Study on the risk profile of the funds allocated to finance the back-end activities of the nuclear fuel cycle in the EU

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Abstract

Many of the expenditures associated with the nuclear back-end occur once a nuclear facility has ceased revenue generation. This creates a need to ensure adequate finances are available to meet these costs as and when required, usually through an advance funding arrangement during the operation of the facility. Arguably the ability to demonstrate that these costs can be met effectively without placing an undue financial burden on public finances or future generations is crucial to the future of nuclear power generation. This study considers the various funding arrangements that have been set up across the EU for purposes of meeting these back-end costs. It includes a detailed analysis of the risk profile of these funds, considering the key features of current funding and investment arrangements as well as the risks attaching to both the investments held and the future liabilities these investments are intended to meet. The study also investigates the best practices as concerns prevailing funding arrangements, investment and governance approaches as well as identifies key emerging trends and challenges.

Executive Summary: Study on the risk profile of the funds allocated to finance the back-end activities of the nuclear fuel cycle in the EU (№ ENER/D2/2016-471-2)

1. Background and context

The significant costs associated with the back-end of the nuclear fuel cycle creates a need to ensure adequate finances are available to meet these costs when required, usually through some form of advance funding arrangement.

This study analyses the risk profile of the resulting funding and investment strategies and the associated governance arrangements for the funds allocated to the back-end costs of the nuclear fuel cycle, identifying trends, challenges and best practices.

This study provides a framework, based on international best practices, for the funding, investment and governance of funds set up to meet the back-end costs of the nuclear fuel cycle. Using this framework, this study focuses on:

- The likely adequacy of available funds and the methods used to determine future funding requirements;
- The extent to which potential future cost escalation has been taken into account;
- The appropriateness of investment strategies, the associated asset-liability risks and other key risk issues;
- Existing governance and oversight arrangements and whether these are adequate.

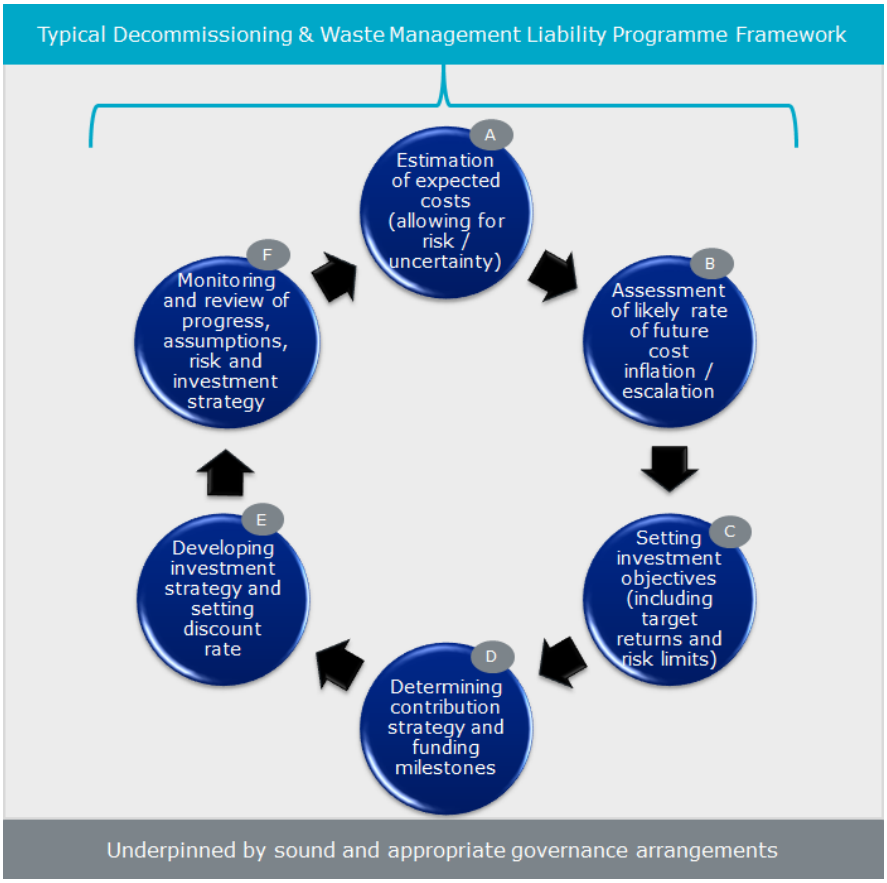
The primary focus of this study is on the following Member States: Belgium, Bulgaria, Croatia, Czech Republic, Finland, France, Hungary, Italy, Germany, Lithuania, The Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden and the UK. The depth of country-specific analysis reflects the quantity and quality of the available data.

2. Framework for the effective management of the funds set up to meet the back-end costs of the nuclear fuel cycle

Best practice for ensuring the funds set aside to meet the costs of back-end nuclear activities are able to meet their future decommissioning and waste management obligations requires sound funding and investment approaches, supported by ongoing governance, monitoring and risk management processes.

Ideally this should be carried out within a well-defined, national decommissioning and waste management liability programme framework, describing how the EU directives and other guiding principles are applied, a roadmap for securing adequate future funding, funding and investment principles, roles and responsibilities and the approach to fund management.

This is illustrated in the chart below:



a) Estimation of expected future costs

Recognising the liability-driven nature of the funds set up to meet the back-end costs, a clear understanding of the future costs is required before any realistic consideration of funding and investment related issues is possible. The NEA, IAEA and EC's International Structure for Decommissioning Costing ("ISDC") has been developed to assist and its use should be regarded as best practice. Nevertheless, no standards exist as concerns radioactive waste generated outside decommissioning projects and spent fuel management.

None of the national programmes analysed in the framework of this study included a full cost profile over time (although some were subsequently provided upon request). It has also not generally been possible to ascertain what allowances have been made for risks and uncertainties from the information available. Additional disclosure and transparency in this regard should therefore be encouraged.

b) Assessment of the likely future rate of cost inflation

Setting an assumption for future cost escalation requires an understanding of general long-term inflation expectations and nuclear specific cost considerations. Market implied inflation and long-term consensus forecasts can provide a reasonable starting point but may fail to capture nuclear specific inflation elements.

It would be spurious to analyse each individual cost component and a pragmatic approach of identifying a few major cost drivers and determining reasonable inflation assumptions for each of these is likely to be appropriate.

c) Setting investment objectives, target levels of return and risk limits

An appropriate rate of expected future nuclear cost inflation should provide the minimum bound for the level of target investment return (i.e. discount rate). The discount rate can be thought as the minimum return that must be achieved on the fund assets each year in order to meet decommissioning and waste management costs at the end of Nuclear Power Plant's operating life without additional funding.

Government bond assets, typically regarded as "risk-free" are unlikely to provide positive real returns at present and therefore targeting a level of investment return equal to or above some measure of future inflation will involve taking some level of investment risk.

At present, investing in "risk-free" assets would not be expected to provide sufficient returns to allow a fund to outperform the expected inflation of the decommissioning and waste management costs (i.e. the discount rate would be below the expected rate of inflation). It is therefore necessary to invest in assets that provide a higher expected return. Pursuit of investment returns in excess of a risk-free rate requires taking risk and taking risk implies that it is possible for investment returns to be lower than expected.

Recognition of these points, the formation of a view on what constitutes an acceptable level of investment risk and capturing this information in a formal policy document are important in developing appropriate funding and investment strategies.

d) Determining contribution strategy and funding milestones

Given realistic assumptions for future cost inflation and target levels of investment return it is possible to calculate the level of contributions that will need to be received.

Best practice might then be to develop an "intended funding path", specifying the percentage of the total liability (i.e. the funding level) that should be accumulated at different points in time, together with details on how any deviations from this intended funding path will be dealt with. Although some Member States will clearly have developed such funding milestones, additional disclosure and transparency would contribute towards a greater understanding of the resulting risk profile.

e) Developing an investment strategy

The next consideration is how best to construct an investment portfolio that is expected to deliver the required level of investment return over time with no more than the acceptable level of risk. If the investment strategy cannot deliver the target level of return, then over time the fund will start to fall behind its intended funding path, creating a need for additional funding contributions or even higher target levels of return in future (which may not be commensurate with the acceptable level of risk).

Deriving a suitable investment strategy requires a detailed assessment of the investable universe and the expected cost / liability risk profile, taking full account of:

- Return and risk expectations for different asset classes;
- Correlations between different asset classes, diversification benefits and how both of these might vary in different financial market conditions;
- Underlying drivers of risk and return, including the extent to which interest rate and inflation risk can be hedged and the appropriateness of active management;
- Investment management fees, liquidity considerations and the relative complexity inherent in different asset classes.

Capturing details of the strategic asset allocation and how it is to be implemented in a formal policy document should be seen as a key governance requirement.

f) The importance of ongoing monitoring and regular reporting/disclosure

Ongoing monitoring of and regular reporting on the development of a fund's assets relative to its liabilities (and how this compares to an intended funding path) is essential for ensuring that the investment strategy remains appropriate and that a fund is able to react quickly in light of emerging risks or opportunities.

The level of detail and frequency of monitoring/reporting updates should be based on the specific circumstances of each fund, although something like quarterly or semi-annual monitoring would be typical for other large institutional investors.

A detailed update of future cost estimates might only be carried out, for example, every three to five years. However, as these cost estimates should be the primary driver of funding and investment strategy, it would be reasonable to expect the following to be reviewed in light of any material changes to the future cost estimates:

- The methodology used to determine the assumed rate of future cost inflation;
- Investment objectives, target levels of return and risk limits;
- The adequacy and appropriateness of currently agreed funding contributions;
- Strategic asset allocation (taking account of underlying market conditions); and
- A Statement of Investment Principles (or similar policy document).

The remainder of this executive summary presents the key findings in each of the areas described above.

3. Nuclear specific inflation considerations

The table below shows the assumed rates of future cost escalation used in this study.

Figures in €m	France (operators)	UK (NLF)	Germany (FNWM)	Spain (PGRR)	Slovakia (NNF)	Hungary (CNFF)	Sweden (NWF)
Assumed inflation rate	1.6% (Member State assumption)	4% (Member State: RPI of 3% plus 1% for nuclear specific inflation)	3.57% (Member State: 1.6% plus 1.97% for nuclear specific inflation)	2% (Assumption based on long-term ECB target)	2% (Member State assumption)	2% (Assumption based on long-term ECB target)	1.8% (Author's estimate based on long-term consensus forecasts)[1]

Where a Member State has disclosed a specific inflation assumption, this has been used without adjustment. Where no assumption was disclosed (i.e. Spain and Hungary), a simplifying assumption of 2% to reflect the ECB's long-term inflation assumption has been used.

The use of materially different inflation assumptions for different Member States introduces an element of inconsistency. This is primarily the result of the inclusion by certain Member States of a specific assumption for nuclear related inflation over and above general market inflation. The inflation assumptions for the other Member States (Spain, Slovakia, Hungary and the French licensees) do not appear to include a nuclear related inflation component.

[1] For Sweden, a simplifying assumption of 1.8% based on long-term consensus forecasts has been shown. In practice, Sweden makes allowance for a nuclear specific inflation rate (similar to the UK and Germany).

In some other Member States, future inflation expectations are set based on historical realised inflation, which is unlikely to be a reliable indicator of future inflation. Recognising the Member States' unique situations, a consistent approach should nonetheless be encouraged.

4. Investment strategy and risk management

The table below shows the allocation to sovereign bonds and cash in the Member State funds as well as the duration[2] of the liabilities they are intended to meet.

Figures in €m	France (operators)	UK (NLF)	Germany (FNWM)	Spain (PGRR)	Slovakia (NNF)	Hungary (CNFF)	Sweden (NWF)
Sovereign bonds and cash	20%	79%	Assumed 20%	76%	100%	100%	40%
Duration	24	55	33	30	35	43	19

The allocations above are obtained from individual member states, apart from Germany, where the author assumed an allocation of 20%.

In light of current market conditions, government bonds and cash are highly likely to underperform inflation and it is questionable whether certain of the portfolios above can be regarded as having a sufficiently "secure" risk profile from an asset-liability perspective. It is also questionable whether these portfolios are sufficiently diversified and are likely to have shorter duration than that of the liabilities shown above.

The primary risk exposure for these Member States is to long-term interest rates and inflation and the effect they have on the assessed liabilities. Holdings of other asset classes like equities and alternatives create additional risk exposures although they do offer diversification benefits and the prospect of higher future investment returns.

There is evidence to suggest that some Member States are already taking steps to address the above points. However, for most Member States it is not apparent that meaningful investment objectives or a risk based approach to determining investment strategy have been adopted.

Key risk issues in other Member States

Funds in Belgium and Finland are permitted to issue loans of up to 75% of the assessed liability to the nuclear operators. These funds are therefore exposed to credit risk from the nuclear operators. The ability of funds to make loans to their primary contributors would be questioned for other institutional investors.

German nuclear operators retain provisions on their balance sheets for the future costs of decommissioning. The size of these provisions is material – for all three of the largest NPPs, nuclear provisions constituted more than 50% of their market capitalisation at 31 December 2017. The German operators do not make use of a nuclear specific inflation assumption for their decommissioning costs in the same way as the FNWM does for its waste storage and disposal costs – largely because decommissioning is expected to take place over a much shorter period of time in the foreseeable future.

5. Governance and monitoring

[2] Duration is the cash flow weighted average time (in years) until a bond is repaid. Duration therefore allows one to measure how much a bond price, or the present value of future liabilities, will change when interest rates change. For more information, please refer to section 3.8.

The majority of Member States have established segregated funds to meet the costs associated with the back-end of the nuclear fuel cycle. Furthermore, most of these are funded by the nuclear operators and are therefore consistent with the generally accepted "polluter pays" principle set out in the EU directives.

Adopting a framework like that outlined in Section 2 for the effective management of these funds is only possible if sufficient resources and a commensurate governance budget exist. With this in mind, the extent to which existing governance bodies have sufficient levels of investment and funding expertise to manage institutional, liability-driven investment portfolios, and the extent to which they rely on professional support and are free from political interference, warrants further consideration.

The extent to which regular ongoing monitoring of funding and investment issues is carried out in practice could not emerge from this study but should be encouraged as a means to improve overall governance and risk management.

Noting potential confidentiality issues, increased levels of disclosure and transparency should be encouraged. At present, there are marked differences in the level of transparency provided by the Member States.

6. Funding and liability valuation

A funding assessment has been carried out for the Member States that have set aside investment funds and where sufficient data was available. Although a funding level lower than 100% may at first appear concerning, full funding is, in theory, only required at the end of all nuclear activities or the termination of contributions to the fund. For example, a nuclear facility that has operated for, say, 30 years of an intended 60 year operating life would not need to (or be expected to) have achieved full funding and, depending on the way in which future contributions are structured, might more reasonably be expected to have a funding level of c.50%.

The table below shows the current funding position and reflects the estimated future costs and assumptions provided by the Member States.

Figures in €m [3]	France (operators)[4]	UK (NLF)	Germany (FNWM)	Spain (PGRR)	Slovakia (NNF)	Hungary (CNFF)	Sweden (NWF)
Asset value	45,300	10,973	24,148	5,018	1,399	910	6,839
Liability value	46,617	38,289	13,946	10,971	11,537	2,205	10,522
Funding level	97%	29%	173%	46%	12%	41%	65%

Differences in the funding levels shown above will, in part, reflect differences in the technical approaches adopted as well as differences in progress made to date. However, the discount rates used are not always wholly consistent with current (2018) market conditions or the future investment returns that might reasonably be expected on the basis of conservative investment strategies. Therefore, for the sake of the analysis, the above liabilities have been restated using assumptions that tried to reflect the Member States' individual circumstances. The results of this exercise are shown in the table below (see Annex 2 for detailed analysis).

[3] Figures shown are as at 30 September 2017. Asset values are provided by the Member States and the liability and funding level figures have been calculated by the author.
[4] Figures shown reflect the combined position for EDF, Orano and CEA but exclude EDF's provisions for spent fuel management linked to the operating cycle.

Figures in €m	France (operators)	UK (NLF)	Germany (FNWM)	Spain (PGRR)	Slovakia (NNF)	Hungary (CNFF)	Sweden (NWF)
Asset value	45,300	10,973	24,148	5,018	1,399	910	6,839
Restated liability value	67,310	63,621	19,400	18,713	11,537	7,983	12,328
Funding level	67%	17%	125%	27%	12%	11%	55%

The differences between the liability values shown in the two tables above quantifies the amounts of additional financing required which are not covered by existing funding and investment arrangements. Given as an assumption the persistency of current (2018) market conditions, the longer this possible underfunding is left unchecked, the greater the likely financial impact of required future corrective action will be.

Key findings and best practices

Funding and liability valuation

Best practices

- A discount rate (or target level of return over inflation) should be derived that is realistic in light of prevailing market conditions and intended investment strategy. The methodology and assumptions used as well as the results obtained should be clearly set out and provided to relevant oversight bodies.
- A regular (e.g. semi-annual, but no less frequent than annual) monitoring and reporting regime, which requires consideration of how the level of funding and exposure to risk have developed relative to expectations and in light of changing market conditions should be required. Results should be made publicly available to the extent possible.

Observation	Key findings
Discount rates are often not consistent with investment strategies and prevailing market conditions	• Discount rates in a number of Member States are not realistic in light of the future investment returns that might reasonably be expected from their investment portfolios. This suggests material underfunding in several key Member States. • In some Member States, discount rates reflect historic investment performance rather than forward-looking estimates. In others, there is an element of smoothing (or other adjustment) applied which is not wholly consistent with prevailing market conditions. • Information on the methodology used to set the discount rate is limited in some cases and there are inconsistencies in the methodologies used by different Member States.
Monitoring and review of funding assumptions and the development of funded status is sometimes insufficient	• Discount rates (and the inflation assumption – see below) must be kept under review to ensure they remain appropriate in light of emerging market conditions. It is not apparent that this practice is widespread. • Despite being recognised as a key governance process for institutional, liability-driven investors, it is not clear that regular (e.g. quarterly or semi-annual) monitoring of the development of a fund's assets and liabilities against expectations is in place.

Nuclear specific inflation considerations

Best practices

- Detailed consideration of the likely future rate of nuclear decommissioning and waste management cost escalation should be required, with detail on the methodology used and results obtained clearly set out and provided to relevant oversight bodies.

Observation	Key findings
The specific nature of likely future cost escalation is often not adequately considered	• Although some Member States (e.g. Germany, Sweden and the UK) make allowance for nuclear decommissioning and waste management specific inflation, this practice is not widespread. • In some Member States, future inflation expectations are based on historical realised inflation, rather than forward-looking estimates. • In other Member States, an implicit assumption is made with little detail provided on the underlying methodology.
A pragmatic approach is possible despite the complex nature of the underlying costs	• Little evidence of market implied inflation and long-term consensus forecasts being used in order to form an initial view on long-term inflation. • Approach adopted by Sweden is to focus on additional nuclear specific cost drivers for a few major decommissioning and waste management cost categories (e.g. labour costs). There is little evidence that other countries adopt a similar approach.

Investment strategy and risk management

Best practices

- A meaningful assessment of what constitutes an acceptable level of funding and investment risk should be required, with detail on the methodology used and results obtained clearly set out and provided to relevant oversight bodies.
- A dynamic investment strategy should then be designed to achieve a target level of return over the likely future rate of nuclear decommissioning and waste management cost escalation, subject to the acceptable level of funding and investment risk and recognising that both the investment strategy and acceptable risk level may change over time.
- In some cases, a significantly less constrained investment universe (including a broader set of securities) could be appropriate, provided this can be supported by existing governance arrangements (see below). This may require changes to individual Member State restrictions on investment.
- Use of both professional advisers and an expanded range of professional investment managers could contribute to improved investment performance over time in case of lack of specific expertise in house.
- The ability for funds to make loans to their primary benefactors should be restricted.

Observation	Key findings
Sometimes there is little evidence of meaningful investment objectives or adequate consideration of risk	• The funds considered in this study are liability-driven investors. Their investment objectives and approach to risk management should be explicitly linked to their liabilities. • However, there is little to suggest that these funds have sought to set a target level of return that reflects the inflation linked nature of their liabilities or to define an acceptable or tolerable level of investment risk in pursuit of such a target return. • There also appears to be little recognition of the need for investment strategy and the level of acceptable risk to evolve over time to reflect the lifecycle of the nuclear facility and the resulting implications for liquidity and cash flow matching.
Investment strategies in some Member States are scarcely diversified and overly simple given the size of the funds involved	• Several Member State investment portfolios are dominated by Government bonds and cash investments which, in current market conditions, are unlikely to keep pace with the inflation linked nature of their liabilities. • Investment portfolios with such material government bond/cash holdings fail to capture available diversification benefits and, with limited exceptions, there is also no diversification across investment managers. • In a number of Member States, investment also appears to be largely on a passive, buy-and-hold basis.
Certain investment practices or approaches may be questionable	• The ability of funds in Belgium and Finland to make loans to their primary contributors would be questioned for other institutional investors (although the extent and the manner to which these loans are secured would need to be considered). • It is sometimes unclear whether segregated internal funds are legally ring-fenced in the case of operator insolvency. If this is not the case, then these arrangements may warrant consideration.

Governance

Best practices

- Standard disclosure requirements related to funding and investment issues should be required in national reports and, ideally, also in statutory corporate accounts (even if not explicitly required by the relevant accounting standards). Examples of the types of disclosures needed are provided in this study.
- Delegation of investment and funding matters to a governance body with the requisite level of skill and expertise should be required. These bodies should be tasked with regular scrutiny of the emerging funding position and exposure to risk and should also have the requisite time, resources and skills to consider a more comprehensive range of investments (and associated risks). If this is not possible, fiduciary management approaches may provide an attractive solution.
- A requirement for the funds to produce and make publicly available a formal Statement of Investment Principles (or clarify the extent to which this is beyond their direct control) would greatly improve transparency and facilitate a better understanding of their risk profile. Such a Statement of Investment Principles (or equivalent) would need to be kept up to date in light of any material revisions to underlying cost estimates or other material changes.

Observation	Key findings
The levels of transparency and disclosure are not consistent across Member States	• There are notable differences in the level of detail contained within Member State national programmes and reports, as well as within operators' published annual reports and accounts on funding and investment matters. • None of the national programmes include full cost profiles over time (some were subsequently provided on request) or detail on the allowances made for risk and uncertainty. • There is limited detail on how funds intend to get from their current funding positions to positions of full funding at a required target date (i.e. their intended funding paths). • There is also limited information and disclosure on the ability of government to influence asset management or to direct the use of accumulated funds.
The extent to which required funding and investment expertise exists in key governing bodies is sometimes not clear	• At a high-level, governing documentation requiring properly constituted management boards with clear delineation of powers and duties appear to be in place. • Some Member States have delegated responsibility for investment matters to separate subcommittees but it is not clear whether these matters receive the level of scrutiny expected for funds of this size. • Elsewhere, the extent to which existing governance bodies have sufficient levels of investment and funding expertise to manage institutional, liability-driven investment portfolios is unclear. • Where this expertise is lacking, there is little evidence to suggest that professional support or delegation of certain investment related matters to independent experts are undertaken.
Documentation of investment and funding related policies and processes could be improved	• Whilst some Member States have developed some form of "Statement of Investment Principles (SIP)" it is not clear that this is widespread or that these SIPs contain detail on things like investment objectives, risk limits or performance benchmarks. • It is also not clear whether these SIPs are updated in light of material changes to underlying cost estimates.

1. Introduction and overview

1.1 Background

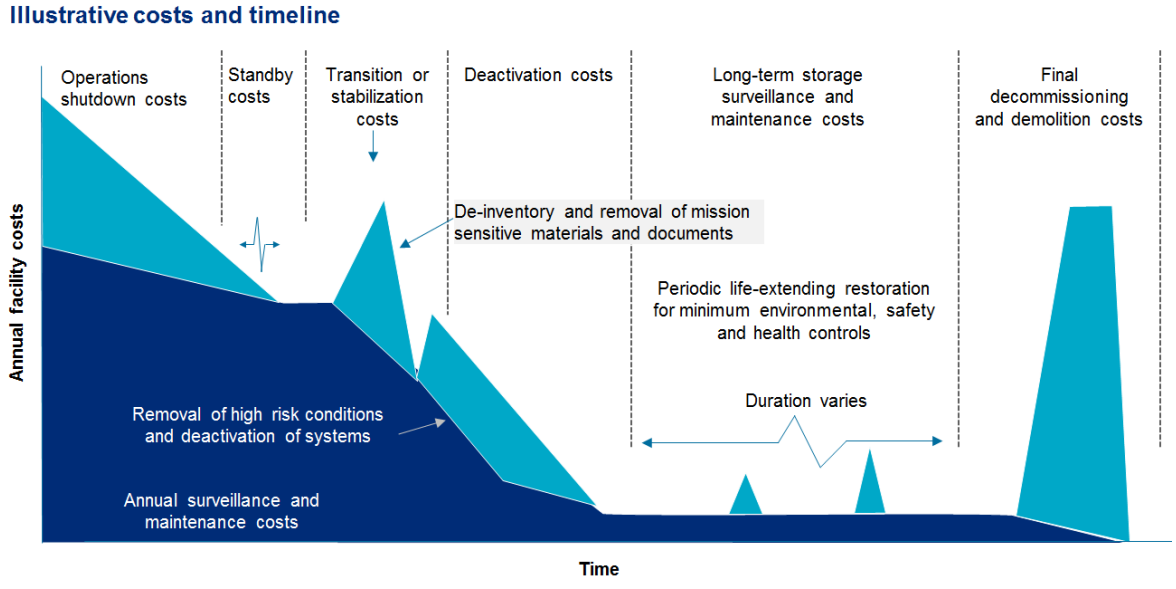
The back-end of the nuclear fuel cycle encompasses all the activities following irradiation in a nuclear reactor as well as the activities related to establishing the infrastructure for management and disposal of the resulting radioactive wastes. These activities include removal of spent fuel, decommissioning and radioactive waste management. Although all these activities are highly interconnected, it is worth noting the following:

- The activities following the removal of spent fuel differ depending on whether or not the irradiated fuel is reprocessed and the nuclear material is recycled.
- Decommissioning refers to all administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility.
- Radioactive waste management refers to all administrative and operational activities involved in the handling, pre-treatment, treatment, conditioning, transport, storage and disposal of radioactive waste.

In a wider sense, the back-end also includes all the activities related to treatment, conditioning, packaging, and disposal of radioactive wastes created during operation of nuclear facilities.

In this study, we will use the generic terms "decommissioning and waste management" or "back-end activities" to refer to these interconnected activities.

Decommissioning and waste management is a complex, highly regulated and labour intensive process and is subject to extensive operational and financial risks. Furthermore, decommissioning and waste management activities are typically carried out over very lengthy timeframes – for new nuclear facilities, these activities are likely to continue well into the next century. The chart below provides an illustration of the typical activities involved[5]:



[5] The chart is intended to reflect an "immediate decommissioning" approach. Other approaches to decommissioning (deferred decommissioning and entombment) are also recognised.

Most of the costs related to decommissioning and waste management occur once a facility has stopped generating power[6] and, therefore, revenue. To ensure that finances are available to meet the significant costs of these activities and to ensure nuclear safety, regulators and/or legislation often require nuclear licensees to establish some form of advance funding arrangement during the operation of the facility.

Furthermore, the "Council Directive of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste (2011/70/EURATOM)" and the "Commission Recommendation of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste (2006/851/Euratom)" contain a number of key guiding factors related to the funding/financing of future decommissioning and waste management liabilities. Relevant extracts are contained in Appendix 3.

The need to develop an appropriate and cost-effective funding arrangement for meeting future decommissioning and waste management costs is of critical importance. The lengthy timeframes required for decommissioning and waste management, as well as the lack of reliable past experience, increase the levels of uncertainty associated with future cost estimates, creating a need to regularly monitor and review the development and continued appropriateness of the funding strategy.

In most Member States, national legislation and nuclear regulators specifically define the method for constituting and securing funds to meet the future costs of decommissioning and waste management and different Member States have adopted different models for building up these required funds.

The approaches adopted by the Member States are generally intended to reflect the requirements of Article 3(e) of EU Council Directive 2011/70/EURATOM: "*the costs for the management of spent fuel and radioactive waste shall be borne by those who generated the materials*" although there are differences within the EU Member States as to who bears this burden (i.e. investors/owners or ratepayers).

In addition to the definition of the funding model used, legislation and/or regulators in the Member States will often set out rules regarding how any funds can be invested.

1.2 Objectives of this study

The primary objective of this study is to present an analysis of the risk profile of the investment strategies and policies of the existing European Union ("EU") Member States' funds allocated to finance the back-end activities of the nuclear fuel cycle, identifying trends, challenges and best practices.

Secondary objectives of this study include:

- Analysing the practices followed in different EU Member States with regards to the funding and financing of the back-end activities of the nuclear fuel cycle, against best practices, identifying trends and challenges.
- Analysing the past investment performance of these funds.
- The creation of an inventory of the funds allocated to finance the back-end activities of the nuclear fuel cycle across all Member States.

[6] Costs associated with the disposal of low and intermediate level waste and potentially costs associated with construction of geological disposal facilities may occur during a facility's operating life.

- Providing detail on the legal ownership and governance arrangements of these funds, including an assessment of independent verification processes and a calendar for future verification.

A key desired outcome from this study is therefore to provide the Member States with meaningful conclusions and actionable recommendations to improve and better support the investment and risk management of funds allocated to finance the back-end activities of the nuclear fuel cycle in future.

This study also considers the approaches taken to investment, risk management and governance amongst other institutional investors (notably pension funds and insurance companies) across Europe and the extent to which these would be appropriate for the funds allocated to finance the back-end activities of the nuclear fuel cycle.

1.3 Risk assessment methodology

Analysing the risk profile of the funds allocated to finance the back-end activities of the nuclear fuel cycle requires asset-liability modelling ("ALM"). ALM studies consider not only capital market risks related to the investments held in the funds themselves but also those risks that impact the liabilities these funds have been established to meet[7]. ALM therefore allows us to consider what is arguably the most important risk of all: that the funds set aside will prove insufficient to meet the expected future decommissioning and waste management costs as and when they fall due.

By definition, ALM requires consideration and analysis of expected future decommissioning and waste management costs. For purposes of this study, all cost data has been assumed to be correct – an assessment of the completeness, accuracy or methods of determining these costs is beyond the scope of this study.

1.4 Sources of data and information

The primary sources of data and information used to prepare this report include:

- The National Programmes and Reports submitted by Member States to the Commission in the basis of the Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.
- Published annual reports, financial statements and other reference documents for various nuclear licensees across the EU Member States.
- Previous analysis and reports prepared by or for the Commission, including:
  - Communication on a Nuclear Illustrative Programme (PINC) COM(2017) 237 final, and Accompanying Staff Working Document SWD(2017) 158 final.
  - Communication from the Commission to the European Parliament and the Council on the use of financial resources earmarked for the decommissioning of nuclear installations, spent fuel and radioactive waste. COM(2013) 121 final.
  - Comparison among different decommissioning funds methodologies for nuclear installations. Final Report on behalf of the European Commission Directorate-General Energy and Transport, Service Contract TREN/05/NUCL/S07.55436
  - Commission Recommendation of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste. OJ L 330, 28.11.2006, p. 31-35

[7] More detail on these items is provided in Section 3.

- OECD Nuclear Energy Agency presentations delivered during a workshop in May 2017 whose authors have agreed to share their presentations with us.
- Data and information provided by Member States to the EC in response to data requests developed for purposes of carrying out this study.
- Market performance and other data from publicly available sources including Thomson Reuters Datastream, Bloomberg, the World Bank, OECD and Standard & Poors.
- Surveys, studies and analyses carried out by Mercer as well as publicly available studies from other market participants including OECD, EIOPA, GSAM, BlackRock and Willis Towers Watson.

Appendix 4 provides a comprehensive listing of the data and information used to produce this report.

1.5 Overview of report

This report is focused on the following current EU Member States: Belgium, Bulgaria, Croatia, Czech Republic, Finland, France, Hungary, Italy, Germany, Lithuania, Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden and the UK. High level comments for the remaining Member States are however included in Annex 1.

The layout of this report is as follows:

- Section 2 contains an overview of the funds set aside to meet future decommissioning and waste management costs in different EU Member States. It includes detail on the structure, nature and legal ownership of these funds as well as the costs that each fund is intended to meet and who bears responsibility for meeting future decommissioning and waste management costs.
  - Annex 1 provides a more detailed country by country analysis of the specific arrangements in place in each EU Member State.
  - This also includes high level comments for the 11 current EU Member States who have no active nuclear power programmes and/or where historical nuclear activities have generally been limited to government owned research facilities.
- Section 3 provides an introduction to the concepts of risk and asset-liability risk as well as the role of capital market investments. It defines the key risk metrics that are analysed for the different Member States in subsequent Sections.
- Section 4 provides an overview and comparison of the investment strategies and risk profiles of the funds allocated to the back-end activities of the nuclear fuel cycle in relevant EU Member States.
  - Annex 2 provides a more detailed country by country analysis of the investment strategies, risk profiles and past performance of the funds in each relevant EU Member State.
- Based on the information set out in Sections 2-4, we have then attempted in Section 5 to outline what might be regarded as "best practice" for the funds allocated to finance the back-end activities of the nuclear fuel cycle. In doing so, we have considered both international best practice as well as the requirements of the EU Waste Directive, recognising that the different circumstances of EU Member States mean that there is no single best-practice model that could be applied by all Member States.
- Section 6 presents conclusions and recommendations.

2. Approaches to financing, funding and governance in different EU Member States

2.1 Introduction

Before any analysis of the investment strategies, risk profiles and past performance of the funds allocated to finance the back-end activities of the nuclear fuel cycle can be carried out, it is first necessary to examine the existing nuclear landscape and the different approaches taken to financing/funding future decommissioning and waste management costs in each relevant EU Member State.

Some Member States make use of a single fund and this is usually intended to cover both radioactive waste management and decommissioning activities for all nuclear facilities. However, in other Member States, separate funds exist (i) for different facilities and/or (ii) for different activities. Separate financing regimes also exist, for example:

- In the UK, where a different financing regime exists for new nuclear build projects, under which operators are required to advance fund future liabilities, and legacy nuclear sites, where the costs are met by current and future taxpayers.
- In Germany, following the decision to cease nuclear energy, an external public fund has been established to meet future waste management and disposal costs whilst Operators retain provisions on their balance sheets for the future costs of decommissioning.

Although specific practices for ensuring sufficient funds are available as and when needed differ between Member States, it is possible to identify a few general approaches:

- A segregated external fund:
  - External to the operator of the installation and exists e.g. in Finland and Sweden, where the funds are also external from the state budget.
- A slightly different version of the segregated external fund:
  - Although the fund is external to the operator it is incorporated within the State budget, exists in Hungary, Romania, Slovakia and Bulgaria.
- A segregated internal fund:
  - Kept by the operator of the installation, but as a separate budget which can only be used for decommissioning, spent fuel and radioactive waste management purposes and under the control of the national body. Funds of this type exist for example in France and Belgium.
- Non-segregated internal book reserves:
  - where the Commercial Law requires the companies operating NPPs to build up provisions on their balance sheets for future decommissioning costs (e.g. German nuclear operators, since 2016 for decommissioning activities only).
- Non-segregated Government liabilities:
  - Funds are made available for decommissioning and waste management purposes from the State on, say, an annual basis (e.g. in Italy)[8].

Section 2.2 below provides a high-level comparison of the practices adopted in the Member States and groups the various decommissioning and waste management funds into different clusters. This serves as an inventory of existing decommissioning

[8] This is also the default scenario throughout the EU in most cases not covered in this Report, i.e. where Governments are responsible for legacy nuclear facilities and waste.

and waste management funds and also identifies the legal owner, structure and nature of each such fund as well as the activities they are intended to cover.

Section 2.2 provides a qualitative overview of the different funding/financing regimes. The corresponding quantitative performance and risk analysis is contained in Section 4 (and Annex 2). Together these form the basis for assessing the approaches taken by the funds in different clusters against what might be considered best practice for that cluster in Section 5.

In Annex 1, we have provided a more detailed assessment of each EU Member State in turn, with specific focus on:

- Identifying those funds that have been set aside for decommissioning and waste management purposes and the activities they are intended to cover;
- Identifying the legal owner, structure and nature of each such fund;
- Providing a summary of the management/oversight bodies responsible for each of the funds and the general approach to fund governance;
- Summarising the approach taken to independent audit and verification with detail on how frequently such work is performed;
- Identifying the parties and processes involved in determining expected future decommissioning and waste management costs and how frequently these are updated.
- The methodology used to determine the fees, levies or contributions payable to the funds, including the frequency with which these calculations are updated;
- The underlying investment policies, principles, constraints and other factors that influence how these funds are invested.

2.2 Comparison of practices followed in different EU Member States

There are a number of funds across the EU Member States that have been established to meet the costs associated with the back end of the nuclear fuel cycle and there are important differences in the structure of these funds, the costs they are intended to cover and the sources from which contributions/financing are received. It is however possible to identify a number of "clusters" as follows:

- Cluster 1: Segregated external funds with contributions received from nuclear operators only.
- Cluster 2: Segregated external funds with contributions received from nuclear operators and other sources.
- Cluster 3: Segregated internal funds with contributions received from nuclear operators only.
- Cluster 4: German nuclear operator utilities (distinct from the FNWM, which is in cluster 1).

In addition to these clusters, there are two cases[9] that do not fit neatly into any of the above clusters: Italy (the Electricity Equalisation Fund); and Lithuania, Slovakia and Bulgaria who have historically received financial support from the EU.

Except where explicitly stated, the various State funded liabilities for legacy, R&D and other facilities have not been considered. Owing largely to data limitations

[9] Arguably, Belgium and Finland may be considered special cases. The material proportions of the established funds lent back to the operators as loans make these more similar to the German operator model. This is discussed in more detail in Section 4.

consideration of nuclear liabilities for commercial fuel cycle, military or industrial, medical, and other activities not related to nuclear power have also been excluded[10].

The remainder of this section sets out the individual funds in each of these clusters together with some high-level comments and an indication as to whether the risk profile of these funds is considered in Section 4 (and Annex 2). Individual country summaries are contained in Annex 1.

Cluster 1: Segregated external funds with contributions received from nuclear operators only.

The table below shows the funds in this cluster as well as a high-level summary of the costs and facilities they are intended to cover and the legal owner of the fund:

Funds	Decommissioning costs?	Waste management costs?	Facilities in addition to commercial NPP's?	Legal owner	Risk profile analysed in Section 4?
Croatia (Krsko)	✓	✓	☒	State	☒
Slovenia (Krsko)	✓	✓	☒	State	☒
Czech Republic (nuclear account)	☒	✓	☒	State	☒
Finland (NWMF)	✓	✓	✓	State	✓
Germany (FNWM)	☒	✓	☒[11]	Public Foundation	✓
Hungary (CNFF)	✓	✓	☒	State	✓
Lithuania (Ignalina Fund)	✓	☒	☒	State	✓
Netherlands (SKOKB)	✓	☒	☒	SKOKB	☒
Netherlands (COVRA)	☒	✓	✓	State	☒
Romania (Decommissioning fund)	✓	☒	☒	State	☒
Romania (Waste disposal fund)	☒	✓	☒	State	☒
Sweden (NWF)	✓	✓	✓	State	✓
UK (NLF)	✓	✓	☒	Nuclear Trust	✓

Key: ✓ - included; ☒ - not included

This is the largest of the clusters and the funds shown above are aligned to several of the key points contained in the EU Waste Directives (see Appendix 3), in particular:

- The "polluter pays principle" is in force as it is the nuclear operators who are required to ensure the availability of adequate financial resources in advance of required decommissioning or waste management expenditure, typically from the revenues generated from nuclear activities during the operational period.
- Segregated funds are viewed as the preferred option for all nuclear installations, aiding both transparency and reducing the scope for a number of potential operational risks.

[10] In some cases, funds that are being included in this Report (may) address legacy, military etc. liabilities as well as those for commercial nuclear power plants but it is beyond the present scope to analyse and compare such structural differences. However, please note our recommendations, in particular Section 5.

[11] The FNWM is intended to cover the commercial NPP share of waste only. Government is responsible for 100% of the waste but not all of this comes from the NPP operators. The other "polluters" are charged annually by the government for the anticipated costs of the bck-end.

- The external nature of the funds provides additional comfort that the accumulated resources will be available even if the operators run into financial difficulties.

The German FNWM is included in this cluster as the funding received by the FNWM for future waste management activities was provided by the nuclear operators. The Lithuanian Ignalina fund is included despite no ongoing contributions being received.

It is interesting to note that some countries (e.g. Germany, Netherlands and Romania) have chosen to establish separate funds for decommissioning and waste management/disposal whilst others are intending to cover both broad sets of costs from the same fund. In practice, there are arguments that can be made to support either approach and this is discussed in more detail in Section 5.

Cluster 2: Segregated external funds with contributions received from nuclear operators and other sources.

The table below shows the funds in this cluster as well as a high-level summary of the costs and facilities they are intended to cover and the legal owner of the fund:

Funds	Decommissioning costs?	Waste management costs?	Facilities in addition to commercial NPP's?	Legal owner	Risk profile analysed in Section 4?
Bulgaria (RAO Fund)	☒	✓	☒	State	☒
Bulgaria (IEYaS Fund)	✓	☒	☒	State	☒
Slovakia (NNF)	✓	✓	☒	NNF	✓
Spain (PGRR)	✓	✓	✓	State	✓

The Funds shown above are similar to those in the first cluster – the key difference is that they receive funding from sources other than the nuclear operators themselves (although in all cases the nuclear operators still provide in most cases the vast majority of funding). The funds in Bulgaria and Slovakia may receive funding directly from State budgets and historically have received funding from EU sources, which are wholly separate funds to the State funds. Spain relies on an electricity tariff to finance the costs of nuclear sites that ceased operations prior to 2010.

Cluster 3: Segregated internal funds with contributions received from nuclear operators only.

The table below shows the funds in this cluster as well as a high-level summary of the costs and facilities they are intended to cover and the legal owner of the fund:

Funds	Decommissioning costs?	Waste management costs?	Facilities in addition to commercial NPP's?	Legal owner	Risk profile analysed in Section 4?
Belgium (Synatom)	✓	✓	☒	Operator	✓
Czech Republic (CEZ blocked accounts)	✓	✓	☒	Operator	☒
France (Operators/ licensees)	✓	✓	✓	Operators/ licensees	✓

Unlike the first two clusters, these funds are not held in vehicles that are legally independent from the operators themselves. The funds are however notionally segregated from other general assets of the operators and can only be used for clearly defined purposes. In France, these funds are legally ring-fenced from the rest of an operator's balance sheet (even in the event of bankruptcy/insolvency of the operator) and the authorities can require an operator's parent company to finance the costs should the operator fail to do so. As a result, the funds in France are similarly aligned to the key points contained in the EU Waste Directives (see Appendix 3).

For France, this study considers the funds that have been established not only by the operator of its commercial Nuclear Power Plants (EDF) but also for its other nuclear licensees (Orano and CEA). This differs from the approach taken for other Member States where the primary focus is on commercial nuclear power plants only. The reason for adopting a different approach in France is largely due to the materiality of the funds (and associated liabilities) involved – only the UK would have similar levels of liability from other licensees but, unlike France, no separate funds exist in the UK (beside the NLF). Unless otherwise stated, all comments and analysis in this study reflect the combined position of EDF, Orano and CEA but exclude EDF's provisions for spent fuel management linked to the operating cycle.

It is not immediately clear whether the blocked accounts in the Czech Republic are legally ring-fenced in the case of operator insolvency. If this is not the case then arguably these are more similar to the German nuclear operators (the primary difference then being the nature of the backing balance sheet assets and potential differences in accounting treatment).

Although the blocked accounts in the Czech Republic are intended to cover decommissioning costs only, ČEZ, a. s. has established similar provisions for the storage of spent fuel and hence these are shown as covering both decommissioning and waste management costs in the table above.

Cluster 4: German nuclear operators.

German operators establish balance sheet provisions in respect of their future decommissioning liabilities. These balance sheet provisions are not backed by specific segregated assets and, together with the operators other liabilities, are covered by their general balance sheet assets. These provisions cannot therefore be regarded as funds in the same way as those included in clusters 1 and 2.

Funds	Decommissioning costs?	Waste management costs?	Facilities in addition to commercial NPP's?	Legal owner	Risk profile analysed in Section 4?
Germany (Operators)	✓	☒	☒	Operators	✓

Other cases

Funds	Decommissioning costs?	Waste management costs?	Facilities in addition to commercial NPP's?	Legal owner	Risk profile analysed in Section 4?
Bulgaria (KIDSF)	✓	☒	☒	EU	☒
Italy (Electricity Equalisation Fund)	✓	✓	✓	State	✓
Lithuania (IIDSF)	✓	✓	☒	EU	✓
Slovakia (BIDSF)	✓	✓	☒	EU	☒

Italy is unique in that funding for future decommissioning and waste management costs are predominantly provided from levies on the electricity price. Because of the legacy nature of Italy's nuclear programme and the fact that nuclear power plants were taken out of operation prematurely, it is not possible for the polluter pays principle to be applied. The decision was made to allocate costs of decommissioning and waste management to electricity rate payers rather than (future) taxpayers.

Furthermore, unlike the other funds shown above, the Electricity Equalisation Fund is unrestricted and can be used for purposes other than nuclear decommissioning and waste management.

Bulgaria (KIDSF), Lithuania (IIDSF) and Slovakia (BIDSF) historically received funding support from the EU to help meet the costs of decommissioning legacy facilities earlier than expected. No such support should be assumed in the future and therefore there is a need for the national governments to make sure adequate funding is available as and when needed.

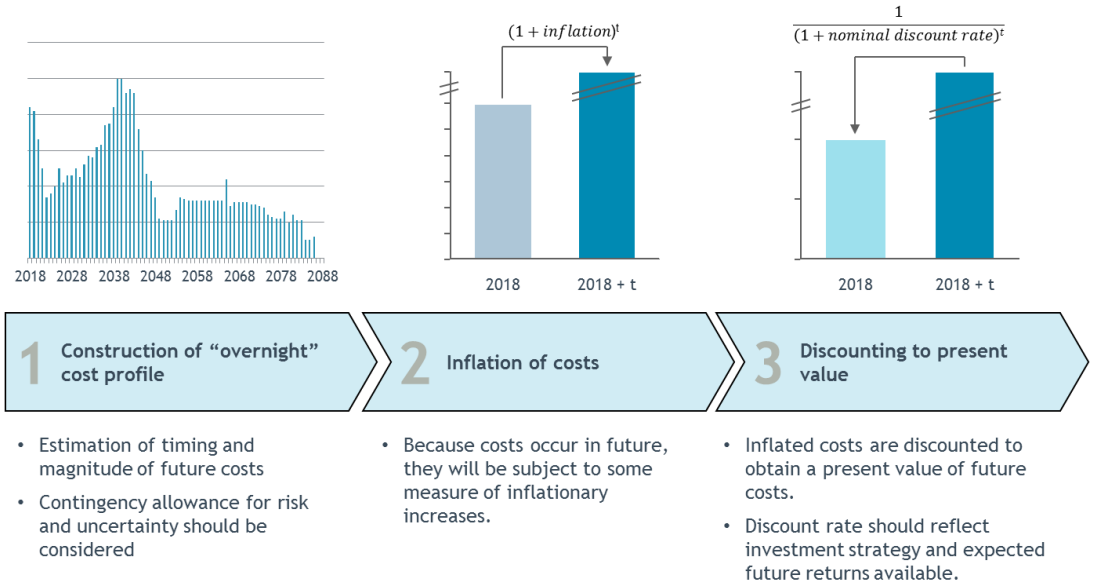
3. Understanding risk, the role of investments and asset-liability risk

3.1 Overview of funded decommissioning and waste management

To help provide context for a discussion of the risks inherent in funding for future decommissioning and waste management costs, a high-level illustration of the general principles involved has been provided.

The first step is to assess the underlying cost estimates themselves and to prepare a *liability cash flow profile* with all expected future costs on a *real (i.e. uninflated) basis*. Expected or projected inflation is then applied to this cash flow profile and the resulting inflated cash flow profile is then discounted to determine the liability. The selection of the appropriate *discount rate* is a complex process which must take into account the expected timeframe of the decommissioning and waste management costs, inflation expectations as well as the chosen investment strategy and the future investment returns expected to be achieved.

Assessing expected future costs and the present value of liability

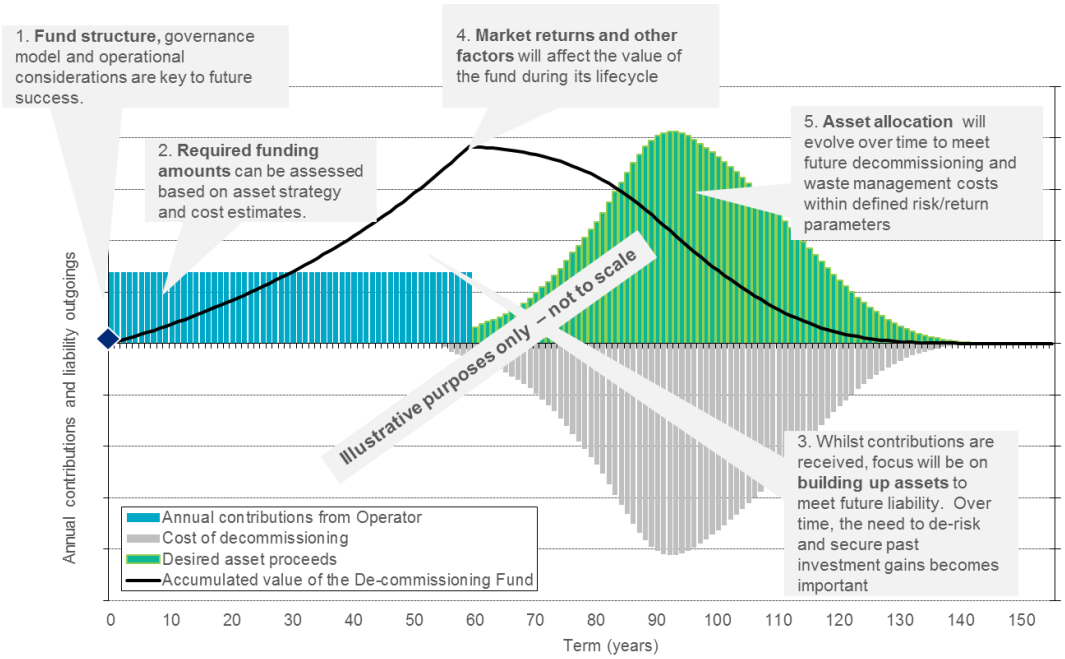


Developing an initial investment strategy and funding plan

The next consideration is *the accumulation of capital / financial assets* and the subsequent disbursements needed to meet future cash flows when they fall due.

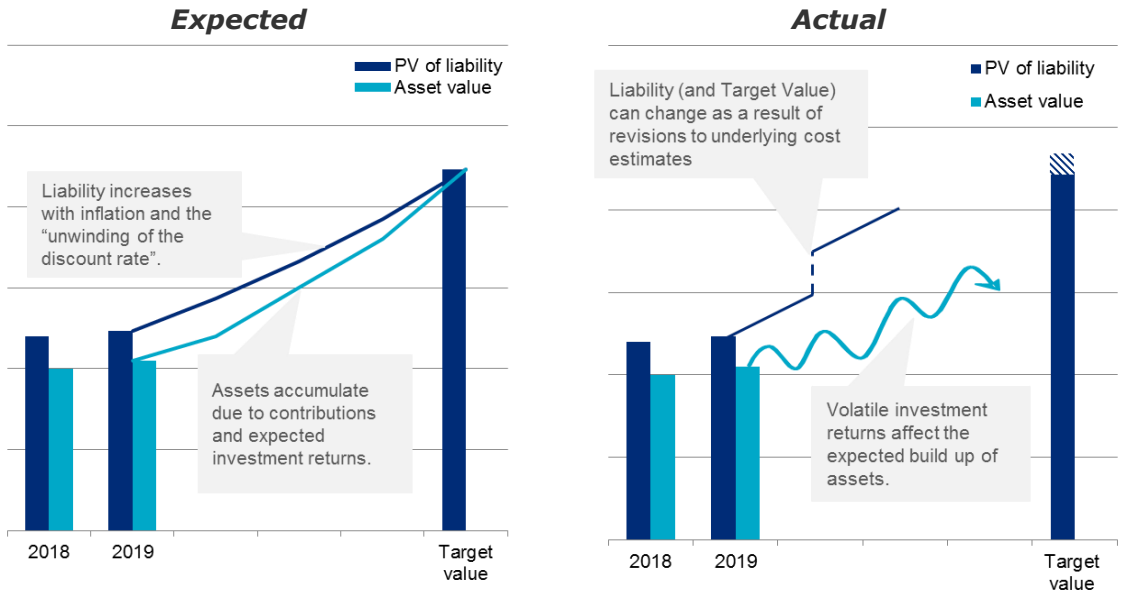
Operators typically make financial contributions during the years when their NPPs are in operation and these contributions are invested in financial assets. The level of *contributions* and the expected returns from the *investment strategy* should be set to give a reasonable level of confidence that future costs will be met. The relative balance between contributions and expected returns must reflect the operators' attitude towards risk and its ability to underwrite the risk of investment underperformance.

Generally speaking, the discount rate should not exceed the expected return from the investment strategy[12]. This helps avoid a situation where the liabilities will increase at a faster rate than the investments, resulting in funding shortfalls over time.



Allowing for actual experience over time

Finally, it is crucial to recognise that the performance of the invested financial assets, changes in the decommissioning and waste management costs and the need to update financial assumptions must continue to be monitored over time. Actual *long-term investment performance* may be fundamentally different from expected due to a number of factors. One measure that becomes instrumental in understanding the relative change in the value of assets and liabilities is the funding level: the ratio of assets to liabilities.



[12] Because there is, by definition, a 50% chance that actual returns will be less than expected, use of a discount rate lower than the expected return may be prudent.

3.2 Expected future decommissioning and waste management cost estimates

In order to analyse investment performance and risk for the funds set aside to meet the back-end activities of the nuclear fuel cycle, it is necessary to start by considering the expected future decommissioning and waste management costs that these funds have been set up to meet. It is also important to understand that these funds (and their legal owners) are liability driven investors. That is, their primary objective is to ensure, in so far as possible, that sufficient funds are available to meet defined future decommissioning and waste management costs as and when they occur (rather than, for example, to achieve a given percentage return each year). Risk might therefore be interpreted as anything that affects these funds' ability to meet this objective.

In order to achieve this objective, it is of course necessary to first identify exactly which costs will need to be met from a given fund and then to estimate both the magnitude and expected timing of these costs. To assist with this exercise, the OECD Nuclear Energy Agency ("NEA"), the International Atomic Energy Agency ("IAEA") and the EC developed the International Structure for Decommissioning Costing ("ISDC")[13]. The ISDC sets out the following 11 Principal Activities:

- Pre-decommissioning actions;
- Facility shutdown activities;
- Additional activities for safe enclosure or entombment;
- Dismantling activities within the controlled area;
- Waste processing, storage and disposal;
- Site infrastructure and operation;
- Conventional dismantling, demolition and site restoration;
- Project management, engineering and support;
- Research and development;
- Fuel and nuclear material;
- Miscellaneous expenditures.

These activities are divided into two further levels and the following four cost categories are defined at each level:

- Labour costs – payments to employees, payments to social security and health insurance according to national legislation and overheads;
- Capital/equipment/material costs;
- Expenses – consumables, spare parts, taxes etc.; and
- Contingencies – a specific provision for unforeseeable elements of costs within the defined project scope.

A similar reference structure for spent fuel and waste management costs outside decommissioning projects is not available.

Further commentary on specific decommissioning and waste management activities or the methods for estimating their expected future costs is beyond the scope of this study. For purposes of this study, it is sufficient to note that:

- Robust methods for identifying all future decommissioning and waste management costs and estimating their expected amount and timing are essential. Getting this right is perhaps the single biggest factor in ensuring that a given financing/funding system achieves its objective.
- Estimation of future decommissioning and waste management costs is challenging and complicated by a range of factors, including but not limited to:

[13] OECD/NEA, IAEA, EC, International Structure for Decommissioning Costing (ISDC) of Nuclear Installations (2012)

the long timescales involved, uncertainty regarding plans for final disposal of spent fuel and other high-level waste (including site selection), ongoing technical developments, labour market developments, regulatory changes and the wider political and economic landscape.

3.3 Operational risks and uncertainty

Decommissioning and waste management involves a large number of interrelated operational and financial risks. Operational risks include those associated with:

- Waste handling, processing, storage and disposal;
- Nuclear safety;
- Human resources and workforce planning/transition;
- Earlier than planned decommissioning;
- Regulatory and legislative change; and
- Maintenance, asset management and overall project management.

For known risks in several of these areas, it may be possible to assign or estimate the probability of occurrence. However, a decommissioning and waste management project is also likely to be exposed to a number of additional uncertainties, for which reliable probabilities cannot be determined.

Seeking to understand the potential impact of these risks and uncertainties on the expected future decommissioning and waste management costs is critically important as they can lead to material changes in both the amount and timing of expected future decommissioning and waste management costs.

Material revisions to future cost estimates can have a significant impact on the levies or contributions that may become payable to the established funds. In the extreme, or for example as a result of earlier than planned decommissioning, material changes to cost estimates could result in the established funds having insufficient resources to meet their future commitments, potentially placing an additional burden on Member States and taxpayers. This risk increases as the time to decommissioning draws nearer (although the ability to more accurately estimate future costs should also improve).

Consideration of the range of potential operational risks and uncertainties, the methods for assessing both their likelihood and financial impact as well as the appropriate means of allowing for them in future decommissioning and waste management cost estimates is beyond the scope of this study. However, we do note the following:

- Deterministic stress tests can be used to assess the potential impact on expected future costs should certain defined events occur.
- Scenario analysis can be used to extend the stress tests described above by allowing several (or indeed all) of the factors included in the stress tests to be considered together.
- Stochastic (or probabilistic) modelling techniques can be used to facilitate a better understanding of the potential for unexpected developments and what these might mean for future costs and financing/funding requirements.

3.4 Decommissioning and waste management cost inflation risk

Due to the long time periods involved in decommissioning and waste management, the considerable difficulties in estimating the expected future costs from these activities and because no published or official inflation index for nuclear decommissioning and waste management costs exists, it is usually the case that cost estimates are prepared in "real" terms. That is, cost estimates are prepared at a given calculation date without allowance for future cost inflation or discounting. The resulting cost estimates are sometimes referred to as "overnight costs" or costs calculated in, for example, "2018 money terms".

Although this is a reasonable approach, it does not diminish the need to understand the underlying drivers of inflation for the main decommissioning and waste management activities. This is because cost estimates prepared in this way will, by definition, increase over time in line with an appropriate measure of realised inflation. Failure to appreciate this can have a material impact on the risk of additional financing/funding requirements or future fund shortfalls.

Although some Member States (e.g. Germany, Sweden and the UK) have made explicit allowance for a specific decommissioning and waste management cost inflation assumption, in other Member States, it would appear that the implicit assumption being made is that decommissioning and waste management costs will increase in line with some official inflation index. Although this may be reasonable, it is not immediately clear that this is something that has been tested or received much attention in practice.

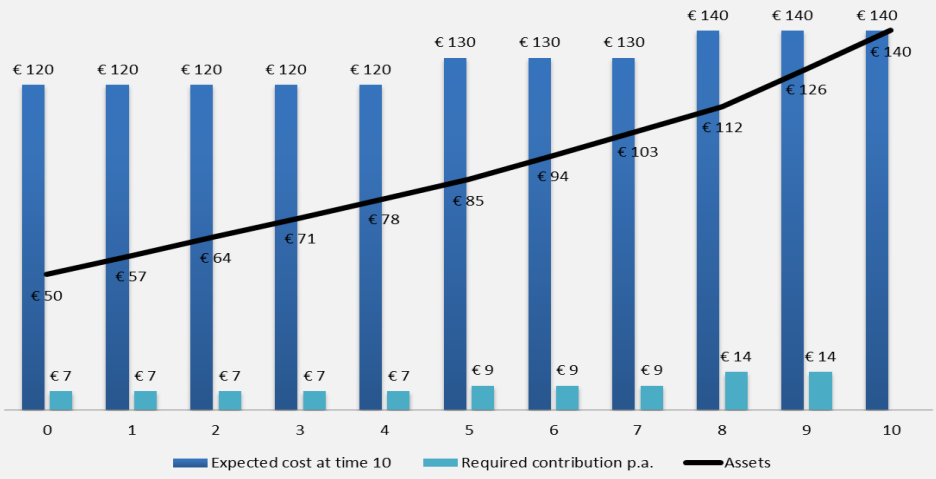
Illustrative example:

Consider the following simplified example:

- An amount of €100 in today's price levels is needed in 10 years' time to meet decommissioning and waste management costs occurring at this time.
- Current assets are equal to €50 (from previous contributions) and are held within a Treasury account and not invested (i.e. no investment returns)
- Expected cost inflation in each of the next 10 years is 2%; this indicates the total nominal cost in at the end of 10 years is expected to be approximately €120.
- Annual contributions of €7 are therefore needed and will accumulate with the current assets to €120 after 10 years' time.
- Reviews of the funding strategy will be carried out at the end of years 5 and 8.

Now, if we assume that the review at the end of year 5 reveals that actual inflation was actually 4% p.a. (or 2% p.a. higher than expected), we will need an amount of approximately €130 by year 10 (assuming that expectations for future inflation remain at 2% for the remaining 2 years). However, we will only have accumulated an amount of €85 (initial asset value of €50 with €7 p.a. contributions for 5 years) and therefore contributions of €9 will be required in each of the remaining 5 years.

Similarly, if the review at the end of year 8 reveals that actual inflation over the period was 4%, or 2% p.a. higher than expected, we will need an amount of approximately €140 at the end of year 10 (assuming that expectations for future inflation remain at 2%). However, we will only have accumulated an amount of €112 and therefore contributions of €14 will be required in each of the remaining 2 years. The required contributions in the final 2 years are twice as high as originally expected. This is illustrated in the chart below.



There are several factors that could result in divergences between nuclear decommissioning and waste management cost inflation and standard inflation measures like CPI, most notably:

- Regulatory costs associated with the need to comply with evolving safety standards and the use of latest available technologies.
- Labour costs due to the specialised nature of certain decommissioning and waste management tasks.

At the same time, there could be factors that result in lower future costs, e.g. decommissioning economies of scale. These should be reflected in the base cost estimates.

Even where an explicit and specific assumption has been made for future decommissioning and waste management cost inflation, the risk that actual, realised inflation could differ remains, with similar implications for future financing/funding requirements.

3.5 Liability discount rate risk

The above points on cost inflation risk are closely related to the issue of discount rate risk.

As mentioned in the introduction it is typical to convert a series of expected future decommissioning and waste management costs into a present value of liability. This is done by discounting future cost estimates to the current date using a given discount rate. The present value of future decommissioning and waste management costs might be calculated for a number of reasons, including:

- To obtain a "Target Value" for segregated fund assets such that if this value of assets were held today, one would expect them to be sufficient to meet all future decommissioning and waste management costs;
- To compare the market value of investments currently held in a segregated fund against such a "Target Value" to determine the adequacy/sufficiency of current investments;
- For purposes of determining future contribution or funding requirements.

Discounting reflects the time value of money – i.e. the fact that investments are expected to generate investment returns over time. The discount rate should therefore reflect the expected future returns from the fund's investment strategy.

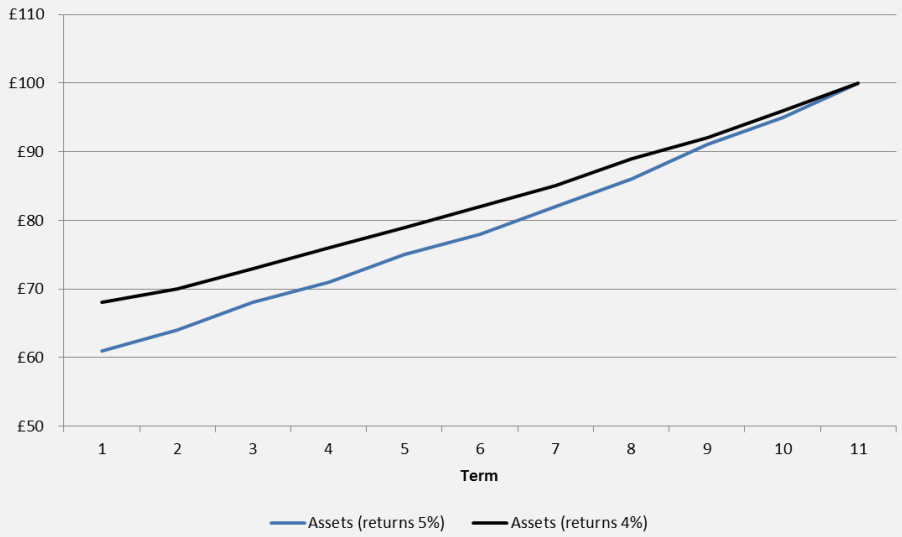
Illustrative example:

Again, this can be illustrated using a simplified example:

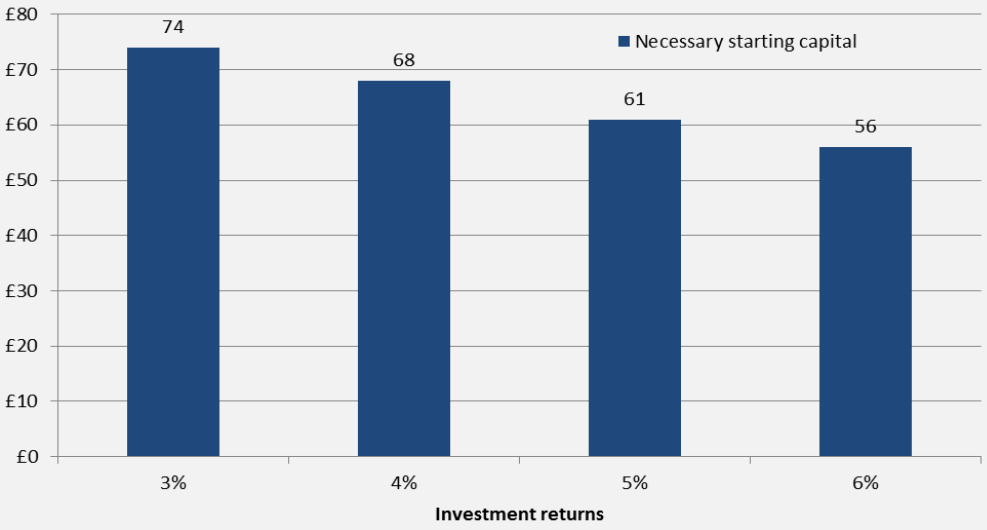
- An amount of 100 is needed after 10 years to meet decommissioning and waste management costs occurring at this time.
- We can invest in a risk-free investment that offers a return of 5% p.a. over the full 10 year period.

If we held an amount of 61.4 in this investment today, it would be expected to grow to 100 after 10 years. Viewed another way, we can say that the present value of our future liability is equal to 61.4 using a discount rate of 5% p.a.

To illustrate the concept of discount rate risk, assume that immediately **before** we were able to make this investment, the return available decreased to 4% p.a. for the 10 year period. This means that we would now need to invest 67.5 to be certain of meeting our future liability. The increase in required capital of 6.1 in this example is due to the decrease in available future returns and represents a crystallisation of discount rate risk.



Discount rate risk is the risk that changes in discount rate (or expected future investment returns) lead to changes in the present value of future decommissioning and waste management costs, which in turn lead to increases in future funding requirements. Discount rate risk may also be thought of as the sensitivity of the present value of future decommissioning and waste management costs to changes in interest rates. It is worth noting that the longer the period over which cash flows occur, the more sensitive the present value is to changes in interest rates.



Where "overnight" cost estimates are prepared without an explicit inflation assumption, it is common to subsequently use a real discount rate to convert these into a present value. That is, the discount rate is defined as the additional expected investment return over (implicitly) assumed future inflation. Whilst this is a reasonable approach, it does not diminish the need to keep the real discount rate under review and ensure it remains appropriate. This is because future returns from all investments are not perfectly correlated with future inflation expectations. Failure to appreciate this can have a material impact on the risk of additional financing/funding requirements or future fund shortfalls.

Aside from revisions to the future decommissioning and waste management costs themselves, discount rate risk can often have the biggest impact on required future

funding/financing. It is therefore vital that the methodology used to set the discount rate is appropriate and fully understood by all relevant stakeholders.

3.6 Investment related risks

As explained above, the funds set up to meet future decommissioning and waste management costs (and their legal owners) are liability driven investors. In order to meet their future obligations in a cost-effective manner, these funds purchase a variety of different investments in the hope of generating income or capital gains.

There are a number of different investment opportunities but the main types include:

- *Public equities:* Represents ownership shares in a public corporation. Returns come from dividends and/or appreciation in the value of the stock price.
- *Fixed income:* An investment that represents either government or corporate debt. Returns typically come from a consistent stream of regular income (coupons) as well as final repayment of the debt at the end of its agreed term.
- *Alternatives:* A broad category of investments including real estate, hedge funds, private market investments and commodities.

Investing in the pursuit of returns brings with it a number of different risks, the most important of which are summarised below:

- *Market risk:* This is the risk of falls in the market value of equity and alternative investments and may be caused by a wide range of factors.
- *Interest rate risk:* If interest rates rise, bond prices usually decline and vice versa. The risk exists because, if interest rates rise, new bonds are likely to be issued with higher yields, making the old or outstanding bonds less attractive. The longer a bond's maturity, the greater the impact a change in interest rates can have on its price.
- *Inflation risk:* This is the risk that, although coupons/redemption payments are received from fixed-income bonds as expected, higher than expected inflation means that these are worth less in real terms than expected.
- *Credit risk:* Fixed income investments carry the risk of default, which means that the issuer fails to make agreed income and principal payments.
- *Reinvestment risk:* During periods of declining interest rates, fixed income investors may be forced to buy new bonds at lower prevailing interest rates (i.e. higher prices). Viewed another way, this is the risk that when income is received there is a lack of attractive options for re-investing the income.
- *Liquidity risk:* This is the risk that an investment cannot be converted into cash on attractive terms as and when required.
- *Currency risk:* This is the risk that income or capital gains received in a foreign currency are worth less when converted into the currency of future decommissioning and waste management costs due to adverse exchange rate movements.

Special considerations apply when the investments backing future liabilities are represented by the general operating assets of a single entity (e.g. German utility balance sheet provisions) or where loans back to the operator are possible (e.g. Belgium or Finland).

3.7 Asset-Liability Management, Risk and Liability Driven Investment

From the above, it is clear that there are important risks associated with both the future decommissioning and waste management costs (or equally, their present value), i.e. the "liabilities", and the investments held to meet these costs, i.e. the "assets". Any meaningful assessment of risk must consider all of these individual risks in a consistent framework. This is known as asset-liability management ("ALM").

Illustrative example:

Consider a simplified example:

- An amount of 100 is needed after 10 years to meet decommissioning and waste management costs occurring at this time.
- It is possible to invest in a risk-free bond that offers a return of 5% p.a. over the full 10 year period.
- As above, the present value of our future liability is equal to 61.4 using a discount rate of 5% p.a.

Assume that 61.4 is available and that this is invested in the risk-free bond. Now assume that immediately **after** this investment was made, the return available on this bond decreased to 4% p.a. This would mean that:

- The present value of the liability would increase to 67.5 (as above).
- The value of the bond would also increase to 67.5 because, as explained above, bond prices are inversely correlated to bond yields.
- Therefore, there is no change in the net position and an asset is held that is still expected to deliver the required amount of 100 in 10 years' time.

Now, instead of investing the full amount in the risk-free bond assume that half of this amount is invested in the risk-free bond and the other half in equities. Furthermore, assume that equities are expected to deliver returns of 1% p.a. above the return from the risk free bond. This would mean that:

- The applicable discount rate to use would now be higher to reflect the higher expected return on our investment. In this case, the resulting discount rate would be 5.5% p.a.
- The present value of the liability would therefore decrease to 58.5.
- In this case, an overfunded position would result as the value of investments (61.4) exceeds the present value of liability (58.5). The surplus is 2.9 and the funding level is 105%

Now assume that immediately **after** this investment was made that the return available on the risk-free bond decreased to 4% p.a. This would mean that:

- The applicable discount rate would reduce to 4.5%.
- The present value of liability would increase to 64.3.
- The value of the bond would increase, in this case from 30.7 to 33.7 but the value of equities would remain unchanged at 30.7. Therefore total investments are worth 64.4
- The value of the surplus has now reduced to 0.1 and the funding level to 100%.

So, when viewed in an ALM context, it is the net impact that is important. In the example above a fall in interest rates, which has a positive impact on fixed-income bond prices, results in a deterioration in funding level because the change in interest rates has a bigger impact on the present value of liabilities than on the value of investments.

3.8 Risk metrics and assessment

Having explained the concept of asset-liability risk, it is now necessary to define some of the key metrics and methodologies that will be used in Section 4 to assess the risk profile of the funds set aside to finance the back-end activities of the nuclear fuel cycle.

Expected returns and discount rate

As discussed above, it is crucial to determine a real discount rate for calculating a liability value and this real discount rate should be determined in light of the investment returns reasonably expected to be achieved in future. Furthermore:

- The construction of the discount rate should be clear and based on actual market variables (e.g. inflation and interest rates) with a term appropriate to the underlying liabilities.
- It is important to understand what would happen to the liability value should interest rates and/or inflation expectations change.
- The expected returns on different asset classes should be realistic and consistent. Shocks to the value of certain asset classes (for example a fall in equity values) can require significant changes in the long-term strategy.
- Financial asset performance needs to be maintained over time and actual (rather than expected) returns have to be monitored and compared with expectations.

In deriving a real discount rate appropriate for decommissioning and waste management liabilities with very long-duration (see below), the following points should be considered:

- Assessment of the assumed rate of future cost inflation should be seen as a pre-requisite for setting the discount rate.
- The assumed rate of future cost inflation should reflect the underlying term of the liabilities. That is, for cash flows expected to occur in the short-term, short-term inflation expectations may be relevant whilst for cash flows expected to occur in the long-term, a longer-term estimate of future inflation is needed.
- Objective inflation expectations across the full maturity spectrum can be derived by considering the difference between the yields on fixed-income government bonds and the yields on inflation-linked government bonds. In addition, long-term economic forecasts from reliable providers or explicit inflation targets from central banks should be considered.
- The real discount rate over inflation should then reflect the expected returns available on the investments held. Models for these expected returns are therefore required and must again take account of the underlying term of the liabilities. A common modelling approach is to set assumptions for the level of expected long-term outperformance of different asset classes over the returns available from fixed-income government bonds (i.e. over the fixed-income government bond yield curve). Because the fixed-income government bond yield curve has a term structure, expected nominal returns from assets over different periods of time will differ.
- Use of such a market-consistent approach implies that both the assumed rate of future inflation and the real discount rate should change in response to changes in either the level or shape of either the fixed-income or index-linked government bond yield curve. This creates a need to regularly monitor these variables to ensure that funding assumptions remain relevant.

Funding level

Changes in the relative value of assets and liabilities can impact a fund's ability to achieve its long-term objectives. It is therefore important to:

- Monitor the progression of the funding level over time (e.g. on a quarterly or semi-annual basis) and understand the reasons behind departures from expectation.
- Assess if any deviation from the long-term investment objectives is temporary or if it requires adjustments to contributions and/or the investment strategy.

Duration

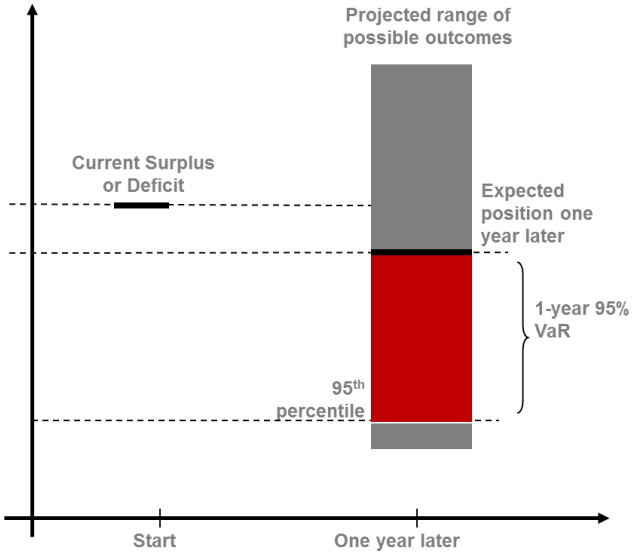
Duration is the cash flow weighted average time (in years) until a bond is repaid. Duration therefore allows one to measure how much a bond price, or the present value of future liabilities, will change when interest rates change. It is important to note that:

- Duration provides a measure for assessing interest-rate risk. The higher the duration of a bond (or present value of future liabilities), the more the bond price (or value of liabilities) will increase/decrease in response to a fall/rise in interest rates.
- When considering bonds, low (or short) duration can mean less than 3 years whilst high (or long) duration might mean anything above 8-12 years.
- In contrast, a present value of future decommissioning and waste management costs will often have a very long duration due to the long timescales involved.
- The governments of Ireland, Belgium and Austria have issued 100 year bonds with long durations, e.g. the Austrian bond has duration of c.44 years.

In practice, the fact that it is usually not possible to invest in bonds with the same duration as the decommissioning and waste management liabilities is a key source of net interest rate risk.

Value at Risk

A very useful metric for assessing the level of asset-liability risk is Value at Risk ("VaR"). This is a probabilistic assessment of the minimum increase in deficit (or reduction in surplus) that might be expected to occur over a given period of time with a given level of confidence. A commonly used measure is the 1-year 95% VaR, which quantifies the difference between the mean and the 95th percentile projected surplus/(deficit) over a 1 year time horizon. This is illustrated in the graphic below:



Using VaR as a risk indicator:

- Provides an indication of the overall level of risk to which a decommissioning and waste management fund is exposed.
- Allows quantification of the potential financial loss in unfavourable conditions and, therefore, quantification of the additional future funding/financing that could be required following a significant downside event.
- Allows identification and quantification of the contribution of each asset class (or risk factor) to the total VaR.

The table below provides an indication of how different factors generally affect the VaR:

	Impact on VaR
Deterioration in funding level	Increase
Increased difference in duration between liabilities and bond portfolio	Increase
Increase in allocation to liability matching bond or derivative assets	Decrease
Increase in duration of bond portfolio to better match liability duration	Decrease
Increase in allocation to growth assets (equities and alternatives)	Increase
Increase in allocation to assets with inflation linkage	Decrease
Use of higher volatility assumptions	Increase
Use of higher correlation assumptions	Increase

4. Funding and investment risk profile of the funds allocated to the back-end activities of the nuclear fuel cycle in relevant EU Member States

4.1 Introduction

This section provides an overview and comparison of the risk profiles and investment strategies of the funds allocated to the back-end activities of the nuclear fuel cycle in the different EU Member States. It is a summary of the more detailed individual country analyses that are contained in Annex 2, which also includes past investment performance data where this was available.

When comparing different Member States' funding levels and investment strategies it must be borne in mind that differences in approach and the resulting risk profile may be due to a number of factors, including:

- Methods and assumptions for cost estimates and resulting future liabilities.
- Back-end management strategies (e.g. reprocessing versus direct disposal)
- Cost incurred to date (e.g. for progress made in waste treatment, storage, and disposal) versus future cost.
- Differences in intended contribution profiles.

A full evaluation of such differences and their implications is beyond the scope of this study.

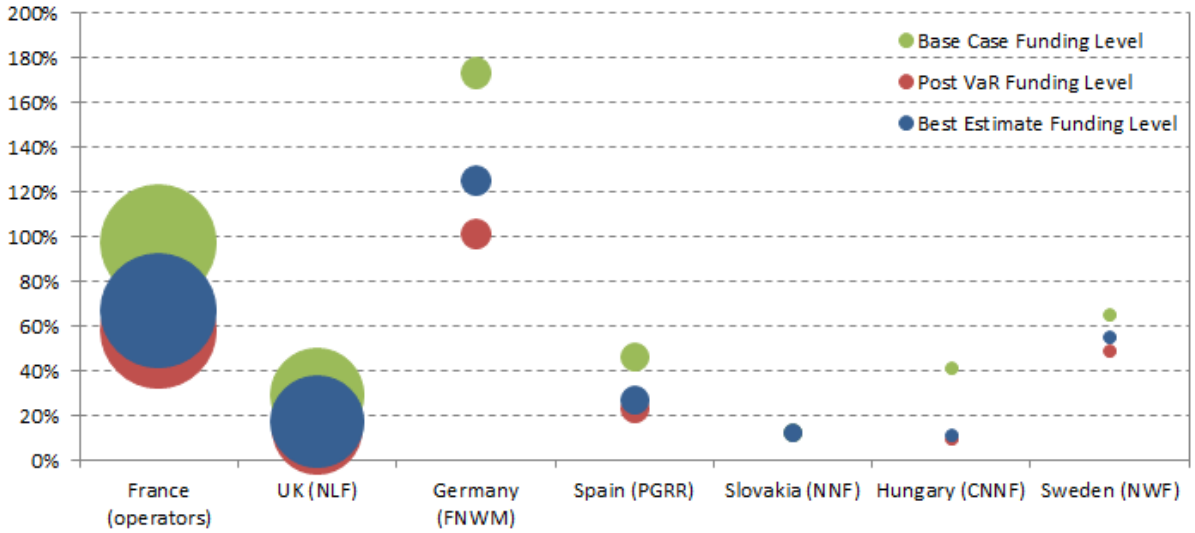
4.2 Overview and high-level assessment of funding and investment related risks in several key Member States

The focus of this section is on those Member States that have set aside investment funds to meet future decommissioning and waste management costs and where sufficient data was provided to carry out a meaningful analysis, namely: France, Germany (FNWM), Hungary, Slovakia, Spain, Sweden and the UK.

To help achieve consistency, objectivity and comparability, a standard approach has been adopted for analysing funding and investment risk in these Member States. More detail is provided in Annex 2 but this standard approach essentially involves:

- Assessment of the ratio of each fund's assets to the calculated value of its liabilities (i.e. the funding level), using the financial assumptions currently adopted by the Member State. The liability so calculated is referred to as the "base case liability" and the resulting funding level as the "base case funding level".
- Assessment of how the funding level would change if the liability were instead calculated using a market-consistent discount rate based on the expected future return on investments and a long-term expected future inflation assumption (the calculation of this parameter requires the use of some assumptions). The liability so calculated is referred to as the "best estimate liability" and the resulting funding level as the "best estimate funding level".
- Assessment of how the funding level might then be expected to change following a material downside economic and financial market event, the severity of which might be expected to occur once in every 20 years. The resulting funding level is referred to as the "post VaR funding level".

The charts and table below summarise the key outputs from this analysis. The sizes of the bubbles in the first chart indicate the relative size of the best estimate liabilities in these Member States. All figures contained in the table have been taken from the relevant country section of Annex 2.



	France (operators)[14]	UK (NLF)	Germany (FNWM)	Spain (PGRR)	Slovakia (NNF)	Hungary (CNFF)	Sweden (NWF)
Asset value (€m)	45,300	10,973	24,148	5,018	1,399	910	6,839
Base case liability value (€m)	46,600	38,289	13,946	10,971	11,537	2,205	10,522
Base case funding level	97%	29%	173%	46%	12%	41%	65%
Base case nominal discount rate	4.2%	3.2%	4.6%	3.5%	1.1%	4.4%	3.3%
Best estimate liability value (€m)	67,310	63,621	19,400	18,713	11,537	7,983	12,328
Best estimate funding level	67%	17%	125%	27%	12%	11%	55%
"Best Estimate" nominal discount rate	2.7%	2.2%	3.5%	1.4%	1.1%	0.9%	2.4%
Assumed inflation rate	1.6% (Member State assumption)	4% (Member State: RPI of 3% plus 1% for nuclear specific inflation)	3.57% (Member State: 1.6% plus 1.97% for nuclear specific inflation)	2% (Assumption based on long-term ECB target)	2% (Member State assumption)	2% (Assumption based on long-term ECB target)	1.8% (Author's' estimate based on long-term consensus forecasts)
Sovereign bonds and cash	20%	79%	Assumed 20%	76%	100%	100%	40%
Duration[15]	24	55	33	30	35	43	19

Asset values, base case nominal discount rate and sovereign bonds and cash allocations were provided by each individual Member State. The rest of the data in the table above have been estimated by the author.

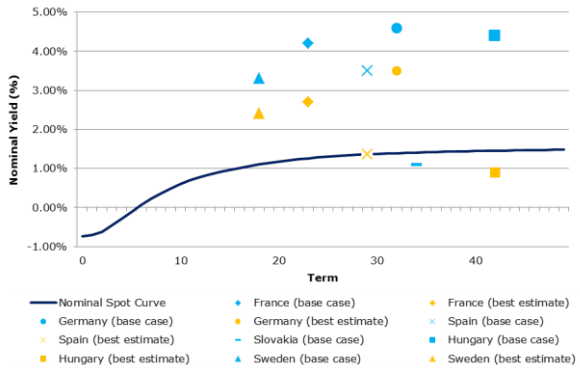
[14] Figures shown reflect the combined position for EDF, Orano and CEA but exclude EDF's provisions for spent fuel reprocessing linked to the operating cycle. This is the case unless stated otherwise.

[15] Duration is the cash flow weighted average time (in years) until a bond is repaid. Duration therefore allows one to measure how much a bond price, or the present value of future liabilities, will change when interest rates change. For more information, please refer to section 3.8.

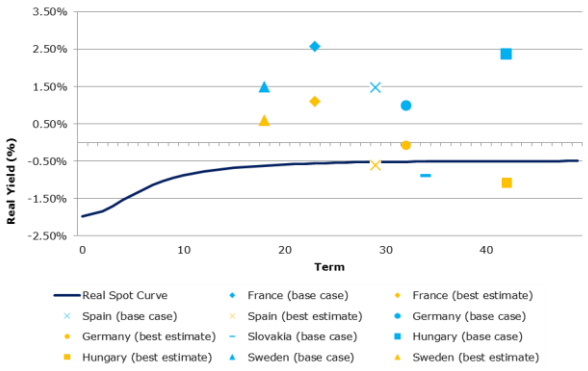
Comparison of discount rates and inflation assumptions with prevailing government bond yields (as at 30 September 2017):

Eurozone (incl. Sweden & Hungary)

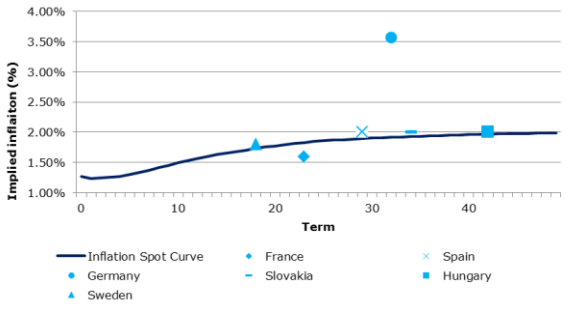
Nominal yields / discount rates



Real yields / discount rates

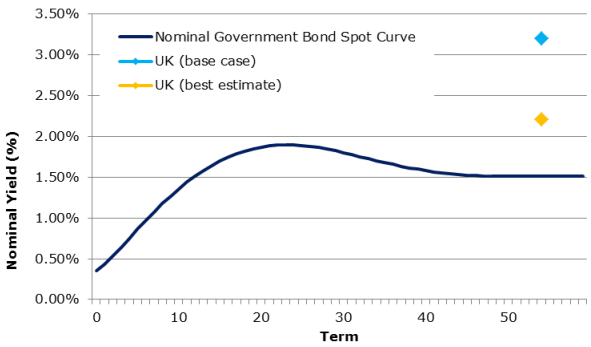


Implied inflation

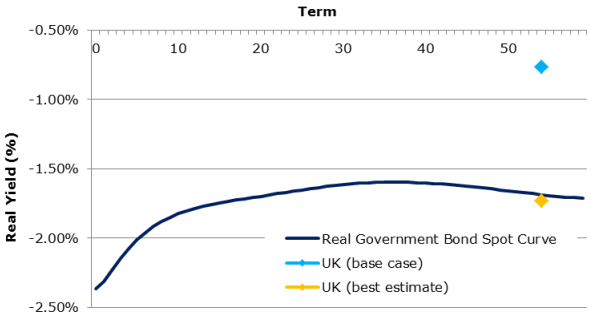


UK

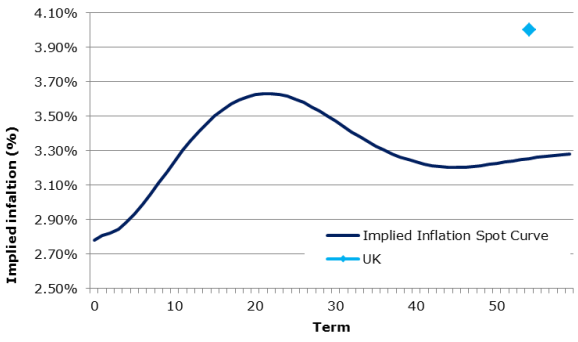
Nominal yields / discount rates



Real yields / discount rates



Implied inflation



Before considering these results in more detail, the following important points must be noted:

- Although a funding level less than 100% may at first appear concerning, this is not necessarily the case. Full funding is, in theory, only required at the end of all nuclear activities or the termination of contributions to the fund. For example, a nuclear facility that has operated for, say, 30 years of an intended 60 year operating life would not need to (or be expected to) have achieved full funding and, depending on the way in which future contributions are structured, might more reasonably be expected to have a funding level of c.50%.

- It is important to focus on the difference between the best estimate liability value and the base case liability value (and the corresponding funding levels) as this quantifies the amount of additional financing required which might not expected to be covered by existing funding and investment arrangements.
- The "best estimate" discount rates have been set such that a fund's investments have an equal (50%) probability of exceeding or underperforming the discount rate. This means that two funds with different investment strategies (even if they have the same future costs to meet) will have different best estimate discount rates and hence best estimate liabilities.
- Where a Member State has disclosed a specific inflation assumption, this has been used without adjustment. Where no assumption was disclosed (i.e. Spain and Hungary), a simplifying assumption of 2% to reflect the ECB's long-term inflation assumption has been used. For Sweden, a simplifying assumption of 1.8% based on long-term consensus forecasts has been used as an approximation to its detailed, nuclear specific inflation calculation.
- It is recognised that the use of different inflation assumptions for different Member States introduces an apparent element of inconsistency. This is primarily the result of the inclusion of a specific assumption for nuclear related inflation over and above general market inflation (e.g. in the UK and Germany) and this issue is discussed in detail in the following section. To the extent the inflation assumptions for Spain, Slovakia, Hungary and the French licensees (EDF, Orano and CEA) are understated due to the exclusion of a specific nuclear related inflation component, the resulting best estimate liabilities may be understated (and therefore the best estimate funding levels may be overstated). Further assessment of this point is beyond the scope of this study.
- The UK inflation assumption is also based on Retail Price Inflation as indicated by the Member State, whereas Eurozone inflation is based on Consumer Price Inflation.
- The difference between the base case funding level and the post-VaR funding level provides an indication of the level of exposure to the different risks presented in the previous Section.

Assessment of the adequacy of existing financial resources

Considering for the moment only the base case liabilities and base case funding levels shown in the chart and table above, and assuming that the base case liabilities are solid estimates, it is apparent that:

- The combined position of EDF, Orano and CEA in France appears to be well funded.
- The UK, Spain, Slovakia and Hungary appear to be less well funded with funding levels of 29%, 46%, 12% and 41% respectively.
- Sweden's funding level is slightly higher at 65%. This Member State also has the shortest liability duration (at 19).
- The German FNWM appears to be overfunded since it includes a risk premium on top of the base case liability.

French nuclear operators are required by law to make a prudent assessment of the costs of decommissioning and waste management and to ensure that the discounted present value of these costs is covered by a portfolio of dedicated assets (i.e. to demonstrate a funding level of 100%)[16]. However, this requirement does not extend to spent fuel reprocessing costs linked to the operating cycle. These spent fuel reprocessing costs (c. €10.3bn) are expected to be met by EDF from ongoing operational revenues and have not been included in the table above.

[16] No dedicated assets can be returned to operators if the funding level is below 110%.

In Sweden, the existence of additional financial guarantees from the nuclear operators provide some security that future decommissioning and waste management costs will be met as and when required.

The apparent low funding levels for the UK, Spain, Slovakia and Hungary imply that additional funding contributions and/or changes in investment strategy will be required in order to ensure sufficient funds are accumulated and available to meet future decommissioning and waste management costs. As stated above, a funding level of 100% is not necessarily required until the later of cessation of all nuclear activities or cessation of contributions to these funds and, as explained in Annex 1, funding arrangements exist in these countries to achieve a fully funded position when required, albeit not necessarily from the original operator.

The asset value used for the German FNWM in this study of €24.1bn reflects the amount that was transferred to the FNWM in July 2017, which included a risk premium of c.35% over the total value of the expected future costs. The base case liability value of €13.9bn has been calculated using assumptions that were set in 2014 – most notably, a discount rate assumption of 4.58% p.a. which is materially above current market yields. The high base case funding level reflects both the risk premium and the use of a relatively high discount rate of 4.58%.

Market-consistent assessment of the adequacy of existing financial resources

The real discount rates currently adopted by all of these Member States are not wholly consistent with current (2018) market conditions or the future investment returns that might reasonably be expected from their investment portfolios. Use of unrealistically high discount rates will understate liabilities for future decommissioning and waste management and the corresponding amount of funding required.

In particular, the following points should be noted:

- Both France (i.e. each of EDF, Orano and CEA) and Hungary make use of a smoothed discount rate[17]. This serves to reduce the level of volatility in the assessed liabilities and future funding requirements. However, given the significant falls in interest rates and government bond yields (at all maturity points) in recent years, a smoothed discount rate is unlikely to be wholly reflective of current market conditions. This suggests that liabilities for future decommissioning and waste management (and hence required funding amounts) are likely to increase over time as the effect of these lower market yields are given greater weight in the calculation (even if all else remains unchanged).
- Sweden currently makes use of an Ultimate Forward Rate ("UFR") of 4.2% in the calculation of the base case liability. However, reflecting the significant falls in long-term interest rates at all maturity points in recent years (and lower expectations for future interest rates), the UFR is set to decrease in future, and hence the present value of the liability will continue to increase (all else remaining equal).
- The German FNWM base case discount rate of 4.58% was set in 2014 and is materially above current German bond yields. As a result of sustained falls in interest rates at all maturity points in recent years, this discount rate is unlikely to remain appropriate. No information has been received from the FNWM regarding how the discount rate may have changed since 2014.

Using Mercer's Capital Market Assumptions[18], the expected investment returns on the assets held by the funds in these Member States have been determined.

[17] Smoothed discount rate is calculated as the rolling 10 year average of the yields on French OAT 2055 bonds, to which the spread of A to AA rated corporate bonds is added, subject to a regulatory cap. For Hungary this is determined as the 15 year average of the Central Bank Base Rate less inflation.
[18] The specific modelling assumptions used are contained in Appendix 4.

The German FNWM is currently in the process of investing its assets and determining its investment strategy. Although it is not yet final, public statements[19] suggest that the FNWM's may follow a diversified investment strategy along the following lines:

- 10% "safe, liquid fixed income to finance payments in the first few years";
- 60% Global Equity and Fixed Income;
- 30% Alternatives like Infrastructure, Real Estate and Private Equity.

The expected investment return on the strategy above has again been determined using Mercer's Capital Market Assumptions as set out in Annex 2.

Using these expected returns as the best estimate discount rates, together with the inflation assumptions shown in the table above, the best estimate liabilities and corresponding best estimate funding levels have been determined.

For the German FNWM, the best estimate funding level is c.125% - primarily due to the risk premium mentioned above. Even following a material downside risk event, the funding level is still above 100%. This would tend to suggest that the FNWM's expected asset allocation is appropriate given its future liability profile and that due account has been taken of the resulting risk exposure.

In the other Member States, it is the differences between the base case liabilities and best estimate liabilities that are expected to give rise to additional funding requirements over time (over and above those already committed). Recognising the need for this additional funding (and/or required changes in investment strategy) and identifying the appropriate way of collecting it is critically important.

Investment strategy considerations

The UK, Spain, Slovakia and Hungary all hold more than 75% of their investments in government bonds and/or short-dated money market instruments. As will be explained in more detail in Section 5, these assets are not necessarily "risk-free" when viewed from an asset-liability perspective.

Falls in interest rates and government bond yields across all maturity points in recent years have contributed to strong investment performance (see Annex 2) but this is unlikely to be the case going forward and these assets currently provide very low yields – indeed, many of these assets currently provide yields lower than expected future inflation. Without changes to investment strategy, this places a greater reliance on cash funding in order to meet future decommissioning and waste management obligations. Slovakia, for example, has noted the need to generate higher levels of investment returns in future to meet future decommissioning and waste management costs.

From a risk management perspective, it is also questionable whether investment portfolios with such material government bond holdings are sufficiently well diversified.

The combined French operator funds (i.e. for EDF, Orano and CEA) in contrast hold more diversified portfolios and invest in a number of additional asset classes. From the end of 2017, the Swedish NWF may also invest its assets in equities and corporate bonds, with certain limitations. This is largely due to appeals by the NWF to permit investment in a wider range of assets in recognition of the low yield environment and the points set out above.

[19] See for example: https://www.private-banking-magazin.de/24-milliarden-euro-vermoegen-atomfonds-chefin-benennt-anlagestrategie/ or http://www.manager-magazin.de/magazin/artikel/atomfonds-was-mit-dem-geld-von-eon-und-rwe-passieren-soll-a-1197237.html

Assessment of asset-liability risk

For the Member States discussed above, the primary risk exposure is to interest rates and inflation and the effect they have on the assessed liabilities. Although holdings of government bonds (and similar interest rate sensitive assets) provide some degree of protection, the risk exposure is significant because:

- Other than the German FNWM, the funds are underfunded on a best estimate basis.
- The liabilities have considerably longer duration than the government bonds currently held and hence their value will change by a greater amount following a change in interest rates or inflation.

Holdings of other asset classes (like equities and alternatives) create additional risk exposures although they do also offer diversification benefits and the prospect of higher future investment returns. These holdings lead to bigger differences between the best estimate funding level and the post-VaR funding level for the German FNWM and the Swedish NWF than the other Member States.

4.3 Non-standard risks in other EU Member States

In Belgium, Croatia, Finland, Italy and Lithuania as well as for the German nuclear operators, the specific nature of the funding/financing arrangements (or the available data) are such that the approach set out in section 4.2 would be of little relevance. This section therefore contains some high-level commentary on the key risk issues in these Member States.

Credit risk and concentration risk

Despite having established segregated funds to meet the future costs of decommissioning and waste management, both Belgium and Finland are notable in that these funds[20] are permitted to issue significant loans (75% of the assessed liability) to the nuclear operators who are responsible for providing financing to these funds to meet future decommissioning and waste management costs.

It could be debatable whether the ability of the nuclear operators in these countries to borrow funds that should be set aside to meet future decommissioning and waste management costs is consistent with the requirement to accumulate adequate financial resources in advance.

In both cases, the primary risk is the credit risk exposure these funds have to the nuclear operators. Assessment of this risk ultimately depends on the commercial terms of these loans (including the manner and extent to which they are secured against other assets and how often this is reassessed), where in the nuclear operators' capital structure these loans rank and whether recourse extends to their parent companies or other group companies. Analysis of these points is not possible from the data and information received and would, in any case, be beyond the scope of this study. It is noted that this level of "self-investment" would be questioned for other institutional investors.

The size of these loans relative to these funds' other investments also results in a significant concentration of risk to entities all operating in the same sector.

Unfunded liabilities and reliance on general balance sheet assets

German nuclear operators retain provisions on their balance sheets for the future costs of decommissioning (waste management/disposal costs being met from the separate FNWM). These provisions are not backed by earmarked investments and are instead covered by the general balance sheet assets of the operators.

[20] Synatom in Belgium (segregated internal fund) and the NWMF in Finland (segregated external fund).

To determine the value of these balance sheet provisions, the three largest NPP's use real discount rates of approximately -1% p.a. The underlying nominal discount rates are generally consistent with long-dated government bond yields whilst the expected future inflation assumptions are all below the long-term ECB target of 2% p.a. It is interesting to note that the German operators do not make use of a nuclear specific inflation assumption in the same way as the FNWM, primarily because the operators are required to meet the costs of decommissioning only and these costs are expected to occur in a relatively short period over the foreseeable future (unlike the FNWM which is intended to cover long-term future waste management costs). Were this the case, the resulting balance sheet provisions would most likely increase.

The table below compares the market capitalisation of these operators with their decommissioning provisions at 31 December 2017 to give a broad indication of the materiality of the potential credit risk involved. For all three of the largest NPPs, nuclear provisions constitute more than 50% of market capitalisation.

NPP	Decommissioning provisions 31 December 2017 (€ million)	Market Capitalisation 31 December 2017 (€ million)	Provisions as % of Market Cap
RWE AG	6,005	9,788.3	61%
E.ON SE	10,455	19,636.5	53%
EnBW Energie Baden Württemberg AG	5,803	7,793.9	74%
Vattenfall GmbH	3,461	N/A	N/A
Stadtwerke München GmbH	775	N/A*	N/A

Source: Bloomberg, Moody's
* Stadtwerke München GmbH is not a listed company. Provision is at 31 December 2016

Use of outdated cost estimates and liability valuations

Current funding contributions to Croatia's Krsko Fund (and presumably Slovenia's Krsko Fund) are based on an assessment of expected future decommissioning and waste management costs carried out in 2003, using financial assumptions that were set at the time. Furthermore, the inflation assumption adopted at the time was based on historical realised inflation, rather than a forward looking measure of expected future inflation.

Given the significant period of time that has elapsed since 2003, it is unclear whether or not these cost estimates and the resulting funding contributions continue to be appropriate. Since 2003, interest rates and realised inflation have changed materially.

A revision of the decommissioning programme is expected to be completed in 2019 which could result in material changes in future funding contributions (for both the Croatian and Slovenian operators) if either or both of the cost estimates or the financial assumptions are revised materially.

Reliance on other sources of financing

In Italy, legacy decommissioning and waste management costs are met by end users of electricity through an annually adjusted levy. Because the levies are adjusted annually and must be paid in order for end users to have electricity, the risk of failing to receive sufficient levies would appear to be remote. However, the potential for material increases in the required levy should not be overlooked and could have important political/policy implications.

Assessment of this point is complicated by the fact that Italy's fund is unrestricted and can be used for other purposes. The lack of transparency regarding the extent to which decommissioning and waste management costs have been funded is, in itself, a key risk issue.

Lithuania needs to ensure that they have adequate funds available in order to meet future decommissioning and waste management obligations (historically, the majority of funding support was provided by the EU).

5. Best practice for the financing, funding, governance and risk management of the back-end activities of the nuclear fuel cycle

5.1 Introduction

This Section provides general commentary on what might be considered best practice when setting aside and investing funds in advance to meet expected future decommissioning and waste management costs. In doing so, two perspectives have been considered:

- The provisions of reference (set out in Appendix 3); and
- Internationally recognised best practice for other long-dated liability driven investors.

As shown in Section 2 (and Annex 1), different Member States have adopted different practices and models for funding future decommissioning and waste management liabilities. This means that not all Member States can reasonably be expected to adopt a single "best practice" model from their current position and indeed there may well be a sound rationale for why certain Member States have deviated from such a "best practice" model in practice.

Appendix 2 includes an assessment of the approaches taken to investment strategy and risk management, as well as emerging trends and challenges, amongst European pension funds and insurance companies. This provides additional context and is intended to help assess the extent to which the approaches adopted by other large, liability-driven institutional investors might be appropriate for the funds allocated to finance the back-end activities of the nuclear fuel cycle.

Section 2 identified four clusters of decommissioning and waste management funds. The largest of these clusters were the segregated external funds with contributions received from nuclear operators only and it is this cluster that forms the basis for the majority of comments set out in this Section. Where applicable comments for the funds in the other clusters have also been provided.

5.2 Fund structure and governance arrangements

Segregated versus non-segregated funds

The primary purpose of establishing a fund to meet future decommissioning and waste management liabilities should be:

- To ensure that nuclear operators (or whoever is deemed to be "the polluter") accumulate a sufficiently prudent amount of financial resources to meet these liabilities; and
- To ensure that these financial resources are available only for the specific decommissioning and waste management purposes for which they were intended, regardless of any restructuring of the Operator or the Group to which it belongs.

The points above should help ensure that the risk of recourse to public funds (i.e. to taxpayers) is limited.

The most transparent and simplest way of ensuring that accumulated funds can only be used only for specific purposes, is to require the use of segregated funds. This is already recognised in Commission Recommendation 2006/851/EURATOM, Section 5 which

states: "A segregated fund with appropriate control on prudent use should be the preferred option for all nuclear installations".

As shown in Section 2, the vast majority of EU Member States have established segregated funds for the back-end costs of their commercial nuclear power plants. In the case of those funds in Cluster 3 (i.e. the French licensees': EDF, Orano and CEA, Belgium and the Czech Republic) the "segregation" is nominal. Special cases also exist where funding partially depends on EU support (Lithuania, Bulgaria and Slovakia). Italy is the only Member State where decommissioning and waste management costs are met through a fund that can also be used for other purposes. The provisions established for decommissioning by German nuclear operators cannot be regarded as "funds" and, because they are backed by general company assets, no segregation exists.

Internal versus external funds

Best practice for other large, liability-driven institutional investors (e.g. defined benefit pension funds) is for financial resources to be accumulated in a fund entity that is legally independent of both the operator and the state. This is also required, for example, by the UK Government for any potential new nuclear build operator in the UK.

There are a number of potential options for establishing an external fund (e.g. a separate company, a trust or a partnership). The choice as to the appropriate structure is likely to be driven in part by tax, accounting and legal issues which are beyond the scope of this paper.

Where the fund is not external to the operator, it implies that the operator is likely to have some ability to influence some or all of the structure, governance, investment strategy and other functions of the fund. This introduces the potential for conflicts of interest and moral hazard. For example:

- If an operator were to get into serious financial difficulty, it may be keen to adopt a higher risk investment strategy with a higher level of expected investment return and associated lower cash funding requirements.
- However, it is arguable that in these circumstances the fund should instead be looking to reduce its exposure to investment related risks since the operator may no longer be able to underwrite or correct for these risks in future.

Establishing a fund that is legally independent of the operator also provides additional comfort that any accumulated financial resources will continue to be available for future decommissioning and waste management purposes following a corporate transaction involving the operator or if the operator were to become insolvent.

The majority of the funds established by EU Member States are external to the operators. The exceptions are those funds in Cluster 3 (i.e. Belgium, Czech Republic (CEZ blocked accounts) and the French licensees) as well as the German nuclear operators.

One fund or multiple funds

It has already been noted that some Member States (e.g. Germany, Netherlands and Romania) have chosen to establish separate funds for decommissioning and waste management/disposal whilst others are intending to cover both broad sets of costs from the same fund. Furthermore, funds in some Member States are intended to cover costs from multiple NPP's/operators (e.g. Sweden, Finland).

In practice, there are arguments that can be made to support either approach, for example:

- The duration and nature of decommissioning costs may be sufficiently different from waste management costs that it makes sense to adopt different investment

strategies for each. Implementation, ongoing monitoring and corrective action may then be easier if different funds are used.
- It is generally the case that economies of scale exist and hence it is usually possible to achieve lower investment related costs if the underlying size of assets is as large as possible.
- Some duplication of governance and administrative functions may well be expected where several funds are used, which could serve to increase both costs to the funds and the time needed from the funds' governing bodies.

Where a single fund exists to cover all costs, efforts should be made to quantify and disclose the liabilities associated with each of the major cost categories. Where a single fund is intended to meet the costs from multiple NPP's/operators, an appropriate apportionment of both fund assets and NPP/operators share of liability should be required. Based on the information received for this study, it would appear as though these practices are followed in most Member States.

High-level governance considerations

Regardless of the nature or number of funds, it is vital that the roles and responsibilities of key stakeholders/parties are clearly defined.

Where an external fund exists, its governing documentation should ensure that a properly constituted management board (or equivalent) is in place. Furthermore, there should be a clear delineation of duties and powers in at least the following areas:
- Setting and reviewing contributions to be made by the Operator to the fund.
- Investing and managing the fund's assets.
- Ongoing reporting (to the operator, government, regulators, or any other relevant stakeholders) of the performance, funding position, level of risk and likely sufficiency of the fund.
- Control of fund disbursements and ensuring their proper use.

Based on the information contained in the Member States' National Reports and Programmes as well as other public sources, it appears as though the above principles are generally being applied across the EU Member States covered in this report.

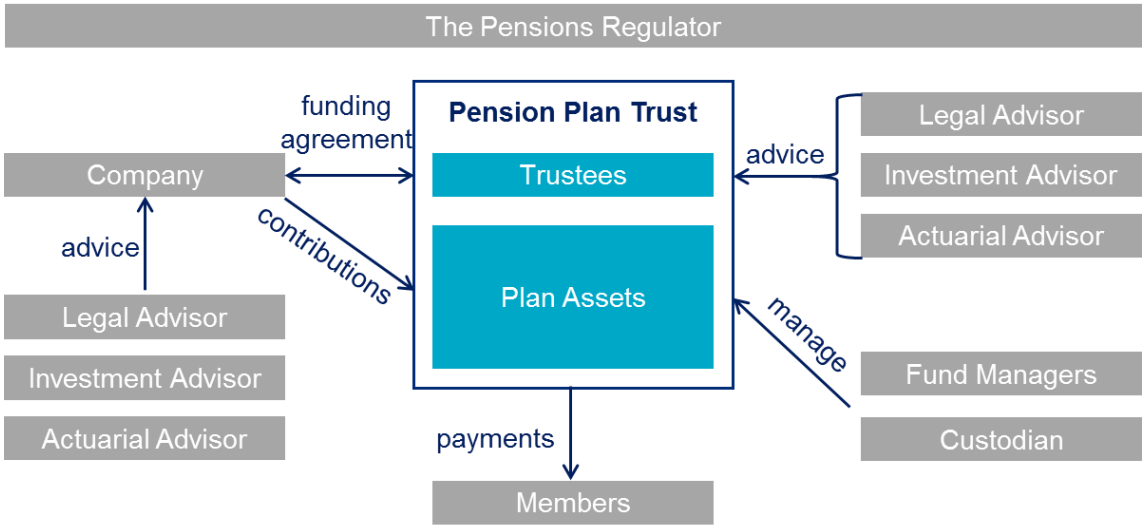
Investment related governance considerations

Another key governance requirement is the need to ensure that any person or entity with governance or management responsibility is competent to discharge these responsibilities. With this in mind, the extent to which existing governance bodies across the EU Member States tasked with managing and controlling fund investments have sufficient levels of investment and funding expertise to manage institutional, liability-driven investment portfolios warrants further consideration.

Before returning to this point, it is helpful to consider the governance arrangements for a typical UK[21] defined benefit pension fund and the way in which investment and funding related matters are dealt with. The average UK defined pension fund has assets of c. £280m and a duration of c. 20 years[22]. The chart below provides a high level overview of the various stakeholders involved:

[21] Although the example used here is UK specific, in practice, several other major DB pension countries (including, for example, the Netherlands and Switzerland) follow very similar governance models.

[22] Noting that there are a large number of small schemes (c. 36% have less than 100 members) and several very large Schemes (the largest 4% of Schemes account for 60% of the total liability). Source: The Purple Book: DB Pensions Universe Risk Profile 2017.



Key points to note include the following:

- Defined benefit pension schemes in the UK are constituted as trusts, separate from the sponsoring employer(s) and operated by a board of trustees – i.e. they are segregated external funds like many of the decommissioning and waste management funds covered by this study.
- The key terms governing the operation of the trust vary from scheme to scheme but will be documented in a Trust Deed and Rules. This forms the basis for constitution of the Trustee Board and provides a clear description of the roles and responsibilities of the various stakeholders.
- The Trustees will appoint a number advisors to support them in their duties including a Scheme Actuary, Scheme Auditor, legal advisors, investment consultants, investment managers and scheme administrators.
- It is common for Trustee boards to delegate responsibility for investment matters to an investment subcommittee who have the required skills and expertise to cover these issues. The Trustee's investment advisor will typically advise this subcommittee and in this way also has a relatively high level of influence over investment strategy. Due to the link between funding and investment, the Trustee's actuarial advisor may also provide high level investment input although this is less common.
- Day to day implementation decisions are typically delegated to fund managers although the degree of delegation can vary.

It would be common for the board of trustees to monitor the funding position of their scheme and for the investment subcommittee to review investment performance and risk on at least a quarterly basis. In addition, it would be common for the board of trustees to carry out a high-level review of the scheme's investment strategy on an annual basis, with a more thorough ALM exercise to assess the continued appropriateness of the investment strategy typically carried out every three years.

Although some Member States have delegated responsibility for investment matters to separate subcommittees (or at least have separate committees with investment oversight roles), it is not clear that these matters are subject to the same level or frequency of scrutiny and independence one would typically expect for investors of this size. It is also not clear whether, or to what extent, the decommissioning and waste management funds in the EU Member States receive professional advice on funding, investment strategy or implementation.

These points may in part reflect the relatively simple nature of the various funds' investment strategies (see section 5.5 below) and/or because the existing governance

bodies lack the time, resources or skills needed to follow such processes or to derive sufficient benefit from professional investment advice. The limited asset information that was available as part of this study would appear to be consistent with this hypothesis.

Outsourcing investment implementation

For large[23] defined benefit pension plans in several EU Member States, it is also worth noting that there is an increasing trend towards so-called fiduciary management solutions.

Even where the trustee boards of these pension plans have the required levels of investment expertise, increasing complexity, market volatility, economic uncertainty as well as time, resource and cost constraints are increasingly leading them and other institutional investors to consider how they are managing their investment arrangements.

A fiduciary management approach is one where some or all of the responsibility for the items shown below can be delegated to a specialist fiduciary manager[24]:

- Dynamic (or tactical) asset allocation;
- Portfolio construction;
- Investment manager selection;
- Risk management;
- Operational oversight;
- Performance and risk monitoring and reporting.

A fiduciary management approach is therefore intended to provide benefits in the following areas:

- Improved overall governance as the asset owner can focus on key strategic issues while outsourcing ongoing governance and oversight to the fiduciary manager;
- The potential for lower investment related costs as a result of the fiduciary manager pooling assets from multiple investors;
- Full control of investment decisions whilst obtaining access to the fiduciary manager's investment platform and operational infrastructure.

5.3 Analysis of expected future decommissioning and waste management costs

Operators (or other parties tasked with the responsibility) must ensure estimates of the costs of decommissioning their sites and for the management and disposal of waste are realistic, well defined, achievable and capable of being undertaken in a way which is consistent with the requirements of the relevant regulatory bodies. Cost estimates should be site (or reactor) specific, robust and up to date (i.e. reflective of knowledge and technology at the time they are determined). The NEA, IAEA and EC's International Structure for Decommissioning Costing ("ISDC") has been developed to assist with this exercise and its use should be regarded as best practice.

Two further considerations that should be taken into account when deriving these cost estimates are:

- Whether decommissioning and waste management costs incurred during the operational phase[25] of a nuclear facility will be met from operating revenues or from a separate fund.

[23] Liability values of c. £500m or higher for UK defined benefit pension plans.
[24] It is typical for the trustee board to retain responsibility for strategic asset allocation.
[25] For example, construction of ILW storage facilities or the purchase of spent fuel storage casks/containers.

- The need to ensure that appropriate allowance is made for all direct and indirect taxes that may be incurred by a separate fund.

The result of the cost estimation exercise should be a detailed cost profile over time based on a clearly defined reference scenario, showing key milestones and with a clear classification of the costs expected to arise in different stages and from different activities. Although these cost estimates should be durable, it will be necessary to ensure they are kept up to date over time. The frequency with which the cost estimates are updated should strike a balance between:

- The time, cost and effort needed to carry out a detailed cost estimation exercise; and
- The extent to which material changes are realistically expected to occur between successive updates.

For example, it would seem excessive to carry out a detailed cost estimation exercise every year as it is unlikely that in the normal course of events estimates of future decommissioning and waste management costs would change sufficiently over such a short period of time. Therefore, a detailed update of future costs might be carried out every three[26] or five years (as set out in paragraph 4.6 of Commission Recommendation 2006/851/EURATOM).

Most Member States considered in this report appear to have adopted such a policy and the following all carry out a detailed review of their future cost estimates with a frequency between three and six years: Belgium, Czech Republic, France, Finland, Netherlands, Romania, Slovakia, Spain and Sweden. In contrast, it was noted earlier that Croatia and Slovenia have not updated their cost estimates since 2004 (although an update is expected in 2019). Best practice would also require the cost estimates prepared by the operators of nuclear facilities (or others) to be subject to independent scrutiny, verification and approval. There is evidence that such processes exist for the majority of Member States analysed in this study.

Another key consideration in the estimation of future decommissioning and waste management costs is the need to make appropriate and adequate allowance for risk and uncertainty (as discussed in section 3.3). Based on the information received for this study, it has not generally been possible to ascertain what allowances have been made for risk and uncertainty within the cost estimates and, therefore, the extent to which these are consistent or comparable across Member States. This would be beyond the scope of this study and would in all likelihood be complicated by several problems:

- Accounting, tax or other rules may prevent/limit the nature and amount of risk that can be justified and accounted for;
- Risks for waste disposal liabilities in most countries are primarily political as regards duration and cost; and
- In many cases these risks are transferred to the State, sometimes by legacy or sometimes against payment of a risk premium (Germany, UK New Build).

As noted in section 3.3, stress tests, scenario analysis and stochastic modelling can all help develop an understanding of how future costs might vary from expectations and therefore what allowance might be appropriate to reflect key risks and uncertainties.

[26] For UK defined benefit plans, a detailed update of expected future pension payments is required to be carried out every three years as part of a formal actuarial valuation.

5.4 Valuation of potential future decommissioning and waste management liabilities

To determine the amounts that need to be paid into a given fund over time, it is necessary to convert the corresponding decommissioning and/or waste management cost estimates into a liability value. This requires assumptions for two main variables, namely:

- The assumed rate of future cost inflation; and
- The discount rate.

Assessment of the assumed rate of future cost inflation should be seen as a pre-requisite for setting the discount rate and developing an appropriate investment strategy. This is especially the case where costs are determined in real (or overnight) terms and the discount rate is set as a real rate over some measure of expected future inflation.

Inflation

Setting an assumption for future cost escalation requires an understanding of general long-term inflation expectations and nuclear specific cost considerations. As described in section 3.8, market implied inflation and long-term consensus forecasts can provide a reasonable starting point but may fail to capture nuclear specific inflation elements.

Recognising that there is no published or official index for nuclear decommissioning or waste management costs, setting the assumption for expected future cost inflation requires analysis of the underlying cost drivers of the different decommissioning and waste management costs. It would however be a complicated and spurious task to analyse each individual cost component. Therefore a pragmatic approach of identifying a few major cost drivers and determining reasonable inflation assumptions for each of these is likely to be a more suitable approach.

There is evidence of some Member States (e.g. Germany, Sweden and the UK) adopting such an approach and this is to be commended. In other Member States the approach taken is typically one of the following:

- To avoid quoting both an assumed rate of future inflation as well as a nominal discount rate, instead quoting only a real discount rate that reflects an implicit assumption that decommissioning and waste management costs will increase in line with some official inflation index or target (e.g. Spain); or
- To explicitly state the assumption that costs are expected to increase in line with some official inflation index or target and then to derive both nominal and real discount rates from this assumption (e.g. France).

As noted in Section 3, even where an explicit and specific assumption has been made for future decommissioning and waste management cost inflation, the risk that actual, realised inflation could differ from the assumption will remain (with implications for future financing/funding). As such, it is important to monitor the development of actual inflation relative to expectation and to consider the need for periodic adjustments to the inflation assumption to ensure it remains appropriate in light of emerging market conditions.

In some Member States (e.g. Croatia and Hungary), the assumption for expected future inflation is determined using historical realised inflation. Although realised inflation may be helpful in forming a view on future inflation, it is unlikely to be a reliable indicator of future inflation (in the same way that past investment performance is not a guide to future performance).

Discount rate

Discounting reflects the time value of money – i.e. the fact that assets held in a fund are expected to generate investment returns over time – and the discount rate should consequently reflect the expected returns (and therefore risk) associated with a fund's investment strategy. The discount rate can be thought of as follows:

- It is the rate at which the liability value will increase each year (after allowance is made for inflationary increases) since all costs are now 1 year closer to being paid.
- It is the minimum return that must be achieved on the fund assets each year in order to avoid a shortfall of assets (including contributions received) relative to liabilities developing over time.

As shown in Section 4, the discount rates adopted by several Member States do not appear to be consistent with the future investment returns that might reasonably be expected from their investment portfolios. Use of a discount rate higher than a realistic estimate of future investment returns (potentially with some allowance for prudence) is likely to understate liabilities for future decommissioning and waste management and the corresponding amount of funding required. There is also limited evidence that the real discount rates adopted by several Member States are reviewed and updated in light of emerging economic conditions.

There are a number of ways in which the discount rate can be defined. EU Member States generally specify the discount rate as the real return over expected future inflation. This may be considered appropriate (as long as sufficient detail on the underlying inflation and nominal discount rate assumptions are provided) for the following reasons:

- Future costs are inherently linked to inflation and, because this is likely to have the largest impact on a fund's actual disbursements, it is sensible to reflect it in the valuation basis.
- Setting the discount rate in this way also allows better understanding of the real asset return needed and to develop an investment strategy that can deliver this over a time period that can be managed effectively.
- Changes in market expectations for future inflation (as opposed to actual realised inflation) need not result in an immediate change to the liability value[27].

5.5 Investment strategy, principles and philosophy

A clear statement of investment strategy and objectives

Best practice for large institutional investment funds is to develop a policy document, often referred to as a Statement of Investment Principles ("SIP"), which would typically contain at least the following:

- A clear statement of objectives (e.g. target levels of real return), which may include different short-term, medium-term and long-term objectives;
- A clearly defined Strategic Asset Allocation, setting out the intended allocation to different asset classes together with limits on the extent to which the actual allocation can vary from its target level;
- Clear definitions for key risk metrics, risk limits and principles for the measurement, mitigation and ongoing monitoring of these risk metrics;
- Details on the mandates given to investment managers and the associated fee structures;
- The benchmarks that will be used for performance measurement;
- Restrictions on the use of certain asset classes or investment practices;

[27] However, to the extent increases in market-implied inflation are associated with higher actual levels of inflation in future then the Fund's assets will need to generate higher gross levels of returns in future in order to prevent fund shortfalls from arising.

- Details on the investment decision making process with clearly defined roles and responsibilities;
- The policy on realising investments;
- The policy on exercising rights attached to any investments;
- The extent to which any social, environmental or ethical considerations will be factored into investment decision making;
- Ongoing monitoring and reporting requirements.

Several Member States appear to have developed some form of SIP, although these were not generally provided for purposes of this study. As shown in Annex 1, several Member States have clear policies for the universe of eligible asset classes as well as limits on the amounts that can be invested in these asset classes.

It is however less clear that the different Member States have developed meaningful investment objectives or a risk based investment approach that adequately reflects the liability-driven nature of the funds set aside to meet future decommissioning and waste management costs. The extent to which the parties responsible for managing the assets have been given clear investment objectives or performance benchmarks is also unclear but the limited investment performance data that was provided for this study suggests that this is not prevalent.

Setting investment objectives

Despite the comment in the previous paragraph, it is worth noting that Commission Recommendation 2006/851/EURATOM includes several references with regards to investment strategy:

- (21): investments should be long-term and have a secure risk profile, while at the same time providing adequate protection of the real value of the funds;
- 7.16: A secure risk profile should be sought in the investment of the assets, ensuring that a positive return is achieved over any given period of time.

The most interesting point to note in the above is that there is no reference to the liabilities that these investments are intended to meet. As explained in Section 3, risk and return (and hence terms like "secure risk profile" and "positive return") from an asset only perspective are different when considered from an asset-liability perspective.

For example, long-dated government bond assets, which as shown in Section 4 constitute the vast majority of fund assets in several Member States, are often considered to be risk free and may well allow an investor to achieve a positive nominal return over the life of the bond. However, relative to inflation (and in all likelihood nuclear specific inflation), government bonds in the majority of EU Member States will currently provide a negative real return. Such bonds purchased today and held to maturity will almost certainly underperform the liabilities and hence it is questionable whether they can be regarded as having a sufficiently "secure" risk profile from an asset-liability perspective.

For liability-driven investors, it is critical that investment objectives and the associated approach to risk management are explicitly linked to the liabilities they are intended to meet.

Risk management

Having defined clear investment objectives, the next step is usually to consider what constitutes an acceptable level of investment risk to take to achieve this objective. This could, for example, be expressed as the maximum level of loss that could be tolerated over a given time frame (i.e. a VaR measure) or as a tracking error relative to the performance/growth in liabilities.

A strategic asset allocation would then be defined that would be expected to generate sufficient levels of return to meet expected future decommissioning and waste management costs (allowing for future inflation expectations) with no more than the acceptable level of investment risk.

An important consideration in determining an acceptable level of risk is the financial strength of the operator (or party liable for future contributions) and its ability to make additional contributions following sustained periods of investment underperformance. Generally speaking, funds backed by stronger operators will have a greater capacity to take on investment risk, as the operator is more likely to be able to provide additional financial support in downside scenarios. Profitability, cashflow generation, credit rating, the size of the balance sheet and a range of other metrics can all be used to form a view on the financial strength of the operator.

There is no evidence to suggest that any of the EU Member States have attempted to specify some form of risk limit or that the resulting investment portfolios have been designed with this in mind[28].

Diversification

Risk and return are related. To obtain higher investment returns, some amount of risk must be taken. However, higher risk does not guarantee higher returns and the intention should be to take only those risks that are expected to be rewarded over time. Diversifying an investment portfolio across different sources of risk and return is generally expected to improve the efficiency of a portfolio and limit the overall impact of significant falls in any one asset class. Diversification is more than a mathematical exercise, and history demonstrates that correlations vary over time and in response to differing market conditions.

Diversification should be considered at the asset class level as well as with regards to factor exposures and underlying investment managers.

As shown in Section 4, the investment portfolios in a number of Member States are dominated by Government bonds and these might be regarded as having relatively low levels of diversification at the asset class level (although it is noted that this might well reflect the requirements of Commission Recommendation 2006/851/EURATOM). There is even less evidence that diversification at the factor exposure or investment manager level has been taken into account.

Use of active investment management

In asset classes where passive management is a practicable option, the relative attractiveness of active and passive management must be considered. Actively managed funds aim to beat the return from a particular market index or defined benchmark through the use of superior knowledge or skill whilst passively managed funds aim to replicate the return from a given market index.

Different markets exhibit varying degrees of efficiency, and therefore certain asset classes (e.g. emerging market equity and debt) may offer greater potential for generation of excess return by active managers. High conviction managers have historically demonstrated a greater likelihood of delivering meaningful excess return after fees.

In assessing the merits of active management it is important to assess whether the active manager is likely to deliver sufficient outperformance in order to justify the higher

[28] However: this has been considered in the design of the UK's new build programme ("Funded Decommissioning Programme"). Germany notably performed a "stress test" to analyse certain aspects of this risk and this was an important input in the political decision making process leading to the establishment of inter alia FNWM.

fees, additional risks and increased governance requirements typically involved. Active management requires an appropriate benchmark to assess the performance of the manager, with a timeframe that is appropriate given the nature of the strategy involved.

Although some Member States (e.g. Sweden) clearly make use of active management, it is less clear that this has been considered in others.

Prohibited practices and restrictions on investment

Generally speaking it would be appropriate to exclude investments in correlated nuclear energy providers (both debt and equity) in order to avoid concentration risk – i.e. the risk that at times when the financial position of a nuclear operator is under pressure, that the value of fund assets will also decrease.

Best practice would also suggest that it would be prudent to prohibit or restrict certain investment activities to prevent excessive risk exposure. In particular, the following should be considered:

- Preventing the fund from guaranteeing the debts of others entities;
- Prohibiting the fund from providing security over its assets;
- Restricting the fund from borrowing money, issuing securities or making loans or advances;
- Limiting the extent to which the fund can engage in physical short-selling of assets or securities lending;
- Prohibiting direct or indirect investment in the equity or debt of (or real estate owned by) the operator or affiliated companies;
- Restricting the use of derivatives to hedging and portfolio management purposes.

Several of the Member States have set out similar restrictions as shown in Annex 1. However, as alluded to in Section 4, the ability of the funds established in Belgium and Finland to make material loans to the nuclear operators are inconsistent with the best practices for segregated external funds set out above and would not typically be permitted for other institutional investors.

De-risking over time / journey planning

Developing an investment strategy and strategic asset allocation for meeting future decommissioning and waste management costs is not a one-off exercise and both will need to evolve over time. It is important to consider the lifecycle of the nuclear facility in question and, in particular, the following points:

- In the early years of a nuclear facility's life, there are many years until decommissioning and waste management costs are expected to be incurred. This should provide greater flexibility in the development of the strategic asset allocation since there is little need for immediate liquidity and a long period of time to correct any shorter-term investment underperformance.
- Most of the cash disbursements related to decommissioning and waste management occur once a nuclear facility has stopped generating power and, therefore, revenue. At this point, funds should not only be sufficient to meet the expected future costs but they should also have taken steps to minimise asset-liability risk. There is significantly less tolerance for investment risk given the need to realise assets to meet cost outgo and given the lack of recourse to additional cash funding.

So, for example, immature funds might be expected to invest in a range of equity and illiquid credit type assets whilst mature funds might be expected to pursue cash flow driven strategies with a focus on low-risk bonds and matching/hedging derivatives.

As the investment strategy moves from one with higher risk tolerance to one with lower risk tolerance, the expected return on the investment portfolio would be expected to decrease. The impact of this on the discount rate used to determine future funding

contributions should be taken into account from the outset to ensure the contribution strategy makes appropriate allowance for expected future changes to investment strategy.

There is little evidence to suggest that the EU Member States have developed investment and risk management strategies that reflect the points above.

5.6 Determining financing/funding requirements

There are a number of ways of determining (and expressing) the contributions or financing amounts that should be payable to a fund set up to meet future decommissioning and/or waste management costs and, as shown in Section 2 and Annex 1, practices vary across different Member States. The key criteria are however that these contributions are determined based on a realistic, market-based assessment of future liabilities and that they take account of the current level of funds accumulated, the expected future returns that might be achieved on these funds in future and the extent to which allowance is made for prudence.

The requirements of Commission Recommendation 2006/851/EURATOM are intended to ensure:

- The availability of adequate financial resources for safe decommissioning by the time the respective nuclear installation is permanently shut down (3.3).
- Nuclear installations set up adequate decommissioning funds on the basis of the revenues obtained from their activities during the designed lifetime (5.7).

One particular consideration relates to the time at which adequate financial resources should have been accumulated and, in particular, whether this should reflect the intended design life of the facility in question or, potentially, an earlier date based on a more conservative reference scenario. This is ultimately a question for national authorities to decide. It would however seem imprudent to assume that potential future lifetime extensions will be approved when making this decision.

It is also possible to structure the required future funding contributions in various ways – for example: front-end loaded, back-end loaded or level contributions. In forming a view on the appropriate way to structure future contributions there are a number of factors to consider:

- A front-end loaded contribution structure is one where higher levels of contributions are received in early years than in later years. The earlier contributions are received, the longer the period over which investment returns can be generated and this would therefore be expected to result in a lower overall cash cost. It also provides some measure of additional security in the event of earlier than planned decommissioning.
- To the extent investment returns turn out to be lower than expected over a given period of time, some increase in future contributions would be expected. Depending on how this is rectified, it might then be expected to introduce some element of back-end loading. If the original contribution structure was back-end loaded to begin with, this may introduce greater risk that adequate funds may not be available when required.
- For commercial (as opposed to government backed) operators, the optimal choice may well need to take account of other costs that the operator is expected to incur, including potential debt repayments to its investors. In these instances, the relative priority of funding contributions, debt repayments and other costs will need to be established.

Arguably, best practice would be to develop an "intended funding path", specifying the percentage of the total liability (i.e. the funding level) that should be accumulated at the end of, for example, each year of operation. This would need to be supplemented with clear policies for the following:

- The frequency with which future funding requirements will be re-assessed, which would, in all likelihood, correspond to the frequency with which the expected future costs of decommissioning and waste management are updated.
- The appropriate period of time over which any shortfalls relative to this funding path will be corrected.
- The actions that might be taken in the event that the fund was ahead of its intended funding path, which might include reducing the level of investment risk or, potentially, reducing future contribution requirements.

5.7 Monitoring and ongoing reporting

As implied from the above, ongoing monitoring of the development of a fund's assets relative to its liabilities is essential to ensure that the investment strategy remains appropriate, that the fund is able to react quickly when risks materialise and therefore that the objectives will be met.

The actual development of any investment strategy will most likely deviate from its expected path and therefore it is important to monitor this development and provide regular updates to relevant stakeholders on the extent of any deviation. Such updates should also provide information on the underlying reasons for the departure so that the most appropriate action can be determined.

Forward-looking risk measures (such as VaR, scenario analyses and stress tests) should be used to help provide an understanding of how the overall risk position might change in light of future changes in market conditions. In this way they can provide an early indication as to which economic outcomes might lead to opportunities to reduce or better manage risk going forward.

The detail and frequency of monitoring updates will need to be determined based on the specific circumstances of each fund. Generally, the frequency of monitoring would be expected to increase over time as a nuclear facility moves from its operational phase into decommissioning. It is, however, worth noting that other large institutional investors will typically carry out such monitoring exercises on a quarterly basis and that paragraph 4.6 of Commission Recommendation 2006/851/EURATOM requires annual review of the financial resources gathered.

The extent to which additional monitoring is carried out (other than the publication of statutory annual reports and accounts and the national programmes/reports of the Member States) is unclear from the information received as part of this study.

5.8 Transparency, disclosure and the publication of information

Council Directive 2011/70/EURATOM clearly recognises the need for and importance of transparency and the availability of information. In particular, paragraph 31 states that: "Transparency should be provided by ensuring effective public information and opportunities for all stakeholders concerned, including local authorities and the public, to participate in the decision-making processes in accordance with national and international obligations." Furthermore, 7.15 of Commission Recommendation 2006/851/EURATOM states that "…All commercially non-sensitive information should be publicly available."

Despite these requirements applying equally to Member States, the information received for this study shows marked differences in the level of detail and the nature of

information disclosed. As an example, paragraph 1h of Council Directive 2011/70/EURATOM requires Member States' national programmes to include: "an assessment of the national programme costs and the underlying basis and hypotheses for that assessment, which must include a profile over time." None of the national programme reports that were received for this study include a full cost profile over time and, as shown in Annex 2, cost profiles for the majority of countries considered were either obtained via separate data requests or using data from other sources (e.g. annual reports published by operators).

It is recognised that the full disclosure of all methodologies and underpinning used to estimate expected future decommissioning and waste management costs (and the resulting costs themselves) is likely to contain confidential information. However, this is not needed in order to meet the requirements of paragraph 1h of Council Directive 2011/70/EURATOM. At a minimum, cost data might be provided in aggregate (or broken down into broad cost categories) and shown in, for example, 5 year buckets.

To help assess the adequacy of the financial resources set aside to meet future decommissioning costs, this should be accompanied by at least the following information:

- Detail on the financial assumptions (i.e. discount rate and inflation rate) used to place a present value on these future cost estimates and how these have been derived;
- An indication as to how the assessed present value would change for a given (small) change in both the discount rate and future inflation assumptions.
- The market value of any investments set aside to meet future decommissioning and waste management costs, broken down by asset class.
- Details on future funding requirements, how these have been derived as well as detail on any material assumptions involved.

There are also notable differences in the level of information contained within the annual reports and accounts published by the various nuclear licensees in the different Member States. At a minimum, best practice suggests that, in addition to the information set out above, operator annual report and accounts should include:

- A reconciliation of the provision for future liability, clearly showing the impact of "interest cost" (i.e. the unwinding of one years' worth of discounting), cash movements (contributions and disbursements), changes in financial assumptions and other adjustments to the provision.
- A reconciliation of the funds held to meet these future liabilities, clearly showing the impact of investment returns, cash movements (contributions and disbursements) and any other material items.
- Expected cashflows over, say, the next five or ten years.

5.9 Assigning liability/responsibility for future decommissioning and waste management costs

In Section 4, the level of funding and the risk of a deterioration in the level of funding were analysed. The focus of this analysis was primarily on whether existing fund assets (together with agreed future funding commitments) were likely to be sufficient to meet the future decommissioning and waste management costs for which these funds were established.

However, this analysis did not address the question of who would bear responsibility for meeting funding shortfalls that may arise if actual costs turn out to be higher than expected.

Decommissioning and waste treatment

Generally, nuclear licensees should be responsible for the design and operation of their NPP's so as to minimize future waste volumes as well as the costs of decommissioning and waste treatment. As such, it is reasonable to expect them to manage their future costs against budgets, and therefore to fund and address any emerging shortfalls accordingly.

Where the licensee is a commercial (rather than Government owned) entity, there is the related question as to whether the licensee would actually be in a position to correct any emerging shortfall. To protect against this risk, it may be reasonable to require some form of additional security to be provided. This additional security could take a number of forms, for example:

- Parent Company Guarantees;
- Insurance or financial instruments from appropriate financial institutions (e.g. surety bonds or letters of credit);
- Granting security over future cashflows from other assets;
- Charges over other physical assets.

Sweden, Germany and Finland, for example, have adopted such an approach and the UK's Funded Decommissioning Programme for new build also provides for it.

Waste storage and waste disposal

Waste storage and disposal typically extends over a much longer period of time than decommissioning. Furthermore, the ultimate costs are likely to be dependent on a number of political and general policy factors that are beyond the control of the nuclear licensee/operator.

As such it may not be reasonable (or possible) for nuclear operators to bear full liability for meeting these costs as and when they occur. In particular, it cannot be taken for granted that a nuclear licensee will still exist when waste disposal costs are actually incurred. However, the "polluter pays principle" would suggest that it is still reasonable for nuclear licensees to bear liability for the expected costs of waste storage and eventual disposal (as well as some of the risk that costs are higher than expected) and to accumulate funds to meet these expected costs during the operating life of their NPP's.

Although this could take a number of forms, it would seem that the solution might be for licensees to accumulate funds during the operating life of their NPP's and to:

- Utilise these funds to meet their decommissioning and waste treatment obligations (as explained above);
- Transfer funds required to meet the expected costs of residual waste storage and disposal, together with payment of a risk premium, to a government related entity as full and final settlement of any future decommissioning and waste management liabilities.

This is the approach that has been adopted in Germany and in the UK for new nuclear build operators. Similar sorts of arrangements exist in other Member States including Belgium, Czech Republic and the Netherlands.

6. Conclusions and recommendations

When considering the back-end costs associated with the nuclear fuel cycle and the risk profile of the funds established to meet these costs, it must be noted that the EU nuclear landscape is characterised by an ageing fleet of reactors and, therefore, decommissioning and the management/disposal of lower and intermediate level waste is a relatively near term prospect. However, with a limited number of exceptions, there is still considerable uncertainty relating to the siting (and therefore costs) of facilities for the final disposal of higher activity wastes and spent fuel. This introduces a considerable level of uncertainty in estimates of future waste management/disposal costs and when they will be incurred, with knock-on effects for the funding arrangements that have been established to meet these future costs.

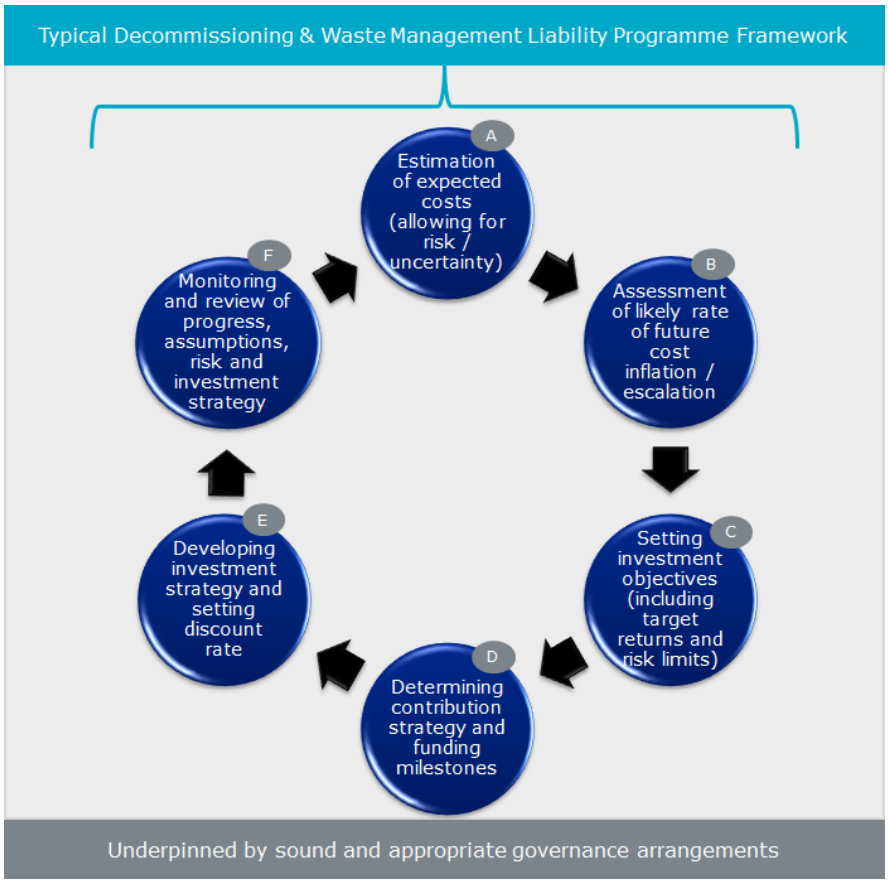
In addition, it is also important to bear in mind that "risk" can mean different things for different stakeholders. There are a number of perspectives that should be recognised in attempting to carry out an assessment of the risk profile of the funds set up to meet the back-end costs of the nuclear fuel cycle. For example:

- From a general society point of view, the key risk is likely to be whether "the polluter" is able to provide sufficient financial resources to meet the costs associated with the management and disposal of radioactive wastes resulting from their operations.
- For equity and debt investors in nuclear operators, the key risk is likely to revolve around whether the returns on their investments will be as expected. A key component of this will be whether or not funding for future decommissioning and waste management activities can be provided in a cost-effective and efficient manner.

Another key consideration is whether the primary responsibility for back-end liabilities resides with the operator, with the accrued funds intended to secure the operators ability to cover future costs, or whether the primary responsibility rests with the State who collects the funds from the operator to cover the future cost. In the first instance, investors face a potentially open-ended financial risk whilst broader society also retains a long-term credit risk. In the latter, investors' liability is likely to be limited but society faces a longer-term cost escalation risk.

Recognising the above points, and as discussed in both Section 3 and Section 5 of this study, there are a number of areas that must be considered in order to form a meaningful view on the risk profile of any fund set up to meet the back-end costs of the nuclear fuel cycle. Ensuring such a fund is able to meet its future decommissioning and waste management obligations is not a one-off exercise and requires ongoing governance, monitoring and the ability to take appropriate decisions in the face of ever changing investment markets.

The graphic on the following page summarises the cyclical nature of the key activities needed. The remainder of this section then considers each of these in turn, setting out the key findings from this study together with suggestions for how current practices might be improved or brought into line with internationally recognised best practice.



Estimation of expected future costs

The ability to determine realistic and robust estimates of potential future decommissioning and waste management costs is critical. Recognising the liability-driven nature of the funds set up to meet the back-end costs, a clear understanding of the future costs a given fund is intended to meet is required before any realistic consideration of funding and investment related issues is possible.

Throughout this study the generic term "decommissioning and waste management" has been used. It is however important to recognise the key differences between these activities and the associated risks:

- Decommissioning is carried out over relatively shorter periods of time (e.g. 10 to 15 years) and, in general terms, represents a well delineated industrial project with known technical parameters. It is generally supported by an experienced operator with specific plant know-how, as well as a relatively experienced global supply chain. Expected decommissioning costs are also relatively insensitive to the length of time a nuclear installation has been in operation.
- The primary risks associated with decommissioning include early plant shut-down due to political or technical reasons, stakeholder interference and/or changing regulatory requirements as well as the uncertainties associated with the disposal pathway for radioactive wastes.
- Waste management/disposal on the other hand involves much longer time periods and is characterised not only by a range of technical uncertainties but also highly uncertain political processes/factors. In addition, waste management/disposal volumes and therefore costs are directly dependent on the length of time a nuclear installation has been in operation.
- The primary risks associated with waste disposal stem from the above factors and their impact on the time and costs of interim storage, the siting and development of disposal facilities and, potentially, their subsequent decommissioning.

- Another major risk is associated with the delays and postponed decisions on final solutions for the disposal of both High Level Waste (HLW) and Spent Fuel (SF).

It is notable that none of the national programme reports received for this study included a full cost profile over time (despite the requirements of Council Directive 2011/70/EURATOM). It has also not generally been possible to ascertain what allowances have been made for the above sorts of risks and uncertainties from the information received for this study and, therefore, the extent to which these allowances might be consistent or comparable across Member States.

Recognising that accounting, tax or other rules may impact the nature and amount of risk/uncertainty that can be justified and included within cost estimates, additional disclosure of and transparency around the approaches taken to risk/uncertainty is recommended. This would also facilitate a better understanding of the resulting impact on investment strategy and the associated level of funding and investment risk. For example, if little allowance is made for risk and uncertainty within the cost estimates themselves, it might be appropriate to adopt a more prudent approach to setting the discount rate.

Assessment of the likely future rate of cost inflation

As noted previously, there is a need to analyse the underlying drivers of inflation for the main decommissioning and waste management activities and to set an assumption for future cost inflation that reflects these nuclear specific cost inflation drivers to the maximum extent possible. Such an assumption should also be a long-term assumption, reflecting the likely timeframes over which decommissioning and waste management will be carried out, and should not be unduly influenced by changes in either short-term inflation expectations or realised inflation over short periods of time (see section 3.8). Disclosure and transparency in this area are again recommended.

Although some Member States (e.g. Germany, Sweden and the UK) have made explicit allowance for a specific decommissioning and waste management cost inflation assumption, this is not generally the case. In other Member States (e.g. Croatia and Hungary), future inflation expectations are set based on historical realised inflation, which is unlikely to be a reliable indicator of future inflation.

When developing nuclear specific inflation assumptions, it is worth noting the following:

- Domestic labour costs may well have the largest impact on future cost inflation. Labour cost inflation is not typically the same as broad market inflation measures.
- The nuclear industry represents a concentrated market with highly specialised labour requirements, which may put further upward pressure on cost inflation.
- Regulatory costs associated with the need to comply with evolving safety standards and the use of latest available technologies will also need to be factored into consideration.

As the existing EU and global nuclear fleet ages, industry will gain experience which would be expected to streamline the decommissioning process and potentially lead to lower future costs. However, this should be reflected in the cost estimates themselves rather than in the assumption for future cost inflation.

Setting investment objectives, target levels of return and risk limits

An appropriate rate of expected future nuclear cost inflation should provide the minimum bound for the level of investment return that should be targeted by a given fund. If the investment return were lower than the rate of future cost inflation, cash funding requirements would exceed the total overnight value of future cost estimates. This would arguably fail to capture one of the most (if not the most) important reasons for setting aside funds in advance – namely, to use investment returns to reduce the amount of expected cash funding required.

In the current low-yield environment, it is by no means easy to achieve long-term returns above inflation. Government bond assets, typically regarded as "risk-free" are highly unlikely to do so at present and therefore targeting a level of investment return equal to or above future inflation will involve taking some level of investment risk.

Recognition of the need to define a target level of return and the need to take risk, the formation of a view on what constitutes an acceptable level of investment risk and capturing this information in a formal policy document should therefore be seen as key steps in developing appropriate funding and investment strategies.

It must again be noted that the target level of return may well need to vary over time (or in distinct time periods / phases of operation) to reflect the lifecycle of the nuclear facility in question.

As noted in Section 5.5, it is not apparent that the different Member States have developed meaningful investment objectives or a risk based investment approach that adequately reflects their liability-driven investment agenda and this is something that warrants further consideration.

Developing a contribution strategy

Given realistic assumptions for future cost inflation and target levels of investment return (i.e. a discount rate assumption), which may vary over time, it becomes possible to calculate the level of contributions that will need to be received by a given fund over time, such that the combination of these contributions and the targeted investment returns achieved on them are expected to be sufficient to meet future decommissioning and waste management costs.

As discussed in section 5.6, funding contributions will need to take account of a number of factors and there are different ways in which the resulting profile of contributions can be structured. Best practice might be to develop an "intended funding path" or set of "funding milestones", specifying the percentage of the total liability (i.e. the funding level) that should be accumulated at different points in time together with details on how any deviations from this intended funding path will be dealt with.

Some Member States do appear to have developed intended funding paths/funding milestones, whilst others appear to have followed processes that would result in an intended funding path or set of funding milestones. However, it has not generally been possible to obtain a full understanding of what these look like in practice and therefore this warrants further consideration. Additional disclosure and transparency in this area would contribute towards a greater understanding of the risk profile of the funds set up to meet the back-end costs of the nuclear fuel cycle.

Strategic asset allocation and the link to the discount rate

With an understanding of the drivers of future cost inflation and clearly defined target levels of investment return (i.e. a discount rate, which may vary over time), focus shifts to the issue of how best to construct an investment portfolio that is expected to deliver the required level of investment return over time with no more than the acceptable level of risk. Following such a process helps ensure that the investment strategy reflects the underlying nature and duration of the expected future costs.

Working through the above process, it should be clear that there is a link between the discount rate and the strategic asset allocation. That is, the discount rate can be thought of as the target level of return used to determine future funding contributions and the investment strategy is then responsible for delivering this target level of return. If the investment strategy cannot deliver the target level of return, then over time the fund will start to fall behind its intended funding path. This would then in turn create a

need for additional funding contributions or even higher target levels of return in future (which may not be commensurate with the acceptable level of risk).

This is of particular importance given some of the key findings of this study, notably:

- The real discount rates adopted by several Member States with material future decommissioning and waste management liabilities do not appear to be consistent with the future investment returns that might reasonably be expected from their investment portfolios.
- As a result, there is widespread and systematic understatement of the liabilities for future decommissioning and waste management and, more importantly, the corresponding amount of funding required. The longer this is left unchecked, the greater the likely financial impact of required future corrective action will be and is therefore something that warrants significant and urgent attention.

Deriving a suitable investment strategy or strategic asset allocation requires a detailed assessment of the investable universe, taking full account of:

- Return and risk expectations for different asset (and sub-asset) classes;
- Likely correlations between different asset (and sub-asset) classes, how these might vary in different financial market conditions and hence the expected benefits from diversification;
- Underlying drivers of risk and return, including an assessment of the potential for active management in different asset classes to provide positive risk (and fee) adjusted performance and the extent to which inflation risk can be (at least partially) hedged using available market instruments.
- Investment management fees, liquidity considerations and the relative complexity inherent in different asset classes.

Again, understanding the above is of particular importance given some of the key findings of this study:

- The investment portfolios in a number of Member States with material future decommissioning and waste management liabilities are dominated by Government bonds and other short-dated, low risk investments.
- In light of current market conditions, such bonds are highly likely to underperform the liabilities (i.e. to underperform the discount rates adopted by several Member States) and hence it is questionable whether they can be regarded as having a sufficiently "secure" risk profile from an asset-liability perspective.
- Such portfolios have very low levels of diversification and, arguably, do not have sufficient regard for either the long-dated nature of decommissioning and waste management liabilities or the fact that a given fund's liquidity requirements will most likely change over time.

There is however evidence to suggest that these points are being recognised and that Member States are becoming aware of the need to reconsider their approach to investment strategy. Slovakia has noted the need to generate higher levels of investment returns in future whilst the Swedish NWF has also taken steps to expand their eligible investment universe. It also appears as though the German FNWM will adopt a diversified investment strategy with holdings in a number of different asset classes.

Capturing details of the strategic asset allocation and how it is to be implemented in a formal policy document should be seen as a key step and something that should be encouraged.

Such a policy document should also clearly set out those investment activities that are prohibited or restricted. With this in mind, it is again noted that the ability of the funds established in Belgium and Finland to make material loans to the nuclear operators is

something that would be questioned for other institutional investors and therefore warrants further consideration.

The importance of ongoing monitoring

Ongoing monitoring of and regular reporting on the development of a fund's assets relative to its liabilities (and how this compares to an intended funding path) is essential for ensuring that the investment strategy remains appropriate and that a fund is able to react quickly in light of emerging risks or opportunities.

Developing a long-term strategic asset allocation is, as explained above, of crucial importance. However, it is also important to recognise that, at any given point in time, the behaviour of market participants can cause the price of an asset class to deviate significantly from its underlying value. A regular monitoring regime can help identify these deviations, creating opportunities to deliver both improved returns and risk management.

The level of detail and frequency of monitoring/reporting updates should be based on the specific circumstances of each fund, although something like quarterly or semi-annual monitoring would be typical for other large institutional investors. The extent to which such additional monitoring is carried out in practice is unclear but should be encouraged as a means to improve overall governance and risk management.

Disclosure, transparency and the publication of information

As set out in Section 5.8, the information received for this study shows marked differences in the level of transparency provided by the Member States.

Whilst Section 5.8 sets out examples of specific items that might reasonably be disclosed, it is also important to note the comments above regarding transparency and the disclosure of information as well as the need for formal documentation in key investment and funding related areas.

The cyclicality of the review and ongoing risk management process

Whilst there is a need for ongoing monitoring and reporting as well as the regular assessment of emerging risks and opportunities, the frequency with which the different activities set out above should be undertaken will also vary.

A detailed update of future cost estimates might only be carried out, for example, every three to five years and most Member States appear to follow such an approach. However, in light of the fact that these cost estimates are (or at least should be) the primary driver of funding and investment strategy, it would be reasonable to expect the following to be reviewed in light of any material changes to the future cost estimates:

- The methodology used to determine the assumed rate of future cost inflation;
- Investment objectives, target levels of return and risk limits (including the methodology used to determine the target level of return and risk limits);
- The adequacy and appropriateness of currently agreed funding contributions and hence whether changes are required;
- Strategic asset allocation (taking account of changes in underlying market conditions); and
- A Statement of Investment Principles (or similar policy document).

There is less evidence to suggest that the above items are reviewed in this way. This introduces the risk that even if all of these factors were appropriately designed at one stage, that they do not remain that way over time.

Supporting governance arrangements

Ideally the framework above should be carried out within a well-defined, national decommissioning and waste management liability programme framework,

describing how the EU waste directives and other guiding principles are applied, a roadmap for securing adequate future funding, funding and investment principles, roles and responsibilities and the approach to fund management. It is not clear that a systematic approach is being adopted in all Member States.

The above comments are intended to outline how Member State practices in the areas of funding, investment and risk management might be improved and brought into line with international best practices. However, this is only possible to the extent such an approach can be supported by fund resources and the available governance budget.

With this in mind, the extent to which existing governance bodies across the EU Member States tasked with managing and controlling fund investments have sufficient levels of investment and funding expertise to manage institutional, liability-driven investment portfolios warrants further consideration. Similarly, the extent to which these governing bodies receive professional advice/support to help them discharge their funding and investment duties on the one hand, and are free from political interference on the other hand, warrants further consideration.

Where other institutional investors have faced similar governance or resource related challenges, they have increasingly considered so-called fiduciary management solutions, which allow them to delegate responsibility for certain areas of activity.

It is also worth noting again that longer-term decommissioning and waste management issues are subject to considerable political uncertainty and decisions that will involve many different stakeholders (with different perspectives on what is meant by risk). With this in mind, this paper has set out several areas that require attention in order to ensure that future decommissioning and waste management costs can be met effectively without placing an undue financial burden on public finances or future generations.

Annex 1: Approaches to financing, funding, governance and risk management in different EU Member States

1. Belgium

Funds allocated to decommissioning and waste management costs

The Belgian nuclear landscape consists primarily of the operational nuclear power plants at the Doel and Tihange sites, which have four and three reactor units respectively. All seven reactor units at these two sites are operated by Electrabel – a wholly owned subsidiary of France's Engie SA.

Belgian law generally limits the operation of nuclear power plants to 40 years, although 10 year lifetime extensions for Doel 1, Doel 2 and Tihange 1 were approved in 2013 and 2015. As a result, all seven units are scheduled to cease operations between 2022 and 2025.

With the exception of the operation of nuclear reactors, **Société Belge des Combustibles Nucléaires ("Synatom")** is responsible for activities covering both the front and back end of the nuclear fuel cycle. With regards to the back-end activities, Synatom is solely responsible for ensuring financial provisions are available to cover the costs of decommissioning and spent fuel management (including interim storage, reprocessing and conditioning). Synatom also collects the special contribution (or nuclear tax) from nuclear operators on behalf of the Belgian State. Synatom is supervised by the Nuclear Provisions Committee ("NPC").

Final storage and disposal of radioactive waste and spent fuel is ultimately the responsibility of the National Agency for Radioactive Waste and Enriched Fissile Materials ("ONDRAF/NIRAS"). ONDRAF/NIRAS, and its subsidiary Belgoprocess, are responsible for the management of legacy nuclear activities, including the Eurochemic reprocessing plant and the former waste management site of SCK/CEN. At present, Belgium has not yet reached a decision regarding the long-term disposal/storage of intermediate and high level radioactive wastes and spent fuel. Once a decision is reached and responsibility for radioactive waste and spent fuel passes from Synatom and the nuclear operator to ONDRAF/NIRAS, Synatom will transfer the funds required to meet future costs to ONDRAF/NIRAS[29].

With the exception of a single "golden" share (more detail below), Synatom is wholly owned by Electrabel. The financing arrangement can nominally be described as a segregated internal fund (or a segregated internal investment company).

Financing and funding arrangements

Every three years, Synatom (with the nuclear operator) is required to reassess expected future decommissioning and waste management costs (based on reference scenarios), calculate the liability (or provision) associated with these costs and submit the results to the NPC. The NPC will seek the opinion of ONDRAS/NIRAS and will then issue an opinion on the calculated provision. At 31 December 2016, the provision was calculated to be c. €9.2 billion (€5 billion for spent fuel management and €4.2 billion for decommissioning).

Synatom is required by law to hold liquid assets at any given time covering the next three years' worth of expected decommissioning and spent fuel management costs. At 31 December 2016, the value of these liquid assets was c. €1.5 billion.

[29] The transfer of funds would only occur when there is a transfer of waste.

Aside from this liquidity requirement, Synatom is also required to ensure that 25% of the value of the provision is invested outside the nuclear sector in dedicated financial instruments and money market funds. In addition to the assets mentioned above, Synatom had made loans to Elia (c. €450m) and Sibelga (c. €22m) and held commercial paper issued by Ores (c. €40m) to meet this requirement.

Subject to credit rating and solvency requirements, Synatom is then able to lend up to 75% of the value of the provision back to the nuclear operator, Electrabel. At 31 December 2016, Synatom had outstanding loans to Electrabel of c. €6.7 billion (roughly 73% of the value of the provision). As such, Synatom does not hold an earmarked portfolio of capital market investments (beyond the short dated assets referred to above) to meet future decommissioning and waste management costs and is dependent on Electrabel to provide the required funding through repayment of these loans in future (in advance of decommissioning).

On behalf of the Belgian state, Synatom collects the special contribution (nuclear tax) in relation to Doel 3, Doel 4, Tihange 2 and Tihange 3, which in total amounted to c. €130m in 2016.

Governance arrangements

As noted above, Electrabel owns all but one share in Synatom. The Belgian State owns a single "golden" share, giving it certain special rights and powers.

Synatom is managed by a Board of Directors and two government representatives. The Directors of Synatom prepare annual financial statements and these are subject to formal, external audit.

Investment strategy considerations

As alluded to earlier, Synatom's investment strategy largely resembles a loan to Electrabel, together with additional holdings in short-dated, liquid assets. In that sense, the funding arrangement does not quite match the concept of a "segregated" internal fund.

However, Synatom's Chief Financial Officer stated in their 2016 annual report that persistently low rates are forcing a thorough review of investment policy and that they are considering diversification of the investment portfolio (recognising that this would increase the need for appropriate risk management).

2. Bulgaria

Funds allocated to decommissioning and waste management costs

The Kozloduy Nuclear Power Plant is the only nuclear site in Bulgaria. It is composed of 6 Soviet-designed nuclear reactors units. As a condition of Bulgaria's accession to the European Union, the four first generation reactor units of the Kozloduy Nuclear Power Plant were required to be closed and decommissioned before the expiry of their intended operational lifetimes. Following safety upgrades and lifetime extension programmes, reactor units 5 and 6 continue to operate at the Kozloduy site.

The **Radioactive Waste Fund ("RAO Fund")** and the **Nuclear Facilities Decommissioning Fund ("IEYaS Fund")** are the main financial vehicles for implementing State policy on the safe management of radioactive waste ("RAW"), the provision and maintenance of RAW management facilities during their operational lifetime and the decommissioning of nuclear installations. Although the RAO and IEYaS Funds are owned by the Ministry of Energy they are managed by the Bulgarian National

Bank and fully controlled by the Bulgarian government. Both are special-purpose segregated external funds but are included within the State budget.

The early shutdown and subsequent decommissioning of Kozloduy blocks 1-4 created a significant financial and economic burden for Bulgaria. The EU therefore agreed to provide financial support and the **Kozloduy International Decommissioning Support Fund ("KIDSF")** was established and subsequently managed by the European Bank for Reconstruction and Development ("EBRD"). The EC is the principal donor.

Financing and funding arrangements

Under Article 91 and Article 48 of the Safe Use of Nuclear Energy Act 2002 ("ZBIYaE"), the Minister of Energy set up the RAO Fund and the IEYaS Fund to finance activities related to radioactive waste management, the activities of the State Enterprise for Radioactive Waste ("DPRAO") and the decommissioning of nuclear facilities. The DPRAO carries out decommissioning work and also treats and processes RAW.

The primary source of funding for both the RAO and IEYaS Funds is from a levy on electricity sold by the operator of the Kozloduy NPP (blocks 5 and 6). Monthly contributions to the RAO Fund are determined by the Fund's management board (which also estimates future decommissioning and waste management costs) based on the type of waste generated and activities carried out. In addition, both the RAO and IEYaS Funds' may receive funding via:

- Legal and natural persons whose activities generate radioactive waste or who operate nuclear installations
- State budget
- Interest on the management of accumulated contributions to the Fund
- Outstanding contribution payments
- Donations and other income

If decommissioning costs turn out to be more expensive than estimates by the IEYaS Fund's management board, the additional costs will be borne by the entity who last operated the nuclear facility.

As mentioned above, the KIDSF was established to manage aid released by the EC to help Bulgaria minimise the financial impact of the early decommissioning of Kozloduy blocks 1-4. The total to be provided for decommissioning activities through the KIDSF in the period 2003–2020 is €788 million.

Resources of the RAO and IEYaS Funds be used for specific, pre-defined purposes and expenditures are planned by the Minister of Energy in the annual budget.

Governance arrangements

As noted above, the RAO and IEYaS Funds are managed by a Management Board, co-chaired by the Minister for the Economy and the Minister for Energy.

The Members of the Funds' Management Board include a Deputy Minister for Finance, a Deputy Minister for Health, a Deputy Minister for the Economy, a Deputy Minister for Energy, a Deputy Minister for the Environment and Water, a Deputy Minister for Regional Development, the Chair of the Nuclear Regulatory Agency, a representative of each licence holder operating a nuclear power plant, and the Director of the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences.

In addition to estimating future decommissioning and waste management costs and the corresponding contributions needed to finance them, the Management Board also controls the management of the Funds' revenues, ensures they are spent appropriately and submits annual reports to the Council of Ministers.

Investment strategy considerations

The funds accumulated in the IEYaS and ROA Funds are kept and managed within the single treasury account system through the use of a separate transit account opened in the name of the Ministry of Energy with the Bulgarian National Bank.

3. Croatia / Slovenia

Funds allocated to decommissioning and waste management costs

Croatia and Slovenia are unique in that they co-own a single operating nuclear power plant, the Krsko Nuclear Power Plant[30], located in Slovenia. It is composed of a single reactor unit. Accordingly, Slovenia has primary responsibility for the Krsko NPP. In 2003, the governments of these two countries signed a bilateral agreement on legal issues relating to the investment, exploitation and decommissioning of the Krsko station. Under the terms of this agreement, they are equal partners with each country sharing the Krsko plant's benefits and subsequent obligations for decommissioning and waste management costs equally.

This agreement also required each country to establish its own segregated external fund and to ensure that sufficient financial resources to meet the expected future costs of decommissioning and waste management are available before the end of Krsko's operations. The funds established are as follows:

- Croatia: the Fund for Financing the Decommissioning of the Krsko Nuclear Power Plant and the Disposal of Krsko NPP Radioactive Waste and Spent Nuclear Fuel.
- Slovenia: The Fund for Financing the Decommissioning of the Krsko NPP and for the Management of Radioactive Waste

The Croatian share of the decommissioning and waste management costs as of 2004 totalled €868.5 million but no more recent update has been received. At 31 December 2016, the value of the Croatian fund was roughly €232 million. No recent value for the Slovenian fund has been received.

Financing and funding arrangements

Hrvatska elektroprivreda ("HEP", the Croatian electricity provider) contributes €14.25 million annually (in the national currency equivalent). This amount was determined in 2004 by appointed expert organizations from Croatia and Slovenia and NPP Krsko according to the bilateral agreement and is fixed for the period between 2004 and 2022. It is expected to be revised at future revisions of the decommissioning programmes.

GEN Energia (the Slovenian electricity provider) makes contributions to the Slovenian fund of 0.30 euro cents per kWh of the Slovenian share of energy produced by Krsko NPP, which roughly equates to about €8 million annually. The reason for lower payments to the Slovenian fund lies in the fact that at the time of the passing the bilateral agreement, the fund in Slovenia had already collected a certain amount of funding.

Governance arrangements

Croatia's fund is segregated from the state budget and contains a Management Board of seven members, who are appointed by the Government for a four-year term. The Board are also responsible for the Fund's statute, the rules of procedure, agenda and financial plan for the year, and also sets the investment policy and makes asset management decisions. The Ministry of Environment and Energy holds the Fund accountable in respect of its work. The State Office for Radiological and Nuclear Safety (SORNS) establishes the

[30] Formerly part of the Socialist Federal Republic of Yugoslavia.

legislative framework, coordinates the drafting of strategy, reporting and public information on the management of radioactive waste and spent fuel. The fund is subject to annual audit by an external audit firm.

Slovenia's fund was founded by the Slovenian National Assembly. The Slovenian government must also give consent to the Fund's Statute, investment policy, financial plan and annual accounts and is also responsible for reviewing the annual report on the Fund's operating activities.

Investment strategy considerations

The Croatian fund is allowed to invest:

- without restriction into bonds issued by the Republic of Croatia, the Croatian National Bank and bonds guaranteed by the Republic of Croatia;
- up to 40% in bonds traded on stock markets or other regulated and organised markets in the Republic of Croatia, Member States of the European Union and Member States of the OECD;
- up to 40% in equities traded on stock exchanges or some other regulated and organised markets in the Republic of Croatia, Member States of the European Union and Member States of the OECD;
- up to 25% in investment funds registered in the Republic of Croatia and in the Member States of the European Union;
- up to 10% in investment funds registered in Member States of the OECD;
- without restriction into money market instruments and deposits at financial institutions, but not more than 10% of the total assets of the Fund into a single financial institution, with the proviso that this amount does not exceed 5% of the regulatory capital of that financial institution;
- up to 20% in repurchase or repo agreements, except repo agreements with government or other bonds unconditionally guaranteed by the Republic of Croatia, in which case there is no restriction;
- in options and forward contracts exclusively for the sake of securing the claims and assets of the fund.

Similar information for the Slovenian fund was not received.

4. Czech Republic

Funds allocated to decommissioning and waste management costs

The Czech Republic's nuclear landscape consists primarily of the four operational reactors at the Dukovany Nuclear Power Plant ("NPP") and the two operational reactors at the Temelin NPP, all of which are operated by ČEZ, a. s. In addition, there are two operational research reactors (LR-0 and LVR-15) and storage facilities for spent fuel ("SF") and other radioactive waste ("RAW") as well as uranium mining.

In the Czech Republic, there are two funding mechanisms that have been established for decommissioning and waste management purposes:

- Internal, segregated funds owned and managed by nuclear operators in so-called **blocked accounts** for purposes of meeting their future decommissioning costs.
- A segregated external **Nuclear Account** owned by the State and managed by the Ministry of Finance. The nuclear account receives contributions from NPP operators and provides financing for the disposal of spent fuel and other radioactive waste (including development of a deep geological repository).

Financing and funding arrangements

Operator contributions to the blocked accounts are determined using methodology approved by the Ministry of Industry. This methodology considers both the assessed

decommissioning liability and the accumulated financial resources in the blocked accounts and contributions are then set so as to achieve full funding on a straight-line basis at the end of the expected period of decommissioning. Each blocked account is held with a local commercial bank.

čEZ, a. s., the operator of the Dukovany and Temelin NPP's, has also decided to create a reserve for the storage of SF. This reserve is intended to cover the costs associated with the storage of SF after the shutdown of the nuclear units.

At 31 December 2016, čEZ, a. s. had established the balance sheet provisions totalling CZK 55.2bn (approximately €2.1bn), broken down as follows:

- Decommissioning: CZK 18.6bn (approximately €0.7bn);
- Interim spent fuel storage: CZK 7.4bn (approximately €0.3bn); and
- Spent fuel disposal: CZK 29.2bn (approximately €1.1bn).

At this same date, čEZ, a. s. had accumulated total assets in blocked accounts equal to CZK 13.0bn (approximately €0.5bn).

Contributions from SF and RAW generators to the Nuclear Account are 55 CZK/MWhe generated. The required contributions are re-assessed by SÚRAO (the Radioactive Waste Repositories Authority) every five years based on updated estimates for the future costs associated with disposal of SF and RAW.

ÚJV Řež (the Nuclear Physics Institute) makes provisions for the decommissioning of the HAW Storage Facility. Decommissioning is projected to take place in 2045 and the expected costs have been verified by SÚRAO. Similarly, CV Řež (a Research Centre) creates a provision for decommissioning the LVR-15 and LR-0 research reactors.

Governance arrangements

SÚRAO, in accordance with the Atomic Act, inspects and verifies the provisions created by operators in blocked accounts for the decommissioning of their nuclear installations. Operators are required to provide updated cost estimates and decommissioning plans (and hence revised contribution schedules) to SÚRAO every five years. External auditors also validate the balances in these blocked accounts on annual basis.

Resources held in blocked accounts can be used only for purposes of decommissioning and SÚRAO is required to approve any disbursements from these accounts. Similarly, the financial resources of the nuclear account can be used only for purposes of SF and RAW disposal as approved by SÚRAO.

SÚRAO does not create any provision for decommissioning as it is a state owned organisational unit in agreement with Section 18, Paragraph 1h) of the Atomic Act. The SÚRAO budget is approved by the Czech Government.

Investment strategy considerations

Funds held in blocked accounts can only be invested in Czech or EU government bonds or bonds issued by a European supranational institution. No target level of return or performance benchmark is specified.

Funds held in the State Nuclear Account may be invested in Czech government bonds, bonds issued by the Czech National Bank or commercial paper issued by highly rated EU Member States (or their national banks) or European supranational institutions. No more than 15% of the funds can be held in commercial paper.

5. Finland

Funds allocated to decommissioning and waste management costs

Finland currently has 4 nuclear reactors in 2 nuclear power plants: one in Olkiluoto operated by Teollisuuden Voima (TVO), and the other in Loviisa which is operated by Fortum Power and Heat (FPH). Additionally, there is a research reactor FiR 1 operated by the Technical Research Centre of Finland (VTT). There is also a 3rd unit at the Olkiluoto site under construction (close to commissioning) and a third nuclear power plant site that is in planning by Fennovoima (FV).

As mandated by the Nuclear Energy Act in Finland, nuclear operators are responsible for meeting all costs associated with decommissioning and waste management from their own resources as and when these costs occur.

Contributions from the nuclear operators are also collected annually into the Nuclear Waste Management Fund (NWMF), which is operated by the Ministry of Economic Affairs and Employment (MEAE). The NWMF is a segregated, special purpose fund independent of the State budget and external to the nuclear operators. At the end of 2017, the total value of the assets in the NWMF was c. €2.6 billion.

TVO and FPH have also established a joint company, Posiva, to manage the final disposal of spent fuel.

Financing and funding arrangements

Nuclear operators prepare updated estimates of future decommissioning and waste management costs every year, which are then subject to evaluation by the Finnish Radiation and Nuclear Safety Authority (STUK) and VTT. Using these cost estimates, the MEAE will assess the total future liability for decommissioning and waste management (assuming operations cease at the end of the year in question) as well as the proportion of this total liability that should be held in the NWMF. In the event of any shortfall relative to this target proportion of liability, the nuclear operators are required to contribute the difference to the NWMF.

The NWMF is not used to meet the operators' decommissioning and waste management costs directly. The NWMF functions as a back-up fund, and is intended to ensure that if for whatever reason the operators are unable to meet their costs directly there will still be sufficient financial resources to carry out these tasks. Once the amount of money in the NWMF exceeds the remaining future liability for decommissioning and waste management (on an undiscounted basis), licensees are reimbursed from the NWMF in respect of the actual costs of decommissioning and waste management they incur.

Nuclear license holders are however allowed to borrow up to 75% of the capital of the NWMF on a collateralised basis (i.e. secured against other assets) and the State has the right to borrow the remaining 25%. The interest rate underlying these loans is 12 month Euribor plus 0.50% and is re-evaluated annually.

Governance arrangements

The NWMF is managed by its board and a director both appointed by the Government. Its financial statements are audited annually by a commercial audit firm.

Licensees are also required to prepare decommissioning plans and updates for regulatory review every five years. All decommissioning measures are carried out under the supervision of the Finnish Radiation and Nuclear Safety Authority (STUK).

Investment strategy considerations

In 2017, operators borrowed 60% of the capital held by the NWMF and the remaining 40% was invested in low-risk State Treasury bonds.

6. France

Funds allocated to decommissioning and waste management costs

Operational commercial nuclear reactors are all operated by EDF, France's main electricity generation and distribution company. In addition there are several shut down nuclear reactors in different stages of decommissioning. The French Government has an 85% stake in EDF. Orano, a separate listed commercial company, is involved with other parts of the nuclear fuel cycle, notably in mining, chemistry, enrichment and back end operations. The French government has a 90% stake in Orano.

With the exception of uranium mining, which ceased in 2001, France is heavily involved in all aspects of the nuclear cycle. Under control of the State, radioactive waste management costs are borne by the nuclear licensees, EDF and Orano, and the state funded French Alternative Energies and Atomic Energy Commission (CEA). These licensees are required to assess the expected future costs of decommissioning and waste management (including spent fuel) and are required to establish balance sheet provisions in respect of these costs. Licensees must then be able to demonstrate full coverage of the expected future costs through a segregated portfolio of dedicated assets. That is, each of these licensees has established and is the legal owner of their own segregated internal funds. For purposes of this study however, it is the combined position of the three main licence holders (EDF, Orano and CEA) that is generally considered (unless stated otherwise).

These provisions and backing assets are closely monitored by the Economy and Energy ministries. Under the terms of the Environment Code, the licensees send the administrative authority a report, every three years, describing their evaluation of the long-term costs, the methods applied to calculate the provisions corresponding to these costs and the choices made with regard to the composition and management of the assets allocated to coverage of the provisions. An update of this report must also be transmitted annually, as well as on the occasion of any event entailing a substantial modification of its content. Also, the licensees send the administrative authority a quarterly inventory of the dedicated assets. Finally, the administrative authority may request from the operators any information, document, as well as any clarification or justification necessary for its mission.

As part of the French Environment Code, operators and holders of spent fuel must provide estimated costs of managing spent fuel and radioactive waste, accompanied by a timetable and indicating the assumptions, to be included in the latest PNGMDR national plan.

Financing and funding arrangements

As required by French law, operators of nuclear facilities are required to make a prudent assessment of the costs of decommissioning facilities and the management of spent fuel and radioactive waste and to ensure that the discounted present value of these costs is covered by a portfolio of dedicated assets. These assets are ring-fenced and can only be used to cover eligible decommissioning and waste management costs. These ring-fenced assets are protected by law and only the French State has any claim over them.

The table below shows the gross costs in 2014 economic conditions (i.e. as at 31 Dec 2015) and the discounted provisions as at 31 Dec 2016:

In billions of euros, as at 31.12.2016	**Gross costs in 2014 economic conditions**	**Updated provisions**	**Provisions to be covered by dedicated assets**	**Value of coverage**	**Coverage percentage**
EDF	75.6	36.0	25.7	25.7	99.8%
CEA	21.6	13.5	13.5	13.6	100.3%
Orano	13.5	7.3	7.3	6.1	82.9%
Total Licensees	**110.5**	**56.9**	**46.6**	**45.3**	**97.3%**

Source: Gross costs from 2016-2018 PNGMDR; provision data from annual reports

The French State analyses the situation of operators and can order corrective measures if assets are determined to be insufficient. If satisfactory corrective actions are not carried out within the set deadline, the administrative authority can impose financial penalties and/or require the operator's parent company to provide the necessary funding as well as various other measures. The Decree of 24 March 2015 establishes that the coverage percentage (or funding level), must be kept at or above 100%. For instance, based on the end 2016 position for EDF, a contribution of €1,095m was required in order to bring the coverage percentage back to 100%. A similar determination is done for Orano, who were given a three year limit to restore full funding. For the CEA, dedicated funds are financed by an annual subsidy of €740m under government budget; this funding mechanism has been in effect since October 2015.

Governance arrangements

Governance is divided into three main functions: policy making / oversight, assessing and implementation. Waste management and radioactive materials policy decisions / oversight falls primarily to the French Government and Parliament. Assessing and monitoring nuclear safety and radioactive protection for nuclear facilities are primarily the roles of the authorities, notably the Nuclear Safety Authority (ASN) and the ASND, who are respectively responsible for civilian and defence-related activities. Implementation falls primarily to the nuclear licensees.

The primary nuclear licensees (EDF, Orano and CEA) are all managed by Boards of Directors with responsibility for, amongst other things, the constitution, management and risk management of the dedicated pools of assets. All of these licensees are also required to have a separate committee that provides opinions on items such as asset management policy, internal control systems, risk assessments and reports provided to the administrative authority.

At least annually, these licensees must also submit internal control reports to the administrative authority and they are all subject to annual audits of their financial statements.

Investment strategy considerations

The three main nuclear licensees have developed strategic asset allocation strategies that consider both asset and liability characteristics in order to optimise risk and return of their portfolios over the long term. For Orano, this corresponded to a portfolio mix of roughly 50% bonds and 50% equities and receivables. For EDF, their target strategic asset allocation includes a financial portfolio and a portfolio of unlisted assets, which are managed by EDF Invest[31]. The financial portfolio includes equities and bonds, whilst the unlisted assets comprise of infrastructure, real state and investment funds.

For all of these licensees, the following investment restrictions apply:

[31] EDF's in-house asset manager.

- No more than 20% of the dedicated assets can be held in shares denominated in a foreign currency;
- No more than 2% of the dedicated assets can be invested in a single entity;
- A third party investment manager cannot manage more than 20% or €1 billion (whichever is higher) of the dedicated pool of assets.

7. Germany

Funds allocated to decommissioning and waste management costs

Under the German Atomic Energy Act and in line with the polluter-pays principle, the operators of Germany's commercial nuclear power plants (NPPs) are responsible for financing the shut-down and dismantling of the NPPs, and for the management of spent fuel and nuclear waste, including the cost of final storage and disposal.

The NPP operators are:
- EnBW Energie Baden Württemberg AG
- E.ON SE
- RWE AG
- Vattenfall GmbH
- Stadtwerke München GmbH

In addition, two former East German commercial nuclear power plants with a total of 6 reactors are being decommissioned by Energiewerke Nord, a federal entity. The cost of decommissioning and waste management is covered by the federal government budget.

Historically the German utilities had accrued balance sheet provisions for their back-end liabilities, by 2014 this amounted to app. €38 billion.

Following the 2011 decision to shut down all NPP's in Germany by the end of 2022, and the related "Energiewende" and its effects on the German utilities, the German government in 2015 performed an analysis and stress-test of back-end liabilities funding. Based on these findings it ordered an expert commission to develop a proposal on how the long-term financing of decommissioning and waste management could be ensured. The final report, published on 27 April 2016, recommended a realignment of responsibilities, financial risks, and funding:

1) The utility operators would continue to be responsible for decommissioning and waste conditioning/packaging. Responsibility for interim storage would shift from the utilities to Government. Government would retain responsibility for siting, developing, and operating waste repositories.
2) Each party should carry the liability and funds related to its responsibilities.
3) Accordingly, utilities would transfer parts of their existing funds plus a risk premium to Government as well as certain physical assets.
4) Government should create a separate public trust fund to manage the funds.

The Act Reorganising Responsibility for Nuclear Waste Management entered into force on 16 June 2017, following its approval under state aid rules by the European Commission. This Act led to the creation of the **Fund for Nuclear Waste Management** ("FNWM"). The FNWM is organised as a foundation under public law. It is in the process of developing its asset management strategy and organization. Around the same time, new State-owned corporate entities were also established:

- the **Bundes-Gesellschaft für Endlagerung** („BGE") for waste repositories and the **Bundesgesellschaft für Zwischenlagerung** („BGZ") for interim storage.

Required financing amounts were verified in the 2015 study by Warth & Klein Grant Thornton AG on the basis of internal company, government and independent expert

data. Cost estimates for central storage facilities and a Pilot Conditioning Plant were derived by GNS, a company specialised in nuclear disposal. The NPPs provided the cost estimates for on-site interim storage. Final disposal cost estimates relate to building, operating and decommissioning deep geological repositories for low and high level wastes.

The Federal office in charge of approvals for transport packages, storage facilities and repositories is the Federal Office for the Safety of Nuclear Waste Management (BfE, Bundesamt für kerntechnische Entsorgungssicherheit). In 2016/17 the tasks concerning nuclear waste management were transferred from the Federal Office for Radiation Protection ("BfS") to BGE.

In early July 2017, the NPP's paid c. €17.9 billion to the FNWM to cover the future costs of interim storage and final disposal plus an additional €6.2 billion "Risk Premium". In addition they are in the process of transferring various assets (in particular interim storage facilities) to BGZ as well as related company holdings and staff to BGE and BGZ. The NPPs continue to hold liability for decommissioning, dismantling, waste treatment and packaging as well as disposal of commercial waste.

Financing and funding arrangements

Operators retain provisions on their balance sheets for the future costs of decommissioning in a financing arrangement best described as non-segregated internal funds. Cost estimates used to determine the provision amounts are based on studies and analyses performed by external specialists and are generally updated and audited annually, in accordance with German and international (IFRS) accounting standards.

The 2017 Annual Reports contained the following provisions, noting that the NPPs use different discount rate and inflation assumptions (see section 4 and Annex 2):

€ million	July 2017 FNWM payment (including risk premium)	31 December 2017 Annual Report Provisions for nuclear decommissioning
E.ON	10,300	10,455
RWE	6,800	6,005[32]
EnBW	4,850	5,803
Vattenfall	1,790	3,461*
Stadtwerke München GmbH	408	775*
Total	24,148	26,499

* As at 31 December 2016

That is, after transfer of the c. €24.1 bn to FNWM in 2017 the utilities retained c. €26.5 bn. provisions.

BGE and BGZ perform their waste management responsibilities with funding from the State. Costs related to commercial NPP radioactive waste storage and disposal will be covered by FNWM, costs for waste from other sources and for legacy issues from the Federal Budget and other sources.

Governance Arrangements

The FNWM's executive board consists of three members. The Federal Ministry for Finance together with the Federal Ministry for Economic Affairs and Energy and the Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety determine the Statement of Investment Principles. A supervisory board acts as the

[32] Includes provision for RWE's 30% share in NPP Borselle in NL.

FNWM's governing body and its members are nominated partly by government and partly by parliament.

The FNWM is to create a Finance and Economic Plan, encompassing
a) A short term plan for the next calendar year;
b) A medium term plan for the next five years; and
c) A long term plan for the next ten years.

The Plan is to be updated annually and requires approval from the Ministries referred to above. The State is to inform the FNWM about planned nuclear waste management activities three months in advance of the start of each calendar year for the next three calendar years for liquidity management purposes. The FNWM has also recently hired an auditor.

NPP Operators prepare and publish audited financial statements each year, which include provisions for future decommissioning, dismantling and related activities. From 2018 onwards, the NPPs will have to provide a more detailed account of reserves and expected costs to the relevant government department. They are also obligated to inform the public in a separate report about steps taken in this regard. In November 2018 the German Bundestag will be presented with a summary report of information reported by the NPPs.

Investment Strategy Considerations
On June 27 2017, the Ministry issued the FNWM's investment mandate. The fund may invest in a broad range of asset classes as specified in Article 215 of the insurance supervision law ("Versicherungsaufsichtsgesetz"). Furthermore, the fund will take so-called Environmental, Social and Governance (ESG) factors into consideration when choosing its investments.

Operators do not hold segregated investment portfolios to back their liabilities for future decommissioning, dismantling and related activities. Balance sheet provisions for these future costs are adjusted for interest annually and backed by the general balance sheet assets of the operator.

8. Hungary

Funds allocated to decommissioning and waste management costs
Hungary currently operates one nuclear power plant (Paks Nuclear Power Plant), which provides approximately 53% of the domestic electric production (as of 2015). Hungary recognised that nuclear energy would play a pivotal part in meeting its energy requirements for the foreseeable future and developed a supporting legislative framework by passing Act CXVI of 1996 on Atomic Energy. The Act declared that a designated organisation appointed by the government, now known as the Public Limited Company for Radioactive Waste Management (PURAM), would be responsible for all tasks related to the disposal of radioactive waste and spent nuclear fuel.

Furthermore, the Act established **the Central Nuclear Financial Fund (CNFF)** at 1 January 1998, intended to cover the future costs associated with radioactive waste and spent fuel management as well as the decommissioning of nuclear facilities.

The CNFF is a segregated fund held on a separate account under the Hungarian government. Payments from the Fund will only be used for purposes as outlined in the Act on Atomic Energy.

As at 31 December 2017, the value of the CNFF was HUF 283.5bn or €0.91bn (1 HUF = €0.00321 as at 31 December 2017).

Financing and funding arrangements

The primary contributor to the CNFF is the Paks Nuclear Power Plant, as it is the largest generator of waste. Expected future decommissioning and waste management costs are estimated in the medium and long term plans prepared by PURAM, which are reassessed annually. These costs are then used to determine the annual payment obligation of the Paks Nuclear Power Plant. The payment obligation essentially ensures that the current value of CNFF assets (together with the present value of these payment obligations) are equal to the present value of the expected future decommissioning and waste management costs.

Minor contributors include the research reactor of the Hungarian Academy of Sciences Centre for Energy Research, and the training reactor of the Institute of Nuclear Techniques at the Budapest University of Technology and Economics. In those instances, their costs are covered by the central state budget. Other institutions and users that utilise nuclear energy pay into the CNFF whenever nuclear waste is transported into their designated storage facility. Two future nuclear reactor units financed by the Hungarian government will also contribute to the CNFF once they are completed and in operation.

Governance arrangements

PURAM prepares a medium and long term plan which specifies use of the CNFF which includes the decommissioning of nuclear facilities, which is then used to develop annual work programmes. The Ministry of Innovation and Technology is responsible for approving these updates and is also responsible for the management of the CNFF.

The State Audit Office of Hungary monitors the Fund every year on the bases of legality, efficiency and effectiveness.

The Ministry of Innovation and Technology is responsible for the management of the CNFF. Meanwhile the Hungarian Atomic Energy Authority (HAEA) has authority over regulation and supervision of radioactive waste storage facilities and facilities of PURAM.

Investment strategy considerations

The assets of the CNFF are kept in a separate treasury account. The CNFF cannot enter into a debt-generating transaction, issue securities (with specific exceptions defined by law), nor conclude a factoring, guarantee or surety agreement.

No additional details on the assets held in the separate treasury account were received.

9. Italy

Funds allocated to decommissioning and waste management costs

After the Chernobyl accident, Italy took the decision in 1987 to shut down all nuclear power plants and the National Electricity Company ("ENEL") was tasked with planning for the decommissioning of these facilities. Although this decision was reconsidered in 2009, a national referendum in 2011 (after the Fukushima accident in Japan) resulted in a decision to continue the suspension of new nuclear projects.

Up until 1987, ENEL had been building up funds to help meet the future costs of decommissioning and waste management. These assets were held in segregated funds for "nuclear facilities dismantling" and "the treatment and disposal of nuclear fuel". In 1999, as part of a privatisation process, decommissioning and waste management

liabilities as well as the above mentioned funds were transferred to the newly established Societa Gestione Impianti Nucleari ("SOGIN").

SOGIN is wholly owned by the Ministry of Economy and Finance and its primary mission is the decommissioning of all nuclear power plants and fuel cycle installations and the safe management of spent fuel and radioactive waste related to those installations.

No nuclear power is currently produced in Italy. Most installations are currently being decommissioned and all are publicly owned or financed[33]. Almost all spent fuel has been sent abroad for reprocessing and, because no domestic reprocessing facilities are available, spent fuel management entails wet storage on site, transport to European reprocessing plants and the subsequent return to Italy of processed materials. A few research reactors remain in operation.

A large research site with various nuclear legacy liabilities, ISPRA, is owned by the European Union and funding for its decommissioning is provided through public means (EU and Italian). This will not be further considered in this study.

Financing and funding arrangements

In addition to the above mentioned funds that were transferred from ENEL to SOGIN in 1999, a Ministerial Decree in 2000 (modified in 2001) created a mechanism for decommissioning and waste management costs to be met by a specific levy on the price of electricity (component A2).

SOGIN carries out an assessment of future decommissioning and waste management costs and submits an annual report with these cost estimates to the National Authority for Electricity and Gas ("AEEGSI"). The levy payable by end users of electricity is then adjusted annually based on the contents of this report.

These levies are paid into a national fund, the Electricity Equalisation Fund, for subsequent transfer to SOGIN to meet decommissioning and waste management costs. The Electricity Equalisation Fund is an unrestricted internal state fund and hence is also used for purposes other than nuclear decommissioning and waste management.

Governance arrangements

SOGIN operates under strategic and operational guidelines provided by the Italian Government and is managed by a Board of Directors consisting of 5 members who are appointed by SOGIN shareholders.

The Company's internal control systems consist of a combination of rules, procedures, systems and organisational structures to assure the propriety of risk management through risk identification, evaluation and monitoring. SOGIN's system of rules and procedures for its core and support operations are promptly revised in line with changes in law, organisation and processes.

SOGIN prepares and publishes audited financial statements each year.

Investment strategy considerations

Because the Electricity Equalisation Fund is an unrestricted internal state fund also used for purposes other than decommissioning and waste management it is not possible to identify separate investments used to meet future decommissioning and waste management liabilities.

[33] Deposito Avogadro is the only Italian nuclear installation owned by a private company. It operates under a service contract with SOGIN, which is the owner of stored spent fuel.

10. Lithuania

Funds allocated to decommissioning and waste management costs

The Ignalina Nuclear Power Plant ("NPP") is the only NPP in Lithuania and both of its two units are being prepared for decommissioning. Unit 1 was shut down on 31 December 2004 and the second unit was shut down at the end of 2009 in line with the obligations set out in the Treaty of Accession to the European Union.

Prior to shut down of Ignalina's two units, funds for future decommissioning were accumulated in the **State Enterprise Ignalina NPP Decommissioning Fund** ("the Ignalina Fund"). Amounts accumulated in the Ignalina Fund are held in a special Treasury account (i.e. it is a segregated external fund) and funding contributions calculated as a percentage of the revenues earned from electricity sales. However, since the shutdown of Unit 2, funding contributions to the Ignalina Fund have ceased (as revenues were no longer being generated). From 2014, all revenue earned from sales of redundant Ignalina NPP assets has been allocated to the Ignalina Fund.

Recognising the funding shortfall in the Ignalina Fund and the financial impact of the early closure of the Ignalina NPP, an EU assistance programme was established and more detail on its operation is set out below.

For other non-NPP institutional waste producers, the State Enterprise Radioactive Waste Management Agency ("RATA") collect fees in a separate dedicated account. Management of historical non-NPP institutional waste, which was collected before 2003, is funded from the state budget.

Financing and funding arrangements

In agreement with the country's commitments to join the European Union, the Ignalina Programme was created in order to provide financial assistance for the decommissioning of the Ignalina NPP. The Ignalina Programme is funded via the EU budget through two primary EC funding mechanisms:

- The Ignalina International Decommissioning Support Fund ("IIDSF"), which receives contributions from donors, the most significant of which is the EC.
- Direct EU funding to the Central Project Management Agency ("CPMA"). Projects that have received the favourable opinion of the Nuclear Decommissioning Assistance Programme Committee and the approval of the EC are contracted through the CPMA in accordance with Lithuanian public procurement policy.

The approved financing for the implementation of the Ignalina programme is €450.8 million (in 2015 money terms) for the period 2014 – 2020. Lithuania contributes 12% of the funds required for the Ignalina Programme.

Funding for decommissioning the Ignalina NPP from the EU (through the IIDSF and the CPMA) and national sources is not expected to be sufficient and it is expected that Lithuania will need additional support over the full period of decommissioning (projected to last until 2038). Lithuania expects that the EU will continue to follow the agreement reached under the Treaty of Accession and will continue to provide additional financing to ensure the decommissioning of the Ignalina NPP.

Governance arrangements

State Nuclear Power Safety Inspectorate ("VATESI") is the state regulatory and supervisory authority in Lithuania for activities involving nuclear materials. VATESI sets safety requirements and regulations, issues licenses, permits and assesses the safety of nuclear facilities. VATESI acts as an independent governmental institution subordinated

directly to the Cabinet of Government and the President. VATESI activities are financed by the Lithuanian state budget.

The Ministry of Energy is responsible for co-ordinating the management of spent fuel and radioactive waste and is required to inform government about these activities on an annual basis.

The EBRD is the administrator of the IIDSF, while the governing body is the Donors Assembly.

The CPMA has been designated by the EC to act on its behalf as the National Agency of the Ignalina Programme. The CPMA is an agency under the Ministry of Finance of Lithuania. The Republic of Lithuania takes responsibility and provides full financial guarantees to the EC in respect of the activities of the CPMA.

Investment strategy considerations

No information was provided on the investment strategies of or the assets held within either the Ignalina Fund or the IIDSF.

11. Netherlands

Funds allocated to decommissioning and waste management costs

Nuclear power has a small role in the Netherlands, generating roughly 4% of total electricity supply. There is a single nuclear power plant in Borssele, operated by Elektriciteits-Produktiemaatschappij Zuid-Nederland (EPZ) and research reactors in Petten and Delft. The High Flux Reactor in Petten is operated by the Nuclear Research & Consultancy Group (NRG) and is owned by the European Commission; it produces approximately 30% of all medical isotopes in the world. The Higher Education Reactor at the University of Technology in Delft is used for research and educational purposes. URENCO operates an enrichment plant in Almelo.

There are also two decommissioned nuclear installations: a nuclear power reactor in Dodewaard (currently in safe enclosure) and the Low Flux operator in Petten, which was also operated by NRG and owned by the European Commission. Radioactive waste is no longer being produced, but waste will arise when installations are dismantled.

In the Netherlands, decommissioning and waste management are considered separate activities and as such, there are separate funds dedicated to each. EPZ contributes to a fund managed by an independent foundation, Stitching Ontmantelingsgelden Kerncentrale Borssele (SKOKB), to cover the future costs of decommissioning. The SKOKB is a separate legal entity and is the legal owner of the funds – that is, financing for decommissioning is via a segregated external fund. At 1 January 2017, the value of the assets held by SKOKB was roughly €205 million.

Under the Dutch Nuclear Act, nuclear operators / licensees are required to transport all nuclear waste to the Central Organisation for Radioactive Waste (COVRA). COVRA is the government mandated body that reserves and manages the financial resources for both long term aboveground storage of waste and for the potential implementation of a deep geological disposal facility.

Via financing schemes between COVRA and waste generators, the necessary financial resources for long term waste management are collected by COVRA. The funds available to and supplemented by COVRA for final disposal are managed by COVRA in a separate fund, on an account held by the Ministry of Finance.

Upon delivery of waste to COVRA the operator transfers all responsibilities for subsequent waste management to COVRA. At the COVRA site, the waste is stored aboveground for at least 100 years and the Dutch intend to use this period of time to conduct research on possibilities for deep geological disposal of waste.

Financing and funding arrangements

EPZ make annual contributions to SKOKB based on the most recent decommissioning cost estimates. The level of contribution is reassessed at least once in every five years when decommissioning cost estimates must be updated and approved by the Authority for Nuclear Safety and Radiation Protection (ANVS). At present, EPZ pays c. €15m annually, which is based on an electricity surcharge.

Funds held by SKOKB can only be used for decommissioning purposes based on a decommissioning plan approved by ANVS.

COVRA uses pricing schemes to finance their operations. For instance, for the transfer of low level and intermediate level radioactive waste, a list of charges is provided to operators for this type of waste and COVRA is then compensated for each waste package received. These charges incorporate the fact that the waste will be placed in a temporary aboveground storage facility for at least 100 years. These charges are corrected annually to allow for inflation with larger structural adjustments every five years. For high level waste, operators of nuclear power plants and research reactors have jointly decided to build a special storage facility, the HABOG. The facility was commissioned on the COVRA site in 2003 - both construction and operating costs are borne by waste generators.

Governance arrangements

The Netherlands require nuclear power stations and research reactors to have a dismantling plan and financial security that must be approved by the Ministers of Infrastructure and the Environment and Finance. This guarantees that in the event of unexpected closure of business, sufficient resources are available.

The SKOKB provides a mandate to a professional fund manager who is then tasked with managing the SKOKB's funds. The SKOKB board and the EPZ treasury committee are responsible for monitoring the results. Once every five years, ANVS is required to approve EPZ's renewed decommissioning plan and financial plan, in which the investment mandate and results are evaluated.

The SKOKB is subject to annual audit by an external audit firm.

Investment strategy considerations

SKOKB's strategic asset allocation is 20% equities, 80% corporate and sovereign bonds, although this will reduce to 100% bonds c.3-5 years before expenditure begins.

At present, COVRA invests a large proportion of its funds with the State via treasury banking. The Board of Supervisory Directors is responsible for supervising this business, and considers the growth of the resources for long-term storage and disposal, subject to a five-year interim assessment.

12. Romania

Funds allocated to decommissioning and waste management costs

Romania has an established nuclear sector and is active in most aspects of the fuel cycle, notably in mining, fuel manufacture and civil nuclear generation. Romania has one nuclear power plant, CNE Cernavoda with two operating reactors operated by Nuclearelectrica (SNN) which is a government owned company. The electricity generated by the plant represents approximately 18% of the total electricity generation in

Romania. A further two more reactors have been planned to be constructed at the same site.

Fabrication of nuclear fuel is completed at the Nuclear Research Institute (ICN) at Pitesti operated by Nuclearelectrica (SNN). There are two research reactors, one operated by ICN and another operated by the National Research and Development Institute for Physics and Nuclear Engineering (IFIN-HH). These facilities are not considered further in this study.

Two segregated external funds have been established to meet future decommissioning and waste management costs: the Waste Disposal Fund and the Decommissioning Fund. These funds are owned and managed by the Nuclear and Radioactive Waste Agency ("ANDR"), under the control of the Ministry of the Economy.

ANDR coordinates the disposal of spent nuclear fuel and other radioactive wastes and the implementation of decommissioning activities. It is also responsible for periodically (at least once every 5 years) updating the decommissioning and waste management cost estimates, and ensuring that adequate funds are available. As at 2014, the Waste Disposal Fund contained 451 million Lei (€102 million) and the Decommissioning Fund contained 209 million Lei (€47 million).

Financing and funding arrangements

Generators of nuclear waste (of which SNN is the most significant) contribute into the funds based on a fee per unit electricity generated. The fee system, established in 2007, for the two funds is as follows:

- €1.4 per MWh per reactor unit paid to the Waste Disposal Fund
- €0.6 per MWh per reactor unit paid to the Decommissioning Fund

Based on current rates of electricity generation, the annual payment to both funds from SNN is approximately €20.8 million. It is understood that ANDR have started the process of reviewing the fees payable to the two funds amid concerns that the current fees received by the funds are inadequate.

Costs associated with the handling, storage, treatment and conditioning of all radioactive waste prior to its disposal will be met directly by the generators of this waste. That is, waste management costs are distinct from decommissioning and waste disposal costs – waste management costs are not met from segregated funds in the same way as decommissioning and waste disposal.

Financial resources for the operation of ANDR, decommissioning of research reactors and other non-NPP facilities as well as the costs associated with the management of institutional radioactive waste are assured from state budget, and from contracts with radioactive waste producers within Romania.

Governance arrangements

The Romanian legal framework consists of three levels: nuclear legislation, regulations on radiological safety and mandatory and enforceable regulations issued by CNCAN (National Authority Responsible for the Regulation of Nuclear Activities).

In addition to coordinating the disposal of spent nuclear fuel / other radioactive wastes, and the implementation of decommissioning activities, ANDR also oversees the construction and operation of new disposal facilities for radioactive waste and develops the National Programme regarding safe management of the radioactive waste and of the spent nuclear fuel.

The funds are restricted and can only be used for explicit decommissioning or waste disposal activities. Licence holders cannot directly withdraw money from the funds, but can request money to cover the costs of legitimate decommissioning or waste disposal activities.

The Romanian Government retains ultimate responsibility for and guarantees the decommissioning of nuclear facilities, as well as the safe management of radioactive wastes and spent fuel generated within Romania

Investment strategy considerations

The funds are managed by ANDR, and are invested conservatively in low-risk arrangements via State Treasuries.

13. Slovakia

Funds allocated to decommissioning and waste management costs

The Slovakian nuclear landscape includes operating nuclear power plants at Bohunice (NPP V2) and Mochovce (EMO 12), both of which are operated by Slovenske Elektrarne a.s. ("SE AS"). Additionally the EMO 34 plant is currently under construction at the Mochovce site.

There are also two nuclear power stations that have already commenced decommissioning. NPP A1 was shut down in 1977 following an accident whilst operations at NPP V1 were terminated in 2006 and 2008. Both of these stations are located at the Bohunice site and owned by Jadrová a Vyraďovacia Spoločnosť a.s. ("JAVYS AS").

The National Nuclear Fund for Decommissioning of Nuclear Installation and for Management of Spent Nuclear Fuel and Radioactive Waste ("NNF") was created by Act no. 238/2006 (as amended). The NNF is an independent legal entity managed by the Ministry of Economy. The purpose of the NNF is to collect and administer the financial resources related to the back-end of the nuclear fuel cycle and to ensure that these resources are used for the purposes they were intended.

Financing and funding arrangements

The NNF receives contributions from a number of different sources, the most significant of which include:

- Obligatory contributions from operators of nuclear power installations (currently only SE AS).
- Transfers from the budgetary expenditure account of the Ministry of Economy as a result of levies charged to the operators of the electricity transmission and distribution systems.
- Subsidies from the State budget.

Prior to 1995, there was no requirement for nuclear licence holders to make contributions intended to meet future decommissioning and waste management costs. Although attempts were made in the early 1990's to introduce such an obligation, it was not properly addressed until passage of the Nuclear Fund Act (Act 238/2006). However, given the lack of advance funding in place at this time, it became inevitable that funding for future decommissioning and waste management activities would need to be collected from energy consumers (in the form of levies collected by network operators) or from taxes (in the case of payments from the State budget), as well as from nuclear operators.

To remove the "historical deficit" due to the lack of funding prior to 1995, a Government Regulation requires operators of the electricity transmission network and regional distribution networks to pay levies each year (based on the quantity of electricity supplied). From 2013, these levies are sent to the income budget account of the Ministry of Economy from where they can subsequently be passed to the NNF. The historical deficit is intended to be addressed over a period of roughly 35 years.

As the only current nuclear operator, SE AS is required to make compulsory contributions to the NNF. These compulsory contributions include:

- A fixed amount of €13,428.26 per annum for each MW of installed electrical output, adjusted every year by the level of inflation for the previous year;
- A variable contribution of 5.95% of the price of the electricity produced in the nuclear installation during the previous year.

In each of 2016 and 2015, SE AS made contributions to the NNF of roughly €60 million.

Contributions received by the NNF are held in a number of different sub-accounts, in relation to the amount of contributions paid by nuclear licence holders and budgetary transfers, with separate sub-accounts for the following (amongst others):

- Decommissioning and waste management costs for each of the A1, V1, V2 and EMO 12 stations (separate account for each);
- Decommissioning and waste management costs for nuclear installations that will be commissioned in future;
- Management of orphan nuclear materials and radioactive waste;
- All aspects associated with spent fuel repositories;

On 1 January 2015, the total market value of the assets held in the NNF was c. €1.225 billion. On this date, SE AS recognised a provision for decommissioning and waste management of c. €2.211 billion as well as a receivable from the NNF for c. €898 million. At 31 December 2016, these figures had changed to c. €1.816 billion and €1.064 billion respectively.

The Bohunice International Decommissioning Support Fund ("BIDSF") was established as compensation by the EU after the Slovakian Government made the decision to prematurely shutdown the NPP V1 facility at the time of joining the EU. The total amount of promised financial assistance through the BIDSF for the NPP V1 facility is roughly €674 million. Grants from the BIDSF are however not paid into the NNF. Instead, funding of relevant activities is directed to JAVYS AS and, in effect, reduces the amount of funding provided from the NNF for decommissioning the NPP V1 facility.

Resources from the NNF can be granted upon application and can be used to meet legitimate costs associated with the back end of the nuclear fuel cycle. Funds will only be granted if the application is compliant with conditions defined in Act No. 238/2006 and after the approval of the Board of Trustees of the NNF.

Governance arrangements

Act 238/2006 sets out the rules for the management, determination and collection of contributions and the scope of activity for the NNF.

The Board of Trustees of the NNF are required to update the draft National Policy and National Programme for the Management of Spent Fuel and Radioactive Waste and submit this to the Ministry of Economy, for subsequent approval by government, every six years. In addition, the Trustees of the NNF also produce an annual report on the implementation of the National Programme over the preceding year and submit this to the Ministry of Economy for approval.

The NNF has its own governing bodies, including a Council of Administrators, Supervisors Board, Director and Auditor.

Investment strategy considerations

The total market value of the assets held in the NNF on 1 January 2015 of c. €1.225 billion comprised the following term deposits:

- €700m with interest at 4.05% until 2020;
- €120m with interest at 4.95% until 2021;
- €70m with interest at 1.5% until 2017;
- €70m with interest at 2.95% until 2022;
- €140m with interest at 2.59% until 2023; and
- €125m with interest at 2.4% until 2034.

14. Spain

Funds allocated to decommissioning and waste management costs

The management of spent fuel and radioactive waste has been entrusted to the Empresa Nacional de Residuos Radiactivos SA ("Enresa") as part of the General Radioactive Waste Plan ("PGRR").

Enresa share capital is wholly owned by the State and it is regulated by the Ministry of Industry, Energy and Tourism ("Minetur") through the Secretary of State for Energy. The State also assumes ownership for spent fuel and radioactive waste once it has been disposed of.

In Spain, financing for the costs of managing spent fuel and radioactive waste is based on the "polluter pays" principle. Funding amounts are therefore paid by waste generators into the **Fund for the Financing of the General Radioactive Waste Plan** ("the PGRR Fund"). The PGRR Fund is managed and administered by Enresa and provides financial support for its present and future activities.

Financing and funding arrangements

Enresa must submit an updated PGRR to Minetur every four years (or more frequently if required by Minetur). The estimated decommissioning and waste management costs contained in the PGRR are based on a set of "reference scenario" assumptions and, using these, Enresa will determine the financing amounts that are payable to the PGRR Fund. The guiding principle for the operation of the PGRR Fund is that at the end of the envisaged period of radioactive waste management and decommissioning, the total amount of funding received (plus investment returns) should cover all costs.

The PGRR Fund receives contributions from the following sources:

- Tax on electricity tariff: method used for financing the costs associated with nuclear sites (including nuclear power plants and fuel element factories) that ceased operations prior to 2010 as well as historical research facilities.
- Tax on nuclear power plants: advance collection system based on the electricity generated annually by each power plant. This is the method for financing all costs expected to be incurred after 2010 for the management of spent fuel, radioactive waste and decommissioning.
- Tax on the Juzbado fuel factory, which covers the provision of management services for radioactive waste arising from the manufacture of fuel elements.
- Tax on other radioactive waste management services, including medicine, industry, agriculture and research.

Roughly 99% of the PGRR Fund's income comes from the taxes on nuclear power plants. If an operator decides to cease operations earlier than expected, any funding shortfall in the PGRR must be paid by the licence holder during the three years after cessation.

In 2016 the total value of contributions received by the PGRR Fund was c. €395 million and at 31 December 2016 the market value of the PGRR Fund was c. €5.0 billion.

Funds held in the PGRR Fund can only be used for specific activities defined in the PGRR. Enresa is required to submit annual reports to Minetur describing its spending plans.

Governance arrangements

A Tracking and Control Committee (attached to Minetur) has been set up and is responsible for the supervision and control of fund investments. This committee prepares half-yearly reports on the PGRR Fund and the financial management of its investments.

Enresa prepares and publishes audited financial statements each year. The Court of Auditors, General State Comptroller and the Ministry for Economy also oversee the PGRR Fund in some capacity.

Investment strategy considerations

Management of the PGRR Fund is governed by the principles of security, profitability and liquidity. Royal Decree 102/2014 sets out the assets in which the PGRR Fund is allowed to invest, which include:

- Listed fixed income and equity securities.
- Government debt, mortgage backed securities and other similar financial assets and instruments.
- Derivative instruments for structuring and hedging purposes.
- Deposits at financial institutions and loans.
- Real estate.
- Foreign securities listed on foreign exchanges.
- Any other investment or asset that the Tracking and Control Committee deems appropriate.

Additionally, the Tracking and Control Committee has imposed the following constraints on the PGRR Fund's investments:

- 100% may be invested in fixed-income securities;
- Up to 20% can be invested in index-linked products (with 100% guaranteed principal);
- No equity or real estate investments are permitted;
- Long-term investments must be investment grade;
- Currency risk must be hedged;
- Maximum of 20% can be invested in assets which have to be recorded at market value for accounting purposes.

The PGRR Fund's minimum target return is the Spanish Cost of Living plus a minimum real yield (which is currently 1.5%).

15. Sweden

Funds allocated to decommissioning and waste management costs

Nuclear licence holders are responsible for the safe handling and disposal of spent fuel and other radioactive waste as well as decommissioning and dismantling of facilities. The Act on Financing of Management of Residual Products from Nuclear Activities (2006, "the Financing Act") contains provisions for how the costs associated with these activities

will be met. Nuclear licence holders have formed a company, the Swedish Nuclear Fuel and Waste Management Co. ("SKB") to assist them in carrying out their responsibilities.

The SKB co-ordinates the submission of decommissioning and waste management cost estimates from licence holders to the regulator (the Swedish Radiation Safety Authority or "SSM") every three years. Based on the SSM's review, nuclear licence holders are then required to pay individually calculated fees to the State, as well as providing additional guarantees (i.e. both the fees and the guarantees are reassessed every three years – a key component in managing risk). The payments made to the State are invested in a segregated external fund, **the Nuclear Waste Fund** ("NWF"), owned and managed on a unit-linked basis by a separate government agency.

The NWF has to date covered SKB expenses for central interim storage of spent fuel, transport, R&D, laboratories and siting and feasibility studies. Future expenses are expected to include costs associated with the encapsulation plant for spent fuel, repositories for spent fuel and other wastes, decommissioning, dismantling and disposal.

Financing and funding arrangements

Fees for reactor owners are calculated in relation to the energy that is delivered and are determined annually by the Government based on SSM's recommendation. The Financing Act determines fees payable by nuclear power plants and separate arrangements exist for other nuclear facilities and legacy waste. During 2017, the NWF received total contributions of c.SEK 3.8bn and at 31 December 2017, the market value of the assets held in the NWF was c.SEK 67.2bn.

In addition, nuclear power plants must also provide two separate guarantees:

- A guarantee covering the shortfall if a reactor is closed before 40 years of operations ("the financing amount"). This guarantee is intended to cover the operator's existing deficit in the NWF assuming no further fees are received; and
- A guarantee to cover costs associated with unexpected events ("the supplementary amount").

The Swedish National Debt Office administers these guarantees. Guarantees are typically provided by parent companies and the Debt Office assesses their value and creditworthiness and issues statements to the Government every third year. For 2015-2017, Government determined a total financing amount of c.SEK 18.5bn and a total supplementary amount of c.SEK 7.9bn for reactor owners[34].

During the past three years, several parent companies have undergone structural changes including divestitures and spin-offs of substantial parts of their business. According to the most recent Opinion for the period 2018 – 2020, published by the Swedish National Debt Office in April 2018, these structural changes combined with an expectation that guarantee amounts will rise substantially have the potential to negatively impact the parent companies' long-term abilities to support their guarantees. For the first time, this year's opinion therefore proposed risk reduction conditions in addition to an assessment of the proposed guarantees, including potential margin calls, expanded disclosure requirements for guarantors and potential consent requirements for sales of parts of the businesses to ensure no negative impact on creditworthiness.
SSM examines and decides how and to what extent NWF assets may be used to meet costs that nuclear power plants and other licence holders are expected to incur over a given period. Each year, parties receiving funds from the NWF must also report on the use of this money. SSM carries out regular audits on funds disbursed.

[34] In addition, SSM has determined a financing amount of SEK 3.3 billion for other fee-liable licensees for the period 2014-2016.

The activities of SSM are financed largely from licensees in the form of fees to cover regulatory costs and related research.

Governance arrangements

The NWF is managed by a Board of Governors appointed by the Government of Sweden. Two of the Governors are however nominated by the nuclear licence holders. Administrative work is carried out by Kammarkollegiet (Legal, Financial and Administrative Services Agency).

The NWF prepares and publishes audited financial statements each year. The Swedish National Audit Office audits the financial statements.

Investment strategy considerations

The NWF's assets must be deposited in an interest-bearing account at the National Debt Office, in treasury bills issued by the state or in covered bonds. The NWF's investment policy must be reviewed at least once a year, including: the target rate of return for the fund's assets, how risks are to be controlled and how results are to be reported. The NWF's assets are actively managed.

The NWF's long-term goal is, taking into account the restrictions imposed by government, to achieve the highest possible real return on managed capital. The current goal is to achieve a nominal return over a 5-year period that exceeds the standard portfolio's comparison index by an average of 0.5% per year.

The NWF has appealed to government to permit investment in a wider range of assets, including equities and both corporate and foreign bonds, with effect from 2018. This will require a re-assessment of the NWF's current goal.

16. United Kingdom

Funds allocated to decommissioning and waste management costs

In the UK, parties with existing decommissioning and waste management liabilities include the Nuclear Decommissioning Authority ("NDA") and EDF Energy Nuclear Generation Limited ("EDFE").

The NDA was created in 2005 and has responsibility for operating and decommissioning the civil public sector nuclear estate. It is responsible for 17 of the 19 historical nuclear sites, including the first generation of Magnox stations, various research and fuel facilities, the low level waste repository and the complex Sellafield site. As at 31 March 2017, the NDA's estimate of the discounted value of future decommissioning and waste management costs stood at c£164 billion. The NDA calculates this provision annually for inclusion in its published financial statements.

In addition to the NDA estate, seven Advance Gas-Cooled Reactors ("AGR") and one Pressurised Water Reactor ("PWR") were privatised in 1996 and are currently owned by EDFE.

EDFE emerged from the restructuring of the former British Energy Group of Companies in 2005. This restructuring led to changes in the way in which the decommissioning and waste management liabilities of EDFE's eight nuclear stations were to be funded and, in particular, resulted in the creation of **the Nuclear Liabilities Fund** ("NLF"), an independent, segregated, external trust set up by the UK Government.

In addition, the UK has developed a new regime[35] for funding the back-end liabilities that will emerge from its planned new nuclear build programme. Because the new build programme has not yet accrued any actual liabilities or funds it will not be considered further in this report. However, this regime may well be considered best practice for a particular nuclear scenario, namely private investment in new reactors in a liberalized energy market.

Financing and funding arrangements

The NDA is a non-departmental public body sponsored by the Department for Business, Energy and Industrial Strategy ("BEIS"). Funding for the NDA's decommissioning and waste management activities comes directly from UK Government, through BEIS[36], and no segregated funds are held for this purpose. The NDA business plan (prepared annually) is the primary vehicle for securing funding as well as setting out the proposed activities for the NDA estate.

EDFE make regular, quarterly contributions to the NLF, under the terms of a Contribution Agreement, aimed at covering the costs of decommissioning and other liabilities. The level of these contributions in 2018 is expected to be c.£1.9m per quarter (based on a 2003 value, adjusted in line with RPI).

Payments from the NLF to meet qualifying liabilities can only be made by application from EDFE to the NDA. Payments from the NLF are thus made in a controlled manner and can only be used for discharging defined decommissioning and historic fuel related liabilities associated with the AGR's and PWR.

[35] THE ENERGY ACT 2008: Funded Decommissioning Programme Guidance for New Nuclear Power Stations (December 2011). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42628/3797-guidance-funded-decommissioning-programme-consult.pdf

[36] The NDA does also generate some revenue through commercial activities such as electricity generation and spent fuel management.

The NLF's objective is to provide funding to cover the costs of decommissioning the eight reactors owned by EDFE as well as the associated waste management and disposal costs. However, there is no guarantee that the NLF will prove sufficient for this purpose and therefore the UK Government has indemnified future funding shortfalls in the NLF. At 31 March 2017, the net assets of the NLF were equal to £9.4 billion.

Governance arrangements

The NDA is sponsored by BEIS, with oversight provided by UK Government Investments ("UKGI"). BEIS (along with Scottish Ministers) approve the NDA's plans and provide a policy framework. Day to day management of the sites for which the NDA is responsible is contracted out to Site Licence Companies ("SLCs").

The NDA Board sets strategic direction and is ultimately responsible for delivery of the NDA's obligations under the Energy Act 2004. The NDA Executive Committee is responsible for implementation of the strategy and plans approved by the Board. The NDA is also responsible for scrutinising EDFE's decommissioning plans, budgets and funding claims for its existing nuclear fleet.

The NLF is owned by the Nuclear Trust (98%) – a public trust established under Scottish Law, the Secretary of State for Business Energy and Industrial Strategy and EDFE (the 'Special Shareholders') (1% each). The Nuclear Trust has five trustees, three of whom are appointed by the UK Government and two by EDFE, who also act as directors of the NLF. The Trustees have delegated responsibility for certain matters to a number of sub-committees, including the investment committee, the audit committee and the remuneration and nomination committee.

The Directors of the NLF prepare annual financial statements in accordance with IFRS and these are subject to formal, external audit.

Investment strategy considerations

The directors of the NLF believe that they should be guided by the Myner's Principles[37] to the extent appropriate. The bulk of the NLF (c.79%) is currently invested in the National Loans Fund with the balance in a growth portfolio managed by BlackRock.

17. Other countries

Austria

In 1978, Austria decided not to start the operation of the completed nuclear power plant in Zwentendorf. Subsequently, Austria's statute as a nuclear free country was introduced in the constitution. The only nuclear installation is a TRIGA research reactor, is operated by the Vienna University of Technology (Institute of Atomic and Subatomic Physics).

Since 2003, producers of radioactive waste are obliged to make a proportionate contribution to the future disposal of Austria's radioactive waste. By law all radioactive waste in Austria has to be delivered for waste treatment and interim storage to Nuclear Engineering Seibersdorf GmbH. The rate that has to be paid for this includes a disposal fee (so called "Vorsorgeentgelt"). The disposal fee will cover the costs for a future disposal facility, including waste transport and long term management of the facility. It was calculated upon the comparison of costs on existing foreign disposal facilities. The

[37] Paul Myners was commissioned to undertake a review of institutional investment in the UK in 2000. His review established a best practice approach and a number of key principles for investment decision making for UK pension funds. The full report is available here: http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/1/6/31.pdf

"Vorsorgeentgelt" is continuously paid into the Austrian state budget, where this special asset is by law exclusively dedicated for financing radioactive waste disposal.

Cyprus

No nuclear applications that could lead to the generation or disposal of spent fuel (i.e. nuclear power plants, research reactors, nuclear treatment facilities, uranium or thorium mines etc.) exist in the country and the use of nuclear energy for the generation of electric power is not considered by the Government in the country's energy mix in the foreseeable future; therefore, there is no immediate prospect of having nuclear materials or spent fuel or activities related to nuclear materials or spent fuel.

The main origin of radioactive waste is from activities in the field of medicine, industry, and research.

Denmark

Denmark has no active nuclear programme and all nuclear installations have been shut down. However, radioactive waste did originate from the decommissioning of research reactors and is managed at the Risø National Laboratory.

All costs associated with managing the above mentioned waste are covered through the State budget, with the Danish State guaranteeing the necessary resources.

Estonia

Estonia has no active nuclear programme and no operational nuclear power plants. It did however inherit a number of installations from Russia, including Paldiski (a former Soviet nuclear submarine training centre).

Current generators of radioactive wastes are medical, industrial and research establishments – all other waste originates from the former Soviet Union.

The costs of decommissioning Paldiski and all other radioactive waste management costs are met by the State.

Greece

Greece has only one research reactor (GRR-1) operated by the Institute of Nuclear Technology and Radiation Protection (INTRP) of the National Centre for Scientific Research "Demokritos", a state organization. GRR-1 is licensed for extended shutdown and the irradiated fuel stored in the reactor is covered by an agreement with the US Department of Energy for shipment back to the USA until 2019.

The majority of radioactive wastes in Greece are Very Short Lived Waste (VSLW), Very Low Level Waste (VLLW) and Low Level Waste (LLW). Very little Intermediate Level Waste (ILW) is likely to be produced from the decommissioning of the GRR-1 and High Level Waste (HLW) does not exist.

GRR-1 is a state facility and therefore the Greek state is responsible for the cost of decommissioning via the state budget. Owners of other radioactive wastes make payments to a deposit fund, which is then used to meet the costs associated with waste management and disposal.

Ireland

Ireland has chosen not to develop a nuclear power industry and the Government has no plans for a change of policy in this respect. It has no nuclear power plants, nuclear research reactors, spent nuclear fuel or reprocessing facilities. Ireland does use radioactive materials in support of its high technology industries and its medical and other societal infrastructure.

There is no specific budget for radioactive waste management. Regulatory activities are funded through annual provisions in the state budgetary process.

Latvia

There was only one fully State-owned nuclear installation in Salaspils Latvia, which was permanently shut down in 1998. The Latvian Environment, Geology and Meteorology Centre (LEGMC) was responsible for the facility and its subsequent decommissioning. In addition, LEGMC manages a waste disposal facility, "Radons".

Estimated current costs for decommissioning the Salaspils facility are approximately €5.5 million and the decommissioning is expected to be completed by c.2020. Decommissioning costs, together with the management and supervision of the Radons facility after its closing) will be met via annual allocations from the State budget.

Luxembourg

Luxembourg has no active nuclear industry or operational nuclear facilities. The limited quantities of radioactive waste that are generated are sent to Belgium where they are stored and subsequently disposed. Costs for the transfer of radioactive waste (including transport costs) are set by the Belgian authorities and paid by the Luxembourg government.

Malta

Malta does not have an active nuclear programme, any nuclear fuel related activities and does not use, handle or store spent nuclear fuel. Government is responsible for meeting the costs associated with the management of any radioactive wastes arising.

Poland

Currently, there is one research reactor in operation although radioactive waste also originates from scientific and educational institutions, industry and medical facilities.

The costs of decommissioning the research reactor as well as the costs of managing and disposing of the waste from the above mentioned sources are met via the State's budget.

Portugal

Portugal has a single research reactor (The Portuguese Research Reactor (RPI)). Spent fuel is due to be returned to the USA by 2019. Portugal is however considering using the fuel beyond this date.

The State is ultimately responsible for management of spent fuel and radioactive waste and meets these costs directly through the State budget. There are no current plans to decommission the RPI.

Annex 2: Analysis of investment strategies, past performance and risk profile of funds allocated to the back-end activities of the nuclear fuel cycle in relevant EU Member States

1. Standard approach for analysing risk

To help achieve consistency, objectivity and comparability, a standard approach has been adopted for analysing funding and investment risk for the following EU Member States: France, Germany (in so as possible), Hungary, Slovakia, Spain, Sweden and the UK. This standard approach involves the following key steps:

1. ***Specification of the profile of expected future decommissioning and waste management costs*** that will need to be met from a given fund. For this purpose, the cost data provided has been relied on and, as noted earlier, it is beyond the scope of this study to comment on the completeness, accuracy or methods of determining these costs. Explanations have however been provided for any adjustments or assumptions that have been made in order to arrive at the cost profile. The total "overnight" cost and the effective year of these costs have also been specified.

2. Analysis of fund's ***asset allocation and the distribution of investment returns*** that might reasonably be expected to be achieved over the next 10 years. In addition to providing detail on investment strategy and the composition of the investment portfolio, this analysis serves two primary purposes:
   - It provides a starting point from which a market-consistent liability discount rate can be developed (see point 3 below).
   - It provides insight into the likely dispersion of future investment returns and therefore into the level of overall investment risk.

3. ***Assessment of the extent to which the financial assumptions used to calculate present values of future decommissioning and waste management costs are appropriate*** in light of the expected future investment returns referred to in point 2 above. Discount rates that are not consistent with a fund's investment strategy are likely to misstate the assessed liability value (and hence future funding requirements). To quantify the potential funding impact, liability values on the following bases have been calculated and compared:
   - Using the real discount rate currently adopted by the Member State. This is referred to as the "***base case liability".***
   - Using a real discount rate derived as the difference between the median expected investment return over the next 10 years and long-term expected inflation. . This is referred to as the ***"best estimate liability"***.

4. Using the best estimate liability, ***deterministic stress testing*** to illustrate the impact (on both investments and liabilities, and hence funding level) of pre-defined changes to equity markets and discount rates.

5. Calculation of the ***1-year 95% VaR (again with reference to the best estimate liability) to provide a measure of the overall level of risk*** and to provide a decomposition of overall risk into key risk drivers.

In Belgium, Finland, Italy, Lithuania and Germany, the specific nature of the funding/financing arrangements are such that the standard approach outlined above would be of little relevance and therefore a bespoke approach has been followed in the

individual country sections below. A high-level analysis has also been carried out for Croatia based on the information available. Sufficient data and information was not provided for Bulgaria, Czech Republic, Romania and the Netherlands.

Performance measurement

Where sufficient data has been provided, an analysis of the past investment performance of the funds set up to meet the back-end costs of the nuclear fuel cycle has also been included. This analysis shows the actual return achieved (in both gross and real terms) by a given fund.

2. Belgium

Expected future decommissioning and waste management cost profile

A full cost profile showing when the expected future decommissioning and waste management costs are expected to be incurred in each future year was not available.

Asset allocation

As noted in Section 2, Synatom may lend up to 75% of the calculated provision for future decommissioning and waste management costs to the operator (its parent company, Electrabel). At 31 December 2016, Synatom had outstanding loans to Electrabel of c. €6.7bn, roughly 73% of the provision for future decommissioning and waste management costs or 70% of the total value of its balance sheet assets.

The remainder of Synatom's assets are either lent to other entities meeting required credit criteria or invested in short-term financial assets. It is understood that Electrabel is required to compensate Synatom for any investment underperformance on a regular basis.

Market consistent assessment of liability

At 31 December 2016, Synatom's provision for future decommissioning and waste management costs was c. €9.2bn (versus c. €8.0bn at 31 December 2015) and was calculated using an assumption for future inflation of 2% p.a. and a gross discount rate of 4.2% p.a. (i.e. a real discount rate of approximately 2.2% p.a).

The gross discount rate is set to reduce to 3.85% at 31 December 2017 and further to 3.5% at 31 December 2018 (the inflation assumption is expected to remain unchanged). Synatom's 2016 annual report notes that this would be expected to increase the provision by c. €1bn (all else remaining equal).

Risk analysis

Synatom's primary risk exposure is the credit risk associated with the loans made to its parent company, Electrabel. The size of these loans relative to Synatom's other investments results in a significant concentration of risk to a single entity.

Assessment of this risk ultimately depends on the commercial terms of these loans (including the extent to which they are collateralised), where in the Electrabel capital structure these loans rank and whether or not Synatom would have recourse to Engie SA in the event of Electrabel defaulting on these loans. Analysis of these points is beyond the scope of this report.

It is however questionable whether the ability to lend such a significant proportion of assets back to the operator is consistent with the objective of funding future liabilities in advance. This level of "self-investment" would be questioned for other institutional investors.

3. Croatia

Expected future decommissioning and waste management cost profile

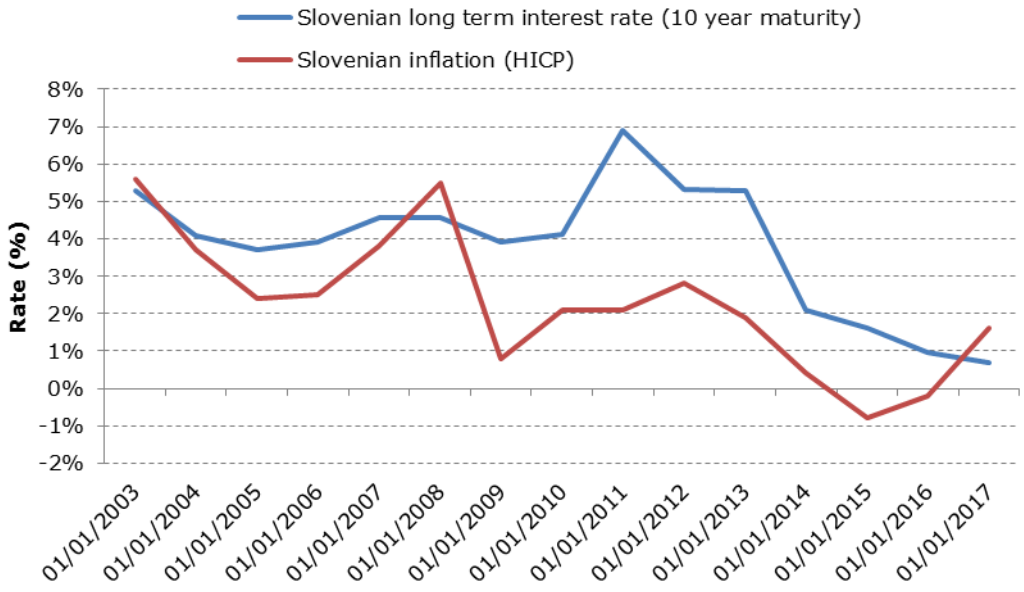
As noted in Section 2, Croatia shares equal and joint responsibility with Slovenia for the decommissioning and waste management costs associated the Krško NPP.

The Croatian share of the total overnight decommissioning and waste management costs was estimated to be €868.5 million in 2003 and was determined as part of the Bilateral Agreement with Slovenia. This analysis was used to determine the annual contributions required by the Slovenian and Croatian electricity operators into their Funds over the period from 2004 to 2022. Further cost analyses have not been completed since, but will be included in the revision of the decommissioning programme expected to be completed in 2019.

Due to the lengthy period of time that has elapsed since this analysis was undertaken as well as data limitations, it would be spurious to attempt to derive an updated cash flow profile.

Discount rate and inflation / indexing of costs

In the 2003 analysis a discount rate of 4.29% p.a. was chosen, based on long term Slovenian interest rates. For the inflation assumption, a rate of 5.23% p.a. was used. Although this was linked to historical price increases, the exact methodology used is not clear from the available data. However since 2003, interest rates and realised inflation in Slovenia have changed materially, as illustrated below:

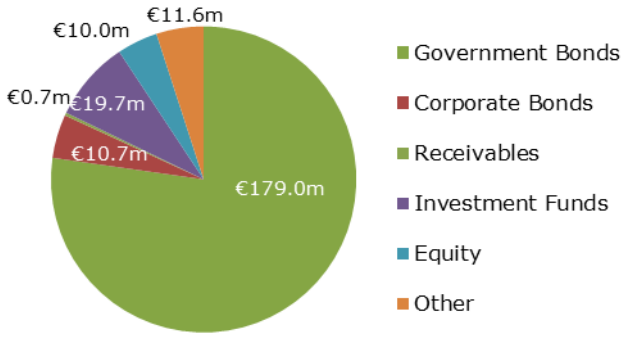


Source: European Central Bank (ECB)

Changes in interest rates and inflation will need to be taken into account in the revision of the decommissioning programme expected to be completed in 2019. To the extent these changes require a revision of the real discount rate used to value the expected future decommissioning and waste management costs, they will also be expected to have an impact on the contributions that the Croatian and Slovenian operators will have to pay into their Funds.

Asset allocation and expected future investment returns

As at 31/12/2016, Croatia's Fund had assets of €232m. Croatia has provided the breakdown of their Fund's dedicated assets as follows. It is not clear how the Government bond allocation is split between different Government issuers.



Market consistent assessment of liability and funding implications

The use of long-term Slovenian interest rates as the basis for setting the discount rate used to calculate future contribution requirements would appear to be appropriate given the large allocation to government bonds shown above (although some allowance for expected equity and investment fund returns as well as any differences between the yields on Slovenian bonds and the actual bonds held would need to be taken into account).

For inflation, adopting an assumption that is linked to expected future cost increases is likely to be more appropriate than the use of historical past inflation.

Performance assessment

The table below was provided by Croatia for purposes of this study and shows the return on the portfolio in previous years. The highlighted cells, which show real returns relative to Croatian inflation, have been appended to this table.

	Portfolio returns							
	2009	2010	2011	2012	2013	2014	2015	2016
Performance	6.20%	5.90%	3.73%	-0.12%	3.89%	2.76%	3.02%	7.07%
Realised inflation - HICP measure	2.20%	1.10%	2.20%	3.40%	2.30%	0.20%	-0.30%	-0.60%
Performance (in real terms)	3.91%	4.75%	1.50%	-3.40%	1.55%	2.55%	3.33%	7.72%

Source: European Central Bank (ECB)

Conclusion

Croatia appears to have robust investment management procedures in place, but have not revised estimates of future decommissioning and waste management costs with Slovenia since the inception of the Bilateral Agreement in 2003, although a revised decommissioning programme is expected in 2019.

Due to data limitations, similar analysis for Slovenia is not possible, although it is likely that cost estimates and the liability value would be similar.

4. Finland

Expected future decommissioning and waste management cost profile

The total costs of decommissioning and waste management for the Olkiluoto and Loviisa stations were estimated to be c. €6.5 billion (in 2012 money terms). The costs associated with spent fuel management account for more than half of this total.

Asset allocation

As noted in Section 2, the NWMF may lend up to 75% of its capital on a collateralised basis and in 2017 had lent c.60% of its capital to the nuclear licence holders.

The remainder of the NWMF's assets are invested in low-risk, liquid state treasury bonds.

Risk analysis

The "back-up" nature of the NWMF would appear to offer an important layer of protection, helping to ensure that each nuclear operator is financially responsible for their share of decommissioning and waste management costs and that sufficient resources are available in advance of any required decommissioning and waste management expenditure.

However, the ability of operators to borrow back a material proportion of the funds held in the NWMF appears to directly contradict this view. That is, the NWMF's primary risk exposure is the credit risk associated with the loans made to the nuclear licence holders. The size of these loans relative to the NWMF's other investments results in a significant concentration of risk.

Assessment of this risk ultimately depends on the commercial terms of these loans (including the manner and extent to which they are secured against other assets and how frequently this is reassessed) and where in the nuclear operators' capital structure these loans rank. Analysis of these points is beyond the scope of this report.

It is however questionable whether the ability to lend such a significant proportion of assets back to the operators is consistent with the objective of funding future liabilities in advance. This level of "self-investment" would be questioned for other institutional investors. Further analysis of the commercial terms of the loans (including how they are secured and other factors) would however be necessary to draw firm conclusions.

5. France

Expected future decommissioning and waste management cost profile

As required by French legislation, licensees send the administrative authority their assessment of long-term decommissioning and waste management costs every three years and the three primary nuclear licensees (EDF, Orano and CEA) must include provisions for these expected future costs in their annual reports.

The licensees have indicated their estimated costs for the next 10 years as follows[38]:

- Orano: around €0.3 bn/year for the next ten years.
- CEA: around €0.4 bn/year for the next ten years.
- EDF: around €0.7 bn/year for the next ten years.

Orano have also disclosed the following high level breakdown of estimated costs:

TENTATIVE SCHEDULE OF PROVISION DISBURSEMENTS (in millions of euros)	
2017	292
2018 – 2020	1,402
2021 – 2025	1,592
2026 – 2035	1,667
2036 and beyond	8,525
Total Provisions Before Discounting	**13,478**

Source: Orano 2016 annual report

[38] These estimates do not include spent fuel reprocessing costs for EDF or the defence plant for the CEA

The licensees have also made available their estimated gross/overnight costs, discounted provisions as at 31 December 2016 (with discount and inflation rate assumptions), and the sensitivity of these discounted provisions to changes in discount rate:

	Gross costs (2014) € Bn	31 Dec 2016 Provision € Bn	31 Dec 2016 Provision to be covered by dedicated assets	Change in discount rate (%)	Sensitivity impact € Bn	Implied Duration (yrs)
EDF	75.6	36.0	25.7	-0.20%	1.25	23.4
CEA	21.6	13.5	13.5	-0.50%	1.0	28.0
Orano	13.5	7.3	7.3	-0.25%	0.4	21.0
Total	**110.5**	**56.9**	**46.6**			**24.0**

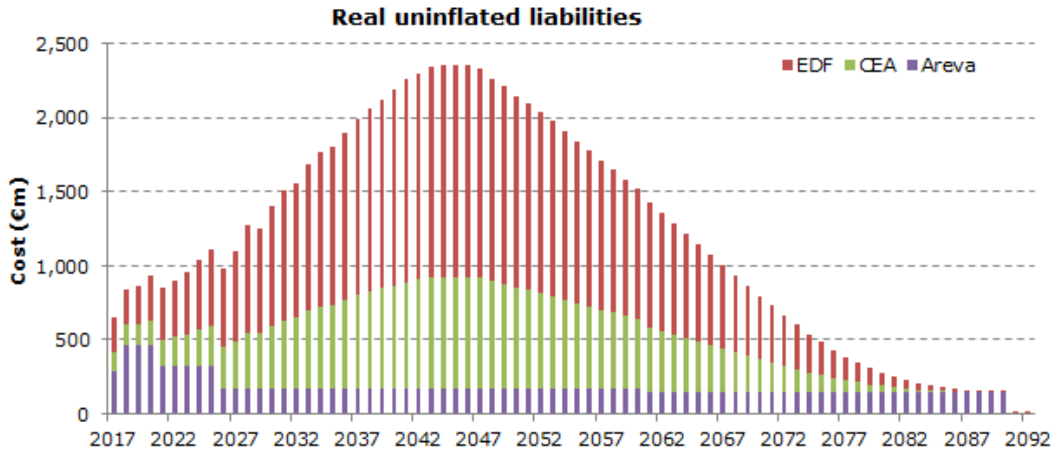
Source: Gross costs from 2016-2018 PNGMDR; provision data from annual reports: Implied Duration calculated by Mercer

31 Dec 2016	Discount Rate	Inflation Rate
EDF	4.20%	1.50%
CEA	4.10%	1.65%
Orano	4.10%	1.65%

Source: Annual reports

As per French regulation (the Law of 28 June 2006), operators of nuclear facilities are required to make a prudent assessment of the costs of decommissioning facilities and the management of spent fuel and radioactive waste and to ensure that the discounted present value of these costs is covered by a portfolio of dedicated assets. However, the law does not cover provisions for spent fuel reprocessing costs linked to the operating cycle (c.€10.3bn as at 31 December 2016), which are financed by operational income. These provisions are treated separately for the analysis in this section and are **not** included in the "Base Case" or "Best Estimate" liability values.

A year-by-year cost profile for the combined position of EDF, Orano and CEA that satisfies the different constraints outlined above (i.e. a similar duration and present value) has been derived and is shown in the chart below; costs are shown in real money terms at 31 December 2016. For the CEA, the cost profile below reflects the full value of the provisions to be covered by dedicated assets and therefore includes expected costs associated with both its civil and defence facilities (see further comments below).



It is acknowledged that the actual cost profiles (for each licensee in isolation and the combined position) will in all likelihood be less smooth than shown above and does not represent a typical decommissioning and waste management cost profile (see for example the chart in the introduction). However, this is unlikely to have a material impact on the results obtained in this study.

To assess the current funding position and allow for the time value of money, a discounted value of the expected future costs is required.

Inflation / indexing of costs

Allowance for expected future inflation is based on consensus forecasts as well as market implied inflation derived from the prices of index-linked and fixed-income government bonds. At 31 December 2016, the weighted average future inflation assumption for the three main nuclear licensees was 1.6% p.a. and this has been used for purposes of analysing the combined position of these three licensees.

Discount rate

The discount rate is calculated by each nuclear operator to ensure the financing of their back-end activities. This calculation must respect the following regulatory provisions (article 3 of the decree of 23rd February 2007):

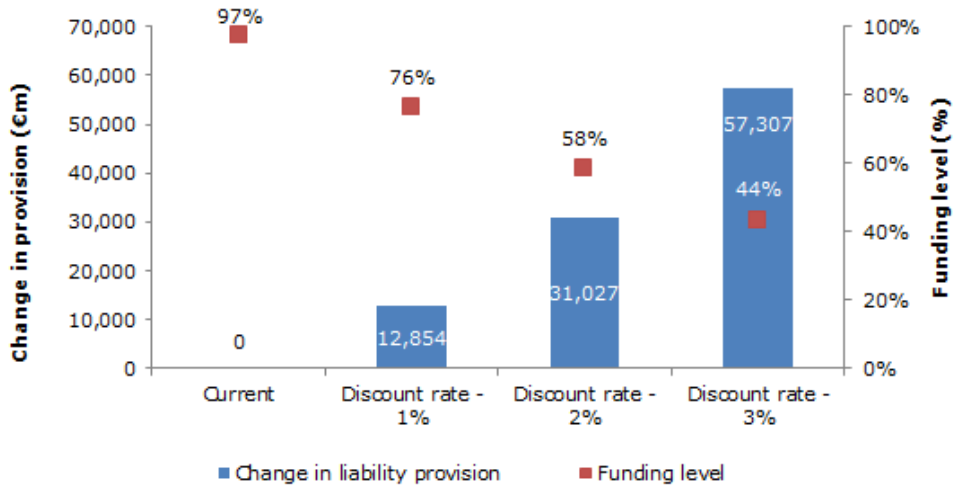
- It must comply with accountancy standards;
- It must not exceed the regulatory cap, calculated according to a defined formula set out in article 3 of the ministerial order of 21st March 2007.
- It must not exceed the expected return of the dedicated assets (with a high degree of trust).

Prior to December 2017, the regulatory cap for the discount rate represented the arithmetic average of the 30 years Constant Maturity Treasury (CMT) rate during the last 10 years. However, going forward, the regulatory cap will progressively take account of the last 4 years instead of the last 10 years.

At 31 December 2016, the weighted average discount rate for the three main nuclear licensees was 4.15% and this has been used for purposes of analysing the combined position of these three licensees.

Based on the assumptions above, the combined present value of the expected future decommissioning and waste management costs for the three main licensees is c. €46.6bn. This compares to a combined market value of assets c. €45.3bn at 31 December 2016 and hence a funding level of c. 97.3%.

Because of the long duration of decommissioning and waste management liabilities, the discount rate has a very large impact on the potential liability value and hence future funding requirements. The chart below demonstrates the impact of adopting a nominal discount rate that is 1%, 2%, or 3% lower than the one currently used. The level of funding (i.e. assets divided by liabilities) for each scenario is also shown.



Asset allocation and expected future investment returns

As at 31 December 2016, the licensees reported the following dedicated asset balances:

31 Dec 2016	Dedicated Assets (€Bn)
EDF	25.7
CEA	13.6
Orano	6.1
Total	**45.3**

EDF's dedicated assets are a mixture of equities, debt, and bespoke allocations that are handled by its investment arm, EDF Invest. These bespoke allocations include infrastructure, real estate, private equity funds and an ownership stake in a public utilities company (Reseau de Transport d'Electricite).

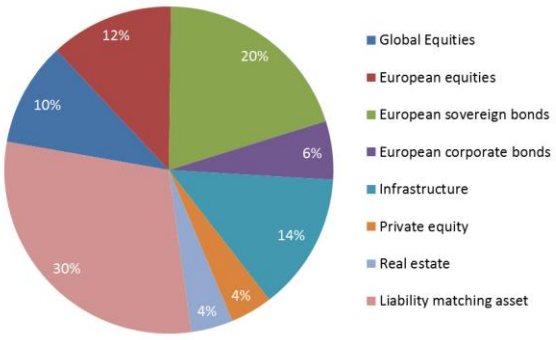
CEA has four civil and defence dismantling funds. The two main funds "FDC" and "FDD" are mainly used to formalise budgetary allocations and cash management. They are almost exclusively financed by an annual State subsidy which increases and decreases in line with the liability. The other two funds (INC and IND), which are much smaller, each have an allocation of c. 55% equities and 45% bonds. As the liability estimate above reflects CEA's expected future costs for both its civil and defence facilities, all of the assets held in these four funds have been considered in the analysis below.

Orano's earmarked assets for nuclear decommissioning and waste management are primarily in equities and bonds.

For purposes of our analysis, the combined asset allocation for the three main nuclear licensees has been derived using the high level asset information provided and the following simplifying assumptions:

- EDF's share in Réseau de Transport d'Électricité (RTE) has been modelled as infrastructure.
- The majority of CEA's earmarked assets have been modelled as a perfect liability matching asset.
- Equities are invested in the Eurozone.
- Sovereign bond allocations include a mixture of nominal and inflation linked securities.

At 31 December 2016, the combined asset allocation so derived is shown below. The accompanying table shows the annualised expected returns over a 10 year period for this portfolio based on Mercer's European Capital Market Assumptions. The expected median portfolio return over the period is 2.7% p.a. and these returns are shown in nominal terms (i.e. these are absolute return numbers rather than the expected returns over expected future inflation).



Percentile	Expected Return
95th	6.8%
75th	4.3%
50th	2.7%
25th	1.0%
5th	-1.7%

Market consistent assessment of liability and funding implications

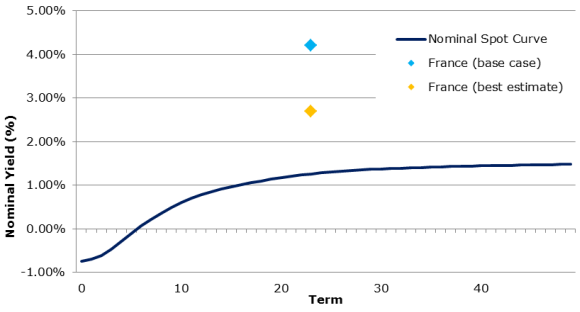
The use of a moving average in the discount rate serves to reduce the level of volatility in the licensees' balance sheet provisions. However, given the significant falls observed in government bond yields in recent years, the current smoothed discount rate is unlikely to be wholly reflective of current market conditions and the provisions are likely to increase over time as the effect of these lower market yields are given greater weight in the calculation (even if all else remains unchanged).

Based on the median expected return (i.e. a "best estimate return" with 50% probability) of 2.7% p.a., the real discount rate would be c.1.1% p.a. Use of a real discount rate of 1.1% p.a. results in a best estimate liability for the three main licensees of c. €67.3bn. This is based on an inflation assumption of 1.6% p.a. as explained above. This inflation assumption has not been adjusted although it is noted that it is below the ECB's long-term inflation target and below the nuclear specific inflation assumptions adopted in certain other countries (e.g. Germany, Sweden and the UK).

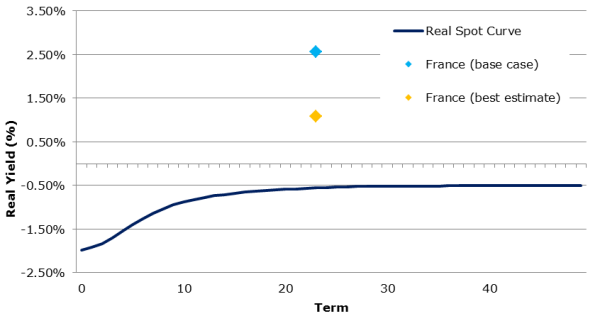
	Liability value	Funding Level
Base case liability	€46,600m	97%
Best estimate liability	€67,310m	67%

The charts below show how the resulting best estimate nominal and real discount rates compare to the corresponding Euro government bond yield curves at 30 September 2017.

Nominal yields / discount rate



Real yields / discount rate



The rest of this section is based on the best estimate liability value.

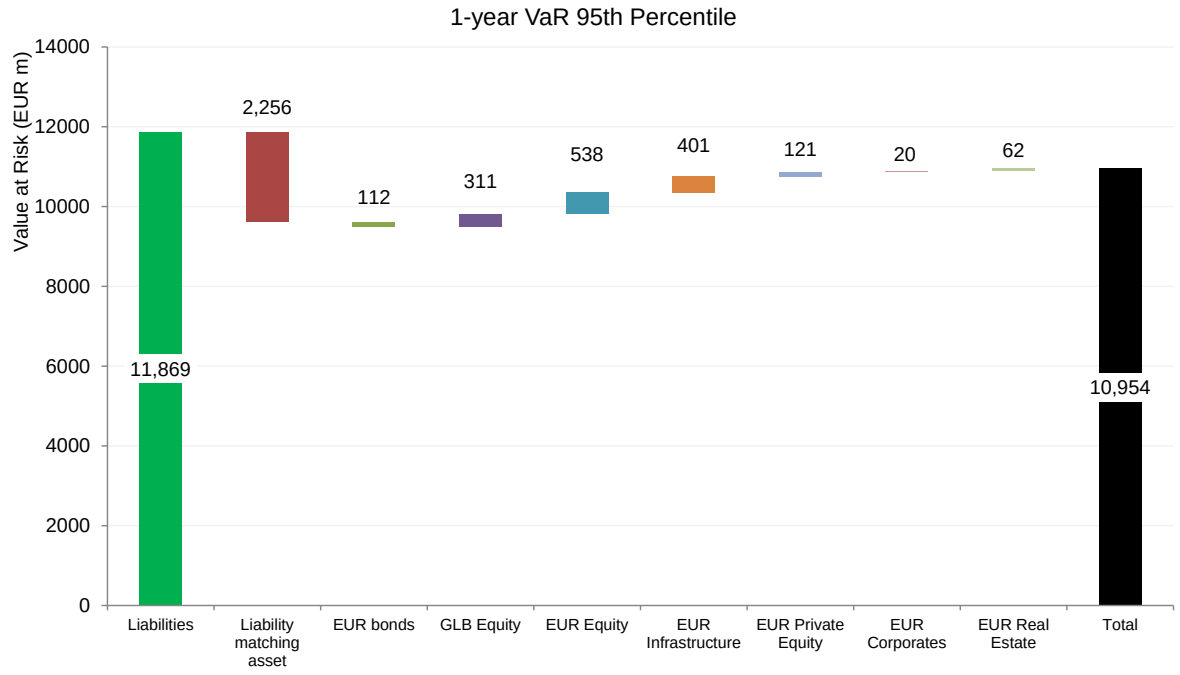
Stress testing

The table below shows the net impact of pre-defined changes to real discount rates (either through changes in nominal interest rates or inflation expectations) and growth markets on both the liability and assets (and hence the funded status) of the combined funds held by the three main licensees. For example, a 0.25% decrease in long-term interest rates, which is equivalent to a 0.25% reduction in the real discount rate, together with a 10% fall in growth markets would increase the combined deficit by a further c. €4.4 bn.

Surplus		Interest Rate								
		-1.00%	-0.75%	-0.50%	-0.25%	*0.00%*	+0.25%	+0.50%	+0.75%	+1.00%
Growth assets (including equities)	+20%	(12,647)	(8,374)	(4,490)	(955)	2,267	5,208	7,895	10,355	12,609
	+15%	(13,214)	(8,940)	(5,056)	(1,521)	1,700	4,641	7,328	9,788	12,042
	+10%	(13,781)	(9,507)	(5,623)	(2,088)	1,134	4,074	6,762	9,221	11,475
	+5%	(14,348)	(10,074)	(6,190)	(2,655)	567	3,507	6,195	8,654	10,908
	0%	(14,915)	(10,641)	(6,757)	(3,222)	0	2,941	5,628	8,088	10,342
	-5%	(15,481)	(11,208)	(7,324)	(3,789)	(567)	2,374	5,061	7,521	9,775
	-10%	(16,048)	(11,775)	(7,890)	(4,355)	(1,134)	1,807	4,494	6,954	9,208
	-15%	(16,615)	(12,341)	(8,457)	(4,922)	(1,700)	1,240	3,928	6,387	8,641
	-20%	(17,182)	(12,908)	(9,024)	(5,489)	(2,267)	673	3,361	5,820	8,074

VaR analysis

The 1-year 95% VaR decomposition is shown below. The key areas of risk are interest rate and inflation and the effect they have on the assessed liabilities, partially offset by the Fund's allocations to sovereign bonds and the majority of the CEA's assets (which are assumed to be a perfect hedge for their liabilities). There is a 1-in-20 chance that the combined deficit for the three main licensees could increase by at least €11bn and decrease the combined funded status from 67% to approximately 58%.



Risk analysis for EDF

Credit risk is arguably the largest risk for the portion of EDF's provisions that is financed from operational income. The table below shows the market capitalisation of EDF at 31 December 2016 as well as the unfunded provisions as a percentage of market capitalisation. The unfunded nuclear provisions constitute more than 50% of market capitalisation as at 31 December 2016.

NPP	Market Capitalisation 31 December 2016 (€ million)	Unfunded Nuclear Provisions as % of Market Cap	Unfunded Nuclear Provisions as % of Market Cap	Credit Rating
EDF	20,390.6	10,305	51%	A3

Source: Bloomberg, Moody's

Performance assessment

The tables below were provided by the Member State and provide detail on the historic performance of the assets held by EDF and Orano (no performance data was provided for CEA). The highlighted cells have been added and show the real returns relative to French inflation.

EDF

Sub-portfolio (€Bn)	*2012*	*2013*	*2014*	*2015*	*2016*
Shares	*7.3*	*7.9*	*7.6*	*7.3*	*8.0*
Bonds	*6.9*	*5.15*	*6.4*	*6.7*	*6.9*
Cash	*0.95*	*0.8*	*0.6*	*0.3*	*0.9*
Unlisted assets and receivables	*2.4*	*7.9*	*8.4*	*9.2*	*9.9*
Dedicated assets	***17.6***	***21.7***	***23.0***	***23.5***	***25.7***
Performance	***10.4%***	***9.4%***	***7.9%***	***3.5%***	***11.1%***
Historic inflation (France CPI)	*2.0%*	*0.9%*	*0.5%*	*0.0%*	*0.2%*
Performance (in real terms)	***8.4%***	***8.5%***	***7.4%***	***3.5%***	***10.9%***

Orano

Sub-portfolio (€ Bn)	*2012*	*2013*	*2014*	*2015*	*2016*
Shares	*2.2*	*2.4*	*2.4*	*2.5*	*2.4*
Bonds (and, before 2014, money market funds)	*2.5*	*2.8*	*2.0*	*2.1*	*2.2*
Cash	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*
Unlisted assets and receivables	*0.9*	*1.0*	*0.8*	*1.0*	*1.0*
Money market funds (post 2014)	*0.0*	*0.0*	*0.9*	*0.9*	*0.9*
Dedicated assets	***5.7***	***6.1***	***6.1***	***6.4***	***6.3***
Performance	***13.1%***	***9.7%***	***4.8%***	***5.8%***	***2.4%***
Historic inflation (France CPI)	*2.0%*	*0.9%*	*0.5%*	*0.0%*	*0.2%*
Performance (in real terms)	***11.1%***	***8.8%***	***4.3%***	***5.8%***	***2.2%***

Conclusion

French nuclear licensees have robust investment management procedures and a number of parties involved with the oversight of dedicated assets. However, the use of a smoothed approach for discounting results in provisions that may not reflect current market conditions – this could potentially result in greater funding requirements in future as the falls in yields in recent years are reflected in the calculation of the discount rate.

6. Germany

Expected future decommissioning and waste management cost profile

As explained in Section 2, the required financing amounts to cover the future decommissioning and waste management costs from Germany's commercial NPP's were based on a 2015 study by Warth & Klein Grant Thornton AG ("WKGT"). The resulting WKGT cost assessment (in 2014 prices) is shown in the table below:

Costs of disposal € m.	NPPs	Calculated on consistent basis[39]
a) Decommissioning	19,614	19,719
b) Containers, transport, nuclear waste	10,252	9,915
c) Interim storage	5,653	5,823
d) Final repository "Konrad"	3,824	3,750
e) HAW Final repository	8,109	8,321
Total	**47,451**	**47,527**

Source: Warth & Klein report, 2015

In order to compile their report on future nuclear waste management and decommissioning obligations, WKGT received access to detailed cost estimates, excerpts from databanks, surveys, expert opinions, technical documentation, calculations and other relevant information used by the commercial NPPs in the calculation of their 31 December 2014 balance sheet provisions. Where significant discrepancies between calculation methodologies, assumptions or classifications of individual costs were identified, WKTG restated the provided cost estimates to ensure a satisfactory level of consistency between the NPPs. The restated values are set out in the second column of the table above.

The 2014 data on which the WKGT report was based was subsequently applied in the 2016 decision making process and updated with real data (waste volumes etc.) for the actual cash transfers to the Fund for Nuclear Waste Management ("FNWM") in 2017.

It must be noted that none of the data or information required to update the 2014 cost estimates set out above was received for this study. Furthermore, any attempt to do so would be beyond the remit of this study. The above cost estimates also do not seek to provide a complete overview of future German nuclear decommissioning costs as they focus exclusively on costs related to commercial NPPs, i.e. about 75% of the estimated disposal volume.

This analyses seeks to assess potential risk by showing what the estimates above, with some modelling adjustments made for the passage of time, might look like under alternative assumptions. The adjusted cost estimates are, however, unlikely to accurately reflect reality, not least because the nuclear decommissioning landscape in Germany has changed dramatically since publication of the WKGT report.

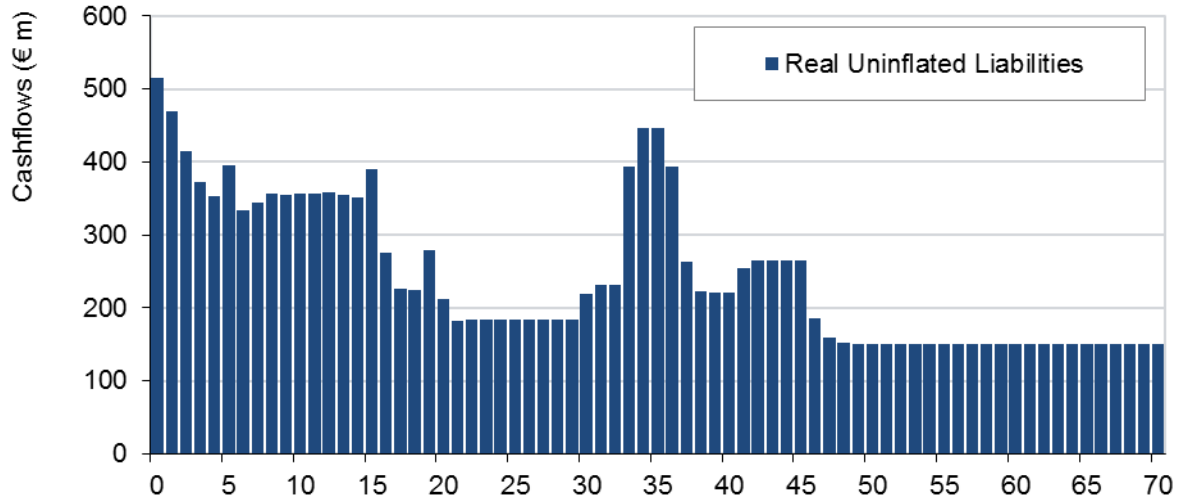
For the purposes of this Report it is understood that the Fund for Nuclear Waste Management ("FNWM") will manage the funds allocated to meet the costs of items c – e in the table above whilst responsibility for a) and b) continue to reside with the NPPs[40].

[39] WKGT adjustments to the individual NPP cost estimates where divergences in the calculation of the estimates provided by the NPPs were identified.

FNWM

Using the year on year cost estimates for items c) – e) provided in the WKGT report, the expected future cash flow profile (in 2017 money terms) for the FNWM has been derived by making the following assumptions:

- Allowance has been made for realised Eurozone HIPC inflation between 31 December 2014 and 30 September 2017
- It has been assumed that the report's additional nuclear specific inflation assumption of 1.97% was borne out in practice.
- It has been assumed that payments from the Fund have been in line with the cost estimates provided for the period between 31 December 2014 and 30 September 2017.



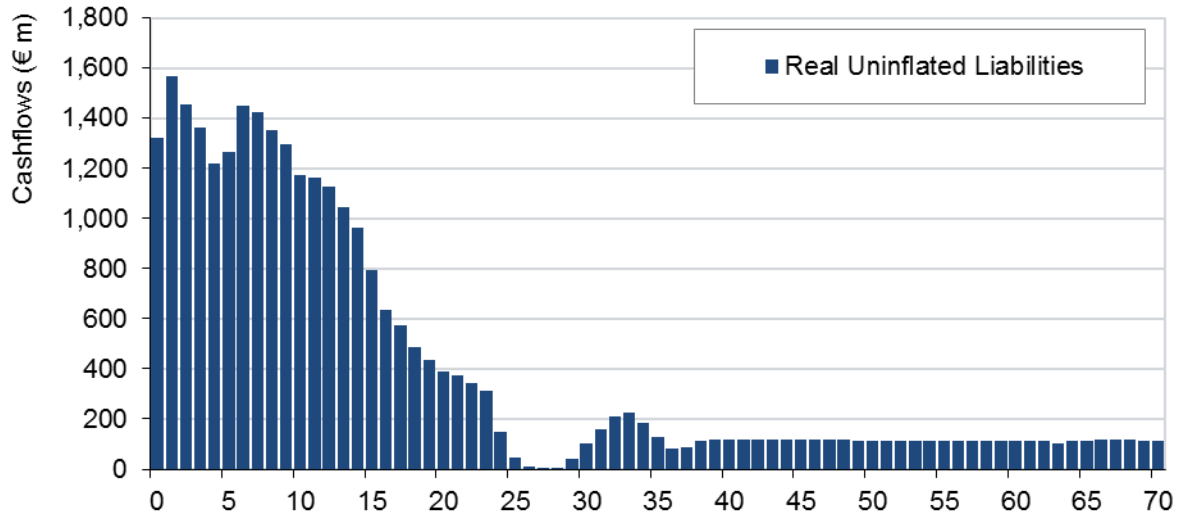
The total overnight cost of the cash flows shown above (in 2017 price levels) is c. €18,906m.

It must be noted that there is particular uncertainty with regards to the cost estimates for the HAW final repository which may require future adjustments to the profile shown above. This, together with other volume based adjustments, was reflected in a c. 35% risk premium which utilities had to pay to the FNWM in addition to the €17,900m cost estimate, adding up to the c. €24,148m transferred to FNWM in July 2017.

Commercial Nuclear Power Plants

Based on the year on year cost estimates for items a) – b) provided in the WKGT report and using the same assumptions to allow for the passage of time as set out above, the expected future cash flow profile below (in 2017 money terms) for the commercial NPPs is obtained (the comments in the footnote on the previous page should however be borne in mind).

[40] It is recognised that item b) is split between the NPPs and FNWM. For ease of analysis in this Report the entire position has been assigned to utilities' responsibility since waste treatment comes first and the waste volume is dependent on utilities' decommissioning processes. Ultimately it was decided that the cost for the transport of the waste to the final repository will be the responsibility of the government and that only the packaging of the waste for on-site intermediate storage facilities has to be borne by the NPP operators as part of the decommissioning process.



The total overnight cost of the cash flows shown above (in 2017 price levels) is c. €29,795m.

Market consistent assessment of liability and funding implications

Commercial Nuclear Power Plants

Discount Rates

The WKGT report assumed an average nominal discount rate of 4.58%[41] p.a., reflecting the individual discount rates of 4.0% p.a. - 4.8% p.a. used by the NPPs in their 31 December 2014 provisions. These discount rates were based on historical German government bond return data.

Inflation

The WKGT report also assumed a future inflation rate of 1.6% plus an additional nuclear specific inflation rate of 1.97%. The use of a nuclear specific inflation rate is noteworthy and will be discussed in more detail in Section 5.

Provisions

Valuing the cash flows in the commercial NPP chart above, based on a nominal discount rate of 4.58% and an overall inflation rate of 3.57% (i.e. a real discount rate of c.1% p.a.), results in a present value of liability of c. €25,300m. It is interesting to compare this value to the actual 2017 balance sheet provisions of the operators, as stated in their Annual Reports. Besides changes in financial market conditions these reflect changes made due to the change in duration and risk profile of the underlying liabilities as a result of the State assuming responsibility for waste storage and disposal.

RWE AG

RWE's provisions are calculated using a discount rate that reflects the current level of market interest rates. At 31 December 2017, the resulting discount rate was 0.6% p.a. The assumed rate of future cost inflation reflects market expectations with regard to general increases in wages, prices and productivity growth. At 31 December 2017, the inflation assumption was 1.5% p.a. As a result, the real discount rate used was -0.9% p.a. The split of the balance sheet provision is as follows:

[41] The WKGT report also contains a variety of scenarios, varying interest rates, inflation and the nuclear specific inflation rate.

Provision for nuclear waste management (€ million)	31 Dec 2017
Residual Operation	2,577
Dismantling	1,766
Processing of residual material and waste management	1,662
Total	**6,005**

Source: Annual Report 2017

E.ON SE

A risk-free discount rate of 0.6% p.a. and a cost inflation assumption of 1.5% p.a. (i.e. a real discount rate of c.-0.9% p.a.) were used to calculate E.ON's balance sheet provision.

Provisions for nuclear waste management obligations in Germany	31 Dec 2017
Retirement and decommissioning	8,872
Containers, transports, operational waste, other	1,583
Total	**10,455**

Source: Annual Report 2017

EnBW Energie Baden Württemberg AG

EnBW's provisions are calculated using a discount rate of c.0.7%p.a. and a cost inflation assumption of c.1.7% p.a. (i.e. a real discount rate of c.-1% p.a.).

€ million	31 Dec 2017
Remaining with EnBW	
Remaining operation and post-operation	726
Dismantling including preparation	3,691
Treatment of residual material, packaging of radioactive waste	969
Other	417
Total	**5,803**

Source: Annual Report 2017

The overnight costs (without taking into account the effects of the discount rate and rate of cost inflation) of the remaining provisions held by EnBW was €5,295.0m as of 31 December 2017.

Vattenfall GmbH

Vattenfall's 2017 Annual Report is not yet available and hence results shown below are based on 31 December 2016 figures. The provisions below therefore still include provisions relating to the €1,790m payment made to the NWMF.

The balance sheet provision is calculated using a discount rate of 1.75% p.a. Inflation assumptions were not provided.

31 Dec 2016	SEK m	€ m
Dismantling of nuclear power plants	14,263	1,489
Handling of spent radioactive fuel	18,906	1,973
Total	**33,169**	**3,461**

Source: Annual Report 2016
1 € = 9.582 SEK

Stadtwerke München GmbH

SWM's 2017 Annual Report is not yet available and hence results shown below are based on 31 December 2016 figures. The provisions below therefore include provisions relating to the €408m payment to the NWMF. Unlike the other Annual reports (prepared under IFRS), the below is based on German GAAP.

The interest rates applied range between 1.6 % and 3.4 %. An inflation assumption of 3.6 % p.a. has been taken into account.

€ million	31 Dec 2016
Provisions	818
Less advance payments made	- 43
Total	**775**

Source: Annual Report 2016

Comparing operator provisions to the outcome of the WKGT study

From the above, it is clear that there are material differences between the assumptions used by the operators to calculate their 31 December 2017 balance sheet provisions and those used in 2014 as reflected in the 2015 WKGT study. In particular, the operators have reduced their discount rates significantly to take account of (i) the current low interest rate environment and (ii) the change in duration and risk profile of their underlying liabilities following the transfer of responsibility for waste management.

Adding up the provisions for the different operators shown above gives a total of c. €26,500m and the average real discount rate used to calculate this value is c.-0.9% p.a. However, if a real discount rate of -0.9% was applied to the cost profile shown for the commercial NPP's earlier, the resulting liability would be c. €35,500m rather than €25,300m.

It is beyond the scope of this Report and on the basis of the available information to analyse these differences in any detail. Potential reasons why this may be case include the period of time that has elapsed since the WKGT report was prepared, actual decommissioning spend over this time and NPP revisions to the expected costs. As noted above there are also differences in the allocation of costs to the NPP's and the FNWM from those derived above.

Risk analysis for the NPP operators

The table below shows, where available, the market capitalisation of the commercial NPPs at 31 December 2017 as well as their provisions as a percentage of their market capitalisation. For all three of the largest NPPs, nuclear provisions constitute more than 50% of market capitalisation.

NPP	Market Capitalisation 31 December 2017 (€ million)	Nuclear Provisions as % of Market Cap
RWE AG	9,788.3	61%
E.ON SE	19,636.5	53%
EnBW Energie Baden Württemberg AG	7,793.9	74%
Vattenfall GmbH	N/A	N/A
Stadtwerke München GmbH	N/A*	N/A

Source: Bloomberg, Moody's
* Stadtwerke München GmbH is not a listed company

FNWM

The FNWM is in the process of investing its assets and carrying out investment manager searches. However, for the purposes of the analysis below it has been assumed that the asset value for the FNWM is equal to €24,148m[42], i.e. that there have been no investment returns, negative interest rates applied to cash deposits, costs or payments from the Fund since the July 2017 FNWM payments (including the risk premium). This is clearly a simplifying assumption but, to the extent the actual asset value does not differ materially from this amount, it is unlikely to have a significant impact on the analysis below.

Using the cost profile shown above together with the financial assumptions set out in the WKGT report results in a "base case" liability for the FNWM of €13,946 million.

The chart below shows the impact of varying the discount rate on the liability value and funding level:

The current funding level of 173% primarily reflects the impact of discounting (at c.4.58% p.a.) and the risk premium.

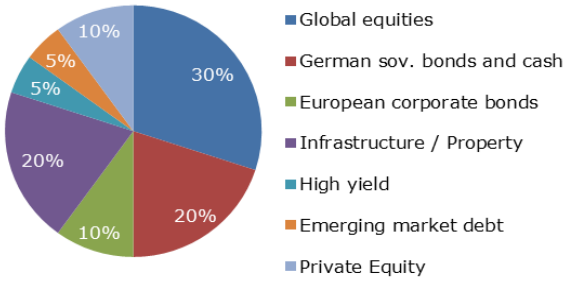
Although it is not yet final, public statements[43] suggest that the FNWM's investment strategy may be something along the following lines:

- 10% "safe, liquid fixed income to finance payments in the first few years"
- 60% Global Equity and Fixed Income
- 30% Alternatives like Infrastructure, Real Estate and Private Equity

This portfolio has been modelled as per the chart shown below. Based on Mercer's European Capital Market Assumptions, the expected nominal return on such a portfolio would be c.3.50%. Using this as the best estimate discount rate would result in a "best estimate" liability of c. €19,400m and a best estimate funding level of c.125%.

[42] Source:http://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2017/20170703-kernkraftsbetreiber-haben-einzahlungen-an-nuklearen-entsorgungsfonds-in-hoehe-von-24-mrd-euro-geleistet.html

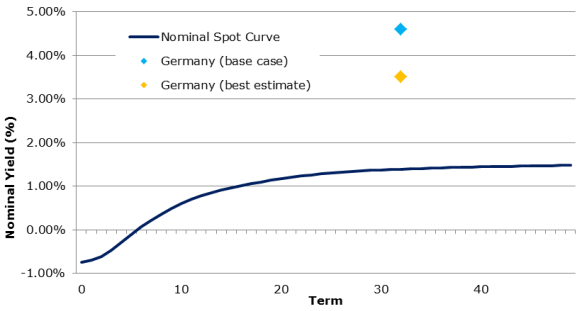
[43] See for example: https://www.private-banking-magazin.de/24-milliarden-euro-vermoege



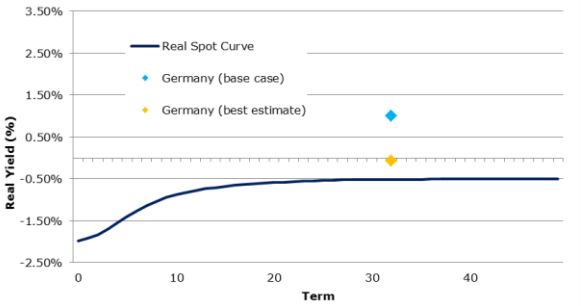
Percentile	Expected Return
95th	8.7%
75th	5.7%
50th	3.5%
25th	1.3%
5th	-2.1%

The charts below show how the resulting best estimate nominal discount rate, expected future inflation assumption and real discount rates compare to the corresponding Euro government bond yield curves and implied inflation curve at 30 September 2017.

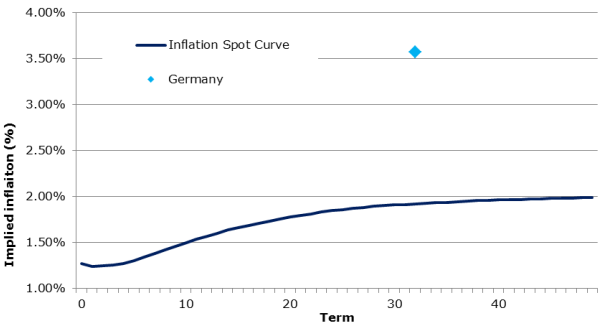
Nominal yields / discount rate



Real yields / discount rate



Market implied inflation



It will be important to examine the FNWM's chosen investment strategy and the resulting discount rate applied to its expected future costs once these items are determined.

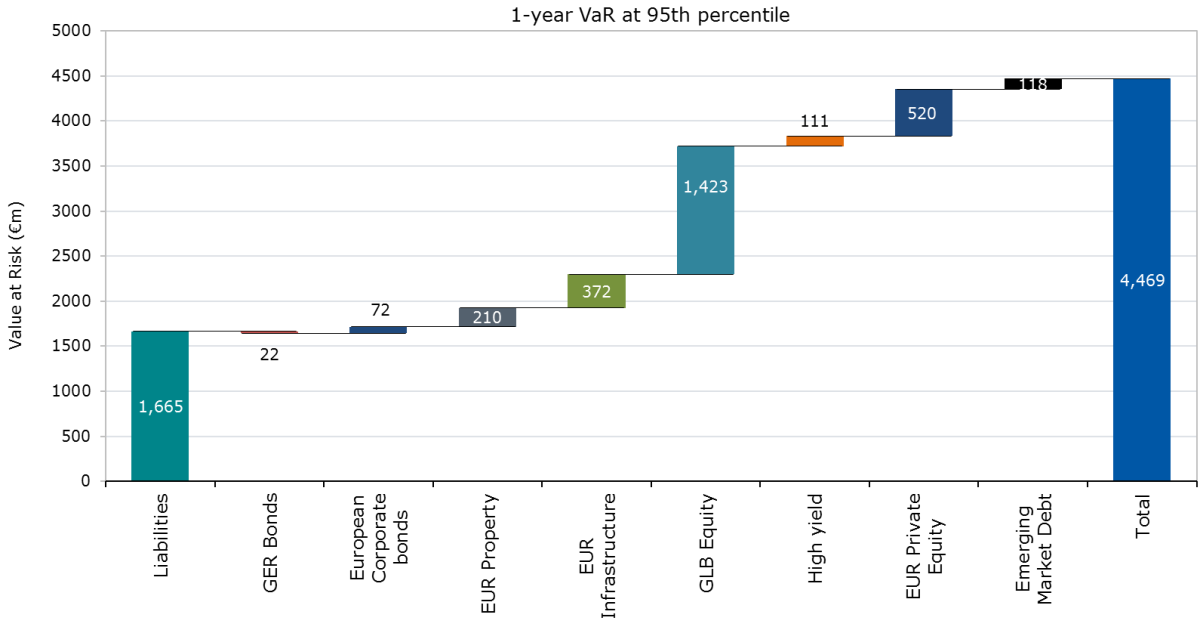
Stress testing for the FNWM

The table below shows the change in the FNWM's surplus resulting from pre-defined movements in either nominal interest rates or inflation. The initial surplus is based on the best estimate position shown above (i.e. liability of €19,400m, asset value of €24,148m and surplus of €4,748m). For example, a 0.25% decrease in the long-term interest rate assumption (or equal to a 0.25% decrease in the real discount rate assuming inflation remains unchanged) would decrease the surplus by c. €1,650m (i.e. from €4,748m to €3,098m). It has been assumed for the below stress test that changes in interest rates affect the liabilities only.

Surplus		Interest Rate								
		-1.00%	-0.75%	-0.50%	-0.25%	*0.00%*	+0.25%	+0.50%	+0.75%	+1.00%
Growth assets (including equities)	+20%	(4,683)	(2,264)	(139)	1,730	3,381	4,841	6,138	7,291	8,321
	+15%	(5,528)	(3,109)	(985)	885	2,536	3,996	5,293	6,446	7,476
	+10%	(6,374)	(3,954)	(1,830)	40	1,690	3,151	4,447	5,601	6,631
	+5%	(7,219)	(4,799)	(2,675)	(805)	845	2,306	3,602	4,756	5,785
	0%	(8,064)	(5,644)	(3,520)	(1,650)	0	1,461	2,757	3,911	4,940
	-5%	(8,909)	(6,490)	(4,365)	(2,496)	(845)	616	1,912	3,066	4,095
	-10%	(9,754)	(7,335)	(5,211)	(3,341)	(1,690)	(230)	1,067	2,220	3,250
	-15%	(10,599)	(8,180)	(6,056)	(4,186)	(2,536)	(1,075)	222	1,375	2,405
	-20%	(11,445)	(9,025)	(6,901)	(5,031)	(3,381)	(1,920)	(624)	530	1,560

VaR analysis

The 1-year 95% VaR decomposition is shown below. The key areas of risk are interest rate and inflation and the effect they have on the assessed liabilities as well the market risk associated with the holdings in equities and alternatives. There is a 1-in-20 chance that the surplus could decrease by at least €4.5bn and decrease the funded status from 125% to approximately 101%.



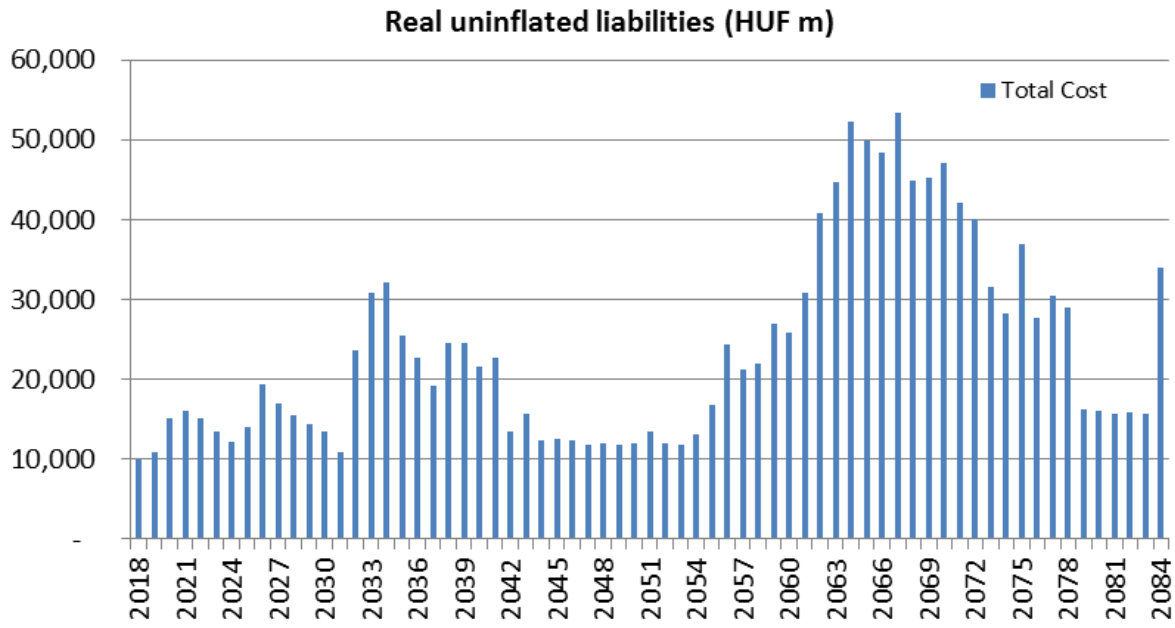
The utility operators provide similar sensitivity analyses in their respective audited financial statements.

7. Hungary

Expected future decommissioning and waste management cost profile

The Central Nuclear Financial Fund ("CNFF") is currently managed by Hungary's Ministry of Innovation and Technology. As mentioned in Section 2, this is a segregated State fund established to finance the costs related to the final disposal of radioactive waste, the interim storage of spent fuel and the back-end of the fuel cycle, as well as the tasks related to the decommissioning of nuclear facilities. Estimates of these costs are prepared by PURAM and approved by the Ministry of Innovation and Technology on an annual basis.

Expected future costs (in 2017 money terms) are shown in the chart below. The total overnight cost of the cash flows shown below is roughly HUF 1,584bn or €5.1bn (in 2017 money terms)

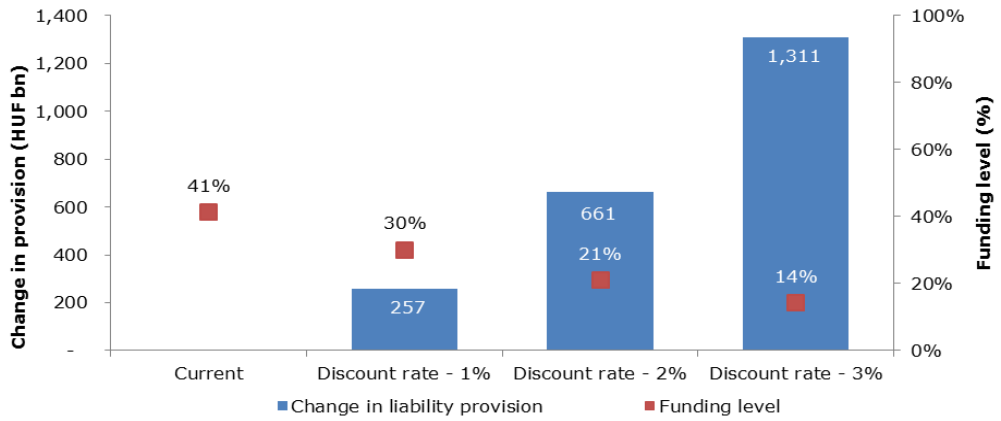


Source: Hungarian government

To assess the current funding position and allow for the time value of money, it is necessary to work with a discounted value of the expected future costs.

In 2016, the real discount rate used was 2.42% p.a. and was determined as the 15 year average of the Central Bank Base Rate less inflation. Applying this real discount rate to the costs shown above results in a present value of the expected future decommissioning and waste management costs of HUF 687bn or €2.2bn (1 HUF = €0.00321). This compares to a market value of assets in the CNFF of HUF 283.5bn (€0.91bn) and hence a funding level of 41%.

Due to the long duration of decommissioning and waste management liabilities, the discount rate has a very large impact on the potential liability value and hence future funding requirements. The chart below demonstrates the impact of adopting a nominal discount rate that is 1%, 2%, or 3% lower than the one current used. The level of funding (i.e. assets divided by liabilities) for each scenario is also shown.



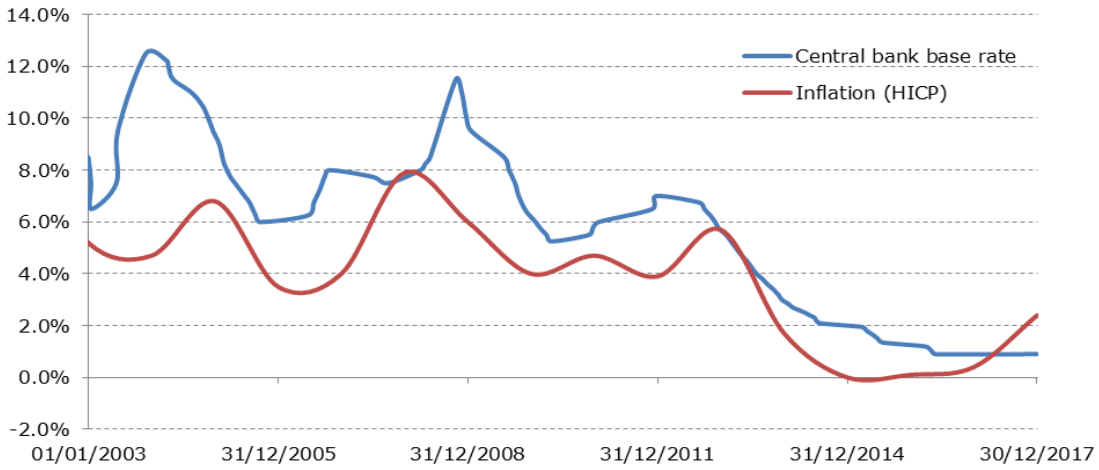
Asset allocation and expected future investment returns

At 31 December 2017 the value of the CNFF was HUF 283.5bn (€0.91bn). The assets of the CNFF are kept in a separate treasury account. For purposes of this study and absent any further details on how these assets are invested, it has been assumed that they are held in cash and short-term money market instruments.

At 31 December 2017, the Central Bank Base Rate was 0.9% p.a. and this has been taken to be the rate of interest applicable to the assets held in the CNFF. It is noted that this is below the yield currently available on long-dated Euro government bonds (at 31 December 2017, long-dated nominal Euro government bond yields were c.1.5% - see below).

Market consistent assessment of liability and funding implications

The use of a 15-year moving average real discount rate serves to reduce the level of volatility in the level of contributions payable to the CNFF. However, as shown in the chart below, there have been significant changes in Central Bank Base Rates in recent years and therefore the current smoothed discount rate is unlikely to be wholly reflective of current market conditions. This means that the level of contributions payable to the CNFF are likely to increase over time as the effect of these lower market yields are given greater weight in the calculation (even if all else remains unchanged).



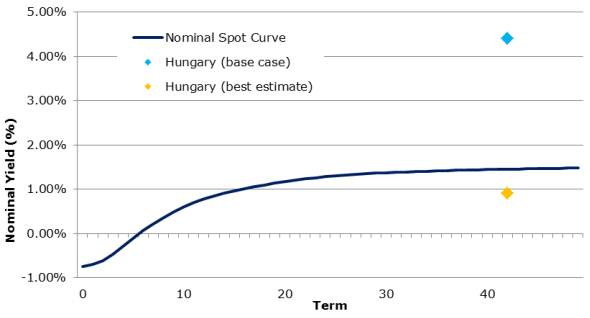
Source: Hungarian National Bank (Magyar Nemzefi Bank), European Central Bank (ECB)
Note: HICP is the Harmonised consumer price index calculated by the ECB

If instead the real discount rate were derived as the difference between the current Central Bank Base Rate (0.9% p.a.) and the long term Euro inflation assumption of 2.0% (i.e. -1.1% p.a.), the best estimate liability would be c. HUF 2,500bn or €8.0bn.

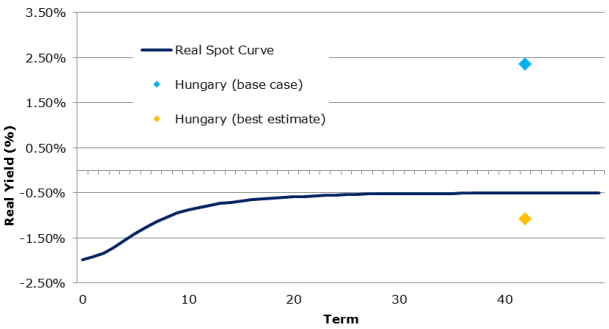
	Liability value	Funding Level
Base case liability	HUF 687bn	41%
Best estimate liability	HUF 2,487bn	11%

The charts below show how the resulting best estimate nominal discount rate, expected future inflation assumption and real discount rates compare to the Euro government bond yield curves and implied inflation curve at 30 September 2017.

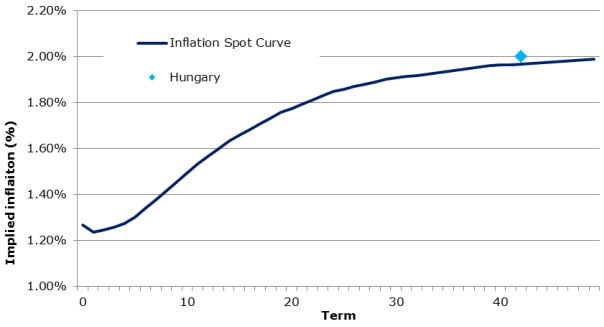
Nominal yields / discount rate



Real yields / discount rate



Market implied inflation



The rest of this section is based on the best estimate liability value.

Stress testing

The table below shows the net impact of pre-defined changes to the best estimate real discount rate, be it through changes in nominal interest rates or inflation expectations. For example, a 0.25% decrease in nominal interest rates, together with a 0.25% increase in inflation would increase the deficit by a further HUF 596bn (€1.9bn). This would effectively result in a net c.0.5% decrease in the real discount rate.

Change in Surplus (HUF bn)		Interest Rate								
		-1.00%	-0.75%	-0.50%	-0.25%	*0.00%*	+0.25%	+0.50%	+0.75%	+1.00%
Inflation	+1.00%	-3,620	-2,933	-2,332	-1,805	-1,343	-937	-580	-266	11
	+0.75%	-2,951	-2,346	-1,816	-1,352	-944	-585	-270	9	254
	+0.50%	-2,361	-1,828	-1,361	-951	-591	-274	6	252	470
	+0.25%	-1,840	-1,370	-958	-596	-278	3	250	469	662
	0.00%	-1,379	-965	-601	-282	0	248	467	661	833
	-0.25%	-972	-607	-286	-3	246	466	660	832	985
	-0.50%	-612	-290	-6	244	465	660	832	985	1,120
	-0.75%	-294	-9	242	464	659	832	985	1,121	1,242
	-1.00%	-12	240	462	658	832	985	1,121	1,242	1,350

VaR analysis

The key areas of risk are interest rate and inflation and the effect they have on the assessed liabilities. There is a 1-in-20 chance that the deficit could increase by at least HUF 530bn (€1.7bn) and decrease the funded status from 11% to approximately 9%.

Conclusion

The use of a smoothed discount rate together with a very conservative investment approach are likely to lead to material increases in the level of contributions payable to the CNFF in future (assuming the expected future decommissioning and waste management costs do not change fundamentally).

8. Italy

Expected future decommissioning and waste management cost profile

No information was available on the expected future decommissioning and waste management costs.

Asset allocation and expected future investment returns

As noted in Section 2, it is not possible to identify separate investments used to meet future decommissioning and waste management costs. As such it is also not possible to comment on expected future investment returns.

Market consistent assessment of liability and funding implications

Without detail on the expected future decommissioning and waste management costs or a segregated investment portfolio, it is not possible to determine a market consistent measure of future decommissioning and waste management costs or the extent to which this is adequately covered by assets held in the Electricity Equalisation Fund and future levies on the electricity price.

Risk analysis

As noted earlier, decommissioning and waste management costs are met by end users of electricity through an annually adjusted levy. The primary risk is therefore that sufficient levies cannot be received in advance of required decommissioning and waste management expenditure (or that, after allowing for other necessary expenditures, funds in the Electricity Equalisation Fund are insufficient to meet these expenditures directly).

Because the levies are adjusted annually and must be paid in order for end users to have electricity, the risk of failing to receive sufficient levies would appear to be remote. However, the potential for material increases in the required levy should not be overlooked and could have important political/policy implications. This should be considered alongside the likely amount of assets in the Electricity Equalisation Fund that could reasonably be assigned to future decommissioning and waste management costs.

The lack of transparency regarding the extent to which decommissioning and waste management costs have been funded is, in itself, a key risk issue.

9. Lithuania

Expected future decommissioning and waste management cost profile

Although detailed information on the expected future decommissioning and waste management costs was not provided, it is understood that the main features of the Ignalina programme include a "brownfield" end state to be achieved by 2038 and a total estimated cost of decommissioning and waste management of €3.377 billion[44].

Asset allocation and expected future investment returns

As noted in Section 2, it is not possible to identify separate investments used to meet future decommissioning and waste management costs. As such it is also not possible to comment on expected future investment returns.

[44] Report From The Commission To The European Parliament And The Council on the implementation of the work under the nuclear decommissioning assistance programme to Bulgaria, Lithuania and Slovakia in 2016 and previous years (http://ec.europa.eu/transparency/regdoc/rep/1/2017/EN/COM-2017-328-F1-EN-MAIN-PART-1.PDF)

Risk analysis

Without detail on the expected future decommissioning and waste management costs or the assets held in either the Ignalina Fund or the IIDSF, it is not possible to determine a market consistent measure of future decommissioning and waste management costs.

It is understood that funding (from the EU and national sources) is expected to be sufficient to cover decommissioning and waste management expenditure to 2020. Furthermore, it is understood that the expected shortfall for the period from 2021 to 2038 remains substantial at €1.561 billion.

Lithuania will therefore need additional support over the full period of decommissioning to 2038 (or later). National legislation requires the Lithuanian government to negotiate such support and commits to charging the State budget for all costs where no other resources are found.

Although Lithuania expects that the EU will continue to follow the agreement reached under the Treaty of Accession and will continue to provide additional financing to ensure the decommissioning of the Ignalina NPP, there is of course a risk that such financing cannot be obtained, in which case the Lithuanian Government will need to meet future decommissioning and waste management costs from the state budget.

10. Slovakia

Expected future decommissioning and waste management cost profile

Slovakia's national programme contains a detailed breakdown of the expected future decommissioning and waste management that will be met from the NNF. This breakdown is shown in the table below and includes:

- The total estimated overnight costs (in 1 January 2015 money terms) of c. €8bn;
- The inflated value of these costs, based on an assumed inflation assumption up to 2.0% p.a., of c. €22.5bn; and
- The discounted present value of these costs, based on an assumed nominal discount rate of 1.1% p.a. (i.e. a real discount rate of c.-0.9% p.a.) of c. €12.2bn.

Cost Item (million €)	in 1/01/2015 prices	in nominal prices	in discounted prices (1/1/2015)
Cost of decommissioning the A1 NPP (including the cost of disposal of RAW in the DDF)	578	689	624
Cost of disposal of RAW from decommissioning the A1 NPP in the Mochovce disposal facility	160	211	181
Contribution of the A1 NPP towards DDF costs (2.70 % of the total costs)	101	368	175
Cost of decommissioning the V1 NPP	358	394	373
Cost of disposal of RAW from decommissioning the V1 NPP	46	53	49
Cost of storage of SNF from the V1 NPP	152	272	194
Contribution of the V1 NPP towards DDF costs (19.81 % of the total costs)	738	2,701	1,286
Cost of decommissioning the V2 NPP	730	1,199	908
Cost of disposal of RAW from decommissioning the V2 NPP	35	56	43
Cost of storage of SNF from the V2 NPP	191	447	275
Contribution of the V2 NPP towards DDF costs (28.34 % of the total costs)	1,056	3,864	1,840
Cost of decommissioning EMO 12	727	1,608	1,032

Cost of disposal of RAW from decommissioning EMO 12	35	74	49
Cost of storage of SNF from EMO 12	54	179	91
Contribution of the EMO 12 NPP towards DDF costs (25.52 % of the total costs)	951	3,479	1,657
Cost of decommissioning EMO 34	736	2,232	1,201
Cost of disposal of RAW from decommissioning EMO 34	35	99	56
Cost of storage of SNF from EMO 34	49	205	92
Contribution of EMO 34 towards DDF costs (23.63 % of the total costs)	880	3,221	1,534
Cost of IRAM	44	197	80
Institutional control of disposal facilities	10	79	25
Decommissioning of non-reactor nuclear installations	244	794	408
Administration of the NNF	65	106	80
TOTAL COST	**7,976**	**22,527**	**12,244**

Source: Draft National Policy and National Programme for the Management of Spent Nuclear Fuel and Radioactive Waste in Slovakia

Although the national programme provides year-on-year cost estimates for 2015 – 2020 as well as combined cost estimates for the period after 2020, it has not been possible to derive a full yearly cash flow profile using the information available.

However, using the information contained in the national programme and SE AS published 31 December 2016 accounts[45], it is possible to derive an estimate of how the total discounted liability shown above might have developed over the period to 31 December 2016. This is shown in the table below with detail on the key assumptions made set up below the table:

Cost Item (million €)	in discounted prices (1/1/2015)	in discounted prices (1/1/2017)
Costs associated with the A1 NPP	978	883
Costs associated with the V1 NPP	1,900	1,858
Costs associated with the V2 NPP	3,064	2,781
Costs associated with EMO 12	2,827	2,566
Costs associated with EMO 34	2,882	2,872
Other cost items (IRAM, disposal facilities, non NPP's, administration)	593	577
TOTAL COST	**12,244**	**11,537**

Key assumptions:

- Allowance has been made for realised Eurozone HIPC inflation between 31 December 2014 and 31 December 2016 of 1.4% (rather than the assumed c. 2% p.a. over this time). All else being equal, this serves to reduce the estimated liability. To the extent actual cost inflation has exceed Eurozone HIPC inflation, the estimated liability will be understated.
- Expected total expenditure figures shown in the national programme for 2015 and 2016 (c. €103m and €107m respectively) have been assumed to equal the actual costs incurred in these years (and therefore reduce the estimated liability accordingly).

[45] Jadrová a vyraďovacia spoločnosť, a. s. ("Javys AS"), Slovakia's other NPP operator, did not report future decommissioning and waste management costs in their 2016 Annual Report.

- Allowance has also been made for the changes in estimates and other adjustments to the provisions in respect of the V2 NPP and EMO 12 as shown in the 2016 year-end accounts of SE AS.

The resulting base case liability estimate at 31 December 2016 is roughly €11.5bn.

Asset allocation and expected future investment returns

The assets of the NNF are primarily deposits at the Slovak State Treasury and commercial banks. Investment returns take the form of interest received from these assets. At 1 January 2015, the value of the assets held in the NNF was c. €1.23bn, held in the sub-accounts below:

Sub-account name	Sub-account	Market value on 1 January 2015 (€ m)
A1 nuclear power plant	A/A1	11.0
V1 nuclear power plant	A/V1	306.5
V2 nuclear power plant	A/V2	532.3
EMO 12 nuclear power plant	B	365.2
New NPP after 1 July 2006	C	-
Management of NM and RAW of an unknown origin	/ D	-
Disposal facilities for RAW and SNF	/ E	1.0
Institutional control of disposal facilities	/ F	-
Storage of SNF in separate NI	G	3.5
Administration of the NNF	/ H	5.2
Management of IRAW	I	0.4
Total		**1,225**

Source: Draft National Policy and National Programme for the Management of Spent Nuclear Fuel and Radioactive Waste in Slovakia

Again using the information contained in the national programme and SE AS published 31 December 2016 accounts, it is possible to derive an estimate of how the total NNF asset value might have developed over the period to 31 December 2016. This is shown in the table below with detail on the key assumptions made set up below the table:

Sub-account name	Sub-account	Market value on 1 January 2015 (€ m)	Estimated Market value on 31 December 2016 (€ m)
A1 nuclear power plant	A/A1	11.0	52.7
V1 nuclear power plant	A/V1	306.5	282.2
V2 nuclear power plant	A/V2	532.3	630.9
EMO 12 nuclear power plant	B	365.2	432.6
New NPP after 1 July 2006	C	-	-
Others	/ D, /E, /F, G, /H, I	10.0	-
Total		**1,225**	**1,399**

Key assumptions:

- The 31 December 2016 SE AS annual report provides a reconciliation showing how the 1 January 2015 values for the A/V2 and B sub-accounts developed over the period to 31 December 2016. Based on this information, the return achieved by the NNF assets over this two-year period was c.2.3% p.a. It has been assumed that this return was earned on all assets held in the NNF.
- Expected total expenditure figures for the NNF shown in the national programme for 2015 and 2016 (c. €71m and €76m respectively) have been assumed to equal the actual costs incurred in these years (and therefore reduce the estimated liability accordingly).
- This expenditure is mainly is respect of the A1 and (to a lesser extent) the V1 NPP's, with a small component related to the other cost items.
- Expected NNF income for 2015 and 2016 (as shown in the national programme) in the form of transfers from the Ministry of the Environment from electricity levies (c. €68m and €71m respectively) have been assumed to have been paid into the A/A1 sub-account.

The resulting estimated asset value at 31 December 2016 is roughly €1.4bn[46]. This compares to the estimated base case liability of c. €11.5bn and hence a funding level of c.12%, as shown in the table below:

Sub-account name	Estimated liability value on 31 December 2016 (€ m)	Estimated Market value of assets on 31 December 2016 (€ m)	Funding level
A1 nuclear power plant	883	52.7	5.97%
V1 nuclear power plant	1,858	282.2	15.19%
V2 nuclear power plant	2,781	630.9	22.68%
EMO 12 nuclear power plant	2,566	432.6	16.87%
New NPP after 1 July 2006	2,872	-	0.00%
Others	577	-	0.00%
Total	**11,537**	**1,399**	**12.1%**

From the above it is clear that there are material funding gaps that will need to be addressed from future contributions and investment returns.

The national programme shows that shortfalls for A1 are expected to be met through transfers from the Ministry of the Environment whilst shortfalls for V1 are expected to be met from the BIDSF and transfers from the Ministry of the Environment. It is however likely that further funding (or increased levels of investment return) will be required.

The national programme also recognises that, after allowing for currently agreed/expected future contributions and expected future investment returns, the assets accumulated in the NNF for V2, EMO 12 and EMO 34 are likely to prove insufficient to cover all future obligations.

Analysis contained in the national programme shows that in order for the NNF to fully meet its future obligations, absent further funding contributions, it would need to achieve future investment returns of 1.28% p.a. above inflation (i.e. a real discount rate of 1.28% or a nominal discount rate of 3.28%).

[46] This is very similar to the expected NNF asset value at 31 December 2016 of EUR 1,412m shown in the national programme.

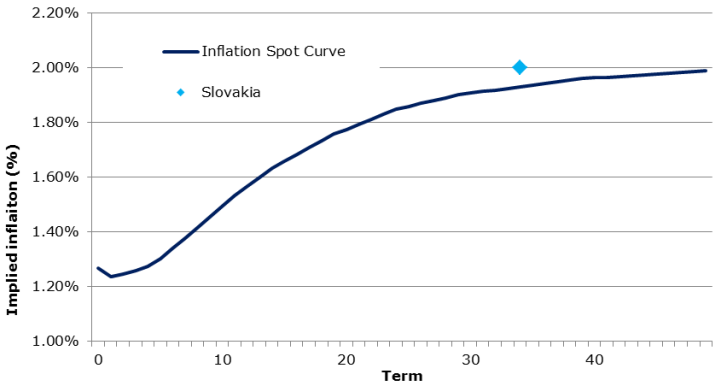
In order to achieve returns of 1.28% p.a. above inflation, it is likely that a fundamental change in investment strategy will be required given the current low yield environment.

The risk analysis contained in the national programme is noteworthy and represents a comprehensive analysis of funding and investment risk. This is discussed further in Section 5.

Market consistent assessment of liability and funding implications

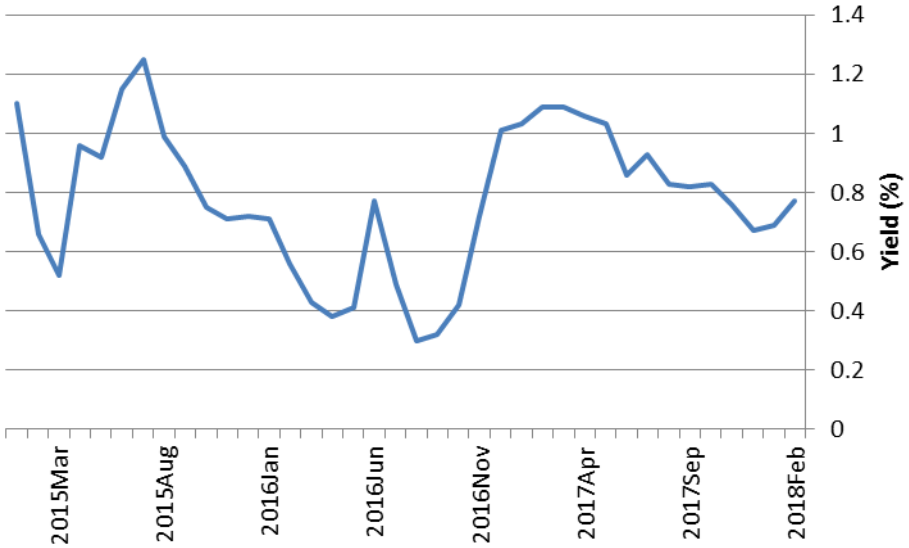
The national programme assumes that the level of inflation applicable to the long-term cost estimates will not exceed 2 % per annum. This is also the inflation assumption used by SE AS when calculating its balance sheet provision for nuclear decommissioning and waste storage costs.

As shown in the chart alongside, this assumption is in line with the long-term ECB inflation target, although does not appear to include allowance for any additional nuclear specific inflation elements:



The Ministry of Finance SR publishes the information needed to calculate the discount rate and, as noted above, a discount rate of 1.1% was used in the various calculations set out in the national programme.

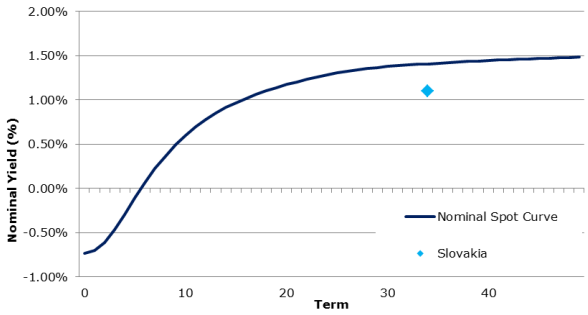
The chart below shows the progression of the market yields on Slovakian government bonds with maturities of close to ten years[47]. The yield at 1 January 2015 was c.1.1% (in line with the discount rate used). Although yields have been volatile, there has been a general downward trend – the yield was c.1.0% at 31 December 2016 and has since fallen to c.0.8%.



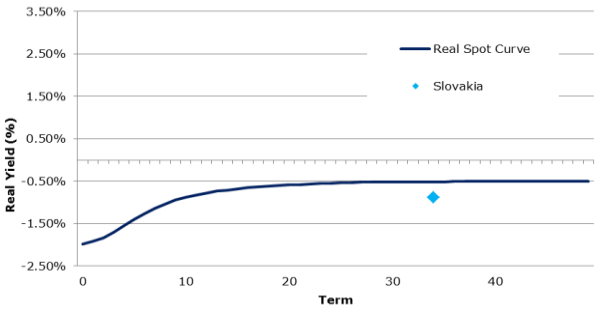
[47] Source: ECD and European Commission. Harmonised long-term interest rates for convergence assessment purposes. Secondary market yields of government bonds with maturities of close to ten years as at 31 December 2017.

The charts below show the nominal and real Euro government bond yield curves at 30 September 2017. The current discount rate assumption of 1.1% p.a. does not appear to be wholly inconsistent with these observed market yields and therefore no further adjustments to the discount rate have been made (that is, the base case liability is equal to the best estimate liability).

Nominal yields / discount rate



Real yields / discount rate



When calculating its balance sheet provision for nuclear decommissioning and waste storage costs, SE AS make use of discount rates between 4.15% and 4.55%. SE AS state that these rates are based on long-term interest rate data although it is unclear how exactly they have been derived. It is notable that these discount rates are generally higher than the yields on the bonds actually held in the NNF (see Section 2) and also appear inconsistent with both the assumption set out in the national programme and the yield charts shown above.

Past performance

The national programme notes that NNF assets are invested in deposits with fixed income and that these achieved an average rate of return of 2.49% p.a. from 2009 to 2014 (vs. inflation of 1.63% p.a.). After deduction of the tax levy for the relevant period, this amounted to an average excess over inflation of 0.39 %.

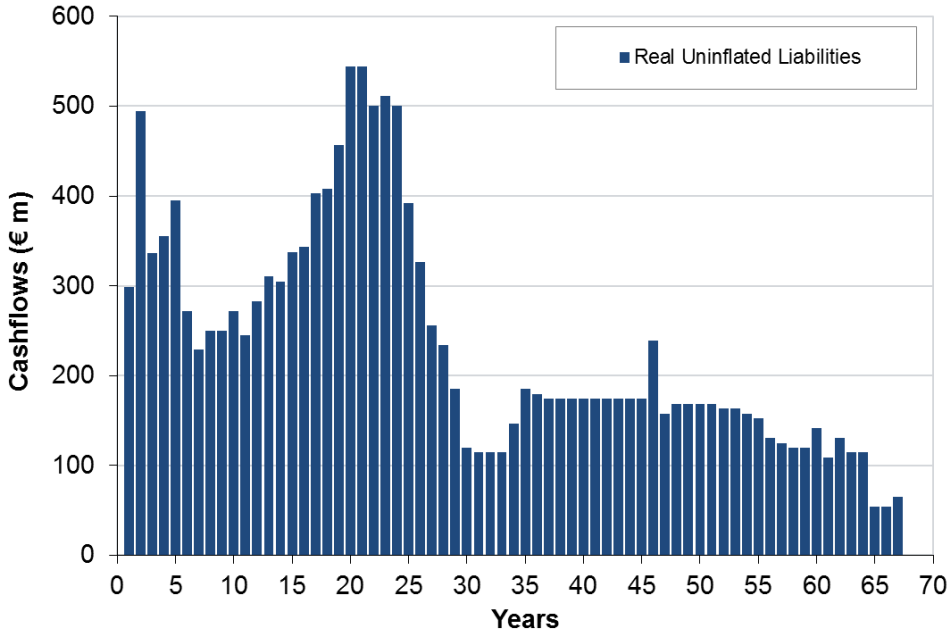
As noted above, performance over the period from 1 January 2015 to 31 December 2016 was c. 2.3% p.a.

11. Spain

Expected future decommissioning and waste management cost profile

As mentioned in section 2, Enresa must submit an updated PGRR to Minetur every four years (or more frequently if required). The estimated decommissioning and waste management costs contained in the PGRR are based on a set of "reference scenario" assumptions and, using these, Enresa will determine the financing amounts that are payable to the PGRR Fund.

The chart below shows the profile of the expected future decommissioning and waste management costs in 30 September 2017 prices and is based on information provided by Enresa. The cost profile below shows undiscounted payments, and therefore does not reflect the time value of money. The total overnight cost of the cash flows shown below is roughly €15.8bn (in 2017 money terms)



To assess the current funding position and allow for the time value of money, it is necessary to work with a discounted value of the expected future costs.

Assumptions:

- The discount rate used by Enresa to value the projected payments is 1.5%. This discount rate is a pre-tax real rate, and was provided by the Ministry of Finance and Civil Service.
- No inflation assumptions have been provided and therefore it has been assumed that costs will increase in line with the ECB's inflation target of 2% p.a.

Based on the assumptions outlined above, the present value of the expected future decommissioning and waste management costs is c. €11bn. This compares to a market value of assets in the PGRR fund of c. €5bn and hence a funding level of 46%.

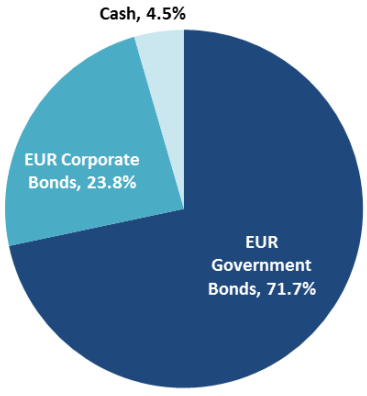
Because of the long duration of decommissioning and waste management liabilities, changes in discount rate can have a very large impact on the potential liability value and hence future funding requirements. This is illustrated in the chart below using the base case liability of c. €11bn. The chart shows the impact of adopting a real discount rate that is 1%, 2% or 3% lower than currently used. The level of funding (i.e. assets divided by liabilities) for each scenario is also shown.

Asset allocation and expected future investment returns

The PGRR Fund currently invests in Spanish Government Debt, other Public Debt, other obligations and bonds, short term assets and has a small allocation to derivatives (i.e. swaps used for hedging purposes only).

For the purpose of our analysis, Spanish Government Debt, other Public Debt and derivatives have been modelled as Euro government bonds. Derivatives are assumed to have interest rate and inflation exposures similar to that of the Government Bonds.

The resulting Fund asset allocation as at 2017 is shown in the chart below. The accompanying table shows the annualised expected returns over a 10 year period for this portfolio based on Mercer's European Capital Market Assumptions. The expected median portfolio return over the period is 1.0% p.a. and these returns are shown in nominal terms (i.e. these are absolute return numbers rather than the expected returns over expected future inflation).



Percentile	Expected Return
95th	2.3%
75th	1.5%
50th	1.0%
25th	0.5%
5th	-0.3%

Assumptions:

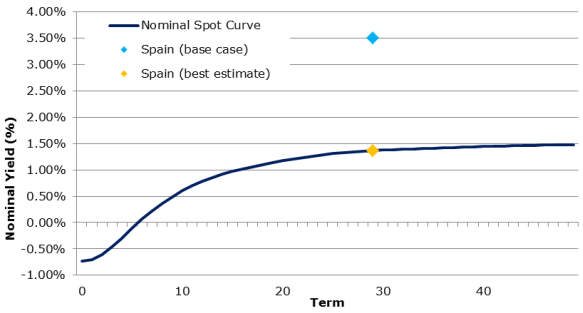
- Market value of the assets is €5,018m.
- Projections assume that 50% of government bond holdings are invested in fixed income government bonds and 50% are invested in inflation linked government bonds.
- Both government bonds and corporate bonds are assumed to be invested in line with broad market indices.

Market consistent assessment of liability and funding implications

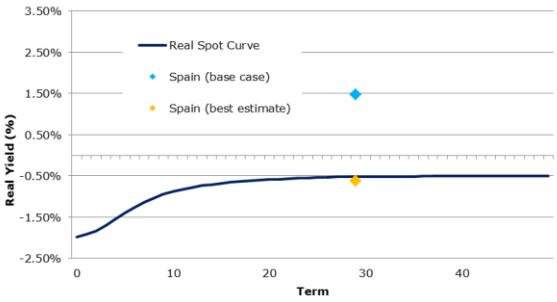
In light of the analysis above, the real discount rate of 1.5% used by Enresa to value the future costs is likely to be unachievable in current market conditions.

The charts below show the nominal and real Euro government bond yield curves at 30 September 2017. It is important to note that the expected return derived above is lower than the nominal Euro government bond spot yield at the relevant duration. Recognising this, the appropriate best estimate nominal discount rate has been set equal to the appropriate spot yield, as shown below.

Nominal yields / discount rate



Real yields / discount rate



Based on a nominal discount rate of 1.4% p.a., the real discount rate would be c.-0.6% p.a. Use of a real discount rate of -0.6% p.a. results in a best estimate liability of c. €18.7bn.

	Liability value	Funding level
Base case liability	€10,971m	46%
Best estimate liability	€18,713m	27%

The rest of this section will be based on the best estimate liability value of c. €18.7bn.

Stress testing

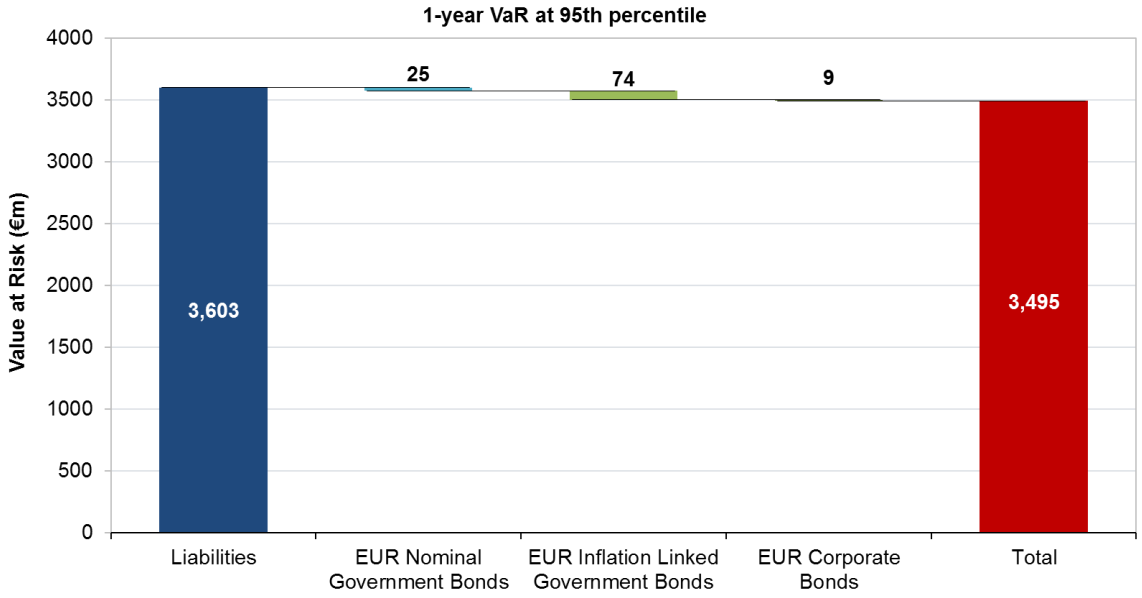
The table below shows the net impact of pre-defined changes to either nominal interest rates or inflation on both the liability and assets (and hence the funded status) of the PGRR fund. For example, a 0.25% increase in the long-term inflation assumption (and hence a 0.25% reduction in the real discount rate) would increase the deficit by a further c. €1.2bn.

Surplus		Interest Rate								
		-1.00%	-0.75%	-0.50%	-0.25%	*0.00%*	+0.25%	+0.50%	+0.75%	+1.00%
Inflation	+1.00%	-14,056	-11,623	-9,456	-7,522	-5,793	-4,245	-2,856	-1,607	-482
	+0.75%	-11,479	-9,317	-7,389	-5,666	-4,123	-2,739	-1,496	-376	634
	+0.50%	-9,162	-7,241	-5,525	-3,989	-2,612	-1,375	-261	743	1,651
	+0.25%	-7,077	-5,369	-3,842	-2,472	-1,243	-136	862	1,763	2,578
	0.00%	-5,197	-3,679	-2,319	-1,098	0	990	1,884	2,692	3,426
	-0.25%	-3,500	-2,151	-940	148	1,129	2,015	2,816	3,542	4,201
	-0.50%	-1,966	-767	310	1,281	2,157	2,949	3,667	4,319	4,911
	-0.75%	-577	487	1,446	2,311	3,093	3,802	4,445	5,030	5,563
	-1.00%	681	1,627	2,479	3,250	3,948	4,582	5,158	5,684	6,163

VaR analysis

The 1-year 95% VaR decomposition is shown below. The key areas of risk in the Fund are interest rates and inflation and the effect they have on the assessed liabilities. This risk is primarily due to the level of underfunding and the low level of hedging provided by the existing assets. There is a 1-in-20 chance that the deficit could increase by at

least c. €3.5bn over a one year period. Such an event would further reduce the funding level to c. 23%.



Performance assessment

The performance over the last 5 years of the PGRR Fund is shown below and has been calculated using information contained in Enresa's annual report and accounts.

	2012	2013	2014	2015	2016
Annual return	6.5%	5.2%	4.7%	4.0%	4.1%
HICP Inflation	3.0%	0.3%	-1.1%	-0.1%	1.4%
Real Return	3.5%	4.9%	5.9%	4.1%	2.7%

Source: Eurostat

The average geometric mean return over the last 5 years is 4.9%.

Conclusion

It appears that, on the basis of best estimate liability calculated above, the current level of funding may be lower than suggested. This may require a review of the current financing amounts in order to ensure that the PGRR proves sufficient.

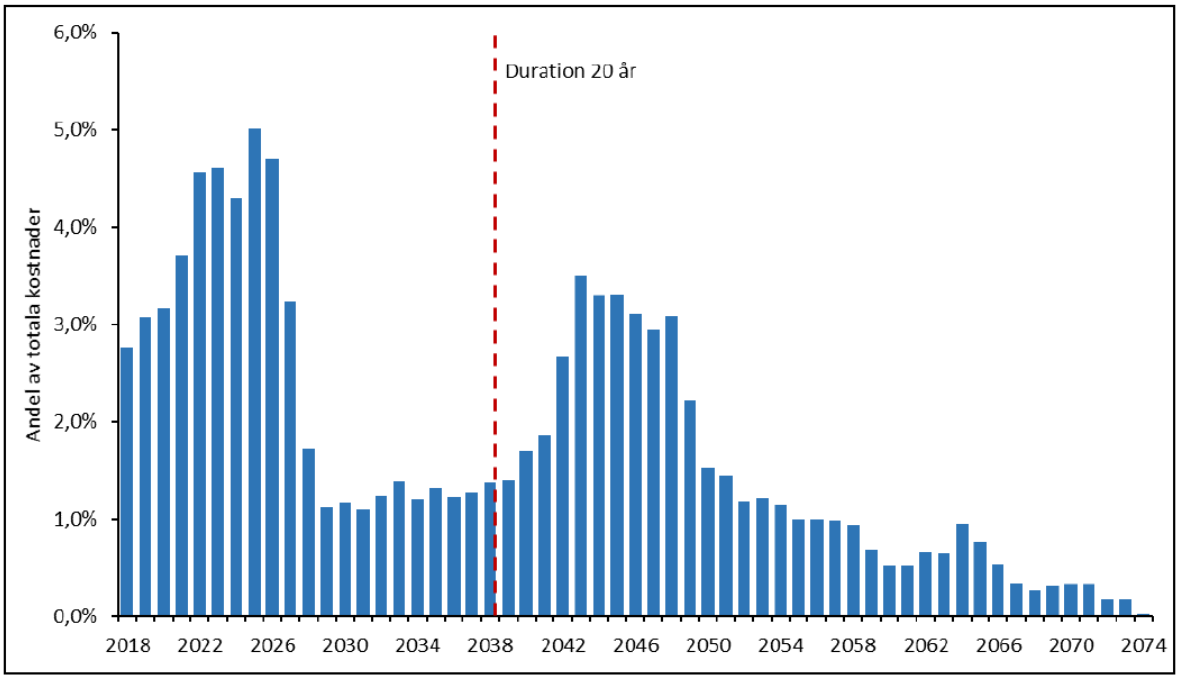
12. Sweden

Expected future decommissioning and waste management cost profile

The Swedish Nuclear Fuel and Waste Management Company, SKB, coordinates the industry calculations of the expected future costs for decommissioning and management and disposal of spent nuclear fuel and nuclear waste. It submits these to the regulator, SSM, every three years. As such, there is a 3-year cycle of new calculations, review and resetting of the level of fees and additional security required. The current fees, as decided by the Government at the end of 2017, apply to the period 2018-2020.

The base cost estimate is made by the industry using Monte Carlo projections. The liability value used for the calculation of the fees is the base estimate adjusted for uncertainty additions.

SSM calculated the following schedule of remaining costs based on the industry submissions for the period 2018 - 2020. In the figure, the y-axis indicates the level of costs as a percentage of the total projected costs.



As explained in Section 2, nuclear reactor owners and other fee-liable licensees also provide guarantees. Reactor owners provide acceptable guarantees to the Nuclear Waste Fund corresponding to the financing and supplementary amounts determined by the Government. Other fee-liable licensees provide equivalent guarantees for the financing amount determined by SSM. These guarantees are listed as follows in the 2017 Annual Report:

SEK thousand	Financing Amount	Supplementary Amount
Guarantee amount for reactor owners	18,480,000	7,922,000
Guarantee amount for licensees	3,312,709	-
Total	21,792,709	7,922,000

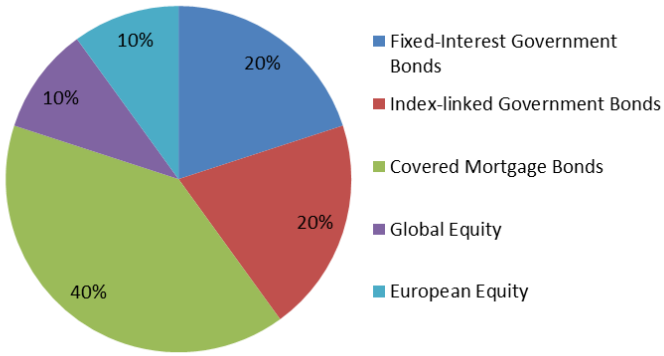
The asset value of c.SEK 67.2bn and the guarantees shown above therefore suggest a liability value of roughly SEK 100bn. It is however understood that the most recent calculations carried out in order to assess future funding requirements revealed a funding level of 65% and hence a base case liability of c.SEK103.4bn. Although this estimate has not been independently verified, it appears reasonable and the analysis below has therefore been carried out on the basis of this base case liability value.

Asset allocation and expected future investment returns

As at 31 December 2017, the market value of the funds held in the NWF was SEK 67,236m (approximately €6.84bn). The NWF's assets are actively managed, meaning that the actual investments held may in practice deviate from the mix of securities that

constitute the benchmark index. From the end of 2017, the NWF may also invest its assets in equities (max. 40%) and corporate bonds, with certain limitations.

An illustrative asset allocation for the period post 2017 was provided as 40% government securities, 40% covered bonds and 20% shares. For the purposes of this study, this has been modelled in line with the chart below. The accompanying table shows the annualised expected returns over a 10 year period for this portfolio based on Mercer's European Capital Market Assumptions. The expected median portfolio return over the period is 2.4% p.a. and these returns are shown in nominal terms (i.e. these are absolute return numbers rather than the expected returns over expected future inflation).



Percentile	Expected Return
95th	4.8%
75th	3.4%
50th	2.4%
25th	1.3%
5th	-0.4%

Market consistent assessment of liability and funding implications

Inflation/indexing of costs

A number of different inflation indices are used by the SKB in order to allow for the expected future inflation of the costs submitted by the nuclear licence holders. Forecasts are developed for real price changes in a number of external economic factors (including payroll costs, productivity trends and costs for various input and machinery) and, based on these forecasts, costs are inflated from the date of calculation to the expected date when they will be incurred.

This focus on the actual cost inflation drivers is noteworthy and will be addressed in more detail in Section 5. However, due to data limitations, no attempt has been made to replicate these detailed inflation calculations in this study. Instead a simplified assumption for future inflation of 1.8% p.a. based on long term consensus forecasts has been used.

Discount Rate

The Nuclear Waste Fund's nominal risk-free discount curve is calculated using the following information:

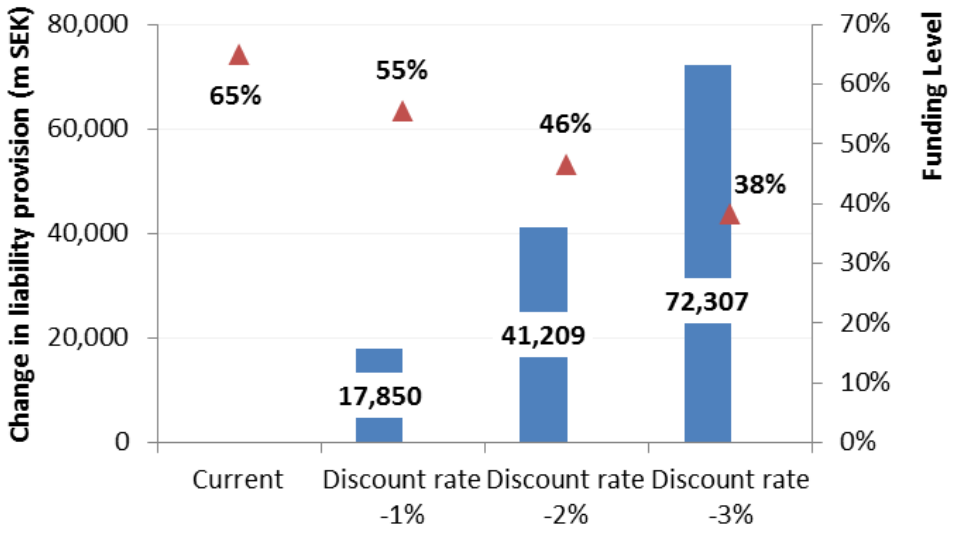
- 1-10 years: market data on interest rate swaps in SEK
- 11-20 years: weighted average of the implied forward rates from the market quotation and long-term forward interest rate of 4.2%
- Over 20 years: long-term forward interest rate of 4.2% (Ultimate Forward Rate, UFR).

A risk premium is then calculated as follows:

Asset Class	Risk Premium for asset class	Holding	Risk premium in the portfolio
Government securities	0.00%	40%	0.00%
Covered bonds	0.50%	40%	0.20%
Shares	2.75%	20%	0.55%
Total			**0.75%**

Using the information above, the nominal single equivalent risk free discount rate has been estimated to be c. 2.6%. Adding the risk premium gives a nominal discount rate of c. 3.3% p.a. As outlined in the section above, the base case liability is c.SEK103.4bn (c. €10.5bn). This compares to a market value of assets in the NWF of SEK 67.2bn (c. €6.84bn) and hence a funding level of 65%.

Because of the long duration of decommissioning and waste management liabilities, the discount rate has a very large impact on the potential liability value and hence future funding requirements. This is illustrated in the chart below using the base case liability of c. SEK103.4bn (c. €10.5bn). The chart shows the impact of adopting a real discount rate that is 1%, 2% or 3% lower than currently used. The level of funding (i.e. assets divided by liabilities) for each scenario is also shown.



If instead, the median expected return of 2.4% p.a. calculated above were used as the discount rate (together with an inflation assumption of 1.8% p.a.), the best estimate liability would be c. SEK 121.2bn (c. €12.3bn) and hence the funding level would be 55%

The best estimate liability is c. 17% higher than the base case liability and this is primarily due to the use of the Ultimate Forward Rate of 4.2% in the base case liability:

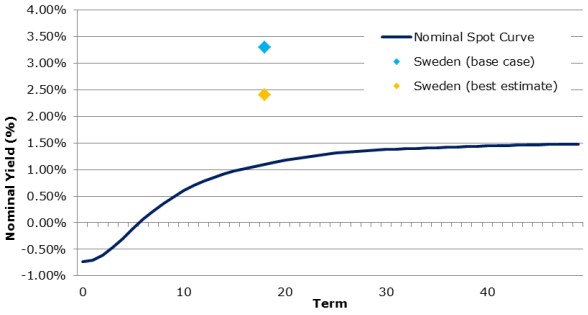
- The Ultimate Forward Rate is based on two components – the long-term inflation expectation plus the long-term expected short-term interest rate. These were initially estimated at 2% and 2.2% respectively, i.e. 4.2% in total.
- However, 20 and 30-year swap rates have remained below 4.2% for an extended period of time, calling into question the appropriateness of the long-term interest rate assumption. Based on revised EIOPA methodology, and reflecting the

significant changes in the long-term expectations of interest rates in recent years, the new calculated value of the UFR is 3.65%.

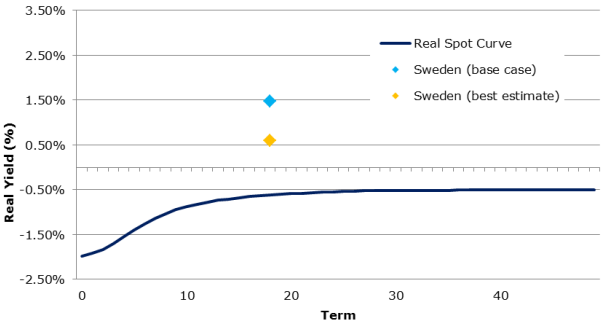
- The first change of the UFR, from 4.2% to 4.05%, was implemented at the beginning of 2018. Annual changes to the UFR will not be higher than 15 basis points. However, it is clear that this rate is set to continue decreasing in the future, and hence the present value of the liability will continue to increase.

The charts below show how the resulting best estimate nominal discount rate, expected future inflation assumption and real discount rates compare to the corresponding Euro government bond yield curves and implied inflation curve at 30 September 2017.

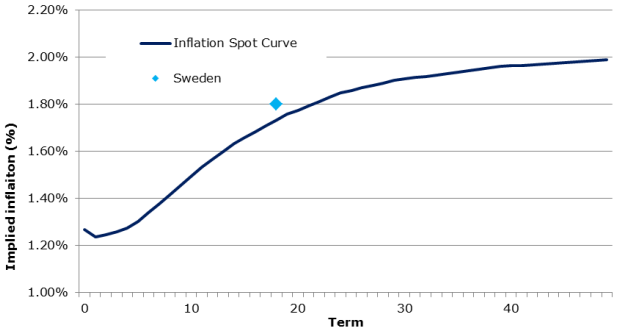
Nominal yields / discount rate



Real yields / discount rate



Market implied inflation



The remainder of this section is based on the best estimate liability.

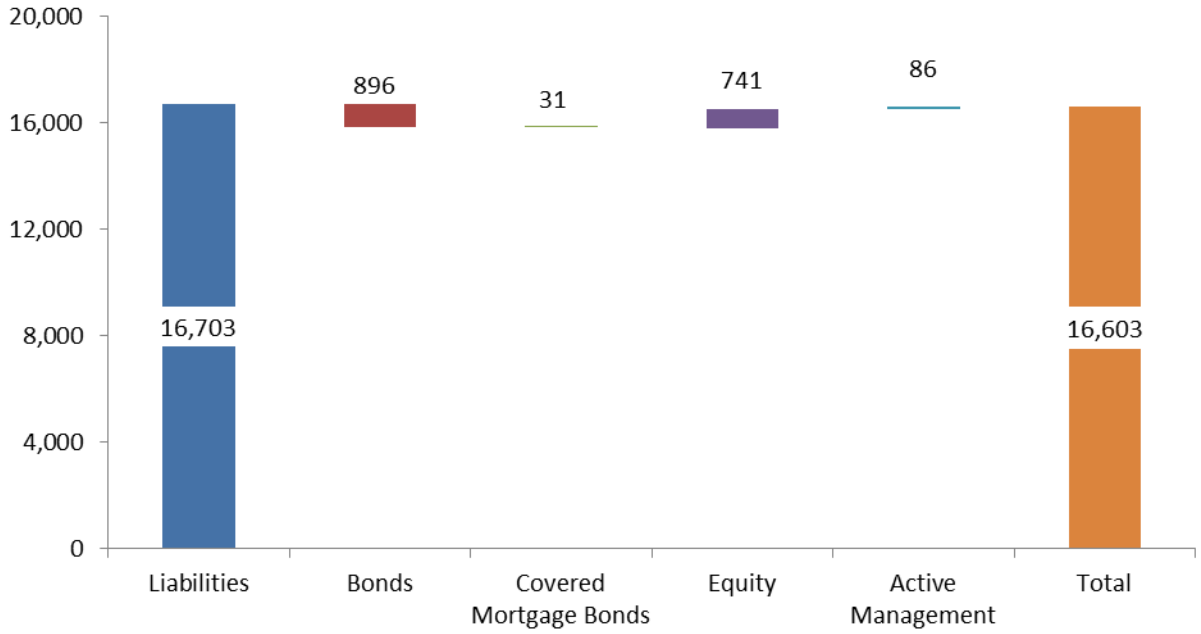
Stress testing

The table below shows the net impact of pre-defined changes to real discount rates (either through changes in nominal interest rates or inflation expectations) and equity markets on both the liability and assets (and hence the funded status) of the NWF. For example, a 0.25% decrease in long-term interest rates (and hence a 0.25% reduction in the real discount rate) together with a 10% fall in equity markets would increase the deficit by a further c. SEK 6.2bn.

Surplus		Interest Rate								
		-1.00%	-0.75%	-0.50%	-0.25%	*0.00%*	+0.25%	+0.50%	+0.75%	+1.00%
Equities	+20.00%	-19,649	-13,351	-7,575	-2,276	2,585	7,046	11,140	14,898	18,346
	+15.00%	-20,295	-13,997	-8,221	-2,923	1,939	6,400	10,494	14,251	17,700
	+10.00%	-20,942	-14,643	-8,867	-3,569	1,292	5,753	9,848	13,605	17,054
	+5.00%	-21,588	-15,289	-9,513	-4,215	646	5,107	9,201	12,959	16,408
	0.00%	-22,234	-15,935	-10,159	-4,861	0	4,461	8,555	12,313	15,762
	-5.00%	-22,880	-16,581	-10,805	-5,507	-646	3,815	7,909	11,667	15,116
	-10.00%	-23,526	-17,228	-11,452	-6,153	-1,292	3,169	7,263	11,021	14,469
	-15.00%	-24,172	-17,874	-12,098	-6,800	-1,939	2,522	6,617	10,374	13,823
	-20.00%	-24,819	-18,520	-12,744	-7,446	-2,585	1,876	5,970	9,728	13,177

VaR analysis

The 1-year 95% VaR decomposition is shown below. The key areas of risk are interest rates and inflation and the effect they have on the assessed liabilities, partially offset by the Fund's allocations to bonds and covered mortgage bonds. There is a 1-in-20 chance that the deficit could increase by at least c. SEK 16.6bn over a one year period. Such an event would further reduce the funding level to c.49%.



Performance assessment

The current investment goal is that the Fund's nominal return over a 5 year period should exceed the portfolio's comparison index by an average of 0.5% p.a.
The comparison index is a composite index consisting of:

- 30% OMRX Real Return Bond Index
- 70% OMRX Bond Treasury Bonds Index

Given the decision to expand the range of permissible investments post 2017, both the composite index as well as the current investment goal will need to be modified.
The Fund's historical performance over the past 5 years has been provided as follows:

Year	Nominal Return (%)	Comparison Index (%)	Active Return (%)	Inflation (%)[48]	Real Return (%)
2012	4.6	2.5	2.1	-0.1	4.7
2013	-0.6	-1.4	0.8	0.1	-0.7
2014	10.7	10.7	0	-0.3	11
2015	-0.5	0.4	-0.9	0.1	-0.6
2016	5.8	5.0	0.8	1.7	4.1
2017	1.5	0.4	1.1	1.7	-0.2
Average per year (geometric mean)	3.3	2.9	0.4	0.7	2.6

[48] Inflation is the Consumer Price Index reported by SCB for December (12 month change in %)

Conclusion

In general, the Nuclear Waste Fund has robust investment management procedures in place. The provision of guarantees by the license fee holders in respect of any deficits, the efforts to allow for a realistic, nuclear specific future inflation rate as well as the regular updating of fee calculations are all positive examples of risk management within the Fund.

13. United Kingdom

Expected future decommissioning and waste management cost profile

As noted in Section 2, EDFE make regular contributions to the NLF aimed at covering the costs of decommissioning and waste management for the eight reactors it owns. Should the NLF prove insufficient for this purpose, the UK Government will indemnify future funding shortfalls.

The table below shows the expected future decommissioning and waste management costs in 2017 money terms. This information is contained in the 2016 EDF Energy Holdings Limited Annual Report and Financial Statements and it has been assumed that costs will continue until 2100. The cost profile below shows undiscounted payments, and therefore does not reflect the time value of money. The total overnight cost of the cash flows shown below is roughly £20.7bn (in 2017 money terms)

	Spent fuel £m	Radioactive waste £m	Decomm-issioning £m	2016 Total £m
Within five years	801	1	149	**951**
6 – 10 years	514	4	1,404	**1,922**
11 – 25 years	505	235	4,438	**5,178**
26 – 50 years	114	343	1,363	**1,820**
51 years and over	721	3,977	6,176	**10,874**
	2,655	4,560	13,530	**20,745**

To assess the current funding position and allow for the time value of money, a discounted value of the expected future costs is needed.

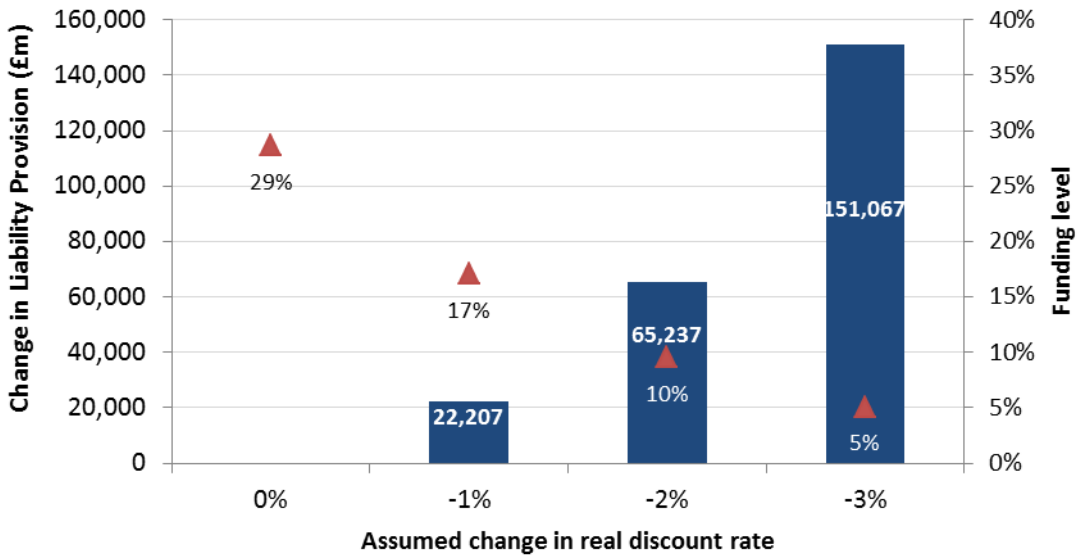
Assumptions:

- The real discount rate used by the Department for Business, Energy & Industrial Strategy ("BEIS") to value the projected payments is -0.8% p.a.
- BEIS have also indicated that the future decommissioning and waste management costs are expected to increase at a greater rate of inflation than the general economy and therefore assume that the costs will increase in line with RPI + 1%.

Based on the real discount rate assumption used by BEIS of -0.8% p.a., the present value of the expected future decommissioning and waste management costs is c.£32.8bn. This compares to a market value of assets in the NLF of c. £9.4bn and hence a funding level of 29%.

Because of the long duration of decommissioning and waste management liabilities, the discount rate has a very large impact on the potential liability value and hence future funding requirements.

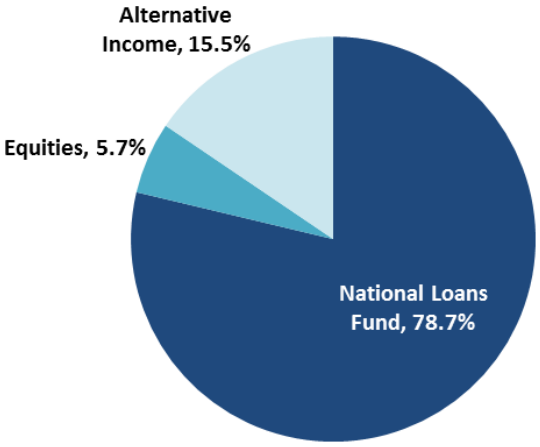
This is illustrated in the chart below using the base case liability of c. £32.8bn. The chart shows the impact of adopting a real discount rate that is 1%, 2% or 3% lower than the -0.8% currently used. The level of funding (i.e. assets divided by liabilities) for each scenario is also shown.



Asset allocation and expected future investment returns

The NLF currently invests in the National Loans Fund and a Mixed Asset Fund held with BlackRock Investment Management (UK) Limited. The latter is a diversified fund, with various equity and alternative income assets.

The Fund's asset allocation as at 2017 is represented in the chart below. The accompanying table shows the annualised expected returns over a 10 year period for this portfolio based on Mercer's European Capital Market Assumptions. The expected median portfolio return over the period is 2.2% p.a. and these returns are shown in nominal terms (i.e. these are absolute return numbers rather than the expected returns over expected future inflation).



Percentile	Expected Return
95th	4.5%
75th	3.2%
50th	2.2%
25th	1.3%
5th	-0.2%

Assumptions:

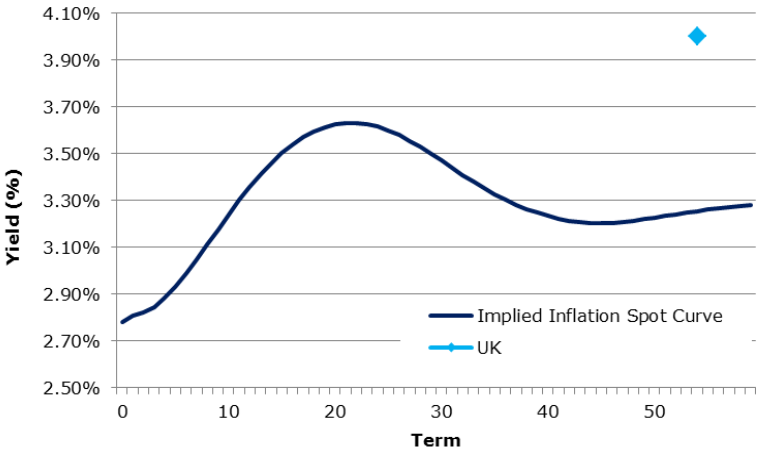
- Market value of the assets is £9,400m. This is taken from the BEIS Annual Report and Accounts.
- Equities are assumed to be invested both in the UK and globally. Alternative income includes assets classes such as: Private Equity, Infrastructure Debt and Equity, Real Estate and Private Debt.
- Three quarters of the holdings in the National Loans Fund are assumed to be in fixed interest gilts with the balance in inflation-linked gilts.
- Both government bonds and corporate bonds are invested in line with broad market indices.

Market consistent assessment of liability and funding implications

In light of the analysis above, the real discount rate of -0.8% used by BEIS to value the future costs is likely to be unachievable in current market conditions.

The UK government's long-term target for CPI is 2% p.a. Owing to differences in the basket of goods included in the index and formula differences, it is expected that long-term future RPI will exceed CPI by roughly 1% p.a.[49].

The chart shows the market implied RPI inflation curve at 31 December 2017. Current long-term market implied inflation exceeds 3% due to the existence of an inflation risk premium of 20-30 basis points and therefore an assumption for RPI of 3% is reasonable. BEIS believe that long-term cost inflation will exceed RPI by a further 1% p.a. As such, a reasonable estimate of expected long-term future cost inflation is 4% p.a. (CPI +1% RPI/CPI gap +1% for nuclear specific inflation), as shown by the blue diamond in the chart alongside.



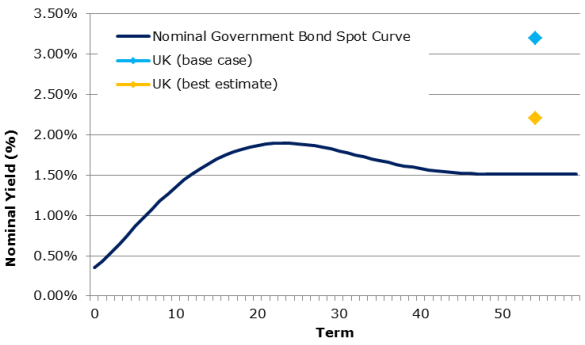
Based on the median expected return (i.e. a "best estimate return" with 50% probability) of 2.2% p.a., the real discount rate would be c.-1.8% p.a. Use of a real discount rate of -1.8% p.a. results in a best estimate liability of c. £54.5bn.

	Liability value	Funding level
Base case liability (-0.8% real)	£32.8bn	29%
Best estimate liability (-1.8% real)	£54.5bn	17%

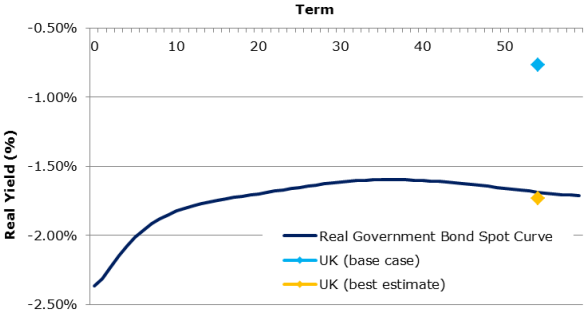
The charts below show how the resulting best estimate nominal and real discount rates compare to the corresponding government bond yield curves at 31 December 2017. The best estimate discount rate of -1.8% p.a. is broadly in line with real government bond yields of the appropriate duration – this reflects the fact that the additional returns above government bond yields expected from the Mixed Asset Fund are offset by expected future inflation above RPI.

[49] See for example the Office for Budget Responsibility Economic and fiscal outlook - March 2015 *"Revised assumption for the long-run wedge between RPI and CPI inflation"*

Nominal yields / discount rate



Real yields / discount rate



The rest of this section will be based on the best estimate liability value.

Stress testing

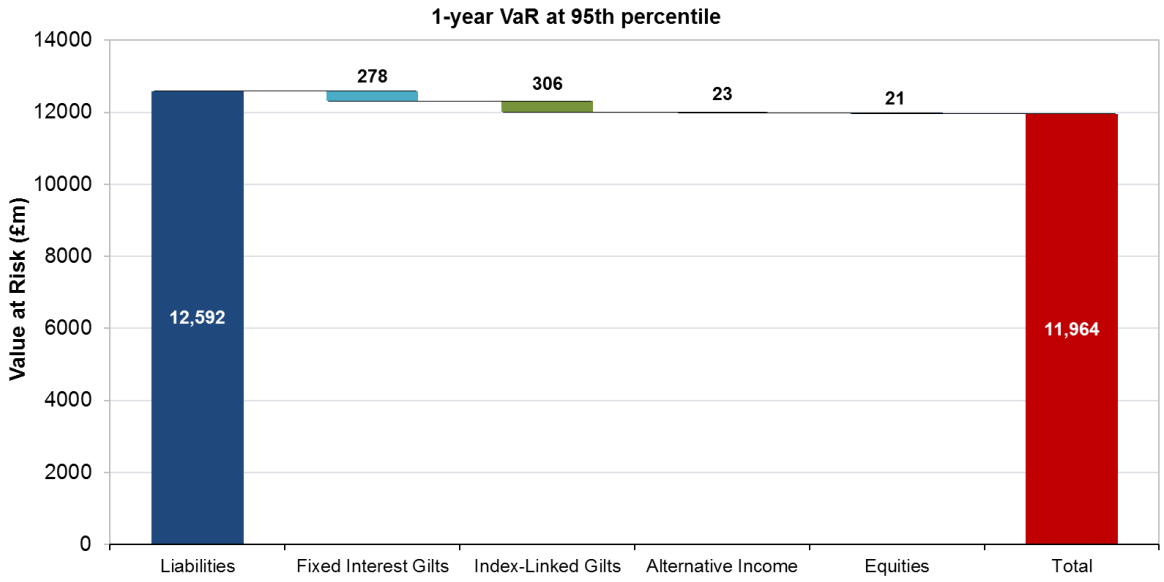
The table below shows the net impact of pre-defined changes to real discount rates (either through changes in nominal interest rates or inflation expectations) and equity markets on both the liability and assets (and hence the funded status) of the NLF. For example, a 0.25% decrease in long-term interest rates (and hence a 0.25% reduction in the real discount rate) together with a 10% fall in equity markets would increase the deficit by a further c. £7.8bn.

Surplus		Interest Rate								
		-1.00%	-0.75%	-0.50%	-0.25%	*0.00%*	+0.25%	+0.50%	+0.75%	+1.00%
Equities	+20.00%	-40,115	-27,372	-16,629	-7,560	108	6,602	12,110	16,791	20,775
	+15.00%	-40,142	-27,399	-16,656	-7,587	81	6,575	12,083	16,764	20,748
	+10.00%	-40,169	-27,426	-16,683	-7,614	54	6,548	12,056	16,737	20,721
	+5.00%	-40,196	-27,453	-16,710	-7,641	27	6,521	12,029	16,710	20,694
	0.00%	-40,223	-27,480	-16,737	-7,668	0	6,494	12,002	16,683	20,667
	-5.00%	-40,250	-27,507	-16,764	-7,695	-27	6,467	11,975	16,656	20,640
	-10.00%	-40,277	-27,534	-16,791	-7,722	-54	6,440	11,948	16,629	20,613
	-15.00%	-40,304	-27,561	-16,818	-7,749	-81	6,413	11,921	16,602	20,586
	-20.00%	-40,331	-27,588	-16,845	-7,776	-108	6,386	11,894	16,575	20,559

VaR analysis

The 1-year 95% VaR decomposition is shown below. Allowance has been made for target returns from active management ("alpha") of 0.5% p.a. with an assumed tracking error of 1%.

The key areas of risk for the NLF are interest rates and inflation and the effect they have on the assessed liabilities. This risk is primarily due to the level of underfunding and the low level of hedging provided by the existing assets. There is a 1-in-20 chance that the deficit could increase by at least c. £12.0bn over a one year period. Such an event would further reduce the funding level to c.14%.



Performance assessment

The performance over the last 4 years of the Mixed Assets Fund has been provided by BlackRock Investment Management (UK) Limited.

	2014	2015	2016	2017
Annual return	4.6%	4.8%	14.7%	11.1%
CPI Inflation	0.5%	0.2%	1.6%	3.0%
Real return	4.1%	4.6%	13.1%	8.1%

The average geometric mean return over the last 4 years is 8.7%.

The above performance is for the Mixed Assets Fund only, which represents 21% allocation of the overall portfolio.

Conclusion

On the basis of best estimate liability calculated above the current level of funding of the NLF may be insufficient. A review of the current financing amounts may therefore be required.

Appendix 1: Glossary and definitions of terms used

- **(Absolute) return investment:** Investment strategy targeting a positive return in absolute terms rather than relative to an index or benchmark.
- **Active management:** Approach to investment management which aims to outperform a particular market index or benchmark through asset allocation and/or selection decisions. In contrast to Passive management.
- **Alternatives:** Investments that do not fit into the mainstream areas of equities or bonds. Examples include private equity, hedge funds and commodities.
- **Asset Allocation:** Distribution of investments across categories of assets, such as cash, equities and bonds.
- **Asset:** A resource that has economic value and has the potential to provide future benefits to an individual or organisation.
- **Asset-liability modelling:** Modelling approach that takes account of both asset related risks and liability related risks in a consistent economic framework and includes allowance for the correlation between different assets and liabilities.
- **Bonds:** A certificate of debt issued by a government or company, promising regular payments on a specified date or range of dates, usually with final capital payment at redemption.
- **Capital markets:** Any financial market upon which securities are traded. For example equities and bonds.
- **Collateral:** Assets placed on deposit as security for an open position (e.g. loan, swap, short sale), which may be used to offset the potential loss by a counterparty should the first party default on its obligation.
- **Commercial Paper:** Unsecured short-term debt issued by banks, corporations and other borrowers
- **Credit risk (or default risk):** Risk of suffering a loss due to another party defaulting on its financial obligations.
- **Currency risk (or exchange rate risk):** Risk of incurring losses in the value of overseas investments as a result of movements in international exchange rates. Can also refer to the additional volatility caused by exposure to assets in foreign currencies.
- **Decommissioning**: administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility.
- **Decommissioning and waste management:** generic term to describe the activities related to removal of spent fuel, decommissioning and radioactive waste management.
- **Defined benefit pension plan:** A DB pension plan is one where the level of pension benefit is defined (usually based on salary and number of years or service) and does not generally depend on investment performance in the period to retirement.
- **Derivative:** Financial instrument whose value is dependent on the value of an underlying asset. Examples include options and forward contracts.
- **Direct disposal:** Disposal of spent fuel and other radioactive waste directly in a geological repository.
- **Disbursement:** The payment of money from a fund.
- **Discount rate:** Rate of interest used to convert future cash flows into a present value.

- **Discounted cash flow / present value:** Process by which future cash flows are adjusted to allow for the time value of money to arrive at a value in today's terms.
- **Duration:** The weighted average time of the cash flows associated with an asset or liability, weighted by present value. The longer the duration, the more sensitive the asset or liability to changes in interest rates.
- **Earmarked Portfolio:** A portfolio that has been set aside for a specific purpose
- **Environmental, Social and Governance (ESG):** A set of standards for a company's operations that socially conscious investors use to screen investments.
- **Equity:** Represents ownership in a company – commonly referred to as shares. Equity can produce dividend income or growth in value.
- **Factor exposure:** A common trait that may lead to correlated returns from a group of securities. For example industrial sector, price to book value or economic growth rate.
- **Fixed Income:** Investment type where the timing and amount of future interest or coupons are specified (and fixed) at the time of issue.
- **Forward contracts:** Contract to buy or sell an asset at an agreed price at a specified date in the future.
- **Funding Level:** The ratio of the market value of investments held to the value of liabilities.
- **Hedge Fund:** Fund that seeks to generate investment return by using non-traditional investment strategies. For example the use of mechanisms such as short selling and leverage.
- **Hedging:** Action taken to prevent the value of a portfolio against a change in market conditions – often used to reduce risk, but similar techniques can be used for market speculation.
- **Index:** Measure updated regularly that gives the representation of the movement in value of a particular market or specified group of securities.
- **Inflation:** Measure of the rate of increase in prices.
- **Inflation risk:** Risk that arises from the decline in value of securities cash flow due to inflation.
- **Institutional Investors:** A non-bank person or organisation that trades securities in large enough quantities or value that it qualifies for preferential treatment and lower commissions; in contrast to a retail investor.
- **Interim storage:** Temporary storage solution for nuclear waste prior to disposal in a geological disposal facility.
- **Interest rate risk:** The risk that an investment's value will change due to a change in the absolute level of interest rates, in the spread between two rates, in the shape of the yield curve or in any other interest rate relationship.
- **Investment grade:** Bond rating of equal or greater than BBB (S&P) or Baa3 (Moody's) indicating lower uncertainty as to the issuer's ability to meet the obligations undertaken in the bond.
- **Investment Strategies / Policies:** Investment decisions based on individual goals, risk tolerance and future needs for capital. Can include asset allocation, buy and sell guidelines and risk guidelines.
- **Liability:** The discounted present value of a series of expected future decommissioning and waste management costs.
- **Liability driven investment:** Process for determining Strategic Asset Allocation based on expected future liabilities and related risks. This is in contrast to a

strategy of targeting a given level of absolute return or return relative to a market benchmark.

- **Liquidity:** The degree to which an asset or portfolio is easily marketable or turned into cash.
- **Liquidity risk:** Risk stemming from the lack of marketability of an investment that cannot be bought or sold quickly enough to prevent or minimize a loss.
- **Market Capitalisation:** Total market value of equity issued by a company. It is calculated by multiplying the share price by the number of outstanding shares.
- **Market risk:** Risk representing the probability of an adverse change in value, which is common to an entire class of assets or liabilities. It is the level of risk that cannot be eliminated by diversification.
- **Nuclear fuel cycle:** Series of industrial processes which involve the production of electricity from fuel in nuclear power reactors
- **Nuclear Reprocessing:** The chemical operation which separates useful fuel for recycling from the waste material.
- **Overnight costs:** Cost estimates prepared at a given calculation date without allowance for future cost inflation or discounting (i.e. overnight costs are not equal to the liability value, as defined above). The resulting cost estimates are sometimes referred to as, for example, in "2018 money terms".
- **Passive management:** Portfolio which aims to replicate a particular market index or benchmark.
- **Radioactive Waste:** Radioactive by-product of nuclear power generation and other applications of nuclear fission or nuclear technology.
- **Radioactive waste management**: administrative and operational activities involved in the handling, pre-treatment, treatment, conditioning, transport, storage and disposal of radioactive waste.
- **Real Estate:** Investments in land, building or housing; also known as physical property to distinguish itself from property trusts.
- **Reinvestment risk:** The risk that proceeds from the payment of the principal and interest, which have to be reinvested at a lower rate than the original investment.
- **Risk management:** process of identifying and taking action to mitigate uncertainty in investment decisions.
- **Risk Profile:** Evaluation of an individual, organisation or funds willingness and ability to take risk, as well as the threats to which it is exposed.
- **Segregated Fund:** Investment fund which is managed on behalf of a single client and has separately identifiable assets.
- **Spent fuel:** Nuclear fuel that has been irradiated in a nuclear reactor and is no longer useful in sustaining a nuclear reaction in an ordinary thermal reactor.
- **Surplus/Deficit:** The difference between the market value of investments held and the value of liabilities. If the market value of assets is greater than (is less than) the value of liabilities, a fund is in surplus (deficit).
- **Swaps:** Financial instrument designed to permit investors to exchange payment streams for their mutual benefit.
- **Value at Risk:** The minimum potential increase in deficit or reduction in funding level for a given percentile outcome (e.g. 95th percentile) over a given time period (e.g. 1 year). This is a downside risk measure, summarising the overall level of asset-liability risk, which can also be used to quantify the contribution to overall risk from individual risk drivers.

- **Volatility:** Variability of the price of a security. Typically quantified as standard deviation.
- **Yield:** Return on an investment expressed as a percentage. Most often refers to the gross redemption yield on a bond.

Appendix 2: Approach to investment, funding and risk management for insurance companies and pension funds

1. Introduction

The demands on investment portfolios are extremely challenging. Meeting these demands in the current market environment requires a holistic approach to investment and risk management, starting with the derivation of an appropriate and optimised Strategic Asset Allocation and extending to implementation, ongoing monitoring, tactical positioning and downside protection against extreme events.

Before considering how the funds set up to meet the costs associated with back-end activities of the nuclear fuel cycle can best meet these demands and putting forward suggestions for what might be considered best practice, it is helpful to analyse the approaches taken by other large liability driven investors like defined benefit pension funds and insurance companies.

Sponsors of defined benefit ("DB") pension plans typically assume responsibility for future pension payments to current and former employees. Like the funds set up to meet the back-end costs of the nuclear fuel cycle, DB pension funds are generally funded in advance to meet these future liabilities. Funding is provided via contributions from the sponsoring employer (and in some instances by current employees), which are then invested in capital market assets to generate investment returns. It is typical for a DB pension plan's assets to be held in a vehicle that is legally independent from the sponsoring employer, with the assets controlled and managed by an independent governing body. DB pension plan's typically have strict and formal governance arrangements in place, often including investment sub-committees with members who are investment experts and whose primary role is to focus on investment and funding related matters.

In exchange for either single or recurring premium payments (which may come from, for example, pension plans looking to transfer liabilities to the insurance market, from individuals seeking to purchase annuities at retirement or from individuals looking to build up personal pension funds before retirement), life insurance companies assume liability for future pension payments to annuity policyholders. Like pension funds, they invest these premiums in capital market assets to generate investment returns. Insurance companies are also required by legislation (Solvency II) to hold additional capital to protect against the investment related risks they are taking on. Management of investment and liability risks and the impact on required capital are critical functions within an insurance company.

The funds used by DB pension sponsors and insurance companies resemble the funds set up to meet the back-end costs of the nuclear fuel cycle in that they all have long-dated and uncertain liabilities spanning several decades and seek to fund their future liabilities in advance through a combination of cash funding and investment returns. There are however a number of important differences:

- Decommissioning and waste management liabilities typically have longer duration than the average DB pension plan or annuity portfolio.
- The main risk factors impacting future payments from DB pension plans or annuity policies are inflation and mortality. Considerable effort has gone into understanding these risk factors and there are established means of either hedging or transferring these risks to other parties[50]. In contrast, the risk factors

[50] In several EU countries, it is possible to hedge inflation risk with inflation-linked bonds, inflation swaps or other inflation linked derivatives. In markets like the UK, it is also possible for pension plans to transfer

affecting decommissioning and waste management costs are less well defined and it is not currently possible to fully hedge or transfer these risks.

- It is common practice for pension funds and insurance companies to set investment strategy based on the profile of their underlying liabilities, using an ALM approach.
- Pension funds and insurance companies typically have a broader investment universe than the funds set up to meet the back-end costs of the nuclear fuel cycle. This may in part reflect the higher level of investment expertise that exists within insurance companies, pension fund sub-committees or investment consultants who work with these funds and companies.
- Pension funds and insurance companies will monitor their funding levels on a regular (at least quarterly) basis with some even considering changes on a daily basis. In contrast, there does not appear to be this same level of focus on monitoring and active risk management within the funds set up to meet the back-end costs of the nuclear fuel cycle.

The remainder of this section examines how the investment strategies of insurance companies and pension funds have evolved in recent years and how they are dealing with current market challenges.

2. Insurance companies

The European insurance industry is the largest global insurance market with a 35% share of premiums. The assets held by UK, French and German insurers account for more than 60% of all European insurers' investment assets.[51]

Insurance companies have been through a period of dramatic change in recent years, with increasingly demanding regulatory regimes, a challenging low yield investment environment, competitive pressures and a need to continually innovate product offerings.

These pressures have served to increase the focus on investment policy and market risks, at times resulting in significant changes to investment strategy and approach. Many insurers now see their investment portfolio as a key component in improving future profitability. Furthermore, with potentially higher volatility in bond yields and exchange rates from economic and geopolitical risks, insurers have, in general, been paying ever-closer attention to minimising unintended ALM risks.

Asset allocations differ by country and insurer type

Insurance companies exhibit substantial heterogeneity across sectors and countries.

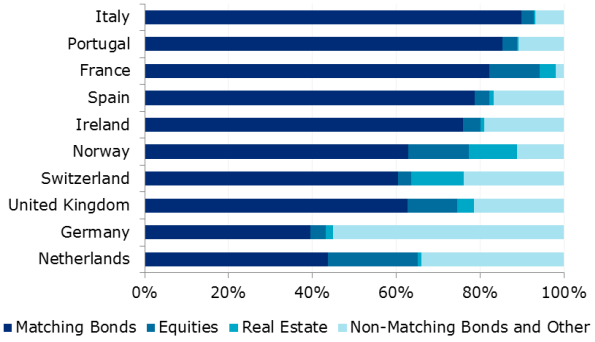
The liability profiles of life insurers, for example, are longer term, relatively predictable and often fixed rather than linked to inflation. In contrast, non-life insurers' liabilities are shorter duration, less predictable and potentially longer tailed. Asset portfolios for life insurers typically show a high concentration of bonds and matching assets whilst asset portfolios for non-life insurers tend to place a higher emphasis on the need for liquidity.

The charts below provide a high-level comparison of how overall asset allocation in 2015 compared for life and non-life insurers in a number of European countries:

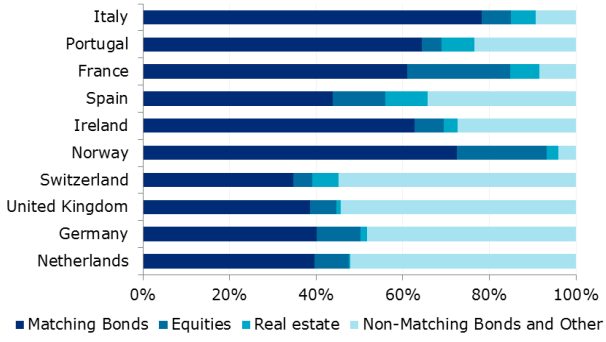
liability risk to the insurance market by entering into longevity swaps. For insurance companies, there may also be a natural hedge for their longevity risk exposure from their life assurance book.

[51] Source: Insurance Europe, European Insurance – Key Facts, August 2015.

Life insurers asset allocation



Non-life insurers asset allocation

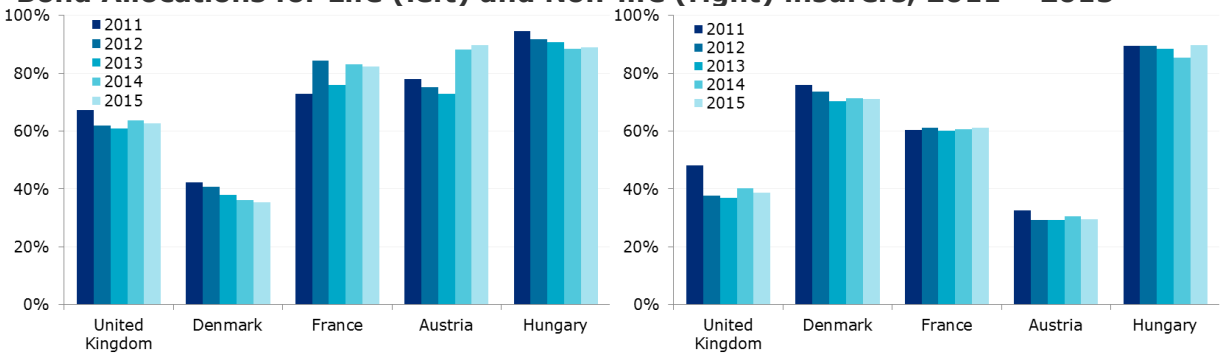


Source: OECD, Global Insurance Market Trends 2016. Data for year ending 31 Dec 2015. Exclude assets linked to unit-linked products. "Other" category for Germany mainly comprises loans and mutual fund investments for which no look-through was available.

Of the 21 countries included in this analysis[52], Hungary and Italy exhibited the largest allocation to bonds with c.90% held by both life and non-life Insurers in Hungary and 90% and 80% in Italy respectively, with particularly high exposures to sovereign debt in both countries.

At the other end of the spectrum, life insurers in Denmark and non-life insurers in Austria have held bond allocations closer to 30% – 40%. On average, bond allocations are around 65% (Life) and 55% (non-life), with the difference between the two remaining relatively constant over recent years.

Bond Allocations for Life (left) and Non-life (right) insurers, 2011 – 2015



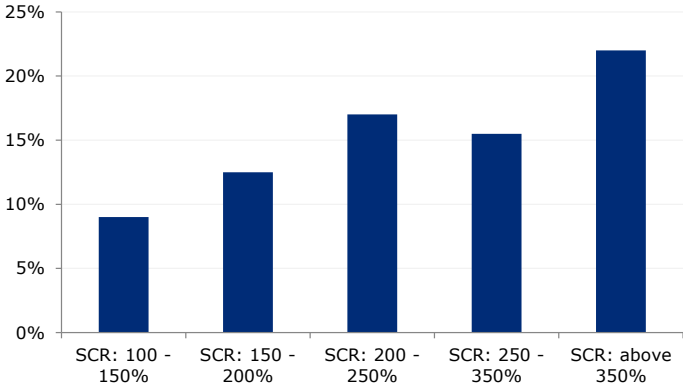
Source: OECD Global Insurance Statistics.

One possible explanation for these differences is variations in national insurer industry capitalisation levels. UK insurers, for example, have historically been well capitalised and, as a result, they may be in a better positon to hold risky assets than less well capitalised counterparts in other countries. The chart below from a recent report by the European Insurance and Occupational Pensions Authority ("EIOPA") [53], comparing the Solvency Capital Requirement ("SCR") for 2016 with equity allocations as a percentage of total assets for European insurers, does seem to lend some support to this explanation.

[52] OECD Global Insurance Statistics 2012 – 2016, available at http://www.oecd.org/daf/fin/insurance/globalinsurancemarkettrends.htm. The following countries have been included: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom

[53] European Insurance and Occupational Pensions Authority ("EIOPA"), Investment Behaviour Report, November 2017

Equity as a % of Total Investment Assets vs SCR



Source: EIOPA report

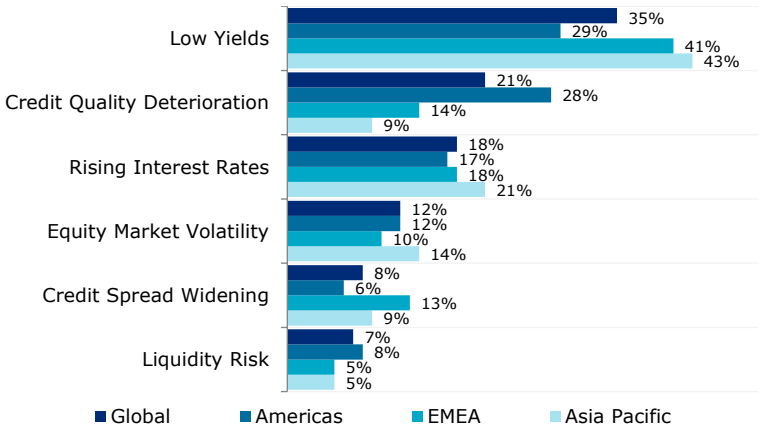
Variations in asset allocation between countries are also likely to reflect differences in the make-up of the insurance sector as well as the competitive and regulatory environment.

How to deal with low interest rates remains the key investment challenge

The global policy focus on monetary stimulus has created an abundance of capital seeking higher investment returns and has led to a reduction in the yields available on the bond type investments traditionally used by insurers. Despite recent moves by key Central Banks to gradually call an end to extensive monetary easing, the challenge of low interest rates remains.

According to a survey by GSAM[54], low yields pose the greatest risk to insurers' investment portfolios. Over 40% of survey respondents in Europe and Asia selected the yield environment as their top portfolio concern:

Please select the investment risk that you are MOST concerned about (%)



Source: GSAM insurance survey

Low interest rates serve to increase the value placed on both an insurer's liabilities and their interest rate sensitive assets (e.g. bonds). The overall balance sheet impact depends on how well these assets and liabilities are matched. Rating agency Fitch justify their negative outlook for the German life insurance industry for 2018, for

[54] Goldman Sachs Asset Management ("GSAM"), GSAM insurance survey: A Reversal in Expectations, April 2017.

example, with a combination of significant asset-liability duration mismatches and an expectation that "market interest rates are likely to remain at historical lows".[55]

The search for yield is likely to lead to increased risk taking and a greater focus on cost control

The need to generate meaningful investment returns in a low interest rate environment has caused many insurers to reconsider the appropriate level of investment risk in their portfolios.

A study conducted by BlackRock[56] found that insurers have tended to focus their efforts on improving investment returns in three areas:

- Reducing investment related fees and expenses;
- Narrowing the mismatch between assets and liabilities (as alluded to above); and
- Increasing risk in other areas (for example, increasing equity allocations or credit risk).

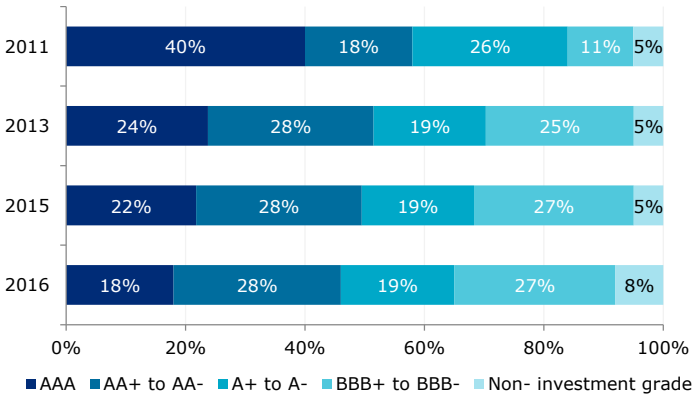
The above mentioned GSAM survey reaches similar conclusions with 26% of insurers surveyed (18% of EMEA insurers) seeking to increase risk. This survey found that globally, insurers were looking to increase equity risk and credit risk whilst also seeking to extend fixed-income bond durations.

The average credit rating of bond portfolios has been declining

The above mentioned EIOPA report found that c.58% of insurers included in their sample reported decreases in the average credit rating of their portfolios over the last five years.

The chart below shows that the overall allocation to AAA rated bonds decreased from 40% in 2011 to just 18% in 2016, while the allocation to non-investment grade bonds increased modestly from 5% to 8% in the same time period.

Portfolio Credit Ratings, 2011 - 2016



Source: EIOPA report

Some of the above is likely due to rating downgrades for bonds held on a buy and maintain basis and therefore conclusions about shifts in strategic investment behaviour based on the above should be drawn with caution.

However, this trend is also identified in the BlackRock study, which found that 30% of respondents were looking to increase their allocation to non-investment grade (versus 12% seeking to decrease their allocation). This compares to just 17% of respondents

[55] Fitch, German Life Insurance Sector Outlook Remains Negative due to Low Rates Challenge. Dec 2017. Available at: https://www.fitchratings.com/site/pr/1033500

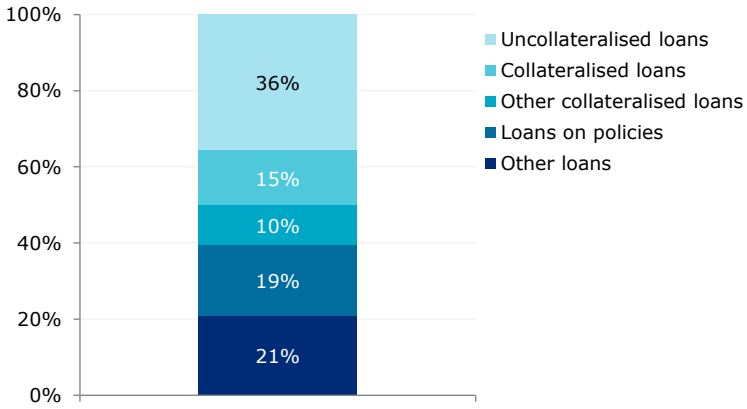
[56] BlackRock, Battling the big squeeze: How insurers are protecting profitability. Global Insurance Report 2017.

who were looking to increase their allocation to investment grade fixed income (versus 18% seeking to decrease their allocation).

The EIOPA report also suggests that the composition of government bond portfolios now includes higher allocations to emerging market issuers, lending support to the hypothesis that insurance companies are attempting to capture increased yields by moving down the rating scale.

When looking at the allocation to loans excluding mortgages, it is interesting to note that uncollateralized loans now make up over a third of loan allocations in aggregate. These loans are higher risk as there are no collateral assets backing them. Overall allocations to this asset class are, however, still very small and uncollateralised loans represent less than 1% of total investment in aggregate.

Allocations to loans excluding mortgages, 2016



Source: EIOPA report

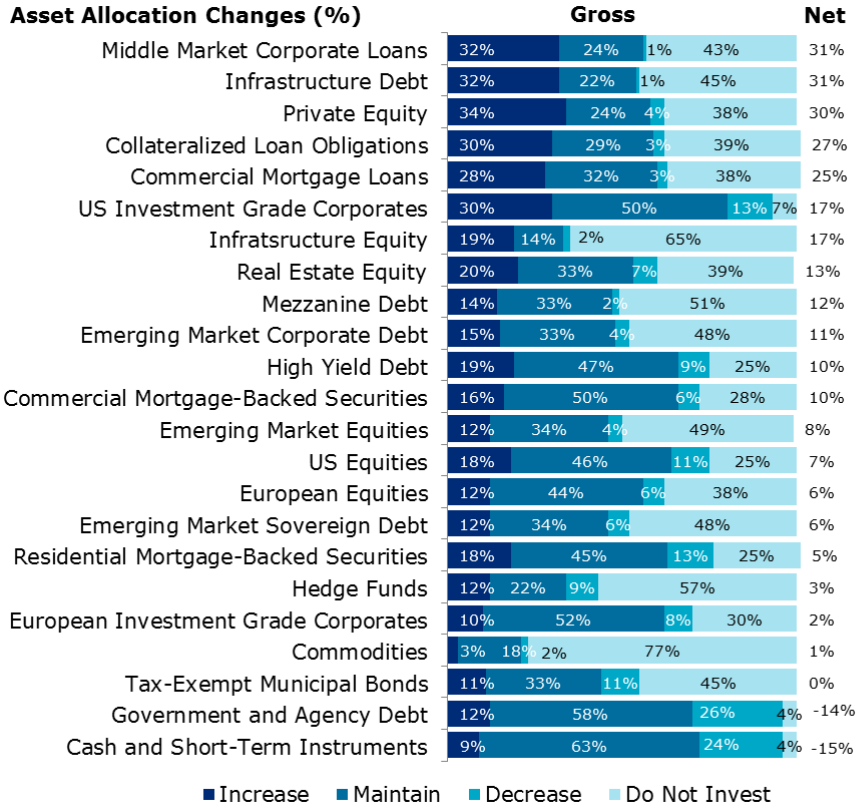
Non-traditional and illiquid asset classes likely to play a more prominent role

To boost returns, insurers are increasingly seeking contributions from non-traditional sources by widening the available investment universe.

The GSAM survey found that insurers continue to express interest in higher returning, less liquid asset classes such as middle market corporate loans (31%), infrastructure debt (31%), private equity (30%) and collateralized loan obligations (27%). For the second consecutive year, insurers also plan to increase their allocation to US investment grade corporates (17%), which provide higher yields relative to other high quality assets. They intend to decrease their allocations to government and agency debt (-14%) and cash and short-term instruments (-15%).

Life insurers are typically long-term investors and are therefore well placed to take advantage of the significant potential benefits offered by illiquid, real assets like real estate and infrastructure. These assets offer the potential for stable cash flows that increase in an inflationary environment and diversification of risk away from traditional sources. The BlackRock report found that 65% of respondents were considering increasing their allocation to these types of assets.

Are you planning to increase, decrease, or maintain your allocation to the following asset classes in the next 12 months?



Source: GSAM insurance survey

In the current environment where growing concerns over the efficacy of ongoing monetary policy interventions could result in the use of fiscal policy for economic stimulus, the attractiveness of these asset classes could well increase. This is because fiscal policy interventions may lead to upward pressure on inflation, which could be matched to some extent by the inflation linked nature of returns from these assets.

Almost half of the insurers included in the GSAM survey believed inflation would be a concern in their domestic market in the next two to three years with a further 20% expecting inflation to become a concern in the next three to five years.

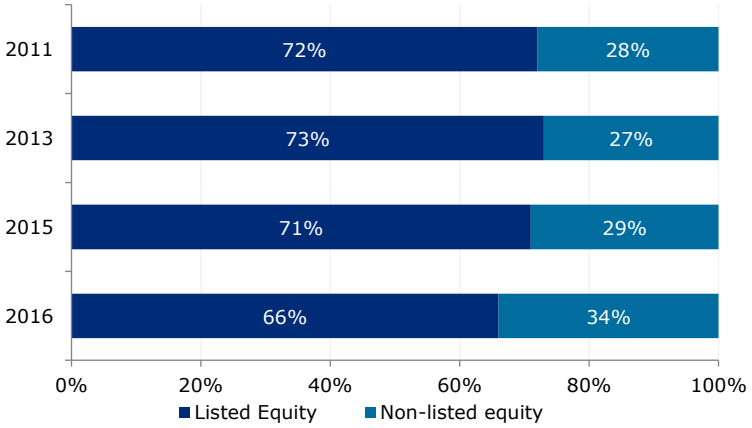
Private market assets are likely to become increasingly important

Another investment approach that is becoming more prevalent is for insurers to move from listed markets to private markets within an asset class (e.g. to move from listed debt to private debt or from quoted equities to private equity).

Private market assets offer the potential for additional returns and the BlackRock report found that 84% of insurers felt that allocating capital to these assets would be an important tool to improve future investment returns. Furthermore, 39% of respondents expected to increase their allocation to these assets.

Around 60% of those included in the EIOPA survey reported a shift towards assets such as private debt and private equity, infrastructure projects and hedge funds, with the main reason given as the potential for yield enhancement. The chart below shows the shift from listed to private equity since 2011.

Allocations to Listed and Non-Listed Equity, 2011 - 2016



Source: EIOPA report

Looking forward, direct lending represents a further opportunity for insurers. As regulatory reform has led to a reduction in banks' willingness and ability to lend to corporates, insurers with excess liquidity may be able to step in as alternative providers of direct lending to generate additional returns.

ESG factors could have an increasingly important impact for insurers

The ongoing global initiative to introduce voluntary climate-related financial disclosures at a company level will potentially have a far-reaching impact on insurers. Insurers will need to consider the potential impact on reporting and disclosure as it may include requirements for a broader understanding of the carbon footprint of equity portfolios and the impact of varying climate scenarios on portfolio returns.

Climate change is only one of many material ESG issues that can have a meaningful impact on risk and return outcomes, and thoughtful consideration should be given as to how best to integrate these wide ranging issues.

What do insurance equity analysts think?

A recent survey[57] by Mercer and Guy Carpenter found that equity analysts had a strong preference for insurers to adopt a risk-focused approach to investments – preferably a robust ALM approach rather than one that focuses on superior return generation.

In addition, the following key points were noted:

- Analysts generally favour a lower level of investment risk-taking for life insurers, but the consensus is less clear for non-life insurers.
- Most analysts feel shareholder capital should be invested largely in medium- to higher-risk assets with a longer-term time frame.
- Analysts generally feel there is sufficient investment governance and management in place to deal with the asset strategies being implemented.
- There is also support for outsourcing the investment function, particularly for smaller insurers.
- In setting an insurer's investment strategies, most analysts are supportive of diversification and investing in less liquid assets to earn additional yield.
- Analysts prefer a blend between very-low-cost asset strategies and higher-cost but potentially better-rewarded strategies rather than focusing only on one type.

[57] Mercer and Guy Carpenter, Assessing Insurers in a Period of Rapid Change: Insurance Equity Analyst Survey 2016

- Although many insurers view environmental, social and governance (ESG) factors as increasingly important, most analysts do not yet see this as an immediate priority.

3. Pension Funds

Despite holding well diversified portfolios that have achieved healthy returns since the financial crisis, many defined benefit ("DB") pension funds have found that their liabilities have grown at a faster rate than their investments, driven mainly by low interest rates[58] and longevity improvements.

DB pension arrangements continue to close to new members and future benefit accrual and, as a result, many are now cash flow negative or will become so in the next few years (that is, their benefit outgo is larger than their income). Cash flow negative plans are less able to tolerate substantial falls in the value of their investments, due to the risk of crystallising losses in order to meet benefit outgo.

Mercer's latest asset allocation survey[59] gathered information on 1,241 institutional pension fund investors across 13 countries, with total assets of around €1.1 trillion, and forms the basis for much of the analysis contained in this section.

Pension fund investment strategy is not homogenous

As with insurance companies, pension funds exhibit markedly different asset allocations in different countries. Differing regulatory landscapes, market environments and social security provisions play a large role, as does the relative importance of occupational pensions in providing income to retirees. In Germany, for example, occupational pension plans tend to be voluntary to offer and participate in. Estimates suggest occupational pensions equate to 13% of Germany's GDP (with half of these schemes funded through book reserves), compared to 111% in the UK and 183% in the Netherlands[60].

Equity allocations vary from 44% in Belgium to 8% in Denmark. A domestic equity bias is most evident in France, with a number of the funds surveyed investing in equity exclusively within the Eurozone.

The allocation to Alternatives and Property is largest for German regulated investors (non-CTA), who invest 46% in these categories. This comparably large allocation is driven by regulatory requirements, as the German *Versicherungsaufsichtsgesetz* (VAG) contains fixed quotas for certain asset classes. It requires, for example, that at least 27.5% of the portfolio is invested in investment grade bonds but also allows, for example, real estate investments of over 25%. In contrast, allocations to real estate and alternatives in Belgium, France, Spain and Portugal are around 7%.

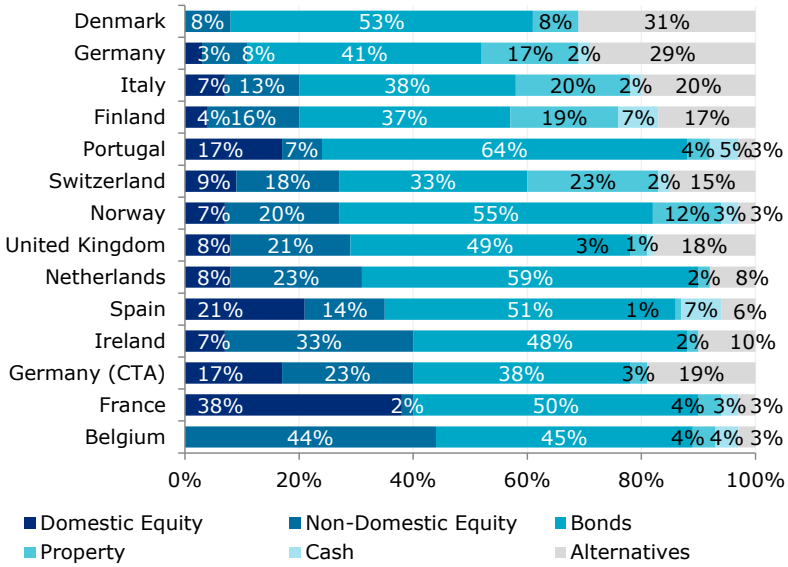
Bond allocations range from 33% in Switzerland to 64% in Portugal. The make-up of plans' bond portfolios is also heavily country-specific, though government bond allocations generally form the largest component. The average corporate bond allocation represents just over a third of all bond holdings.

[58] For IFRS purposes, liabilities are calculated using high quality corporate bond yields. Tightening credit spreads have therefore also served to increase liabilities calculated for accounting purposes.

[59] Mercer, European Asset Allocation Survey 2017

[60] Willis Towers Watson, Global Pension Asset Study 2016

Pension Funds Asset Allocation, 2016



Source: Mercer European Asset Allocation Survey

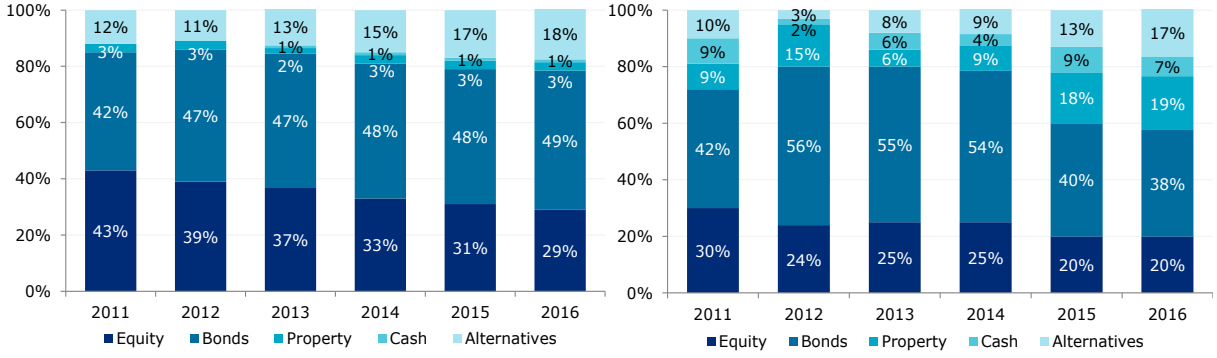
Although overall the allocation to bonds was largely static, it is notable that in Germany, where long-dated yields have been around (or below) zero, bond allocations have fallen substantially.

Regular review of the investment strategy is increasingly recognised as best practice with more than 60% of plans surveyed now reviewing their strategy at least annually.

De-risking is a key theme for pension funds

Equity allocations generally decreased throughout the last five years, with UK DB plans in particular taking opportunities to de-risk in the latter part of 2016 as interest rates and equity markets rose in tandem. This trend looks set to continue, with survey participants indicating their intention to further cut equity allocations in the year ahead.

Strategic Asset Allocation of UK (left) and Finnish (right) Pension Funds, 2011 - 2016



Source: Mercer European Asset Allocation Survey, 2012 - 2017

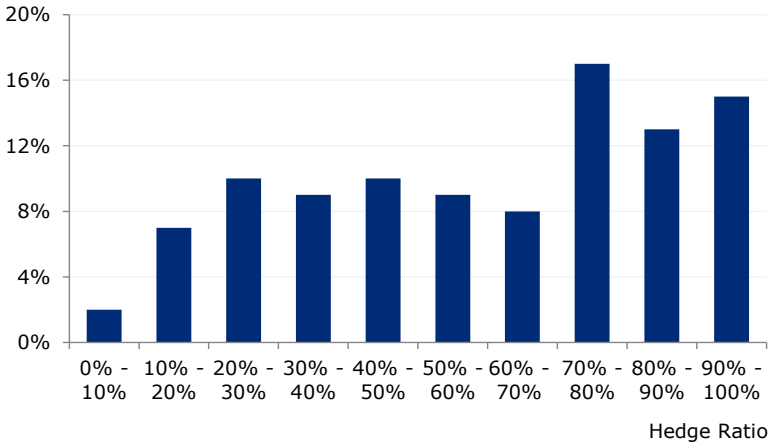
The construction of equity portfolios has also become increasingly sophisticated, with a reduction in domestic bias and the inclusion of low-volatility equities providing a defensive component to offset more high risk exposures such as emerging market equities and small cap stocks. Pension funds are also increasingly considering the use of

equity options to manage their exposure to market falls (although relatively few have implemented such strategies).

As liability driven investors, pension funds are concerned about interest rate and inflation risk and will often seek to actively manage these risks using physical investments or derivatives.

A wide range of interest rate and inflation hedge ratios can be observed among survey participants (average is c.63%). The wide range in part reflects the fact that physical bond holdings will provide some degree of hedging and, as shown above, the allocation to bonds can differ significantly. Beyond this however, some funds have taken steps to achieve a given hedge ratio, using derivatives to obtain/maintain the necessary exposure where necessary whilst others may have strong views on the likely future path of interest rates or inflation and have incorporated these into their investment strategy.

Interest Rate and Inflation Hedge Ratios



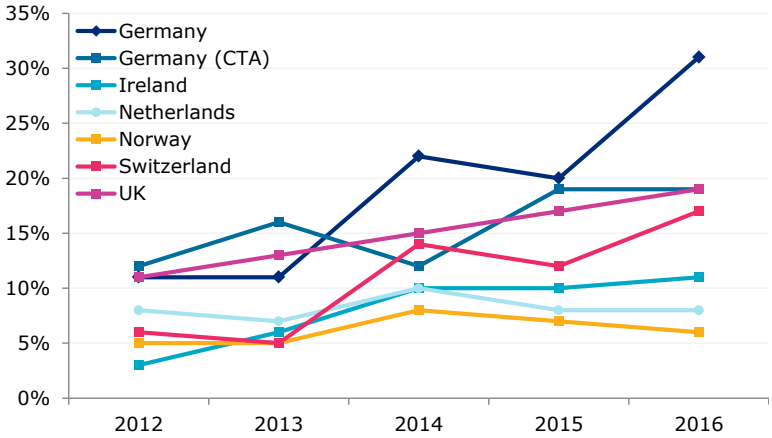
Source: Mercer European Asset Allocation Survey

In order to ensure market opportunities to de-risk are captured when they arise, some pension funds have adopted dynamic, rules based approaches to setting future investment strategy. This commonly involves the development of a "flight path" towards a given long-term funding target and a set of de-risking triggers based on funding level, market variables or time. Once a certain trigger is hit, the scheme will automatically adjust its strategic asset allocation. For example, should funding level increase above a defined trigger level due to strong growth asset performance, a fund might shift assets out of equities and into bonds in order to systematically remove risk from the portfolio. Alternatively, if the funding level trigger is hit as a result of increases in interest rates the pension fund might seek to increase its interest rate hedge ratio. In this way, the probability that the funding level decreases again in the future due to weak growth asset performance or falls in interest rates can be reduced. In the UK, 37% of Plans had adopted formal de-risking triggers in the latest survey.

Allocations to alternative asset classes continue to increase

Since 2013, allocations to alternative asset classes have increased markedly in most countries. Hedge funds, growth oriented fixed income and real assets are the most popular alternative asset classes, while the largest allocations are to multi-asset strategies.

Allocation to Alternative Asset Classes for Pension Funds, 2012 – 2016[61]

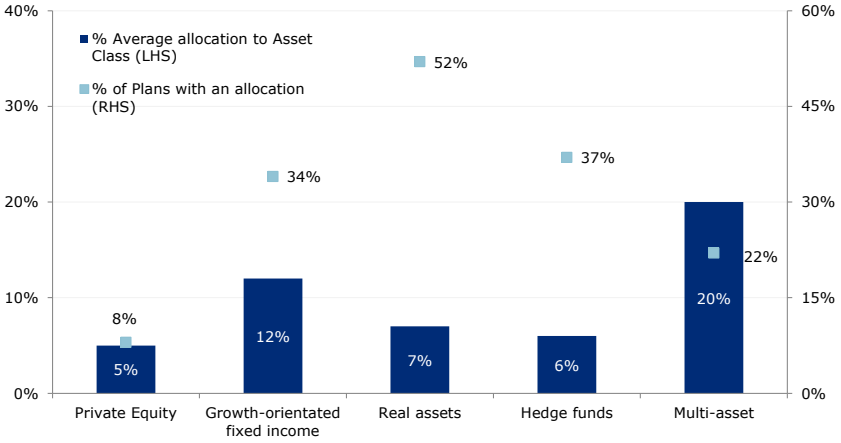


Source: Mercer European Asset Allocation Survey

Multi-asset strategies include diversified growth funds, diversified beta funds and risk parity. These are often seen as a "one-stop shop" for governance and fee constrained investors seeking a diversified and relatively liquid portfolio, so their popularity is perhaps unsurprising.

Hedge fund investments include both direct exposures and investments via so-called funds of hedge funds. Although hedge funds have faced a challenging post crisis environment, with falling volatility and dispersion, pension funds have not lost faith in this asset class. The latest Asset Allocation Survey showed an increase in allocation of 4.6% in the last year as investors respond to the challenging environment for traditional beta.

Allocations to Alternative Asset Classes, 2016



Source: Mercer European Asset Allocation Survey

Growth-oriented fixed income includes fixed income assets and strategies expected to generate returns in excess of government bonds and investment grade credit. With 21% of survey participants allocating to emerging market debt this is the most popular asset class within this space, with the average allocation being 5%. The second most popular allocation is to absolute / total return bonds, with 16% of survey participants allocating an average of 6% to this asset class.

[61] The chart shows the average allocation to alternatives asset classes plus cash, excluding Real Estate.

Real assets include those asset classes for which the return is expected to come largely from the yield on a physical asset with some degree of inflation linkage, such as real estate, infrastructure and natural resources. Real Estate dominates the real assets category, with 54% of participants holding an allocation, in the majority of cases to domestic real estate.

The increases to growth fixed income and real assets are indicative of the search for yield behaviour observed amongst insurers, as well as the need for inflation protection, and reflect the fact that schemes are becoming more aware of their future cash flow requirements.

Cash flow driven financing

The cash flow negative nature of many Funds has helped fuel the interest in income-generative assets and cash flow driven financing strategies. Such approaches involve tailoring investment portfolios so that their income and principal receipts more closely meet projected liability cash flow requirements, whilst improving funding level stability.

In order to meet benefit payments most plans disinvest assets, but 29% have instructed their investment managers to distribute income where possible to reduce the transaction costs associated with disinvestment. Income generating assets have therefore received renewed attention and are likely to play an increasingly important role in the future.

The popularity of cash flow matching strategies is clearly set to grow over time and there has already been increased interest in these approaches. Focusing on income-generation provides much greater certainty of return over the long-term.

ESG awareness increasing but challenges remain

Around 20% of pension funds surveyed integrate ESG risks into their investment beliefs and policies, with 22% having a standalone responsible investment (RI) policy. Investor stewardship and active ownership (exercising voting rights in pursuit of good corporate governance) tend to be the areas in which the most engagement can be observed. 28% of plans consider ESG and stewardship as part of manager selection processes and 29% also request their advisers to monitor stewardship issues on their behalf.

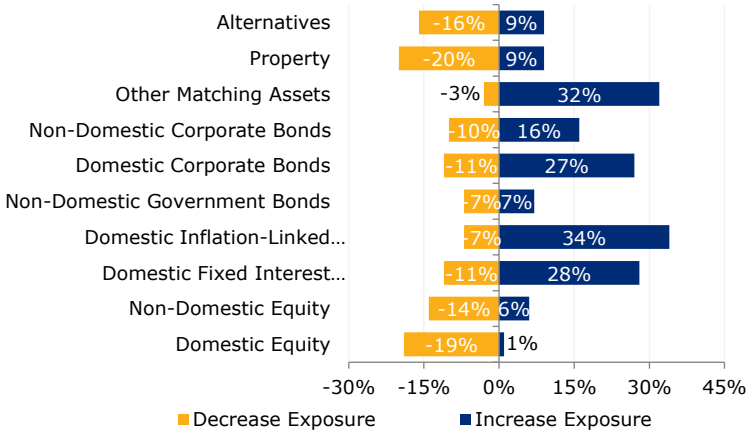
The Paris Agreement, which came into force in November 2016, set an ambitious target to keep global warming well below 2°C above pre-industrial levels, with a stretch target of 1.5°C. However, only 5% of respondents had considered the investment risks posed by climate change in the latest survey. Some of the impediments to ESG integration pension funds face include restrictions in capacity, resources and expertise. There is also some conceptual blurring between ESG and ethical investing. Some pension funds mistakenly believe ESG integration requires a reduction of the investment universe or sacrificing investment returns.

Looking forward

Looking forward plans are, on the whole, expecting to continue reducing allocations to equities and to increase exposure to domestic government bonds, corporate bonds and other matching asses (primarily as part of their LDI strategies).

Interestingly, survey participants are also expecting to reduce allocations to alternatives. In the case of property, this may reflect the strong returns experienced in a number of markets in recent years. The main alternative asset classes expecting to see inflows are private debt, secured finance and infrastructure.

Percentage of Plans Expecting to Change Investment Strategy, 2016



Source: Mercer European Asset Allocation Survey

Appendix 3: Council Directive 2011/70/EURATOM and Commission Recommendation 2006/851/EURATOM

Commission Recommendation 2006/851/EURATOM

Preamble

(18) Ensuring sufficient financial resources when needed requires a sound and prudent analysis of both the sources for such financing and the costs linked to the decommissioning of such installations. The method of determining the amounts of funding for decommissioning has to take account of technological aspects and nuclear safety constraints.

(19) In order to ensure the availability of resources when needed for the purposes of decommissioning nuclear installations, transparent management with appropriate external supervision of such financial resources is of paramount importance; this will also help to avoid obstacles to fair competition in the energy market. Various appropriate management possibilities could be in place in order to ensure such objectives. A dedicated national body should be put in place so as to provide an expert judgment concerning fund management and decommissioning cost matters.

(21) The manner in which these financial resources are invested should be carefully addressed so as to avoid any possible misuse. The investments should be long-term and have a secure risk profile, while at the same time providing adequate protection of the real value of the funds.

SECTION 3

3. The polluter pays principle should be fully applied throughout the decommissioning of nuclear installations. In this regard, the primary concern of nuclear operators should be to ensure the availability of adequate financial resources for safe decommissioning by the time the respective nuclear installation is permanently shut down.

SECTION 4

6. Where not already provided for, Member States should set up or appoint a national body capable of providing an expert judgment on fund management and decommissioning cost matters. This body should be independent as regards the contributors to the fund.

   The national body should annually review the financial resources gathered and periodically, at least every five years, the decommissioning cost estimates. Any shortfall between cost estimates and resources gathered should be addressed in good time.

SECTION 5

7. Nuclear installations should set up adequate decommissioning funds on the basis of the revenues obtained from their nuclear activities during the designed lifetime.
8. A segregated fund with appropriate control on prudent use should be the preferred option for all nuclear installations. The review of the national body provided for in this Recommendation should play a key role in ensuring proper management and use of the funds.
9. New nuclear installations should set up segregated decommissioning funds with appropriate control on prudent use.

SECTION 6

10. In view of the differences in the use of the decommissioning funds gathered, technical decommissioning of the installation, on the one hand, and waste management, on the other, should be addressed separately, on the basis of separate cost calculations.
11. In order to ensure that adequate financial resources are available, cost calculations should be based upon a prudent choice from the realistically available alternatives and subject to the external supervision and agreement of the national body foreseen in this Recommendation.
12. All cost estimates should be site-specific and based upon best available estimates.
13. If during implementation the decommissioning project proves to be more expensive than the approved cost estimates, the operator should cover the additional expenses. This aspect should be carefully addressed should the operator change during or beyond the lifetime of the nuclear installation.
14. Due attention should be paid to cases arising for historical reasons where a special solution is the most appropriate. This case-by-case approach should be transparent and with the full involvement of the national body provided for in this Recommendation.

SECTION 7

15. Financial resources should be used only for the purpose for which they have been established and managed. In this context, due consideration should be given to transparency. All commercially non-sensitive information should be publicly available.
16. A secure risk profile should be sought in the investment of the assets, ensuring that a positive return is achieved over any given period of time.
17. As the operator has no influence on the financial management of an external decommissioning fund, the value of the investments should be guaranteed by the State in order to ensure that adequate funds are available when required, even if a nominal loss is made by the independent manager of the invested amounts by the time these financial resources are to be used. In such cases, the funds should not be supplemented with an amount higher than the loss in the investment.
18. If the management of an internal fund underperforms, the operator should be responsible for ensuring that adequate funds are available when needed.

Council Directive 2011/70/EURATOM

Recitals

(27) Member States should ensure that adequate funding is available for the management of spent fuel and radioactive waste.

(31) Transparency is important in the management of spent fuel and radioactive waste. Transparency should be provided by ensuring effective public information and opportunities for all stakeholders concerned, including local authorities and the public, to participate in the decision-making processes in accordance with national and international obligations.

Article 4

3e. The costs for the management of spent fuel and radioactive waste shall be borne by those who generated those materials;

Article 7

5. Member States shall ensure that the national framework require licence holders to provide for and maintain adequate financial and human resources to fulfil their obligations with respect to the safety of spent fuel and radioactive waste management as laid down in paragraphs 1 to 4.

Article 9

Member States shall ensure that the national framework requires that adequate financial resources be available when needed for the implementation of national programmes referred to in Article 11, especially for the management of spent fuel and radioactive waste, taking due account of the responsibility of spent fuel and radioactive waste generators.

Article 12

1h. The national programmes shall set out how the Member States intend to implement their national policies referred to in Article 4 for the responsible and safe management of spent fuel and radioactive waste to secure the aims of this Directive, and shall include: "an assessment of the national programme costs and the underlying basis and hypotheses for that assessment, which must include a profile over time;"

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Appendix 5: Modelling assumptions

The figures below are annualised over a ten year time horizon.

Mercer European Capital Market Assumptions – 30 September 2017

	Returns Q3 2017	Volatility Q3 2017
Cash Portfolio	0.58%	3.05%
Euro Gov Nominal AS	0.99%	3.17%
Euro Gov Nominal 5+	0.93%	3.70%
Euro Gov Nominal 10+	0.88%	5.97%
Euro Gov Inflation Linked AS	1.03%	4.50%
German Nominal Bonds	0.52%	1.85%
German Inflation Linked Bonds	0.55%	3.65%
EUR Credit All Stock	1.19%	2.60%
EUR Credit 5+	1.15%	3.24%
EUR Credit 10+	1.08%	4.92%
HY Global Hedged	2.91%	9.74%
Junior Private Debt	4.22%	11.83%
Senior Private Debt	2.92%	8.80%
Global eq hedged - Passive	5.03%	17.31%
Global eq unhedged - Passive	5.00%	18.86%
Private Equity Hedged Beta	7.77%	24.62%
Small Cap - Passive	5.23%	22.09%
Emerging Market eq - Passive	7.26%	29.37%
Euro Property	3.57%	14.61%
Commodities	0.99%	20.60%
Emerging Market Debt – Local	4.64%	11.98%
Hedge Funds – Defensive	2.45%	7.33%
Hedge Funds – Standard	2.87%	7.32%
Infrastructure Unlisted Eq	4.69%	14.76%
Multi Asset Credit	4.00%	7.47%
Absolute Return Bonds	1.99%	3.92%
Diversified Growth Fund	4.30%	10.83%
Mercer Liquid Alternative Strat	3.44%	7.33%
Mercer UTICS Alternative Strat	3.15%	7.33%

Asset Class	Cash Port	Euro Gov Nom AS	Euro Gov Nom 5+	Euro Gov Nom 10+	Euro Gov Inf'l Linked AS	German Nom Bonds	German Inf'l Linked Bonds	EUR Credit All Stock	EUR Credit 5+	EUR Credit 10+	HY Global Hedged	Jr. Private Debt	Sr. Private Debt	Global eq hedged	Global eq unhedged	Private Equity Hedged Beta	Small Cap	Em Mkt eq	Euro Property	Commodities	Emerging Market Debt	Hedge Funds - Defensive	Hedge Funds - Standard	Infra Unlisted Eq	Multi Asset Credit	Abs Ret Bonds	Div Growth Fund	Mercer Liquid Alt Strat	Mercer UTICS Alt Strat
Cash Port	1.00																												
Euro Gov Nom AS	0.12	1.00																											
Euro Gov Nom 5+	(0.20)	0.79	1.00																										
Euro Gov Nom 10+	(0.44)	0.75	0.89	1.00																									
Euro Gov Inf'l Linked AS	0.48	0.25	0.45	0.24	1.00																								
German Nom Bonds	0.32	0.64	0.67	0.56	0.27	1.00																							
German Inf'l Linked Bonds	0.59	0.27	0.43	0.27	0.81	0.33	1.00																						
EUR Credit All Stock	0.35	0.51	0.45	0.29	0.36	0.63	0.32	1.00																					
EUR Credit 5+	0.00	0.55	0.64	0.57	0.19	0.64	0.12	0.91	1.00																				
EUR Credit 10+	(0.35)	0.53	0.75	0.80	(0.03)	0.59	(0.12)	0.65	0.90	1.00																			
HY Global Hedged	0.22	0.17	0.11	(0.00)	0.24	0.14	0.21	0.49	0.43	0.25	1.00																		
Jr. Private Debt	0.28	0.11	0.01	(0.09)	0.22	0.08	0.21	0.34	0.25	0.08	0.38	1.00																	
Sr. Private Debt	0.44	0.09	(0.07)	(0.19)	0.25	0.11	0.28	0.32	0.17	(0.04)	0.27	0.30	1.00																
Global eq hedged	0.04	0.18	0.17	0.11	0.14	0.11	0.09	0.42	0.44	0.33	0.71	0.37	0.19	1.00															
Global eq unhedged	0.03	0.17	0.16	0.10	0.13	0.11	0.08	0.38	0.40	0.30	0.65	0.33	0.17	0.90	1.00														
Private Equity Hedged Beta	0.02	0.16	0.15	0.11	0.11	0.10	0.07	0.34	0.36	0.28	0.56	0.31	0.20	0.72	0.67	1.00													
Small Cap	0.02	0.15	0.15	0.10	0.12	0.10	0.09	0.34	0.37	0.28	0.57	0.29	0.16	0.82	0.75	0.59	1.00												
Em Mkt eq	(0.05)	0.13	0.16	0.12	0.08	0.10	0.06	0.30	0.35	0.30	0.49	0.27	0.13	0.71	0.65	0.59	0.59	1.00											
Euro Property	0.19	0.04	(0.01)	(0.08)	0.15	0.07	0.17	0.21	0.16	0.05	0.18	0.30	0.25	0.24	0.23	0.20	0.19	0.24	1.00										
Commodities	0.15	0.03	(0.02)	(0.06)	0.07	0.06	0.08	0.08	0.03	(0.03)	0.04	(0.01)	(0.03)	0.03	0.04	0.01	0.01	0.02	0.05	1.00									
Emerging Market Debt	0.13	0.14	0.13	0.04	0.20	0.16	0.20	0.35	0.34	0.22	0.43	0.21	0.10	0.53	0.48	0.45	0.44	0.68	0.19	0.03	1.00								
Hedge Funds - Defensive	0.37	0.11	(0.00)	(0.11)	0.23	0.15	0.23	0.29	0.18	0.02	0.36	0.19	0.10	0.49	0.45	0.34	0.39	0.36	0.18	0.06	0.26	1.00							
Hedge Funds - Standard	0.33	0.16	0.05	(0.06)	0.22	0.17	0.22	0.41	0.32	0.13	0.56	0.28	0.15	0.77	0.70	0.57	0.64	0.56	0.22	0.07	0.42	0.45	1.00						
Infra Unlisted Eq	0.07	0.14	0.13	0.07	0.14	0.10	0.11	0.37	0.38	0.27	0.60	0.35	0.20	0.82	0.75	0.60	0.67	0.60	0.39	0.05	0.46	0.40	0.61	1.00					
Multi Asset Credit	0.36	0.18	0.08	(0.07)	0.32	0.17	0.31	0.54	0.43	0.20	0.77	0.74	0.44	0.67	0.60	0.55	0.54	0.55	0.38	0.06	0.64	0.43	0.59	0.60	1.00				
Abs Ret Bonds	0.69	0.11	(0.11)	(0.29)	0.37	0.23	0.42	0.36	0.10	(0.18)	0.23	0.09	0.03	0.35	0.32	0.22	0.31	0.23	(0.00)	(0.03)	0.18	0.15	0.49	0.27	0.21	1.00			
Div Growth Fund	0.11	0.19	0.18	0.09	0.21	0.17	0.18	0.47	0.47	0.33	0.71	0.38	0.21	0.93	0.92	0.71	0.82	0.81	0.39	0.05	0.66	0.46	0.71	0.79	0.74	0.30	1.00		
Mercer Liquid Alt Strat	0.37	0.11	(0.00)	(0.11)	0.23	0.15	0.23	0.29	0.18	0.02	0.36	0.19	0.10	0.49	0.45	0.34	0.39	0.36	0.18	0.06	0.26	1.00	0.37	0.41	0.34	0.35	0.46	1.00	
Mercer UTICS Alt Strat	0.37	0.11	(0.00)	(0.11)	0.23	0.15	0.23	0.29	0.18	0.02	0.36	0.19	0.10	0.49	0.45	0.34	0.39	0.36	0.18	0.06	0.26	1.00	0.37	0.41	0.34	0.35	0.46	1.00	1.00

Mercer United Kingdom Capital Market Assumptions – 30 September 2017

	Returns Q3 2017	Volatility Q3 2017
CashPortfolio	1.39%	4.26%
FIG All	1.37%	4.57%
FIG Over15	1.04%	9.85%
ILG All	0.85%	8.21%
ILG Over5	0.81%	8.53%
iB GBP Corps All	2.20%	3.57%
iB GBP Corps Long	1.97%	5.99%
HF Defensive	3.18%	8.00%
HF Standard	3.61%	8.02%
DGF	5.08%	11.68%
PrivateDebt junior	4.66%	12.91%
PrivateDebt senior	3.58%	9.69%
HY Global	3.23%	10.24%
EMD Local Currency	4.03%	14.46%
EMD Hard Currency	3.40%	8.73%
MAC	4.59%	8.43%
ARFI	3.11%	4.68%
Infra Unlisted Eq	4.66%	15.78%
HLV	3.01%	8.31%
UK Property	3.55%	15.03%
Defensive Equity Hedged	4.64%	14.59%
Global Equity Hedged	4.88%	18.20%
Global Equity Unhedged	4.47%	19.74%
Global Equity Hedged Active	5.79%	18.74%
Global Equity Unhedged Active	5.49%	20.32%
Global SmallCap Unhedged	5.02%	23.71%
EM Equity Unhedged	4.39%	30.17%
EM Equity Unhedged Active	5.53%	30.71%
Private Equity	5.52%	26.06%
Commodities	(0.68%)	20.68%

Asset Class	CashPortfolio	FIG All	FIG Over15	ILG All	ILG Over5	iB GBP Corps All	iB GBP Corps Long	HF Defensive	HF Standard	DGF	PrivateDebt junior	PrivateDebt senior	HY Global	EMD Local Currency	EMD Hard Currency	MAC	ARFI	Infra Unlisted Eq	HLV	UK Property	Defensive Equity Hedged	Global Equity Hedged	Global Equity Unhedged	Global Equity Hedged Active	Global Equity Unhedged Active	Global SmallCap Unhedged	EM Equity Unhedged	EM Equity Unhedged Active	Private Equity	Commodities
CashPortfolio	1.00																													
FIG All	(0.40)	1.00																												
FIG Over15	(0.61)	0.96	1.00																											
ILG All	0.12	0.14	0.08	1.00																										
ILG Over5	0.10	0.15	0.10	1.00	1.00																									
iB GBP Corps All	(0.14)	0.83	0.74	0.21	0.22	1.00																								
iB GBP Corps Long	(0.42)	0.90	0.90	0.15	0.17	0.94	1.00																							
HF Defensive	0.47	(0.17)	(0.27)	0.12	0.11	0.05	(0.10)	1.00																						
HF Standard	0.45	(0.16)	(0.26)	0.14	0.13	0.13	(0.03)	0.51	1.00																					
DGF	0.14	0.03	(0.03)	0.19	0.19	0.29	0.20	0.47	0.70	1.00																				
PrivateDebt junior	0.35	(0.16)	(0.23)	0.08	0.07	0.10	(0.03)	0.34	0.41	0.42	1.00																			
PrivateDebt senior	0.53	(0.25)	(0.35)	0.05	0.04	0.00	(0.16)	0.34	0.37	0.27	0.36	1.00																		
HY Global	0.30	(0.07)	(0.15)	0.13	0.13	0.23	0.10	0.44	0.61	0.71	0.42	0.33	1.00																	
EMD Local Currency	0.15	(0.02)	(0.07)	0.14	0.13	0.16	0.08	0.25	0.34	0.59	0.24	0.16	0.37	1.00																
EMD Hard Currency	0.34	(0.07)	(0.17)	0.12	0.12	0.18	0.04	0.33	0.41	0.54	0.32	0.29	0.46	0.78	1.00															
MAC	0.45	(0.16)	(0.27)	0.14	0.13	0.18	0.01	0.48	0.61	0.72	0.78	0.57	0.76	0.64	0.66	1.00														
ARFI	0.76	(0.32)	(0.48)	0.13	0.12	(0.03)	(0.29)	0.43	0.60	0.28	0.33	0.42	0.34	0.18	0.33	0.44	1.00													
Infra Unlisted Eq	0.11	0.00	(0.04)	0.16	0.16	0.22	0.16	0.41	0.61	0.80	0.39	0.25	0.61	0.37	0.37	0.59	0.23	1.00												
HLV	0.25	(0.02)	(0.10)	0.38	0.38	0.13	0.04	0.26	0.32	0.42	0.35	0.30	0.30	0.20	0.24	0.41	0.23	0.41	1.00											
UK Property	0.21	(0.09)	(0.15)	0.07	0.06	0.06	(0.02)	0.26	0.33	0.46	0.41	0.34	0.31	0.17	0.22	0.44	0.19	0.48	0.76	1.00										
Defensive Equity Hedged	0.14	0.01	(0.04)	0.13	0.13	0.26	0.18	0.50	0.75	0.93	0.41	0.25	0.72	0.43	0.44	0.66	0.29	0.82	0.32	0.36	1.00									
Global Equity Hedged	0.08	0.03	(0.01)	0.13	0.12	0.27	0.21	0.47	0.73	0.93	0.39	0.22	0.71	0.43	0.42	0.64	0.25	0.82	0.30	0.35	1.00	1.00								
Global Equity Unhedged	0.06	0.04	0.01	0.12	0.12	0.25	0.20	0.42	0.65	0.91	0.35	0.20	0.64	0.39	0.38	0.57	0.21	0.74	0.27	0.31	0.90	0.90	1.00							
Global Equity Hedged Active	0.07	0.03	(0.01)	0.13	0.13	0.26	0.20	0.46	0.71	0.91	0.39	0.21	0.70	0.42	0.42	0.63	0.24	0.81	0.30	0.35	0.98	0.98	0.89	1.00						
Global Equity Unhedged Active	0.05	0.04	0.00	0.13	0.12	0.24	0.19	0.42	0.64	0.90	0.34	0.19	0.63	0.39	0.37	0.56	0.21	0.73	0.27	0.31	0.89	0.89	0.99	0.91	1.00					
Global SmallCap Unhedged	0.06	0.03	(0.01)	0.12	0.12	0.22	0.17	0.36	0.59	0.80	0.30	0.18	0.56	0.35	0.34	0.51	0.21	0.67	0.24	0.27	0.81	0.81	0.74	0.82	0.75	1.00				
EM Equity Unhedged	(0.05)	0.08	0.06	0.12	0.12	0.23	0.22	0.29	0.47	0.79	0.24	0.10	0.46	0.55	0.45	0.50	0.08	0.57	0.25	0.27	0.69	0.70	0.64	0.69	0.63	0.57	1.00			
EM Equity Unhedged Active	(0.06)	0.08	0.06	0.12	0.12	0.23	0.21	0.29	0.46	0.79	0.24	0.09	0.46	0.55	0.45	0.50	0.08	0.57	0.25	0.27	0.69	0.70	0.64	0.71	0.65	0.59	0.99	1.00		
Private Equity	0.04	0.06	0.03	0.08	0.08	0.24	0.20	0.32	0.52	0.70	0.32	0.21	0.56	0.35	0.35	0.52	0.14	0.59	0.25	0.29	0.72	0.72	0.66	0.71	0.65	0.58	0.58	0.58	1.00	
Commodities	0.20	(0.09)	(0.13)	0.04	0.03	(0.02)	(0.08)	0.10	0.11	0.06	0.07	0.08	0.10	0.04	0.08	0.10	0.13	0.06	0.06	0.06	0.06	0.05	0.05	0.04	0.05	0.02	0.01	0.00	0.02	1.00

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