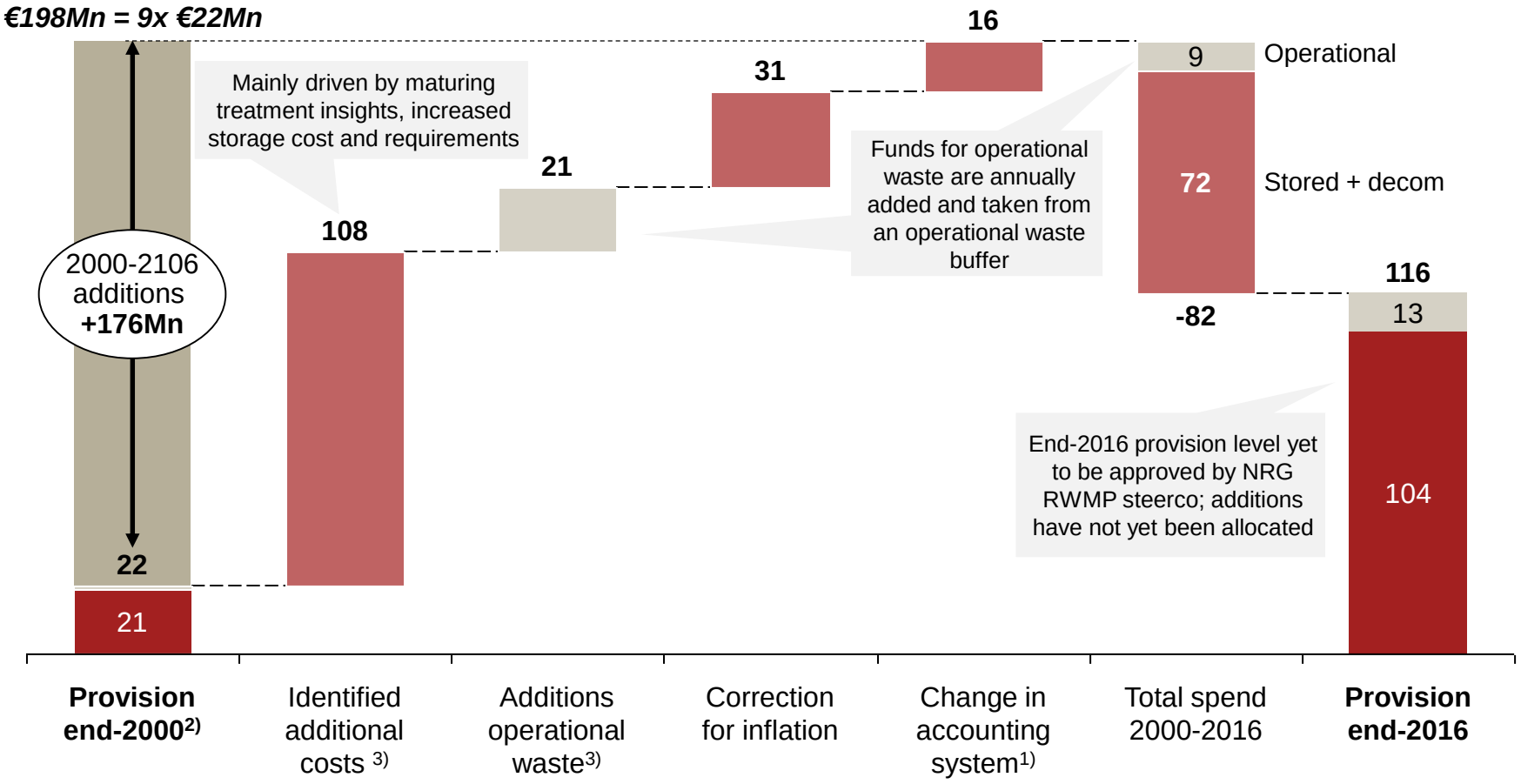
Part of RWMP provision for historical waste



Source: Strategy&

Over time, RWMP cost projections increased by a factor 9 (€198Mn vs. €22Mn in 2000) and €82Mn has been spent

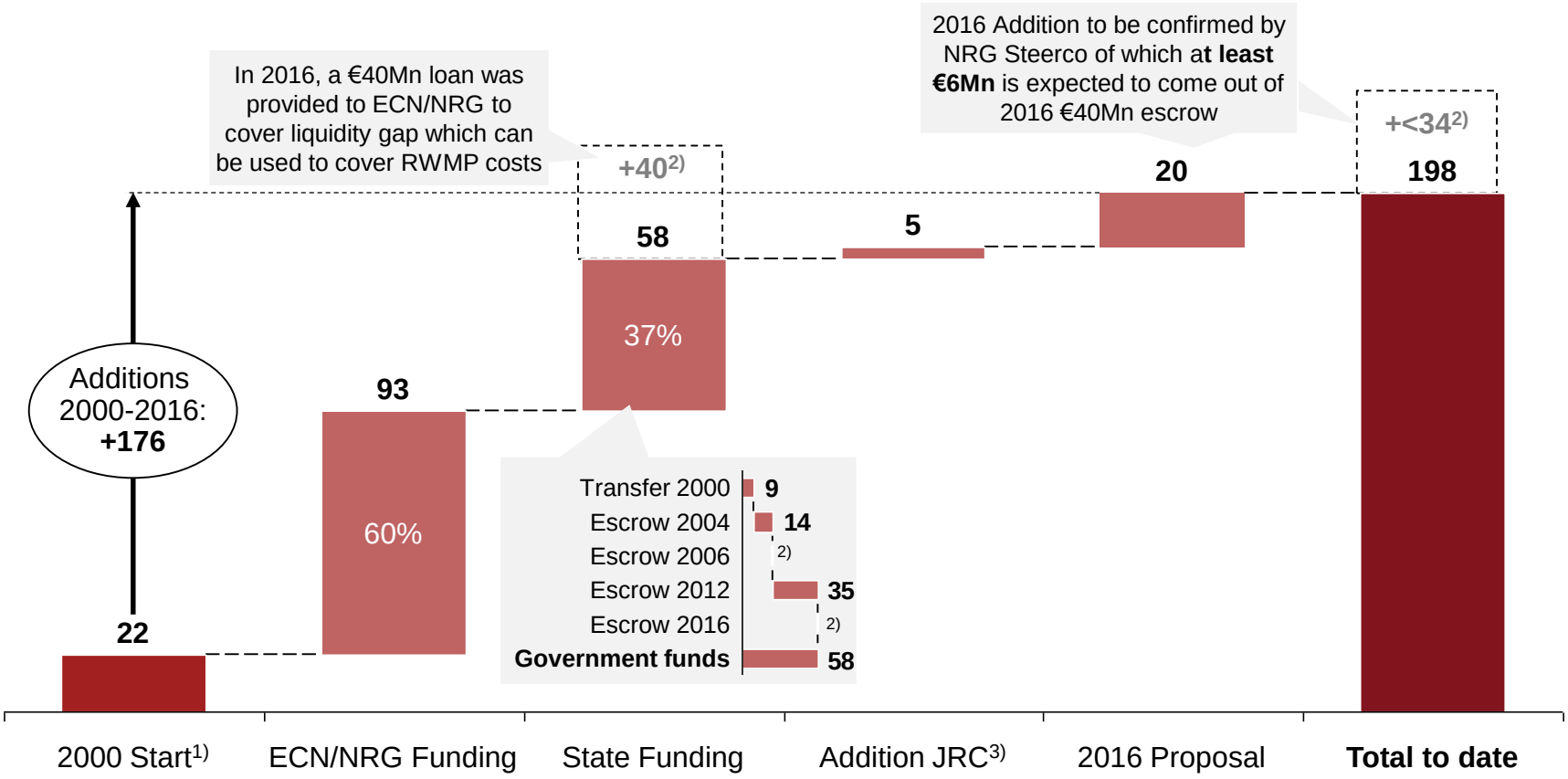
Development of RWMP provision 2000-2016, in €Mn



1) Including operational provisions in tariff instead of retrospective allocation, and change to constant value calculations 2) No insights available from NRG for costs made before 2000, or how € 22 Mn provision end 2000 was funded 3) Includes total of €20Mn (of which €4,5 Mn for operational waste) proposed addition in 2016, to be approved by NRG Steerco; Source: Strategy& analysis, "Overzicht ontwikkeling voorziening RWMP vanaf 2000

Since 2000, the government contributed €58Mn to RWMP costs plus a €40Mn loan in 2016 for general purposes

Financing of RWMP provision additions 2000-2016, in €Mn



1) No insights available from NRG of how €22Mn provision end 2000 was funded;
2) 2016 Escrow of €40Mn was not formally added to RWMP provision – at least €6Mn is expected to be used to cover 2016 additions; 2006 Escrow was not added to RWMP provision but used for Pension funding support (confirmed by both EZ and ECN/NRG finance departments)
3) Compensation for transfer of waste responsibility from Joint Research Center in 2005
Source: "Overzicht ontwikkeling voorziening RWMP vanaf 2000, NRG, Ministry of Economic Affairs, Strategy& analysis

EZ has received requests from ECN and the Dutch parliament regarding ECN's historical radioactive waste

Summary of ECN requests and EZ response

ECN request (2016)

- In 2014, the ECN/NRG business case identified key risks, but **investment was attractive compared to discontinuation scenario** (€120Mn termination cost)
- Recently, ECN revised its business case substantially downwards and now projects €83Mn negative liquidity by 2026 – €152Mn below its previous (2024) projection
- As a consequence, **ECN concluded it cannot cover the costs of historical waste disposal** and requested EZ to take over the related liability and costs as part of a broader support package

Government response

- To **ensure long-term continuity** of ECN/NRG's nuclear research and isotope supply the Ministry of Economic Affairs decided to grant **further financial support** (extra loan and interest rate reduction)
- In addition, the Ministry decided to investigate **further structural solutions**:
  - **Carve-outs** of ECN Duurzaam activities and "Rekenmeester Functie"
  - Options for more **cost-efficient historical waste disposal** and **considerations for potential separation** and/or take-over of related activities, costs and liabilities

In this context, EZ requested a study to gain insight into the definition, costs and potential bandwidths of the historical waste, cost-efficient solutions and potential separation scenario's

Source: ECN Business Case August 2014, Current MJV, MJV Presentation to EZ, Letter to Dutch Parliament by Minister of Economic affairs of 30-9-2016; Strategy& analysis

Context & main conclusions

Appendix 1: Introduction

Appendix 2: Cost & uncertainties

Appendix 3: Operational improvements

Appendix 4: Organizational & financial improvements

Our cost and uncertainty assessment is based on a ~4 month internal NRG technical review

NRGs RWMP cost estimation update 2017

NRG

Update RWMP
Kostenraming

Eindrapportage

Vertrouwelijk

In opdracht van Programma Manager RWMP

rev. nr.	datum	omschrijving
A	31-01-2017	Definitief (commentaar stuurgroep verwerkt)

auteur(s):	J.P. Boogaard J.G. Arends (Financiele Onderbouwing)	beoordeeld:	M.W.M. Smit N.J.M. Kroone
naam:	Update RWMP Kostenraming	goedgekeurd:	J.A. Vreeling
referentienr.:	K6019.10/16.141420	Status:	Definitief
62 pagina's	31-1-2017		

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Behoudens hetgeen met de opdrachtgever is overeengekomen, mag in dit rapport vervatte informatie niet aan derden worden bekendgemaakt en is NRG niet aansprakelijk voor schade door het gebruik van deze informatie.

- Our assessment of cost and uncertainty estimates are based on the RWMP cost update review, finished in January 2017 by NRG, supplemented by key staff interviews and underlying data analysis
- NRGs RWMP cost estimate update is the result of the work covering a ~4 month period which included multifunctional technical brainstorm sessions to detail costs and uncertainties
- ECN/NRG disposal plans are to some extent still not mature and waste streams complex and difficult to assess and therefore these estimates cannot be considered as final and could ultimately exceed current projected bandwidths
- ECN/NRG claims that these estimates do not reflect the associated risks, that these risks be quantified and that therefore these numbers cannot be relied upon
- Based on our review and interviews we believe that ECN/NRG's most recent projections provide a fair indication of potential costs, uncertainties and bandwidths based on information and expertise that is currently available and time that has been invested on a best-effort basis
- There is general industry consensus that the final costs for nuclear (decommissioning) waste treatment cannot be fully certain until disposal operations are fully completed

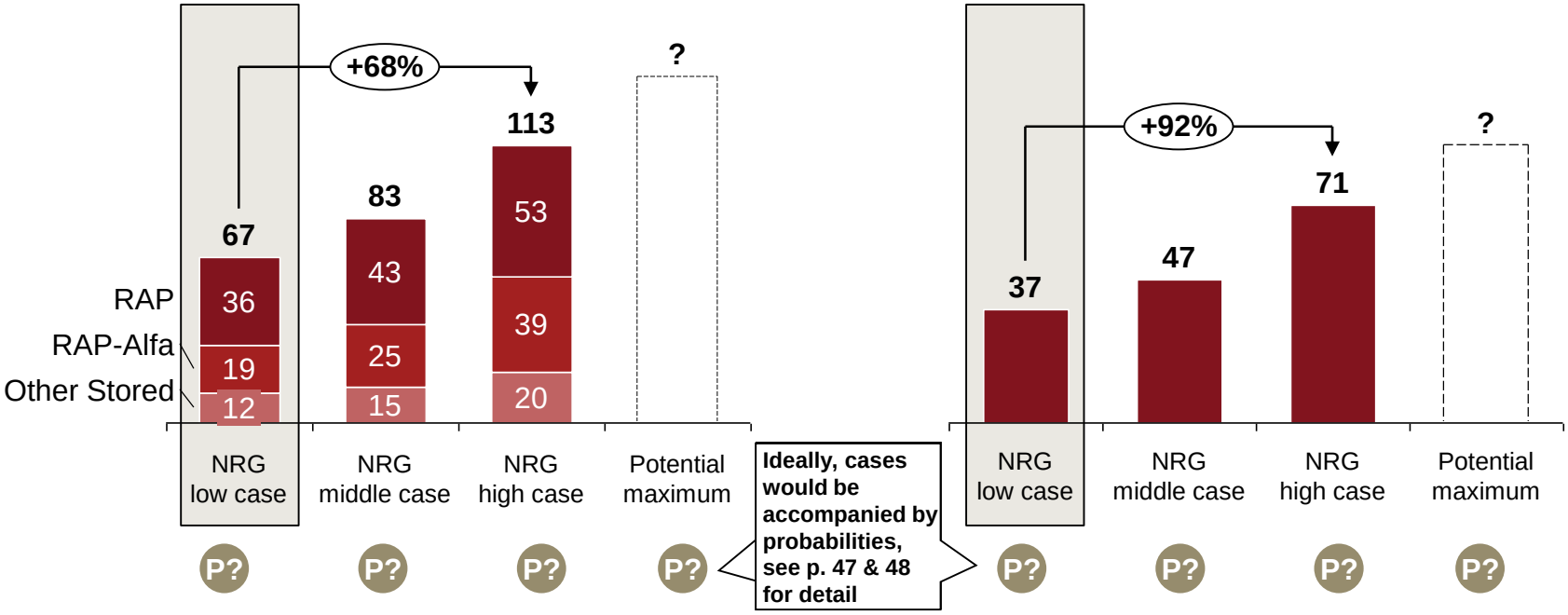
Source: Strategy&, "Update Kostenramping RWMP

NRG's cost analysis demonstrate that RWMP costs could far exceed current provision levels if uncertainties materialize

Projected radioactive waste cost ranges[1], €Mn

1 Historical Stored waste | **2 Decommissioning waste**

ECN/NRG's RWMP provisions are **based on the "Low Case"** which **do not include contingencies** for (un)known uncertainties



There is no guarantee that costs remain within bandwidth, or not exceed high case, as waste streams are complex, most disposal plans are not very advanced, and not all (external) cost drivers are factored in

1) Estimations preliminary, to be approved by NRG RWMP steerco; uncertainty as defined in J. Boogaards Eindrapportage "Update RWMP Kostenraming"
Source: Strategy& analysis, Eindrapportage "Update RWMP Kostenraming"

There is a risk that costs could exceed even the high cases, as NRG perspective does not account for all key uncertainties

Key overarching uncertainties

			Part of current estimate	Cost impact	Hist. impact	Future uncert.
1 NRG internal	**Technical complexity**	• **High uncertainty in hours, investments, 3rd party costs and amount of rework needed drive by required (sometimes still unknown) new solutions** – Lack of reference cases on unique treatment routes – Uncertainty on actual composition of historical waste	✓	−	◕	◑
	Operational efficiency	• **Process speed uncertainty increased** by critical staff that has to balance commercial and waste activities • **Learning effect uncertainty**; effect and impact hard to estimate: – Stream variances – Critical staff changes and difficult staff hiring/training • **Duplication of work** between COVRA & NRG	✓	+/−	○	◔
2 External	**Acceptance criteria**	• **COVRA's acceptance criteria uncertainty:** unclearly defined or unknown for all streams, driving uncertainty about requirements and risk of rejected waste (e.g. RAP Family II) • **Double education** at the handover COVRA-NRG needed, due to standalone NRG operations; Lack of quality control & assurance by COVRA of NRG operations	✓	−	◔	●
	Legislation/ regulation	• **Uncertainty on shifts in regulations**, could impact feasibility and costs of RWMP when processes need to be adapted	✗	−	●	?
	Price increases	• **COVRA price uncertainty**; periodically revised to cover final storage • **Other 3rd party price uncertainty**; e.g., BelgoProcess, **cannot be directly controlled**	✗	−	◔	◕

Source: Strategy& analysis, NRG interviews, Eindrapportage "Update RWMP Kostenraming"

NRG's cost projections are most advanced for RAP and further detailing is required for most other waste streams

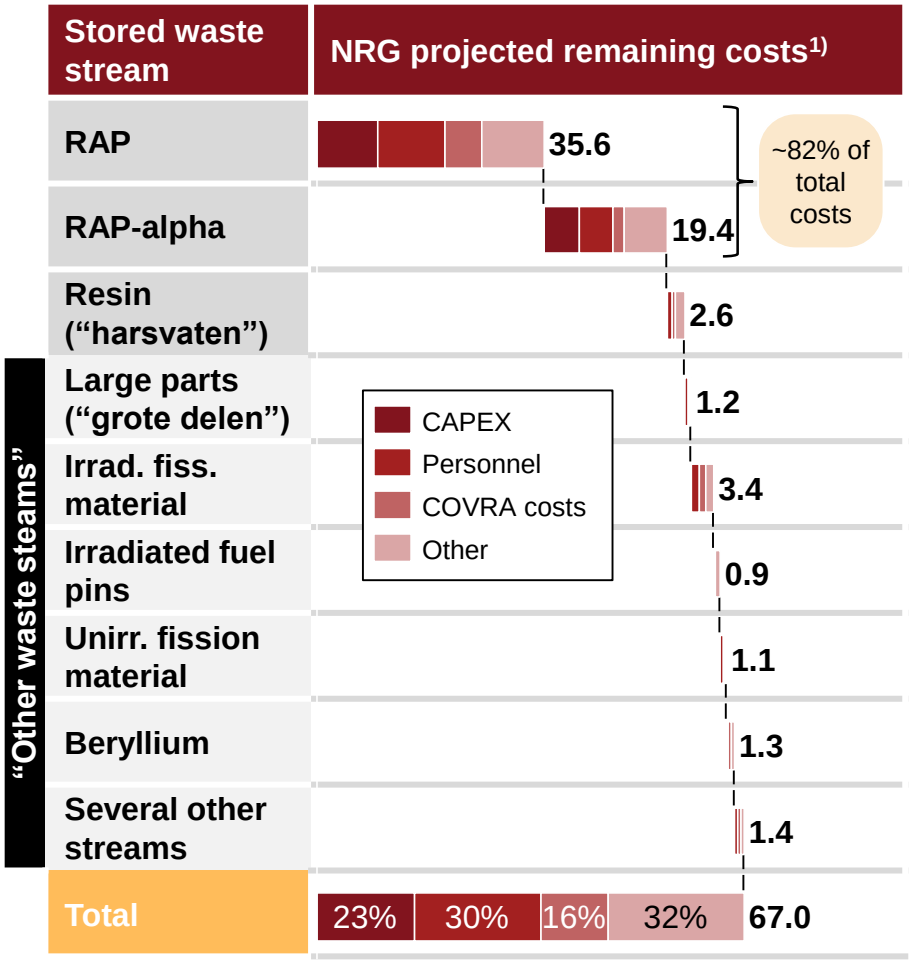
Assessment of latest NRG cost estimate robustness

		Robustness of current NRG estimates	Key weaknesses
Stored waste	RAP	◔ • Based on **known facts** (such as process speed, personnel cost, storage costs) or **reasonably estimated figures** (e.g. level-mix of waste) • Estimates revised **based on first experiences**	• **No budget for unforeseen costs**, all included in uncertainty bandwidth • Estimates **not aligned with COVRA** to test completeness of process costs
	RAP-Alfa	◑ • Based on **similar known facts as RAP** • Alpha cell costs based on **quotes and expert opinions,** using conservative assumptions on specs	• CAPEX for **alpha cell is rough estimate** as specifications are still unknown • Storage prices are **not fixed with COVRA** • **Adjustments to building 24 not included**
	Resin	◔ • Cost estimate for sampling and characterization is based on **quotes by external laboratories** • Cost estimate for incineration is **based on quotes** and **studies of similar disposal cases**	• **Service fees of external service providers vary greatly** depending on the result of sampling and characterization
	Large parts	○ • Very rough estimate based on **outdated provision**	• **No detailed numerical substantiation** provided for costs
	Other waste streams	◑ • **Comparable to RAP-alpha**: preliminary route estimates are based on current personnel costs, storage costs and reasonable CAPEX estimates	• **Routes are untested and unproven,** so uncertainty remains high
Decom	Decom-misioning	◔ • Based on **nuclear decom standard levels** of plan maturity and **LFR experiences** • Costs indexed based on **factual cost increases seen for LFR**	• **No budget for unforeseen costs**, all included in uncertainty bandwidth • **Only preliminary decom studies**, no detailed engineering fact base

Source: Strategy& analysis, Eindrapportage "Update RWMP Kostenraming"

○ Low ● High

Cost for disposal of remaining stored waste is projected to be €67Mn of which ~82% is attributable to RAP(-alpha)



Main cost items

CAPEX:
- WTU to be built to repackage medium/high level waste for transport **(€8.3Mn)**
- Containers for transport to BP/COVRA **(€4Mn)**
- Alpha cell to be built to sort RAP-alpha, including required adjustments to building 24 **(€5Mn)**

Personnel:
- Researching and developing disposal routes
- Operating storage facility, hot cells and WTU

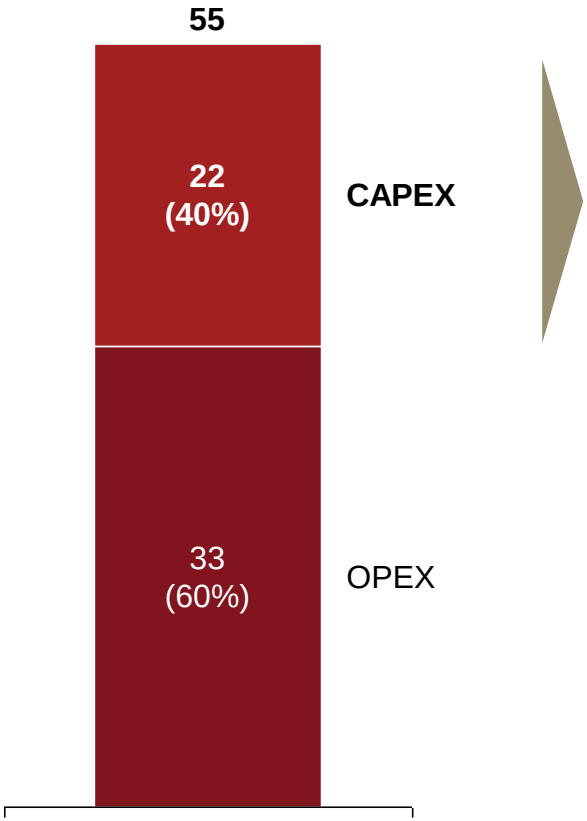
COVRA costs:
- COVRA fees for
  - Conditioning low level waste
  - Storing and disposing of all radioactive waste

Other:
- Costs for service providers, e.g.:
  - BelgoProcess for conditioning medium/high level radioactive waste
  - 3rd party for incinerating resins

1) Estimations preliminary, to be approved by NRG RWMP steerco. Source: Strategy& analysis, NRG interviews, Eindrapportage "Update RWMP Kostenraming"

There are some large investment in the CAPEX plans which is 40% of total projected RAP(-Alfa) costs

CAPEX as share of total RAP(-Alfa) costs, in €Mn



Key CAPEX items

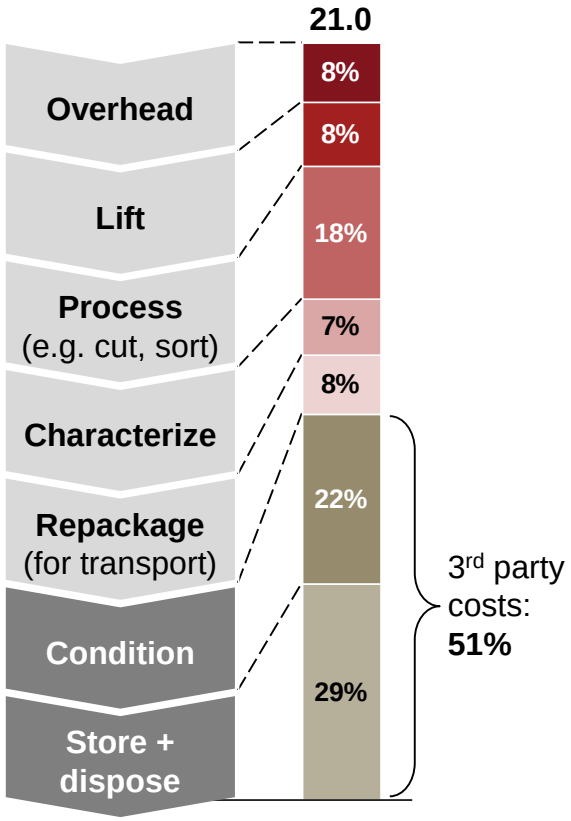
• **WTU** to repackage medium/high level waste for transport	**€8.3Mn**
• **Alpha cell** to safely sort RAP-alpha and all required adjustments to **building 24**	**€5.5Mn**
• **Transport containers**	**€4.0Mn**
• Adjustments to **BelgoProcess installations** to accommodate RAP waste	**€2.3Mn**
• Additional adjustments to **characterization equipment (VINISH)**	**€1.2Mn**
• **WRU** to lift corroded canisters from the WSF	**€400k**

Source: Strategy& analysis, NRG interviews, Eindrapportage "Update RWMP Kostenraming"

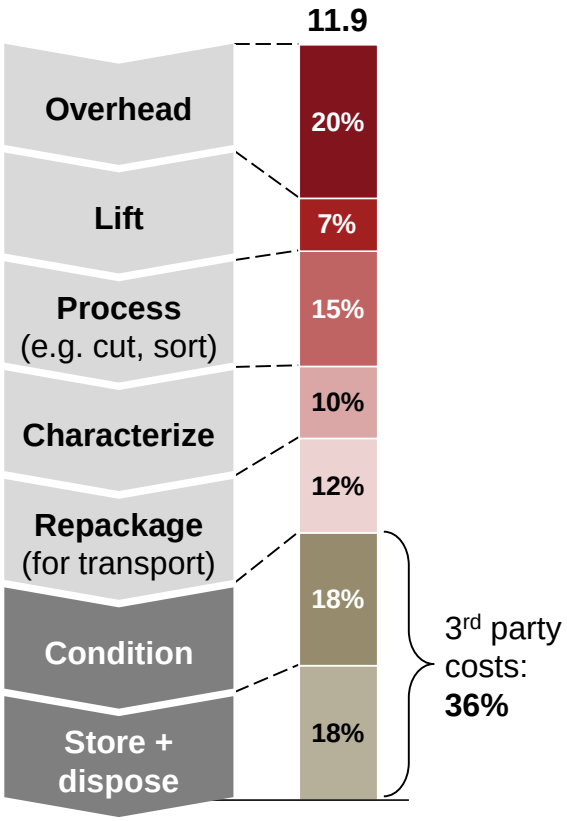
OPEX consists of 36% and 51% in third party costs (COVRA and BelgaProcess) and the balance from NRG internal costs

Breakdown of OPEX per process step, in €Mn

RAP



RAP-Alfa



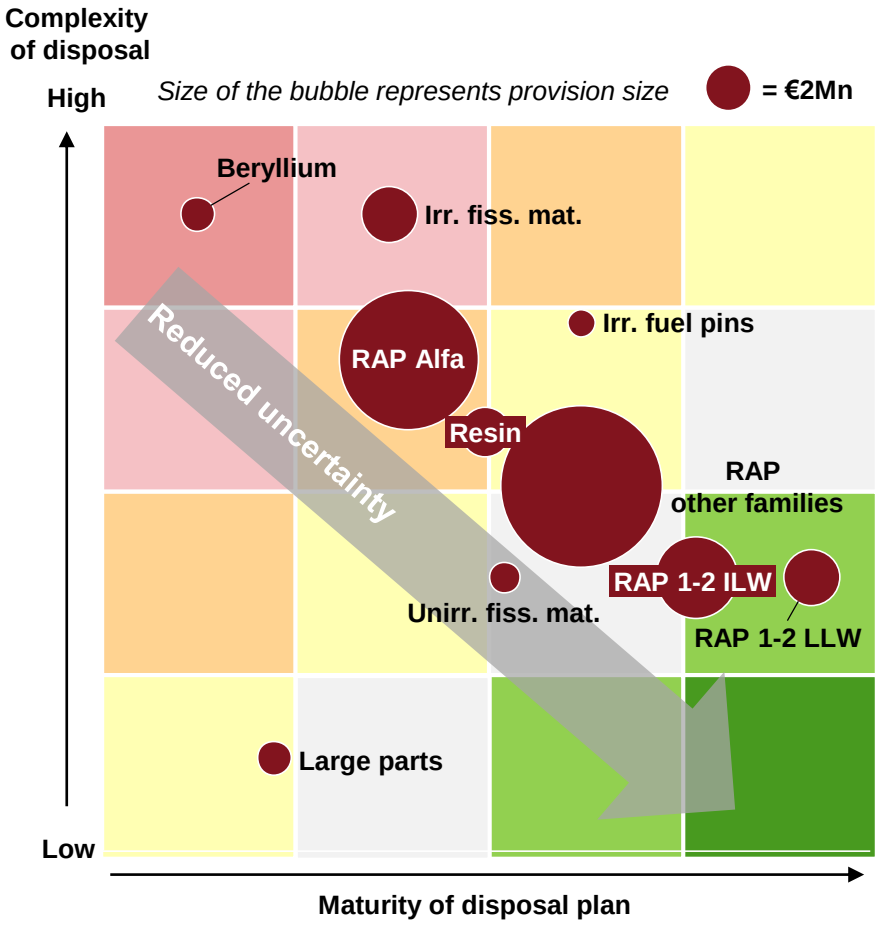
Comments

- The **OPEX drivers** of RAP and RAP-Alfa are **similar**, although the latter has higher remaining overhead costs due to its lower maturity
- The **largest share of OPEX** of both waste streams is attributable to **third parties** such as BelgoProcess and COVRA
- These costs are largely **determined externally** and are therefore not in direct control of NRG

Source: Strategy& analysis, management interviews, RAP model kostenraming, RAP-Alfa model kostenraming

Waste disposal plan complexity and maturity level drive cost uncertainties and vary between the stored waste streams

Complexity and maturity of disposal routes of stored waste streams



Stored waste stream	Development of disposal route	Un-certainty[1)]
RAP	• First canisters treated • Only LLW can be conditioned	+20% – +50%
RAP-alpha	• Route similar to RAP route • Alpha cell still in design phase	+30% – +100%
Resin (“harsvaten”)	• Characterization in pilot phase • Tender still to be held	+20% – +50%
Large parts (“grote delen”)	• No work plan in place • Radioactivity of parts unknown	+30% – +100%
Irrad. fission mat.	• Route similar to RAP route • Transport container unknown	+30% – +100%
Irradiated fuel pins	• Rods cut and transported with irradiated fiss. mat. waste	+10% – +30%
Unirrad. fission mat.	• Disposal route well developed • Acceptance criteria unknown	+10% – +30%
Beryllium	• No agreement between NRG and COVRA	+30% – +100%
Other	• Some disposal routes tested • No major unknowns	+10% – +30%

1) As defined in J. Boogaards Eindrapportage “Update RWMP Kostenraming”; Source: Strategy& analysis, NRG interviews, Eindrapportage “Update RWMP Kostenraming”

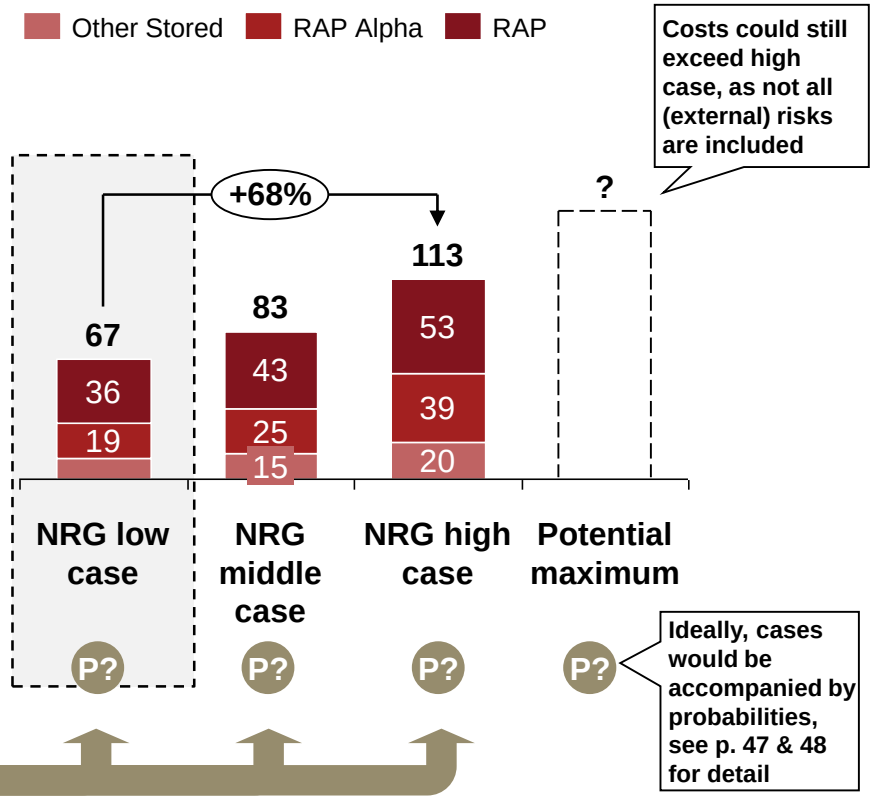
○ Low level of maturity ● High level of maturity

Based on NRG's estimates disposal cost for remaining stored waste could exceed current projections by 70% or even more

Stored waste cost uncertainty and NRG projected cost range, in €Mn

Stored waste stream	NRG projected remaining costs[1]	Uncertainty of costs[2]
"Other waste steams"		
RAP	35.6	+20% – +50%
RAP-Alfa	19.4	+30% – +100%
Resin ("harsvaten")	2.6	+20% – +50%
Large parts ("grote delen")	1.2	+30% – +100%
Irrad. fiss. material	3.4	+30% – +100%
Irradiated fuel pins	0.9	+10% – +30%
Unirr. fission material	1.1	+10% – +30%
Beryllium	1.3	+30% – +100%
Several other streams	1.4	+10% – +30%
Total	67.0	+23% – +68%

Note: Besides uncertainty bandwidth, NRG cost projections (Low Case) do not include any other provisions for unforeseen costs or risk buffers



1) Estimations preliminary, to be approved by NRG RWMP steerco
2) As defined in J. Boogaards Eindrapportage "Update RWMP Kostenraming"; Source: Strategy& analysis, Eindrapportage "Update RWMP Kostenraming"

A more granular analysis considering uncertainty level per process step results supports NRG's more high-level results

Granular view on uncertainties RAP(-Alfa)

Process step	Uncertainty level RAP[1)]	Uncertainty level RAP-Alfa[1)]
Overhead	+3% – +15%	+30% – +100%
Lift	+10% – +30%	+20% – +50%
Process (e.g., cut, sort)	+20% – +50%	+30% – +100%
Characterize	+30% – +100%	+30% – +100%
Repackage (for transport)	+20% – +50%	+20% – +50%
Condition	+10% – +30%	+30% – +100%
Store + dispose	+20% – +50%	+30% – +100%
Weighted average uncertainty level	**+18% – +47%**	**+29% – +93%**
NRG uncertainty level	**+20% – +50%**	**+30% – +100%**

Comments

- We have estimated and discussed with NRG the **uncertainty at process step level**
- The mentioned uncertainty bandwidths are derived from **cost estimation methodologies as a proxy**, no specific method in place at NRG at the moment
- The resulting weighted average uncertainty of RAP and RAP-alpha are **similar** to NRG's more high-level uncertainty level approach

Resulting overall uncertainty levels are **consistent** with NRG's uncertainty estimate

1) Determined during workshop sessions with RAP experts
Source: Strategy& analysis, management interviews, RAP model kostenraming, RAP-Alfa model kostenraming

NRG's €37Mn provision for decommissioning waste is driven by costs projections related to the WSF, HCL and DWT

NRG provision per facility to be decommissioned[1)]

Facility	NRG proposed provision
LFR	3.4
WSF	8.3
HCL	8.3
DWT	6.4
MPF[3)]	1.3
Sea drainage	2.8
Channel system	2.4
JGL	1.8
Building no. 5 & 6	1.6
Other buildings	0.9
Total	37.0

Decommissioning in progress[2)]

Main cost buckets

Project management

Pre-decommissioning actions:
- Research and development
- Engineering/ contracting
- Permits

Facility shutdown activities:
- Removal of fuel and radioactive materials

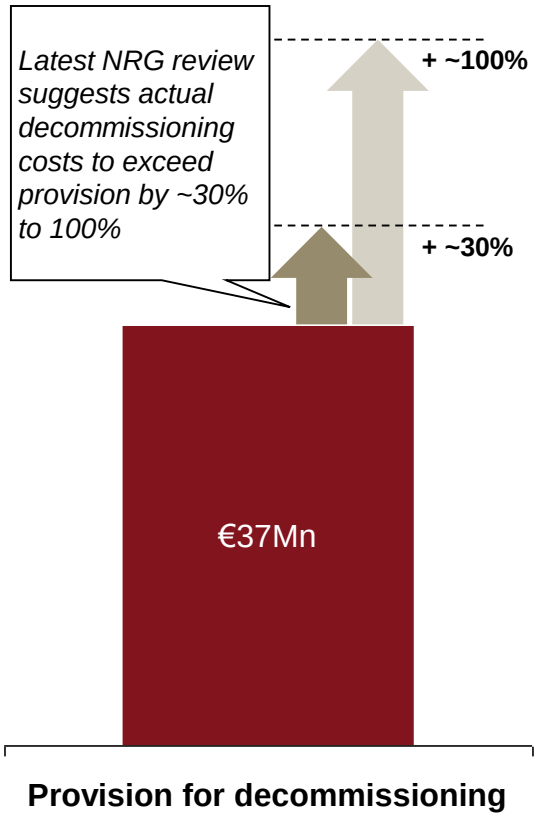
Dismantling activities:
- Radiological inventory categorization for decommissioning and decontamination
- Dismantling of reactor
- Removal of nuclear systems
- Radioactive material characterization

Waste processing and disposal
- Repackaging of waste
- Transport to and storage at COVRA
- Final disposal by COVRA

1) European committee is responsible for the decommissioning of the HFR, hence it is excluded in the NRG provision; 2) Decom in progress, provision only reflects remaining costs; 3) MPF is co-operated by Mallinckrodt; who committed €2.5Mn for decommissioning which is deducted to arrive at NRG provision
Sources: Strategy& analysis, www.nrg.eu, 'Update … raming' (2017), 'Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG (2007)', 'Kostenraming Decommissioning Nucleaire faciliteiten ECN-terrein & afvoer radioactief afval (1998)', 'Update RWMP Kostenraming (2017), 'Onderbouwing update DECOM kostenraming voorz ult 2016.xlsx,', 'update voorziening RWMP ult 2016.xlsx'.

ECN/NRG applies a uniform cost bandwidth of +30 to +100% for all buildings regardless of decommissioning complexity

Uncertainty bandwidth of NRG's cost estimation and underlying key uncertainties



Key uncertainties	Explanation
Only rough cost estimates available	• Most recent cost estimation of all individual facilities dates back to 1998 and is very high level • Current estimates of facilities mostly extrapolate on these estimations
No comparable reference case for estimation	• Hardly no comparable projects worldwide • Criteria for decommissioning differ significantly among countries
In general large uncertainty around decommission	• Foreign experiences with decommissioning generally shows significant budget overruns • Regulations & acceptance requirements could change significantly over decom period (until ~2030)

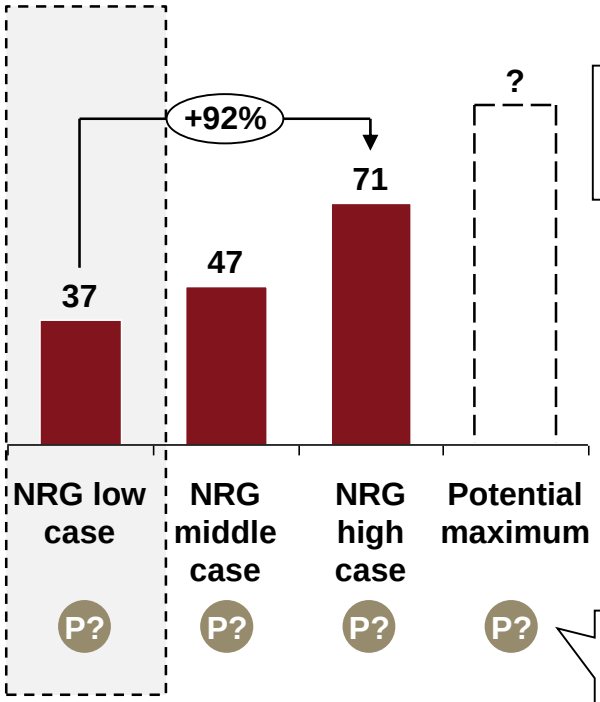
Sources: Strategy& analysis, www.nrg.eu, 'Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG (2007)', 'Kostenraming Decommissioning Nucleaire faciliteiten ECN-terrein & afvoer radioactief afval (1998)', 'Update RWMP Kostenraming (2017), 'Onderbouwing update DECOM kostenraming voorz ult 2016.xlsx,', 'update voorziening RWMP ult 2016.xlsx'

Decommissioning related costs could exceed current provision of €37Mn by 90% or even more

Decommissioning cost uncertainty and NRG projected cost range, in €Mn

Decom stream	NRG projected remaining costs[1]	Uncertainty of costs[2]
LFR	3.4	-10% – +15%
WSF	8.3	+30% – +100%
HCL	8.3	
DWT	6.4	
MLF	1.3	
Sea drainage	2.8	
Channel system	2.4	
JGL	1.8	
Other buildings	2.4	
Total	36.9	+26% – +92%

Note: Besides uncertainty bandwidth, NRG cost projections (Low Case) do not include any other provisions for unforeseen costs or risk buffers



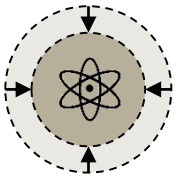
Costs could still exceed high case, as not all (external) risks are included

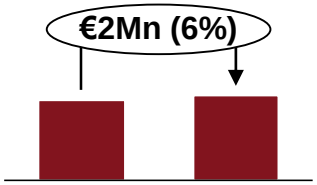
Ideally, cases would be accompanied by probabilities, see p. 47 & 48 for detail

1) Estimations preliminary, to be approved by NRG RWMP steerco, excluding PM RAP post for potential optimization and additional characterization resources
2) As defined in J. Boogaards Eindrapportage "Update RWMP Kostenraming"; Source: Strategy& analysis, Eindrapportage "Update RWMP Kostenraming"

Impact of 2018 regulation changes are not yet included in the decommissioning provision and could have a ~€2Mn impact

Pending regulatory change





Stricter exemption threshold

- Materials with non-threatening activity levels[1)] are **exempt from COVRA storage & final disposal**
- **In early 2018** the exemption threshold for the predominant nuclide in OLP facilities (Co-60) is **scheduled to change from 10Bq/g to 1Bq/g,** decreasing by a factor 10
- This **increases the amount of radioactive decommissioning waste** that requires relocation, interim storage and final disposal
- The effects of this regulatory change have **not been taken into account in NRG's latest cost estimations**

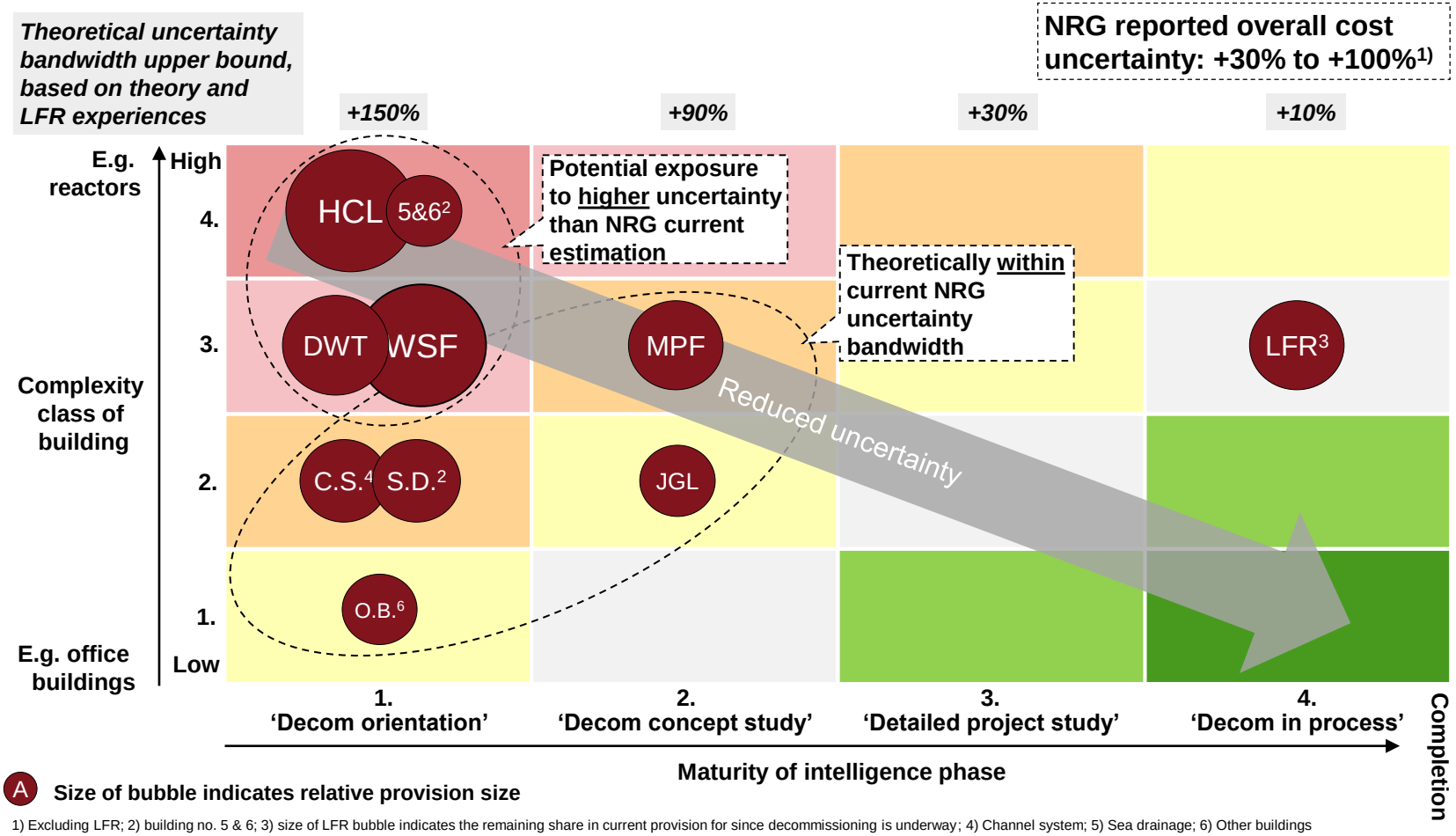
Higher cost of decommissioning

- **A first high level NRG assessment shows a potential increase for LFR waste costs of ~6%, driven by a 30% increase of COVRA storage cost**
- **Extending this to other buildings would result in an increase of € ~2Mn, assuming:**
  - The lower threshold only has effect on COVRA costs (transportation, storage and disposal) and not on treatment costs
  - NRG estimates that COVRA costs (transport, interim storage and final disposal) will increase with 20% due to this change in regulation
  - ~30% of decommissioning costs are COVRA costs at current price levels

1) ANVS enforces exemption thresholds per nuclide based on Euratom guidelines
Source: NRG estimates; Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG Update 2007; Strategy& analysis

Most decommissioning plans are relatively immature and cost uncertainties could be higher than NRG's estimate

Building complexity and maturity of intelligence phase



1) Excluding LFR; 2) building no. 5 & 6; 3) size of LFR bubble indicates the remaining share in current provision for since decommissioning is underway; 4) Channel system; 5) Sea drainage; 6) Other buildings

Sources: Strategy& analysis, 'Update kostenraming RWMP 2016', 'Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG (2007)', 'Kostenraming Decommissioning Nucleaire faciliteiten ECN-terrain & afvoer radioactief afval (1998)', Onderbouwing update DECOM kostenraming voorz ult 2016.xlsx, 'update voorziening RWMP ult 2016.xlsx', 'NRG interviewing'

LFR decommissioning demonstrates that cost estimates are more reliable as disposal plans become more mature

Matching of LFR cost estimation stages with theoretical phases

	Phase 1	Phase 2	Phase 3	Phase 4
Name	**'Decommissioning orientation study'**	**'Decommissioning concept engineering study'**	**'Detailed decommissioning engineering study'**	**'Decommissioning in process'**
Theoretical uncertainty[1)]	-50% to +150%	-40% to +60%	~-20% to +30%	~-5% to +10%
Match?				
Estimated costs in €Mn[2)]	**4.1**	**3.0**	**6.1**	**5.8**
Year	2007	2010	2015	2017
LFR deviation with final amount (Ph 4)	+~40%	+~90%	-~5%	N/A
Within theoretical uncertainty range?	Yes	No	Yes	N/A
Potential differentiated uncertainty range for NRG decom	~0-150%	~80~90%	~30%	~-5% ~ +10%

Feb. 2015 receipt of permit at €1Mn

Feb. 2016 start LFR decom.

Planned completion before 2018

1) standard ranges used in NRG decom study 2007 and referenced to BelgoProcess expert standard 2: estimation excludes "unforeseen" item, but includes (estimated/secured) permit costs

Sources: : Strategy& analysis, 'Update kostenraming RWMP 2016', 'Kostenraming en PvA decommissioning nucleaire faciliteiten ECN/NRG (2007)', 'Kostenraming Decommissioning Nucleaire faciliteiten ECN-terrain & afvoer radioactief afval (1998)', Onderbouwing update DECOM kostenraming voorz ult 2016.xlsx, 'update voorziening RWMP ult 2016.xlsx', 'NRG employee interviewing'

Going forward, we recommend NRG to improve value chain collaboration, program management and (cost) transparency

Drivers of cost estimate robustness

Currently being pursued	**Technical foundation**	• Use **multifunctional technical teams** to come to creative solutions • **Leverage all available internal expertise**, including e.g. former employees • Test findings with **international peers**
Room for improve-ment	**Holistic approach across disposal chain**	• **Improve three party collaboration** between COVRA, NRG and ANVS[1)] • **Include COVRA expertise and cost estimates and ANVS expertise input in developing safe and economically optimal disposal chain solutions** • Identify potential optimization scenario's and quantify benefits and synergies
	Active program management throughout life cycle	• **Set-up dedicated and separate RWMP organization** and **align resources with defined and agreed objectives and KPIs** for safe, quick and cost efficient disposal • **Enhance RWMP program management capabilities** and **implement structured stage-gate process** and **provide regular updates** on costs and maturity progress
	Possibility-linked reporting	• **Report cost projections** using more industry standard **probabilistic models**, and **reevaluate requirements for provision level** and impact from potential changes • Clearly **differentiate communication and cost projection reporting** between **stored** (immediate focus) **and decommissioning waste** (longer-term focus)

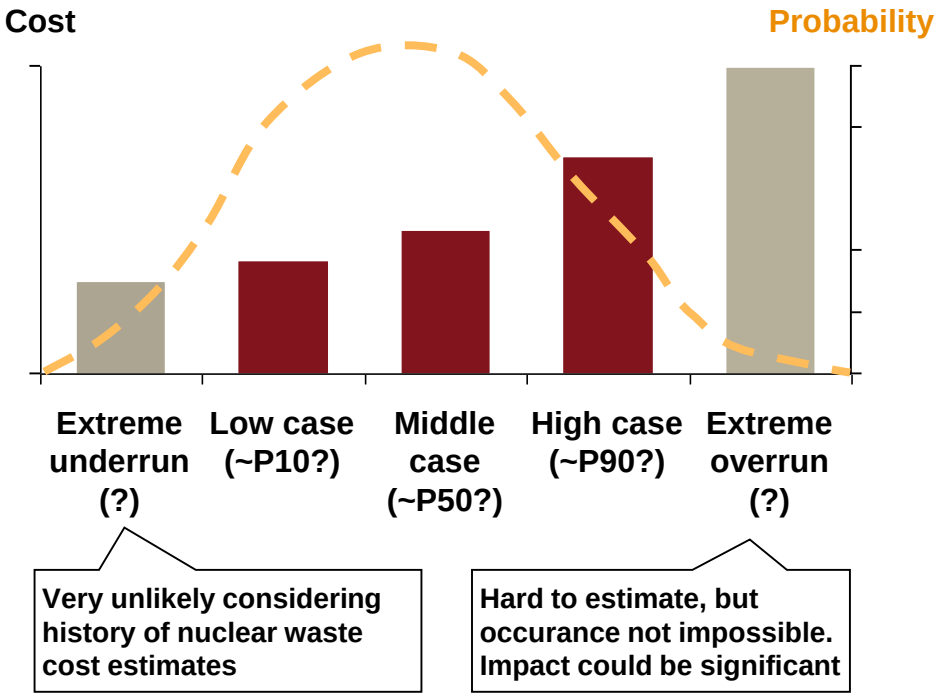
1) ANVS can give input to NRG/ECN and COVRA operational planning, using their expertise and knowledge, but will always remain to have an independent safety auditor role as well; Source: Strategy& analysis

A known best practice of probibalistic cost estimation could give NRG guidance and improve transparancy

Expected cost vs. probability of occurance

ILLUSTRATIVE

Px means that there is a x% probability that the result will be lower than the Px value



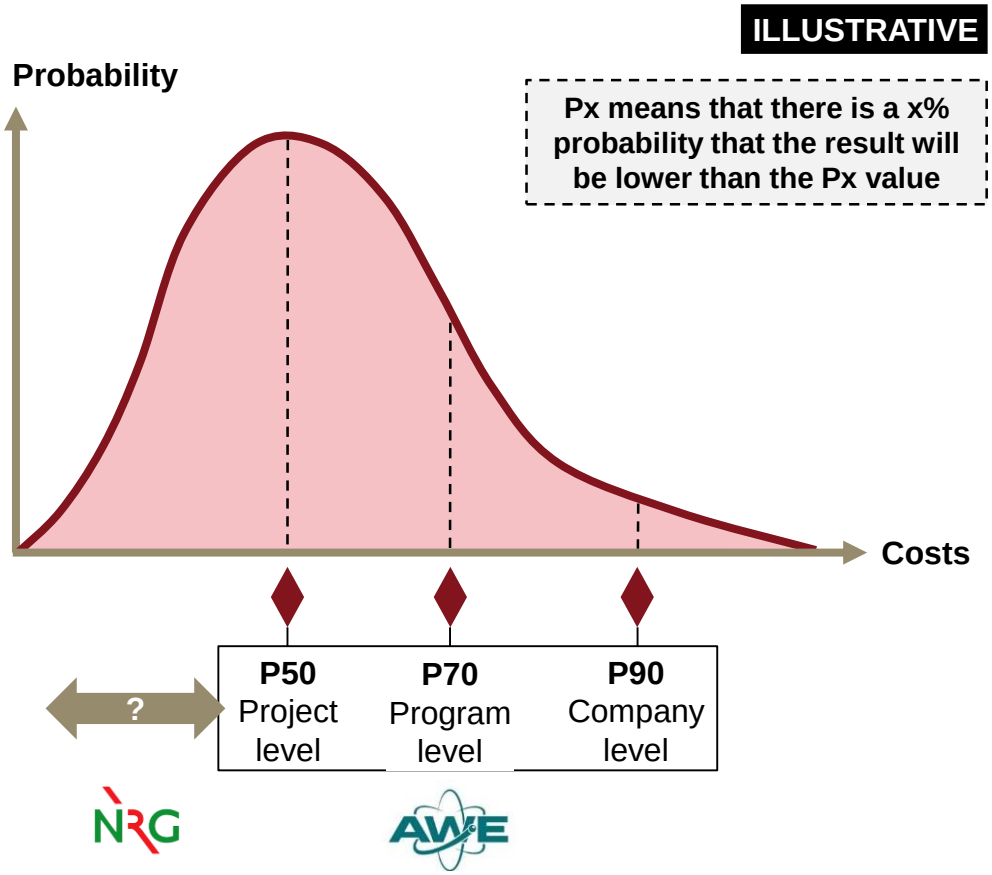
Comments

- An often used method in respresenting cost uncertainties is through **probibalisic estimations** based on an **internal**, **continuously updated risk registry**
- NRG would benefit of using such a framework going forward
  - Offers **context for technical discussions** during new cost estimation exercises (“do we see this as a cost estimate that would cover everything 90% of the times?”
  - Offers **input / guidance for accounting discussions** on what level to hold cost provision
  - **Improves transparency in discussions with all stakeholders** on how to interpret uncertainty bandwidths
- NRGs **current cost estimations are not made using such a framework**. P-values can only function as illustrative figures for low, middle and high case cost estimates
- Using developing knowledge and growing performance data, **NRG can gradually introduce this method** into its processes

Source: Strategy&

Case example: AWE reserve requirements for different project levels range from P50 to P90

Probabilistic cost modelling



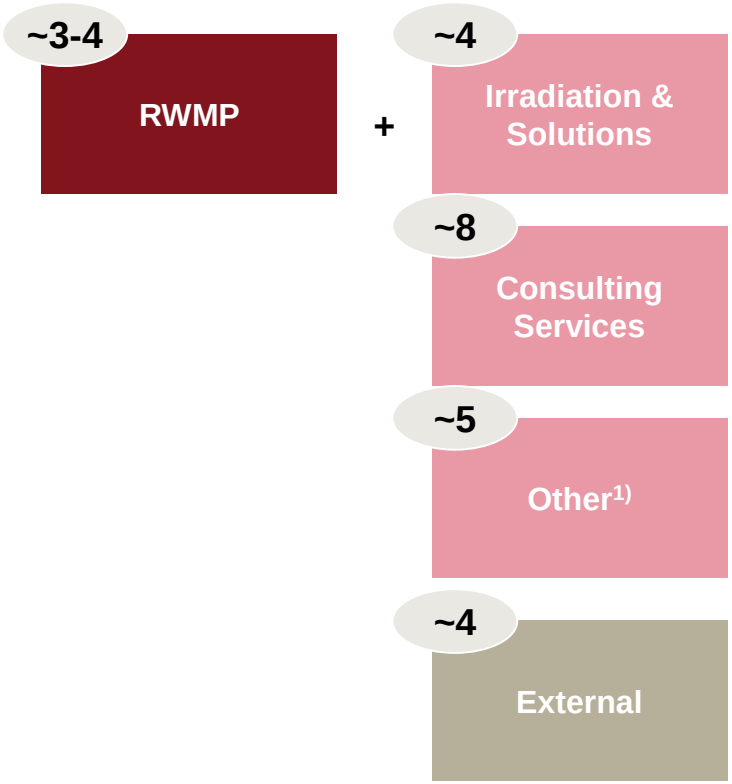
AWE's reserve requirements

- AWE is responsible for the design, manufacturing and support of nuclear warheads for the UK's national deterrent
- AWE uses probabilistic cost modelling **to adjust reserve requirement to the level of uncertainty**
- **AWE differentiates on 3 levels**:
  - Project value reserve: P50
  - Program value reserve: P50-P70
  - Company reserve: P70-P90
- All AWE's mandated reserve levels seem **higher than the effective level applied by NRG**, although exact comparable method is not in use at NRG

1) Indicative level, probabilistic cost modeling method currently not used in ECN/NRG
Source: Strategy& analysis; PWC's risk contingency management

RWMP organization can be further strengthened by creating a dedicated organization and greater incentives alignment

Staff per OU dedicated to waste activities,
FTE, indicative[2)]



- Current RWMP organization has limited 'own staff' and **uses mostly staff from other OU's**
- Staff from other OU's are **either fully or partially allocated to support RWMP**
- **New fully dedicated program leader** has been appointed in 2016
- Program has seen **many staff changes** over the last years, e.g.
  - Departing RAP program lead
  - RAP operational team transferred to HCL team
- **Key technical staff is utilized for other NRG activities** and **incentives and KPIs appear not to be fully aligned with RWMP objectives**

1) F&C, HCL, ECN-EEE, R&I 2) organization data not conclusive on level of dedication and full time equivalency
Source: Strategy& analysis, NRG

NRG should implement a stage-gate process and report progress against its roadmap & KPIs more transparently

Recommended program management improvements

Implement stage-gate process and roadmap

- **Develop stage-gate process** to progress disposal plans (for decommissioning and stored waste) through a structured cycle with clear milestones, requirements and KPIs in each stage
- **Create further alignment on stakeholder (EZ, ANVS) objectives** and **agree on metrics and KPIs** (safety, speed and costs)
- **Enhance overall roadmap** and timeline per individual waste streams that is aligned and agreed with key stakeholders (EZ, ANVS, COVRA, other 3rd parties)

Stored waste has short term priority

- Key subject of public focus: "*stored waste needs to leave Petten ASAP*"
- Activities are ongoing
- Planning is more mature, but varying per stream

Implement regular update cycle

- **Implement a probabilistic cost model** and continue to leverage internal and external expertise (COVRA, ANVS, 3rd parties) to further improve robustness of cost estimates
- **Provide regularly updates to key stakeholders EZ & ANVS** on RWMP progress vs. defined and agreed roadmap and cost projections
- Pro-actively **develop business cases** and **investment proposals** for accelerated and/or lower cost disposal of waste streams in line with objectives

Decom has secondary priority

- Less urgent need since buildings will be used until ~2027 and beyond
- Deadline known, planning can be made

Context & main conclusions

Appendix 1: Introduction

Appendix 2: Cost & uncertainties

Appendix 3: Operational improvements

Appendix 4: Organizational and financial improvements

Operational improvements can be achieved from economic trade-offs across the value chain within boundary conditions

Operational improvement categories across the chain

What:
Technology & activities

Reevaluate economic trade-offs per activity (e.g. sorting/characterization):
- Prevent double application of safety margins
- Look beyond stand-alone organization
- Compare newest technological options

When:
Time

Reevaluate optimal treatment timing, to:
- Optimize spread of workload
- Combine with future or external streams
- Reduce radioactivity

Where:
Investments

Reevaluate best place to do activities, to:
- Concentrate investments
- Perform activities at location with best capabilities
- Allow more time for treatment

Who:
Concentrate capabilities

Reevaluate best party per activity, to:
- Find the most cost-efficient solution, using all available technology
- Allocate activities in line with key capabilities and future strategy

Hard boundaries

1. **In the end, all waste will have to go to COVRA for interim storage awaiting final disposal**
2. **All waste needs to be characterized before it is accepted for transport, interim storage or final disposal**

Note: Hard boundaries were presented by EZ and ANVS. Challenging these boundaries was out of scope for this project, but could be very well be the effect of this reports conclusions; Source: Strategy& analysis

For each stream NRG should design and evaluate optimal cost-effective solutions leveraging other stakeholder inputs

Disposal options

		Hard boundary?
0. Base / 'As is'	Process in Petten and store in COVRA in Zeeland using 3rd parties to compliment technical capabilities	👍
1. Unsorted, stored in Petten (ST[1])	Leave unsorted waste in Petten until final disposal by COVRA	⊘
2. Sorted, stored in Petten (MT[1])	Sort and restore waste in Petten until final disposal by COVRA	👍
3. Unsorted, stored at COVRA	Store unsorted and uncharacterized waste at COVRA in Zeeland	⊘
4. Sorted & stored by COVRA	Characterize waste for transport only and do all other activities at COVRA in Zeeland	👍

Possible scenarios

- Of the original scenarios, two can be neglected as they **do not meet hard boundaries**
- **Per stream, NRG should design and evaluate the optimal solution** – leveraging inputs on safety, operations and costs from other stakeholders (COVRA, ANVS, others), e.g.:

0.	RAP canisters
2.	Decom waste & large parts
4.	Waste with highest uncertainty

1) MT = mid-term (~100 years), ST = short-term (~30 years)
Source: Strategy& analysis, EZ, NRG / COVRA management interviews

NOT EXHAUSTIVE

Several opportunities to optimize cost and speed have been identified by ECN/NRG and COVRA during this study

Concrete optimization opportunities to further investigate

Differentiate in characterization	• For special risk streams without current COVRA route available, characterize waste in Petten only for transport and bring to COVRA • At COVRA, choose to perform further characterization, or store temporary in interim storage until routes are further developed
Involve COVRA in treatment before transport	• Include COVRA from the start of disposal route planning: prevent rework because of characterization misalignment • Ensure early alignment on practical vector analysis, for which start is made • Use spare available containers from COVRA to speed up the transport
Combine decom for scale	• Investigate how merging decom waste NRG and Dodewaard can create scale for treatment at COVRA • Leave “large parts” waste in Petten for combination with future decom streams
Investigate new technologies	• Keep investigating alternative technologies (e.g. resin evaporation instead of incineration) • Involve 3rd parties for more cost-efficient execution

Source: Strategy& analysis; EZ/ANVS/NRG/COVRA management interviews

Currently, COVRA and NRG are not yet able to quantify the savings potential of these opportunities

Uncertainty of savings potential

- **Differentiate in characterization**
- **Involve COVRA in treatment before transport**
- **Combine decom for scale**
- **Investigate new technologies**

- Improvement opportunities are still in an **early conceptual phase**, without detailed technical plans
- NRG and COVRA agree there is **significant savings potential**, but a **detailed technical assessment is imperative** to a reliable statement on the size
- Before such an assessment is made, **neither party** indicates that they are able to **provide an estimate**
- Any premature estimation of a savings bandwidth would be **overshadowed by the significant current cost bandwidth**

Next steps

- **Execute detailed technical assessment** of these operational improvements involving all stakeholders
- **Prioritize opportunities** based on estimated savings potential

Source: Strategy& analysis; EZ/ANVS/NRG/COVRA workshop discussions

Context & main conclusions

Appendix 1: Introduction

Appendix 2: Cost & uncertainties

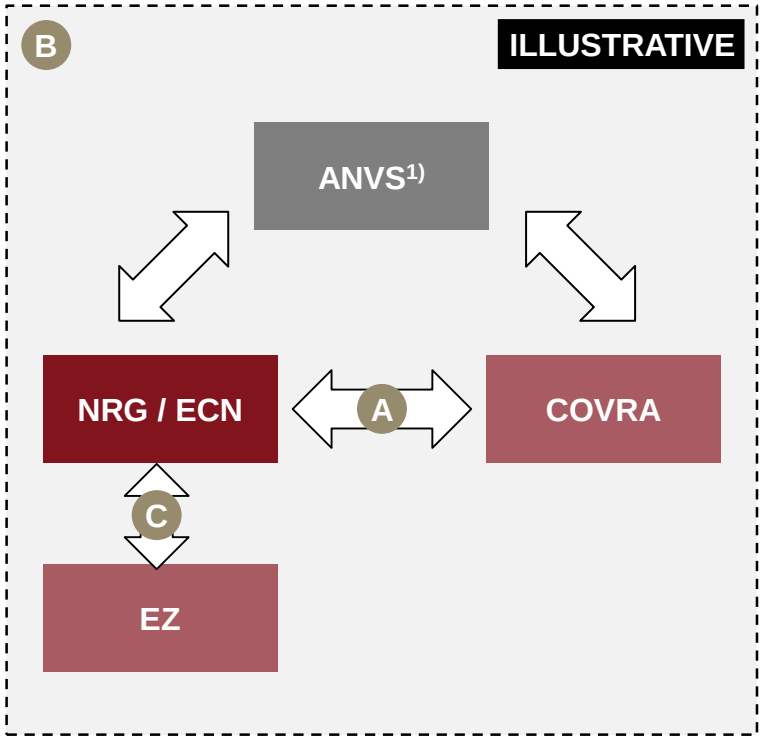
Appendix 3: Operational improvements

Appendix 4: Organizational & financial improvements

Realizing the benefits across the waste disposal value chain requires better collaboration between NRG and stakeholders

Current organizational setup

Involved entities



Improvement options

A — Operational

Improve NRG and COVRA collaboration:
- Reduce rework due to misalignment
- Prevent double knitting of safety margins
- Realign tasks with core competencies

Align incentives to avoid potential conflict of interest NRG with allocation of key staff to non-core competency

B — Governance

Improve holistic value chain view:
- Optimize across value chain, in stead of pushing problem around, due to
  - Missing incentives
  - Missing enforcing mandate

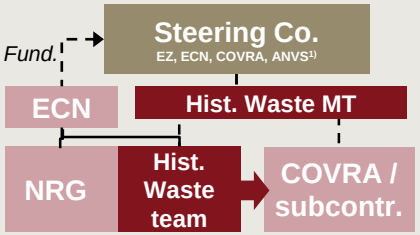
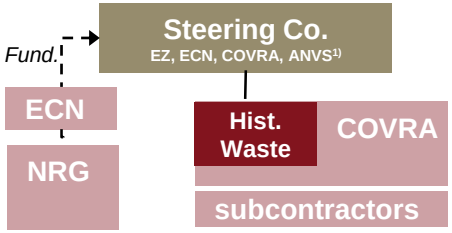
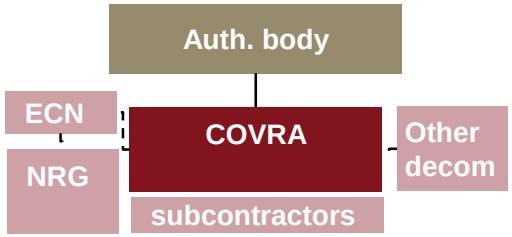
C — Financing

Improve financial support structure:
- Review options to find a more structural solution for financial support, as NRG struggles to absorb RWMP costs

1) ANVS can give input to NRG/ECN and COVRA operational planning, using their expertise and knowledge, but will always remain to have an independent safety auditor role as well; Source: Strategy& analysis, EZ, ANVS, NRG / COVRA management interviews

We identified 3 models to improve organization efficiency – recommended first step involves limited governance changes

Alternative organizational structures

	1 Cross-value chain historical waste management team	2 Integral COVRA historical waste management	3 National nuclear waste and decommissioning authority
High-level Structure			
Roles	**Licensee:** NRG **Operator:** NRG + COVRA **Steering:** Steering Committee **Owner:** ECN / NRG3)	**Licensee:** COVRA **Operator:** COVRA **Steering:** Steering Committee **Owner:** ECN (or State/ COVRA)	**Licensee:** COVRA **Operator:** COVRA **Steering:** Authoritive body **Owner:** COVRA or State
Characteristics	• Dedicated NRG waste team and joint value chain optimization with COVRA • Expert team for operational support and trade-offs (e.g., including ANVS) • Open books between NRG & COVRA to support investment trade-offs • SteerCo approves plans, budget, & investments (ECN or EZ led) • **Optimization of situation with limited changes (org, governance, legal, etc.)**	• Transfer of NRG operational staff and waste mgmt. capabilities to COVRA • COVRA responsible for operation decisions and quality assurance • Expert team for operational support and trade-offs (e.g., including ANVS) • SteerCo approves plans, budget & investments (ECN or EZ led) • **Optimization of historical waste synergy value across the value chain** with substantial changes	• As in model 2, plus: • Historic waste management activities fully integrated in COVRA operations • Authorative body optimizes plans and investment for all Dutch radioactive and decommissioning waste • Requires consolidation of all funds (incl. of commercial / 3rd parties) • **Maximization of synergies** across total **Dutch radioactive waste pool** with **fundamental changes to NL policy**

1) ANVS supports NRG & COVRA in its responsibility as policy preparatory and expert. It will remain to have a separate licensing and auditing role in all three scenarios alike
2) Experts can include others besides EZ, COVRA, ANVS that NRG involves to support business case development (3rd parties, international experts, peers etc.); 3) Depending on ECN carve out results, which were not known yet at the time of this study
Source: Strategy& analysis, EZ, ANVS, NRG / COVRA management discussions

In model 1, a dedicated historical waste organization with cross-value chain expert input is established

Details of organizational structure – Alternative 1

PRELIMINARY AND TO BE FURTHER DETAILED

Who	Responsibilities
• ECN/NRG[1)] (Chair) • COVRA • EZ • (MinFin)	• Safeguard best solution across the chain • Control historical waste treatment strategy • Approve budget, planning, investments • Advise on potential state credit support to supplement ECN/NRG funding
• ECN • NRG • COVRA • ANVS expert input	• Develop investment cases for cost-efficient treatment plans across the chain • Develop overall planning, budget • Supported by Expert input from e.g. ANVS, international peers etc.
• Historical Waste Team • NRG • COVRA • Subcontractors	• Technical operations • Prepare and support development of planning, budget and investment cases • ECN/NRG and COVRA to remain responsible for quality assurance on own sites and vice versa on each others operations

1) Depending on ECN carve out results, which were not known yet at the time of this study
Source: Strategy&, Workshop discussions with COVRA, NRG, ECN, EZ and ANVS

This more integrated focus (model 1) could be a good short-term solution before making more fundamental changes

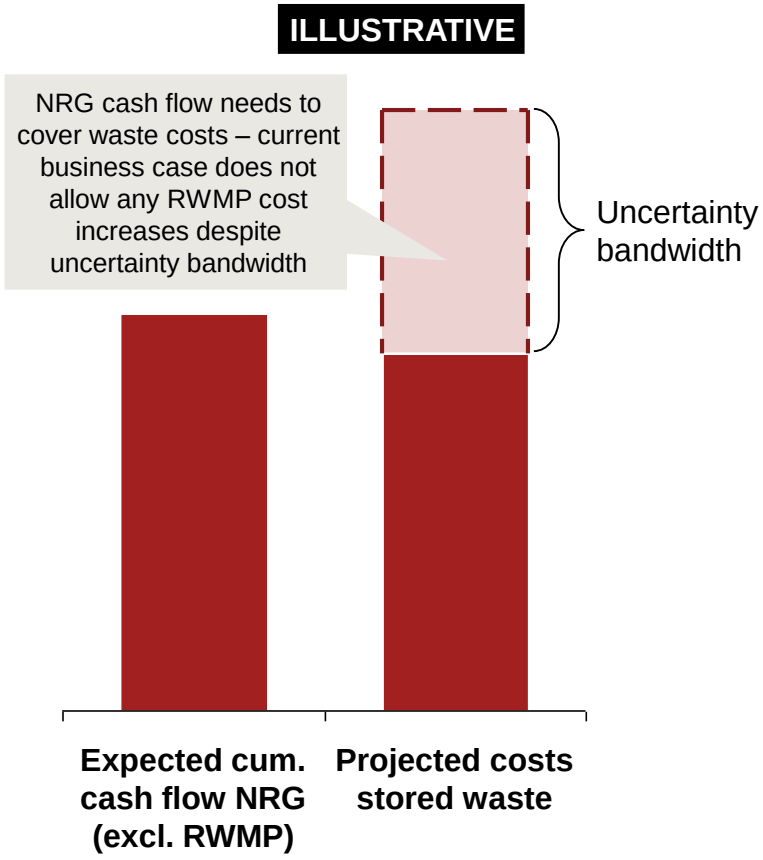
Evaluation synthesis of organizational structures

Alternative	Pros	Cons	Synthesis
1. Cross-value chain historical waste management team	• **Closer cooperation, and management dedication,** no large governance change • **Knowledge concentration**, by including ANVS, COVRA insights • **Less distraction NRG** by fully segregated & dedicated waste staff • **Expert input** to ensure economic trade-offs over whole process chain**,** • **Steering mandate with multi-disciplined committee**	• **Steering mandate could be hindered as** ECN/NRG will remain the key decider as owner of hist. waste organization • **Likely requires additional NRG resources** (to backfill staff now dedicated solely to hist. waste)	**Short-term, simplest improvement of current situation;** possible to **evolve** to alternative 2
2. Integral COVRA historical waste management	• **Full decision mandate on cost-efficiency tradeoffs** with EZ, MinFin, together with COVRA & NRG • **Further synergies & scale** by concentration at COVRA • NRG can fully focus on **core activities**	• Significant **investment needed** to expand COVRA **capabilities** • **Complex** in case of liability transferal • Possible NRG staff **carve-out** to new organization	**Potentially more efficient in long run, but large changes needed;** requires positive business case first
3. National nuclear waste and decom authority	• **Potential scale and synergy benefit,** in case of additional Dutch Decom waste streams can be added	• Most operational radioactive waste streams are **already well defined** • **Requires fundamental change in policy and ownership of waste, associated costs and liabilities** • Decom chain could already be **fully integrated by COVRA** with no need for further steering authority	**Potential scale efficiencies in the long run (~2030+), but large changes needed;** only in case substantial synergies can be realized (i.e. on National level)

Source: Strategy& analysis, EZ, ANVS, NRG / COVRA management interviews

Current situation of repeated credit crises, lack of incentives alignment, transparency and grip on costs is not sustainable

ECN/NRG cannot fully absorb RWMP costs



- There is common agreement that **ECN's current nuclear activities** (research, consultancy and isotopes production) **cannot fully absorb RWMP costs and uncertainties**
- **It is also expected that ECN/NRG continues to contribute to the RWMP disposal costs to the best of its abilities** – there will be no deviation from the "polluter pays" principle
- **Current situation** of repeated credit crisis situations **causes a distraction for all stakeholders involved** and does **not contribute to safe, quick and cost-efficient disposal**
- **It also does not provide a solid basis for maximizing potential benefits from NRG's other activities** (isotopes, research and consultancy activities)
- **In addition, the government has limited instruments to improve transparency and ensure execution of the RWMP in line with its objectives, and…**
- **… the state de-facto already provides financial back-stops to absorb cost increases which is likely to continue as RWMP provision does not include contingencies despite high uncertainty bandwidths which cannot be absorbed by ECN/NRG**
- As a consequence, there are **changes required to the current situation** and a **more structural from of credit support** should be investigated – without compromising on cost control, polluter pays principle, etc.

Source: Strategy& analysis

More structural form of credit provision should relieve the financial burden for ECN/NRG without being a blank check

Rationale for state credit guarantee

Cons: Breaking away from current policy

- x Although government would not take over waste ownership, it would formalize the fact that **the state will take over the specific cost overruns** based on clearly defined and agreed criteria. Whilst this could set a precedent comparative cases are limited.
- x In case of a guarantee, the government would be obliged to **demand market conform premiums** for credit guarantee. The p**rice for such a guarantee** is unknown, but **expected to be high** which would increase the cost to ECN/NRG
- x Without transparency, proper incentives and organization alignment there could be a lack of control and pressure for **ECN/NRG to finish within time and budget** and risk of higher costs and lack of funding coverage from ECN/NRG
- x Clear **separation of non-economical waste necessary** to prevent state aid *(see next pages)*

Pros: Helping with a more structural solution

- ✓ **Gives more long term structure to the current situation** where government **de-facto** provides back-stop credit support for ECN/NRG
- ✓ Relieves ECN/NRG and EZ of **ad-hoc credit requests efforts**
- ✓ Can be a **vehicle for stronger operational excellence incentives,** when combined with terms and conditions of a credit guarantee *(see next page)*
- ✓ Improves NRG's case for **finding external investors** for medical isotopes business from improved **financial ratios, lower risk profile and greater operational focus**

Terms of such support should clearly define objectives and criteria for support, governance model, incentives and KPIs

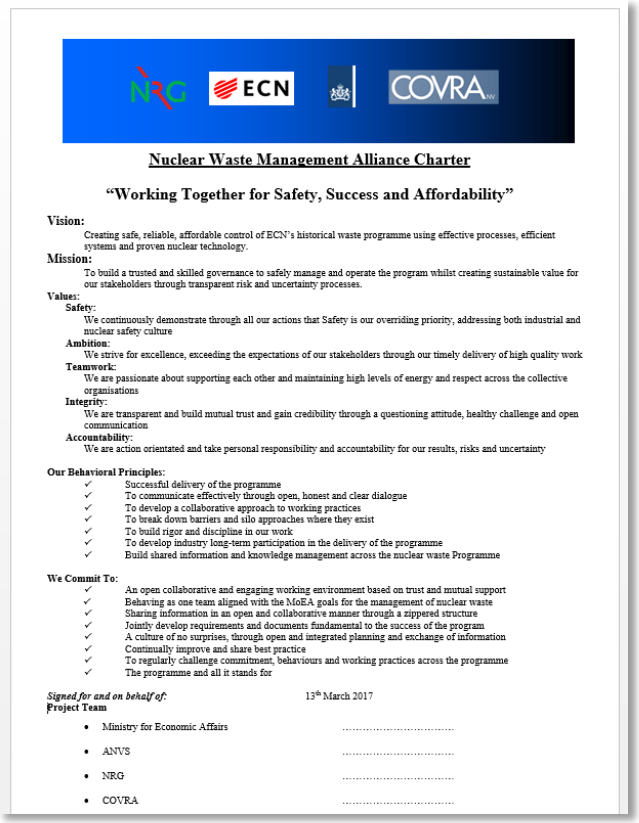
Illustrative performance incentives

- **Performance indicators,** such as:
  - # of staff dedicated to waste organization
  - Volumes characterized, treated, transported
- **Cost efficiency incentives**, such as:
  - Savings compared to upfront agreed estimate
  - Personal management bonus incentives
- **Safety incentives,** such as:
  - # of incidents
  - Downtime key installations
- **Signed intention charter** between parties on a "commitment to delivery & excellence", clearly stating
  - Shared behavioral principles
  - Agreed commitments

Structural evaluation process

- **Periodic review of budget** between Hist. Waste MT and steering committee, including underlying business cases that require further investment
- Government can decide to **incidentally but pro-actively extend further credit** based on these business cases

Intention Charter – Example



Nuclear Waste Management Alliance Charter

"Working Together for Safety, Success and Affordability"

Vision:
Creating safe, reliable, affordable control of ECN's historical waste programme using effective processes, efficient systems and proven nuclear technology.

Mission:
To build a trusted and skilled governance to safely manage and operate the program whilst creating sustainable value for our stakeholders through transparent risk and uncertainty processes.

Values:

Safety:
We continuously demonstrate through all our actions that Safety is our overriding priority, addressing both industrial and nuclear safety culture

Ambition:
We strive for excellence, exceeding the expectations of our stakeholders through our timely delivery of high quality work

Teamwork:
We are passionate about supporting each other and maintaining high levels of energy and respect across the collective organisations

Integrity:
We are transparent and build mutual trust and gain credibility through a questioning attitude, healthy challenge and open communication

Accountability:
We are action orientated and take personal responsibility and accountability for our results, risks and uncertainty

Our Behavioral Principles:
- ✓ Successful delivery of the programme
- ✓ To communicate effectively through open, honest and clear dialogue
- ✓ To develop a collaborative approach to working practices
- ✓ To break down barriers and silo approaches where they exist
- ✓ To build rigor and discipline in our work
- ✓ To develop industry long-term participation in the delivery of the programme
- ✓ Build shared information and knowledge management across the nuclear waste Programme

We Commit To:
- ✓ An open collaborative and engaging working environment based on trust and mutual support
- ✓ Behaving as one team aligned with the MoEA goals for the management of nuclear waste
- ✓ Sharing information in an open and collaborative manner through a zippered structure
- ✓ Jointly develop requirements and documents fundamental to the success of the program
- ✓ A culture of no surprises, through open and integrated planning and exchange of information
- ✓ Continually improve and share best practice
- ✓ To regularly challenge commitment, behaviours and working practices across the programme
- ✓ The programme and all it stands for

Signed for and on behalf of: 13th March 2017
Project Team
- Ministry for Economic Affairs .....
- ANVS .....
- NRG .....
- COVRA .....

Source: Strategy&, PwC UK, UK Case examples

State support is compatible (allowed) for waste that is the result of non-economical activities; Further analysis needed

Historical waste definition background

- ECN/NRG, and before that RCN, has been the license holder and **operator of the nuclear research facility in Petten since 1963** when the HFR first became operational as part of the Euratom treaty

- As such, **ECN/NRG is the owner of the stored waste and key facilities in Petten[1], and thus responsible for the cost of treating and storing all resulting waste**. This principle of 'the polluter pays' is the center of NL and EU nuclear legislation.[2]

- It is possible for the government to support ECN/NRG in funding these costs, as long as it concerns **costs for waste resulting from non-economical activities (non-contracted research).** Support for any other waste streams might be possible, but specific application of state aid rules have to be further analyzed for this case. In case the European Commission would still considered this as non-compatible state aid, especially ECN/NRG would take on additional burden of repayments including interest

- In the case of funding support by the state, or even full takeover of ownership, **a distinction needs to be made between waste from economical and non-economical activities.** Further analyses are needed.

1) Excluding HFR, owned by the European Committee. Source: Strategy&, EZ

ECN/NRG claims that government is responsible as 'original polluter' – however, no legal basis has been provided yet

ECN/NRG states that:

The historical waste was produced as a result of the research programmes of the Dutch government. At that time the organization RCN and ECN were operator of the research facilities.

From 2001 onwards, NRG follows the guideline that all waste that arises from research or isotope production, is paid for by the respective customer. By securing of the payment for the waste, NRG accepts the ownership of the waste. However, this was not the case before 2001: until the late nineties there were no reservations for radioactive waste.

This used to be an accepted way of working by the ECN and RCN board, in which members from the ministry of economic affairs were represented. If we follow "*the polluter pays*"-principle, then the polluter for the historical waste, arising from government funded research programmes, is the government

ECN/NRG's request that the State should take over RWMP costs and liability is premature not substantiated by facts

ECN/NRG requests the State to take over RWMP costs and liability

- "The business case for isotope and consultancy activities is positive, but this business cannot carry costs for historical waste disposal – nor is it meant to, as there is no link between commercial activities and the cost for historical and decom waste"
- "The burden of historical waste jeopardizes the financial viability of ECN/NRG and thereby threatens unnecessary the supply of medical isotopes to 25.000 patients per day, as the costs of historical waste will not disappear when NRG is not viable"
- "The obligation to have enough revenues from medical isotopes to support the costs of historical waste puts a risky pressure on the safety required for nuclear processing. Also when NRG is for too long time under a financial pressure, this could lead to unsafe situations"
- "The burden of historical waste poses a key risk to the success of Pallas as it deters investors"
- "ECN/NRG is not responsible for the historical waste nor decommissioning costs, as both have their origins in the time before the creation of ECN/NRG; thus the Dutch Government carries this responsibility"
- "The waste treatment process lacks a party responsible for the overall cost control; all parties are fully or partially owned by Dutch government and their incentives are driven by reducing only their own risk – ECN/NRG is at the top of this chain and is forced to absorb all cost of other parties and/or the cost implications of their decisions"

Strategy& observation: according to ECN/NRG some form of more structural financial support without liability take-over by the State could also mitigate financial exposure and associated risks for ECN/NRG

Note: ECN/NRG arguments are not well documented in any level of detail and are not substantiated by facts and analyses (e.g., legal or financial underpinning is not available), previous recommendation to create a clear benefits case for liability take-over by the State have not been executed
Source: NRG Management, Strategy& analysis

ECN/NRG's request is not well substantiated and ignores critical opportunities for improvement of current situation

	ECN/NRG rationale for liability take-over	Observations on
Organizational	• Historical waste causes a drain on management attention	• Liability take-over would **limit financial crises situations** and relieve NRG from ad-hoc sr. management attention – however, this **could also be achieved** by more structural credit support **in the as-is situation** • **Additionally, hist. waste will remain a burden, especially for** operational and technical staff as long as the waste has not been transferred to Zeeland
Financial	• NRG business cannot absorb the cost and uncertainties for historical waste disposal • ECN/NRG are not able to attract private financing as a result of the historical waste • Large part of historical waste costs are outside ECN/NRG control and cannot be optimized by one company in isolation	• ECN/NRG is expected to be **able to absorb some of the hist. waste related costs but not all** – State has provided substantial financial contributions in the past whilst maintaining the "polluter pays" principle • Waste treatment **costs will remain uncertain, but simply end-up at other organizations P&L (e.g. COVRA)** • Liability take-over would likely come at a **market based risk premium** and **higher costs which ECN/NRG cannot afford** - to be quantified • External **funding** may remain difficult due to **nuclear and reputation risk** (stop funding of isotopes used in cancer treatments) • **Synergies** from value chain optimization have **not been quantified** and potential **positive effect from liability consolidation is unclear**
Commercial	• Financial ratios and hist. waste risks disqualify NRG for role as coordinator for tenders and … • … prevent investments in attractive business cases (e.g., Pallas)	• **Potential economic impact** from being able to take the coordinator role is expected to be **very small** • **No business cases have been presented** that could not be executed due to RWMP related liabilities • **Pallas business plan** and financing strategy is still under development and investor **requirements not clear**. There could be a potential impact, but currently there is no stated objective that Pallas should fund any historical waste liabilities
Legal	• ECN/NRG is not responsible for the historical waste as this originated before ECN/NRGs inception	• According to legal experts **ownership resides with ECN not the State** – ECN/NRG have provided their opinion, however, with no further legal substantiation
Safety	• Hist. waste financial exposure and risk pressure on NRG organization and poses a safety threat to operations	• The mentioned **safety threat has not been quantified or specified by NRG**. ANVS indicates current EZ/ECN/NRG governance and frequent safety audits have so far **always assured a safe operational environment**. Still, all precautions should be taken by NRG and the State, that **budget scarcity never impacts investments required to upkeep safety**

Source: Strategy&, EZ, MinFin, NRG & COVRA management discussions

In addition, liability take-over would introduce new risks, increase costs and require a significant amount of change

Key risks

Loss of incentive

- In case NRG no longer bares the direct responsibility for the costs, the government will need to ensure NRG **remains cost-efficient and cannot consider waste contract to off-load costs from operational activities** (backfilling commercial project staff with steady flow of work needed on waste treatment)

State Aid

- In case the liability will be transferred to the state, or partially supported by the state, **state aid issues should be taken into account**; details are still under investigation by the government
- Key concern is the possibility to **separate waste from economic and non-economic activities** (see next chapter)

Risk Premium

- The party taking over the liability **will demand a high risk premium**, to take on the underlying cost uncertainty
  - Commercial parties or COVRA will demand risk premium which needs to be funded most likely by additional guarantee of government
  - If government takes over liability, it will have to demand a ‘market conform’ premium as well

Transition

- Transferring the liability, costs and activities will drive **significant legal, financial and other transformation cost** and require (amongst other) substantial **operational, organizational, governance and license changes – which ECN/NRG cannot absorb** given current financial and organizational challenges

Source: Strategy&, EZ, MinFin discussions

In any case, a transfer of ownership is premature, as legal & financial considerations on not yet substantiated

	First legal considerations	Next steps
Legal framework	• Nuclear waste ownership, rights and obligations is primarily **governed by the Nuclear Energy Law** (‘*Kernenergiewet’)* and the **NRG/ECN permit** • The **acquiring party** (incl. any government controlled body) **will need to apply for a permit** under the Nuclear Energy Law	• Establish requirements by **analyzing terms and conditions of the relevant permits**
Transfer	• Assuming the waste is movable (‘*roerende zaak’*), it needs to be **clearly identified and distinguished** to be legally transferred • Secondly, transfer of *movable items* requires **physical delivery** (‘*bezitsverschaffing’*). This would be problematic for waste in process within the WSF or HCL	• Assess which part of the waste is not **moveable** (e.g. buildings) and whether all waste is **clearly identifiable** • In case part of the waste is qualified as ‘immovable’, it would require **involvement of a civil law notary**
Provision	• A transfer of waste could also involve the **simultaneous transfer** of (pro rata parts of) the **provision** (underlying obligations) and assets (cash or guarantee) • This should logically lead to the **disappearance of (parts of) the provision** at NRG	• **Analysis of the terms and conditions** on the **provision** and **supportive loans** from government
Legal Title	• When considering a transfer of movable goods, the obvious legal title would be **purchase** (‘*koop’*). • The **proper transfer/purchase price** should be established and the conditions for the purchase should be determined.	• Assess comparable, **market conform risk compensation** of such a (unique) transfer • Assessment of **tax consequence** (VAT et al) and whether a reverse-charge mechanism would be applicable

Source: PwC legal

Context & main conclusions

Appendix 1: Introduction

Appendix 2: Cost & uncertainties

Appendix 3: Operational improvements

Appendix 4: Organizational & financial improvements

Supplements

- Glossary and guidelines for the use of our reports
- Elements of NRG, COVRA proposals

Glossary

Abbreviations

RAP	Radioactive waste project
RAP-alpha	Radioactive waste project with alpha radiation
C&S	Consultancy & services (NRG business unit)
DWT	Decontamination and waste treatment facility
GCO	Common center for research
HAVA	High-active solid waste / ILW-high
MAVA	Medium-active solid waste / ILW-low
LAVA	Low-active solid waste / LLW
HCL	Hot cell laboratories
HFR	High flux reactor
HLW	High Level Waste (international abbrev. for heat producing waste, such as used nuclear fuel)
ILW-low/high	Intermediate level waste (No-heat producing but medium/high active)
LFR	Low flux reactor
MPF	Molybdeen production facility
RAAVOG	Radioactive waste disposal and demolition buildings
RWMP	Radioactive waste management program
WSD	Waste stream description
WSF	Waste storage facility
WRU	Waste retrieval unit
WTU	Waste transfer unit
IAEA	International atomic energy agency
KeW	Nuclear energy law
HCL-RL	HCL research lab

Terminology

Disposal / end storage	Final underground storage for radioactive waste, currently in research phase
Interim storage	Temporary storage at COVRA in the period before waste is ready for final disposal (e.g., HABOG storage)
Beleidsdocument	Technical documentation describing the RAP(-alpha) treatment plan, agreed upon between COVRA and NRG
Characterization	Different activities require different methods of characterization, such as for transport, conditioning and disposal
Uncertainty	Unmanageable insecurity (in this context mostly concerning costs); can only be integrally decreased
Risk	Event driven foreseeable qualitative risk. Can be mitigated individually

Guidelines for the use and interpretation of our Reports

Guide for the correct interpretation of the "Our scope and process" pages in the report

- Our summary observations aim to communicate those matters which we believe are important when evaluating the findings of our work. They are directional indicators and are not absolute measures. Whilst inevitably subjective these observations set the overall context and framework against which the views expressed in our report should be assessed. The four main areas we assess are: 1) scope, 2) access to management, 3) access to information and 4) the clarity of information.
  - Our scope typically ranges from "limited" to "extensive". Our scope describes the period covered and gives an overall insight in the areas covered. Full detail of the scope is provided in Appendix 1 of the engagement letter.
  - Access to management typically ranges from "none" (e.g. no access due diligence) to "good" (e.g. open, direct, unsupervised access to all necessary members of management). Our assessment is based upon the transaction process, the level of direct access we were granted to the relevant members of management, as well as our observations as to the openness of the lines of communication.
  - Access to information typically ranges from "limited" (e.g. only the information memorandum, perhaps supplemented with some supporting schedules) to "extensive" (e.g. access to all the relevant data, supporting management schedules, and relevant specialists). Our assessment is based upon the extent to which we actually received the information and had the necessary communications during the course of our work.
- The clarity of information typically ranges from "poor" (e.g. no ability to ascertain the performance drivers of the business) to "good" (e.g. there is a substantial amount of robust and relevant information that provides meaningful insight about the most significant risks, trends, and issues of the Target). This assessment is based upon our judgement as to how access to management and access to information facilitate our understanding of the Target.

Basis of our work

- Our work was carried out on the basis that the information is reliable, accurate and complete in all material respects. Unless explicitly stated in our report, we did not verify or check the information with respect to accuracy or completeness. Our work constitutes neither an audit in accordance with any set of generally accepted auditing standards nor a review in accordance with a set of generally accepted review standards globally, regionally, or by individual territory. Accordingly, we do not express an opinion or any form of assurance with respect to any financial statements, information regarding the Target, or technical accounting advice included in our report.
- We make no representations regarding the sufficiency of our work either for the purposes for which our report was requested or otherwise. The sufficiency of the work we perform remains the sole responsibility of the addressee of our report as are any decisions with respect to the proposed transaction.
- Had we been requested to perform an audit or additional work, additional matters might have come to our attention which might be of importance to you.

Guidelines for the use and interpretation of our Reports (cont'd)

Access to our report

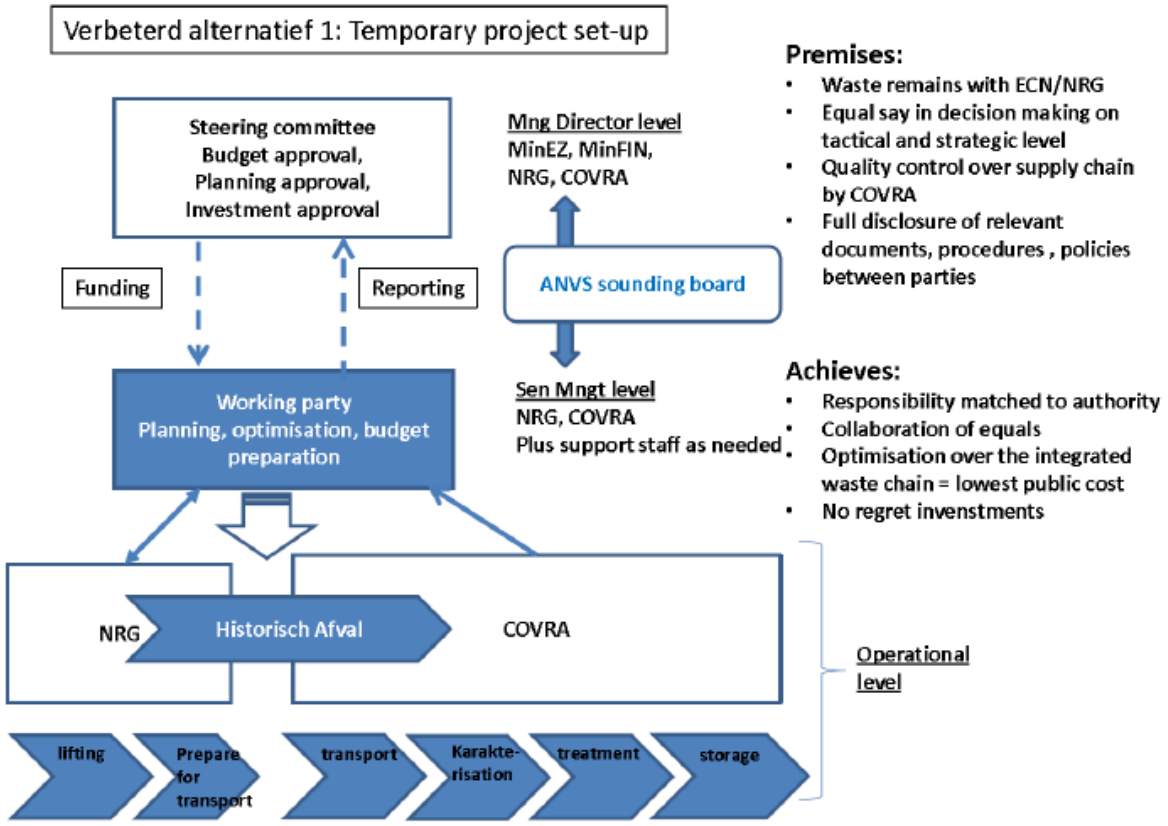
- Our report is supplied on the understanding that it is solely for the use of the client, or those persons who have signed release or reliance letters, and only in connection with the proposed transaction.
- Our report may be shared with your professional advisors solely for the purpose of assisting you in connection with the proposed transaction provided they have accepted the terms as stated in the Contract (Appendix 1). Financing banks may share the report with their professional advisors solely for the purpose of advising them in connection with the transaction under the conditions of the release or reliance letter.
- You shall not provide our report, or a copy or part thereof, to any third party, including financing banks, or refer to us or the Services without our prior written consent, which we may at our discretion withhold or allow subject to the third party accepting our terms and conditions as outlined in a separate release or reliance letter.
- Where an investment bank acts as an adviser, it may only use our report for the purpose of advising you. If the investment bank wishes to use the report for its evaluation as to whether to provide debt finance for or underwrite the acquisition, it may only do so if it has previously signed our reliance letter.
- Except where otherwise stated in the Contract, the release or reliance letters or unless required by law, no report, in draft or final form, provided by us, or a copy or part thereof, should be given to any third party nor should we or our services be referred to without our prior written consent which we may at our discretion grant, withhold or grant subject to conditions.
- Our report is specifically written for identified user(s) with whom we have agreed the scope of work or to whom we have explained the nature and extent of our work. We will therefore not accept any responsibility or liability to any unauthorized reader of our report.

Supplements

- Glossary and guidelines for the use of our reports
- Elements of NRG, COVRA proposals

COVRA proposes a variation between alternative 1 and 2, where organizations stay separate under 1 working party

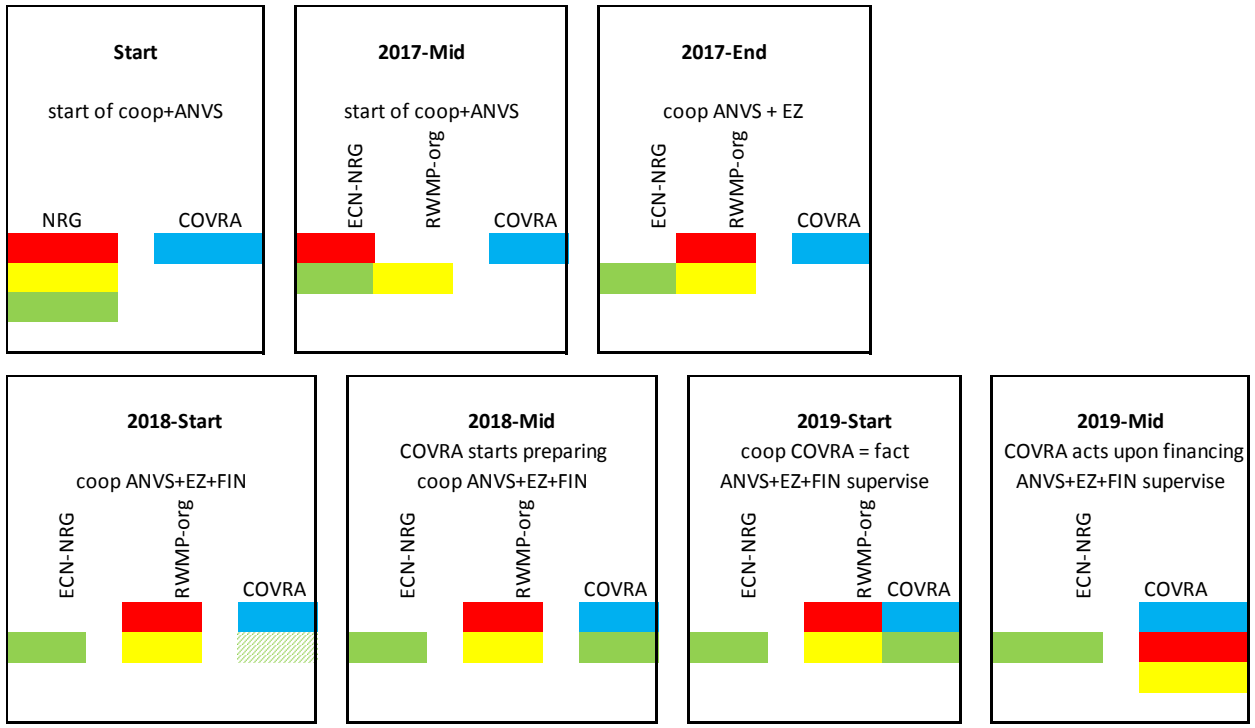
COVRA proposal



Source: COVRA

NRG proposes a gradual transition from the current form to alternative 2, but including a transfer of ownership

NRG proposal on gradual organisational transition



Owner	Responsible for cost of treatment and storage of waste
Operator	In charge of technical operations to treat and transport the waste, and setting up the required organisation
Licensee Petten	Main responsible for nuclear safety adherence in Petten
Acceptance & storage	Responsible for acceptance and midterm storage of the waste

Source: NRG

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