

# concept

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DECISION MAKERS, DOERS AND ADVISORS  
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Strål  
säkerhets  
myndigheten

Swedish Radiation Safety Authority

# The Programme for Nuclear Waste Management in Sweden

Financial and Economic Risk Analysis and Risk  
Management

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## Outline of the Presentation

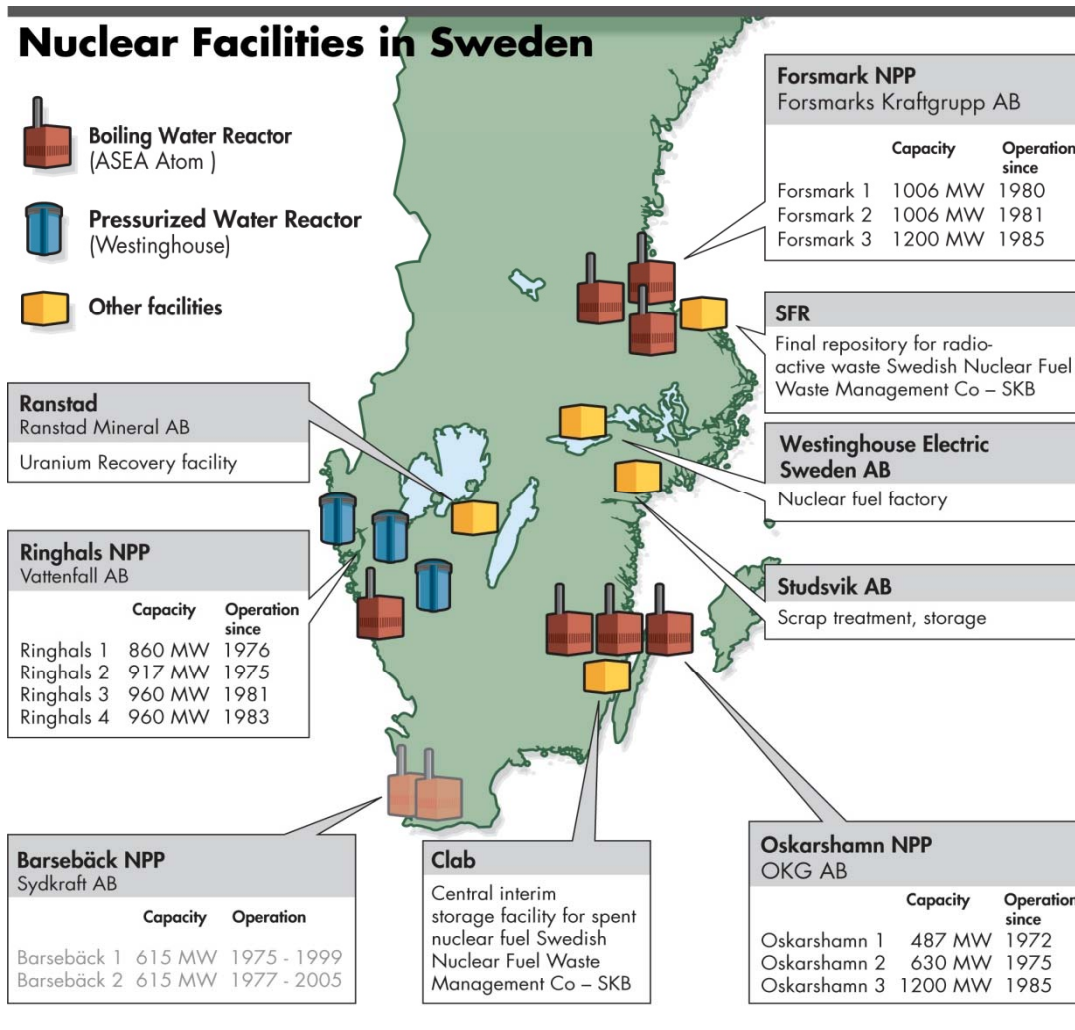
- Scope of the NWM programme – a brief overview
- Cost estimates for the programme
- The financing system – an overview the current design and stakeholders
- Uncertainties and risk as we see them today
- Examples of SSM's work (current and planned) with risk analysis/risk management
- Questions, comments and discussion

# **The Nuclear Waste Programme at a Glance**

- The programme is estimated to be completed in 2070
- The remaining costs are calculated at approx. 8 billion euro (total 10 billion euro incl. sunk costs)
- The industry has the full financial responsibility until all radioactive waste has been safely taken care of. The industry also has the responsibility for cost estimation.
- The state (SSM) supervises the industry. New financial legislation aimed at reducing the risk for future taxpayers (Polluter Pays Principle)
- The programme is financed by a special fee paid by licence holders i.e. the generating companies. The fees are accumulated in a segregated fund managed by a (another) government agency. The assets in the fund at present total 4.2 billion euro. The fee is at present 0.001 euro/kWh.



# What's it all about: Nuclear Facilities in Sweden



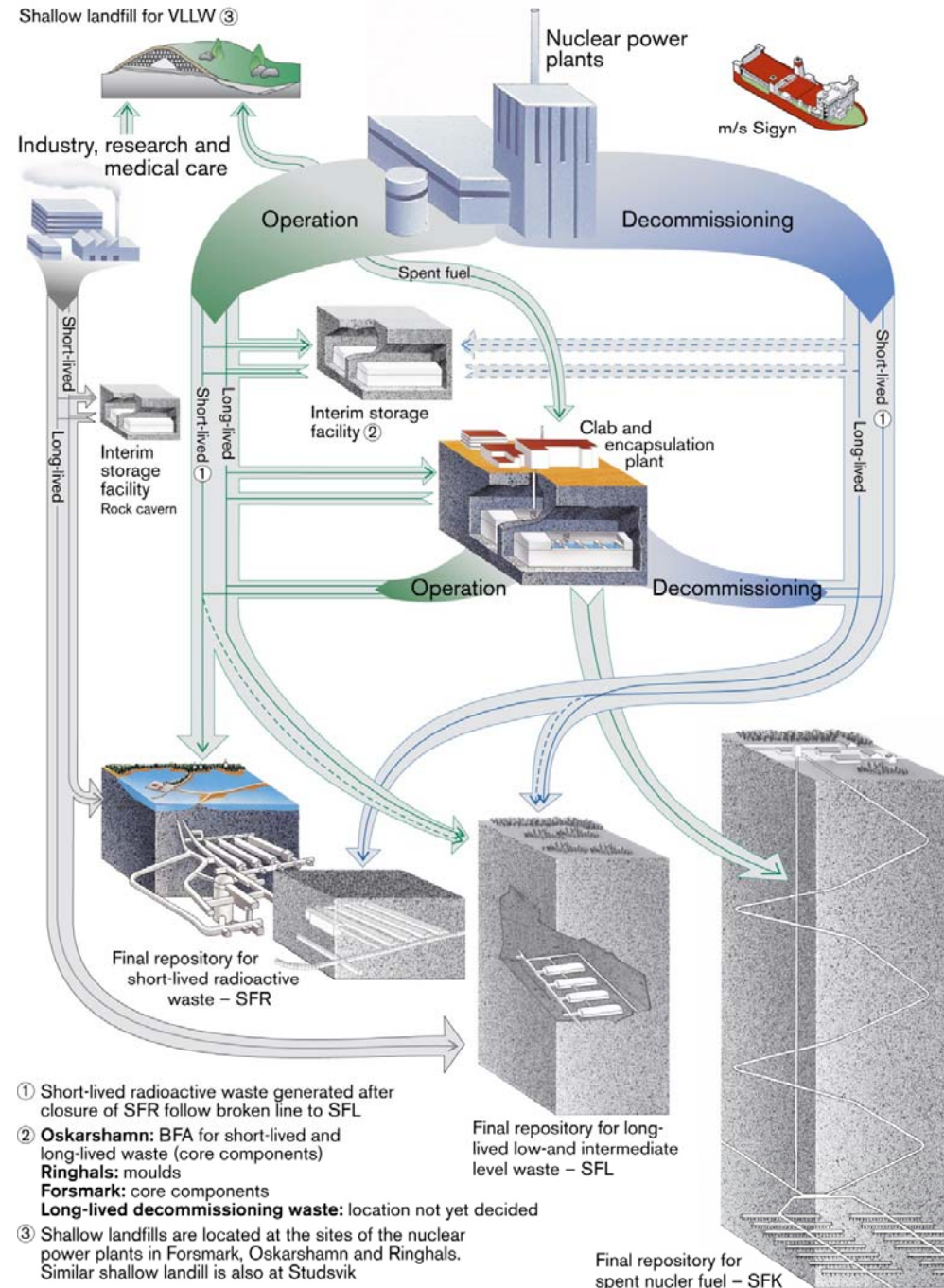
- 10 nuclear reactors in operation
- 5 closed reactors
- Nuclear fuel factory (Västerås)
- Central interim storage facility for spent nuclear fuel – Clab (Oskarshamn)
- Final repository for radioactive operational waste – SFR (Forsmark)
- 4 shallow land disposal facilities for VLLW
- Facilities for fuel and materials performance analysis, radioactive waste processing and storage (Studsvik)
- Uranium recovery facility (Ranstad)



# What's it all about: Waste Flow

## Three major objectives:

- Establish a long term (100,000 years) deep geologic repository for spent nuclear fuel
- Decommissioning and dismantling of NPP
- Establish repositories for other radioactive waste





# Cost Estimates for the Programme

- The industry (four companies – the licence holders) is responsible. The work is done by a jointly-owned company, SKB (Swedish Nuclear Fuel and Waste Management Company)
- SSM is responsible for reviewing the calculations
- New/updated calculations are submitted every three years. And subsequently the fee can be adjusted every three years.
- Calculations are made for **64 different objects** and in two steps:
  1. At first, a reference cost is calculated (deterministic)
  2. The second step is an uncertainty analysis using a probabilistic method “The Successive Principle” (Steen Lichtenberg). Two types of variations general and specific. In total: **90 variations**.

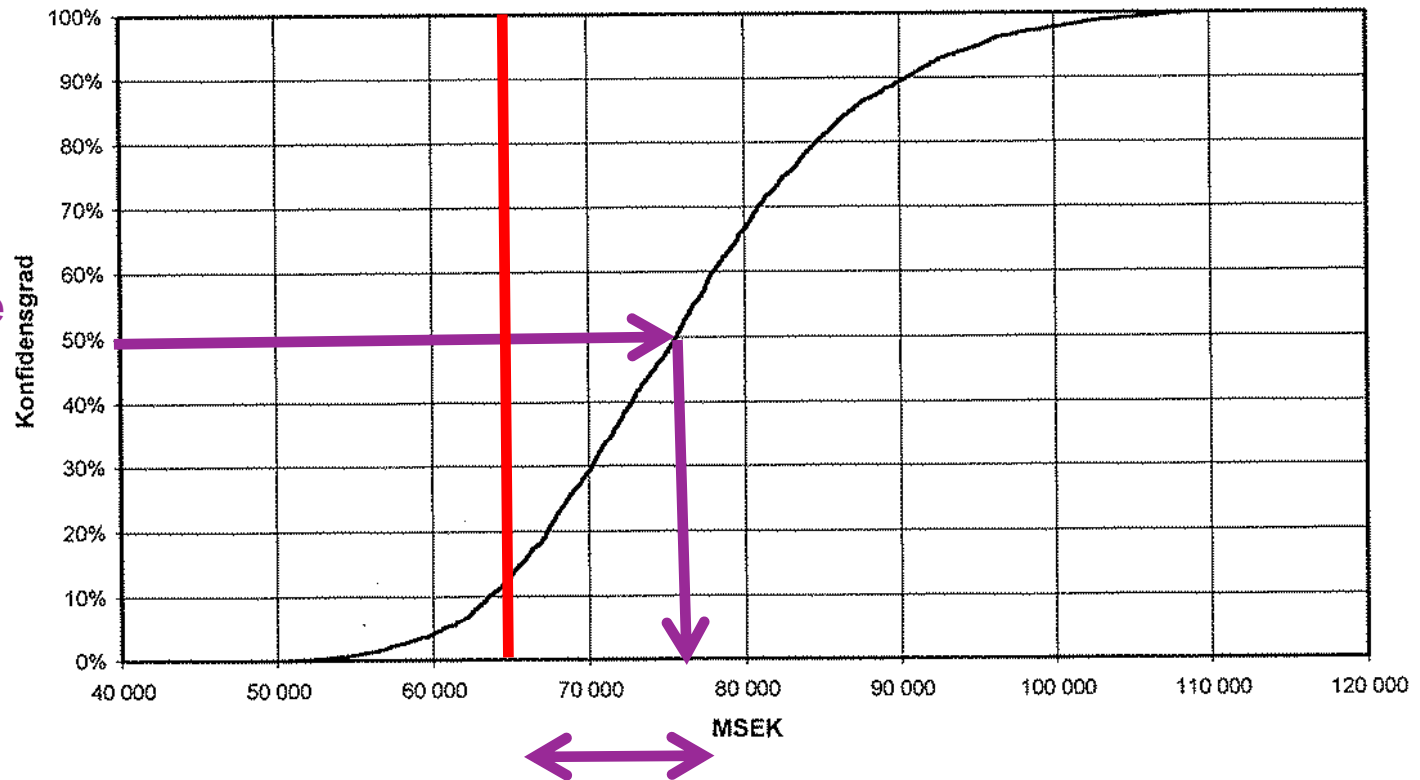


# The Result as an S-curve

Result from the reference calculation



Result from the probabilistic calculations



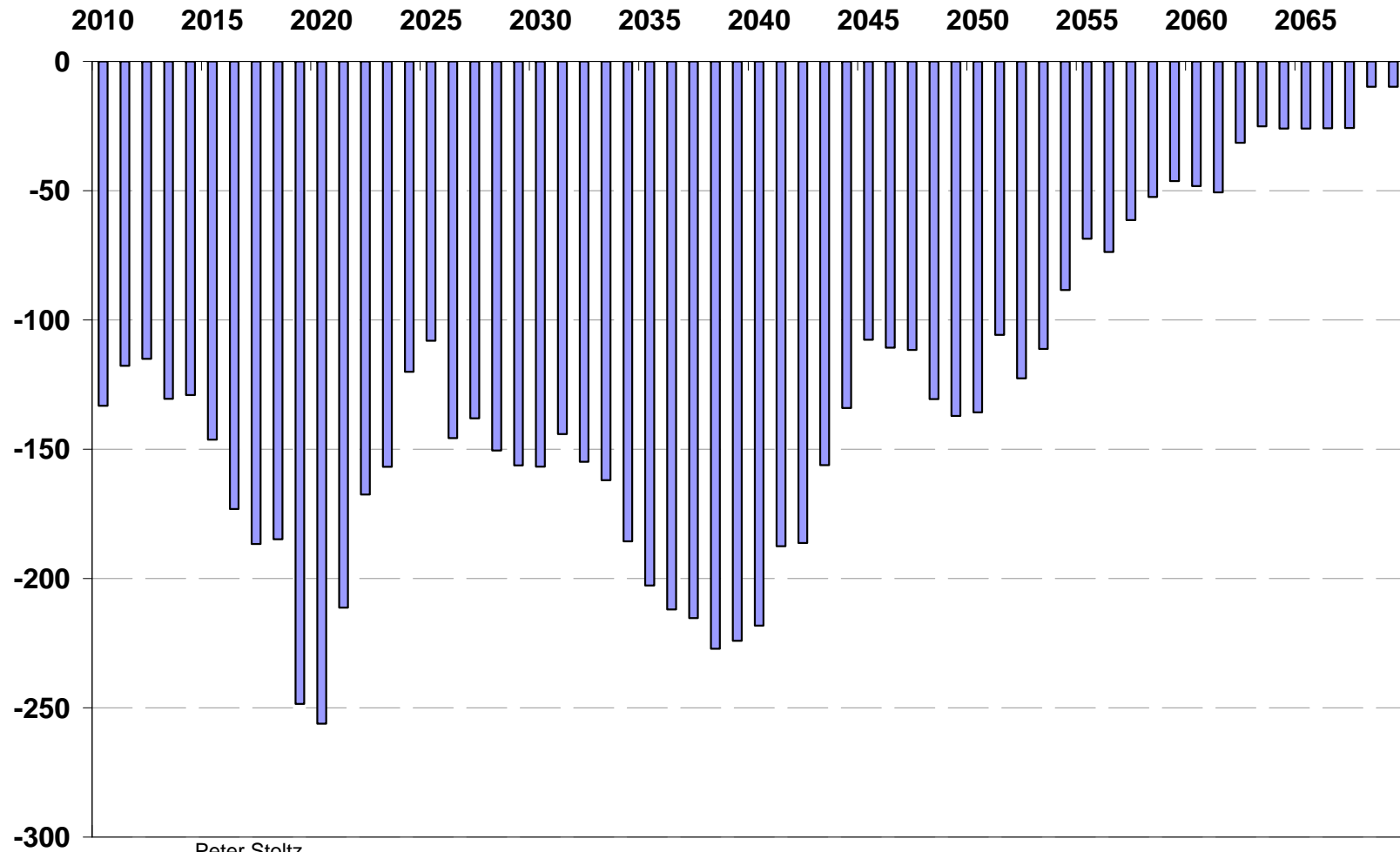
Increase in est. cost by 9.8 billion SEK (14%)





# The Expected Cash Flow

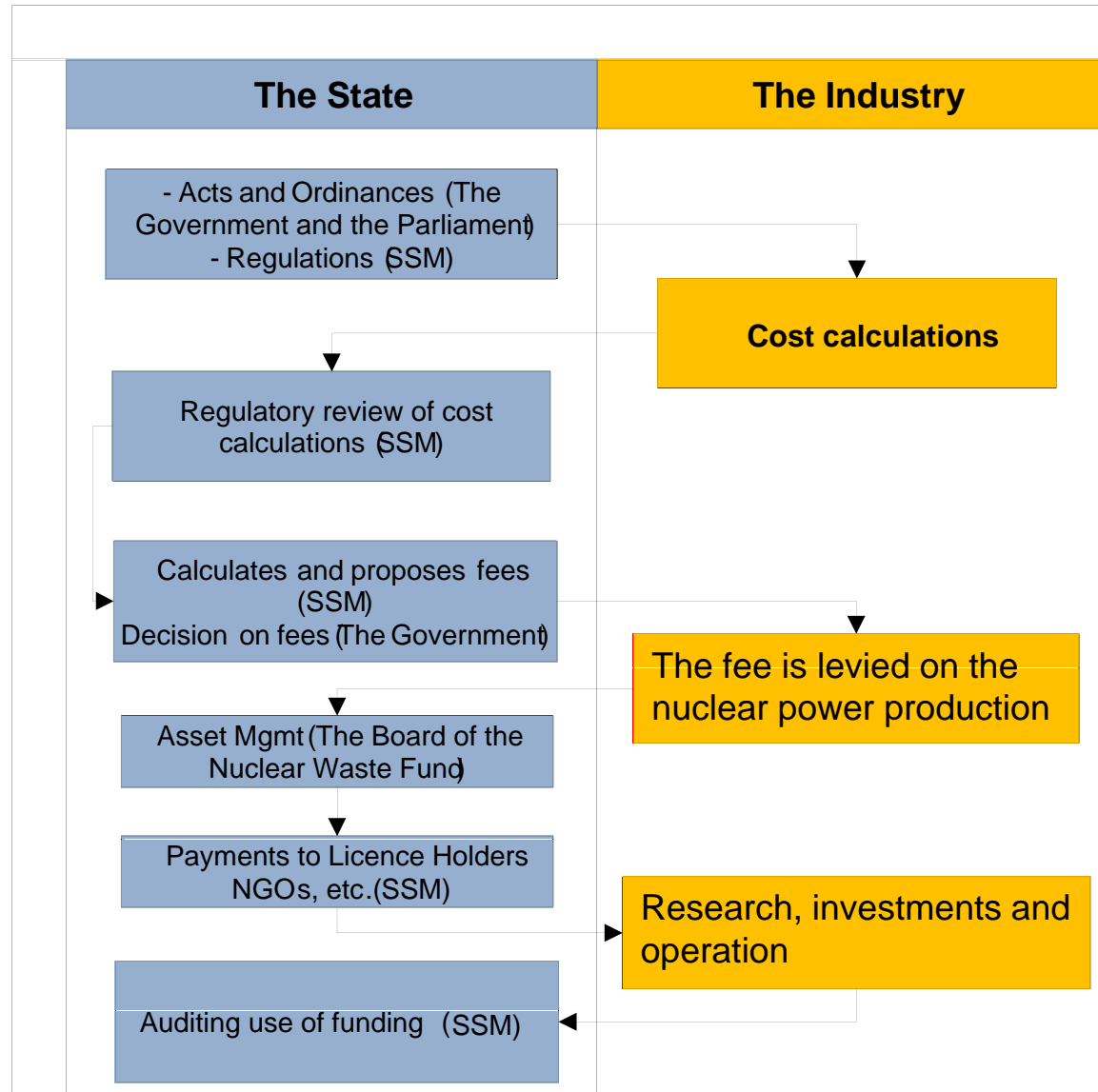
(million euro, fixed prices)



Peter Stoltz

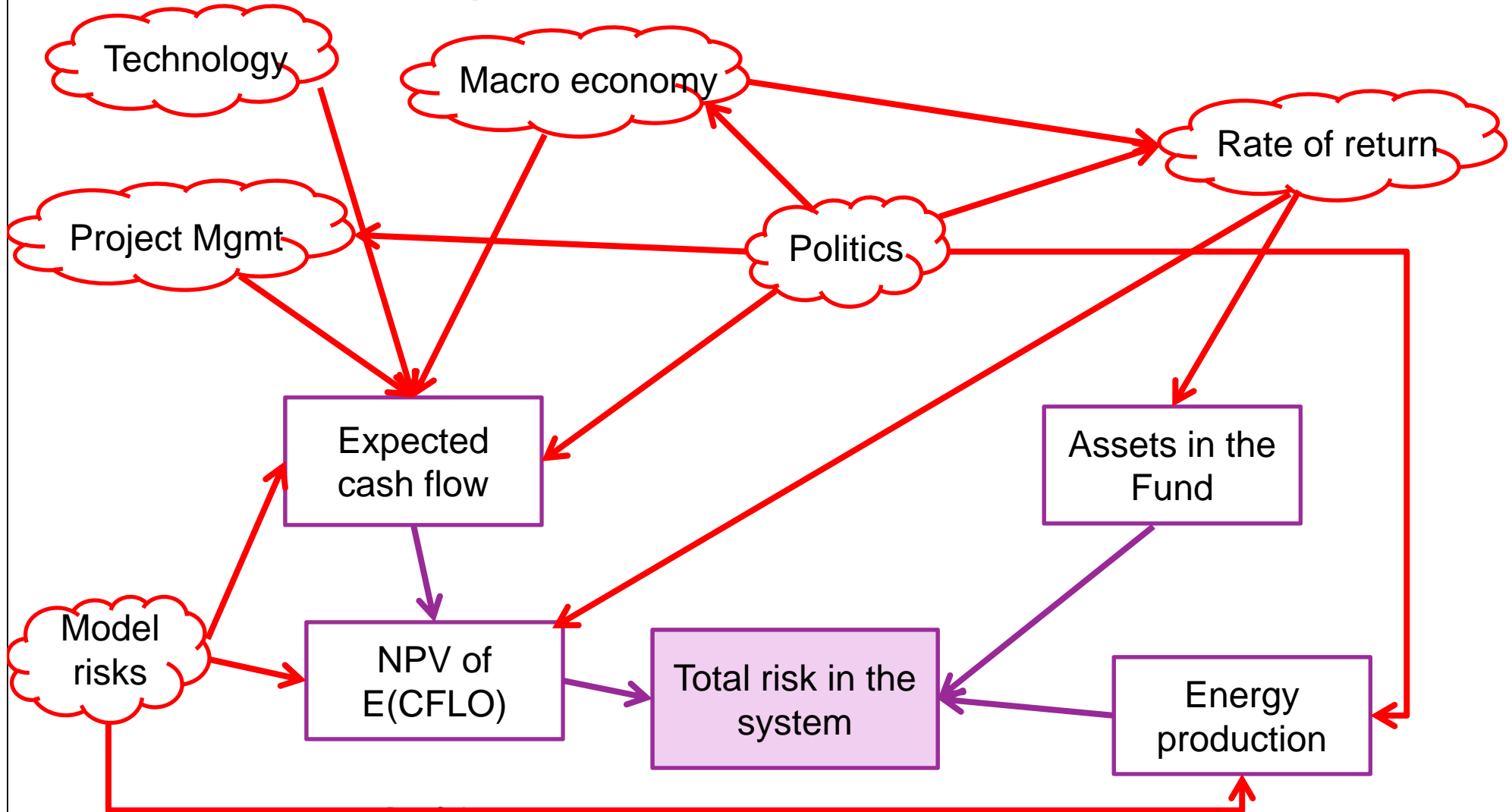
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# The Financing System - Stakeholders





# A Simplified Picture of the Uncertainties





# Technology / Project Management

- ➔ In general:
  - Some of the technology has strong similarities to existing projects, i.e. construction (civil engineering, buildings, tunnels)
  - Some of the technology is specific to this project (e.g. the encapsulation process and the copper canister)
  - Some technology is used elsewhere, but is difficult to benchmark (e.g. decommissioning of NPP)
- ➔ Our starting point:
  - Try to benchmark what can be benchmarked (existing technology)
  - Projects likely to start in the near future (if costs are underestimated, there is only a short time frame for securing adequate funding)



## Technology / Project Management

- Review of the reference cost calculation for the spent fuel repository (investment approx. 800 million euro, facility in operation in 2020)
  - Consultants have made a “shadow” estimate using the layout of the facility in order to benchmark the industry's cost estimate.
  - Preliminary result: No obvious underestimation of the costs and hence no obvious underfinancing.
  - Additional benefit: SSM now has a cost estimation model of its own for the spent fuel repository.
  - Next step: An uncertainty analysis for identifying potential key cost drivers. SSM will target evaluation of these factors and will hopefully get an “early warning system” for cost overruns.



# Project Management / Politics

- The institutional framework/framework for project governance is unclear
- General question: Which stakeholder has the overall responsibility for the total risk in the system?
- At present: many different stakeholders – no one has the overall responsibility
- Additional problem: The Government (not the Parliament) decides on the fees. The Government (the State) is also the main owner of Vattenfall AB (owner of several reactors)
- Work in progress: Project (feasibility study) with NTNU to evaluate the governance of the programme

## Model risks

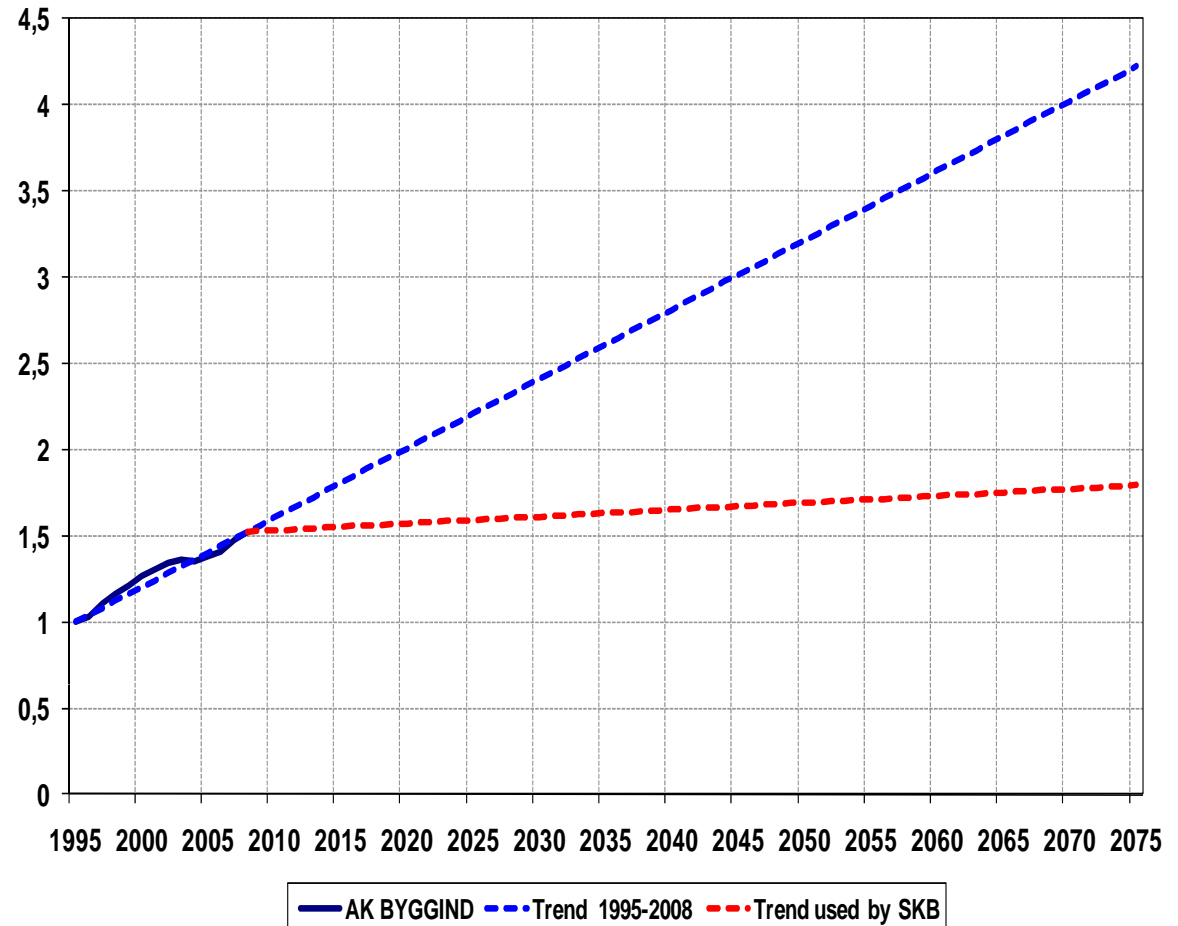
- The model used by the industry is complex:
  - 64 objects
  - 90 variations in the uncertainty analysis
  - Reference group (analysis group) with strong ties to industry
- Model risks?
- SSM has started a project together with NTNU in Trondheim whose aim is to benchmark the model/method for the uncertainty analysis used by SKB. The benchmark in this case is the Norwegian model for infrastructure investments.



## Macro Economics – Labour Cost

- Roughly 70 per cent of the projected total costs relates to labour cost
- The real rate-of-change in labour cost is an important cost driver
- Two different parts in the analysis:
  1. Real change of Labour Costs
  2. Productivity
- Economic theory predicts real increases in labour costs to be the same as increases in productivity for the total economy.

Real labour costs adjusted for productivity  
(construction) Index 1995=1







## Labour costs

- Unlikely that wages and salaries will increase more slowly in this project than in the labour market as a whole
- Long-term forecasts (horizon 2020-2030) for the Swedish economy indicate a sustainable growth rate in labour costs of between 2.0 and 2.5 per cent per year
- Labour supply is projected not to increase, partly due to demographics
- Conclusion: Real labour costs will increase
- What about productivity?



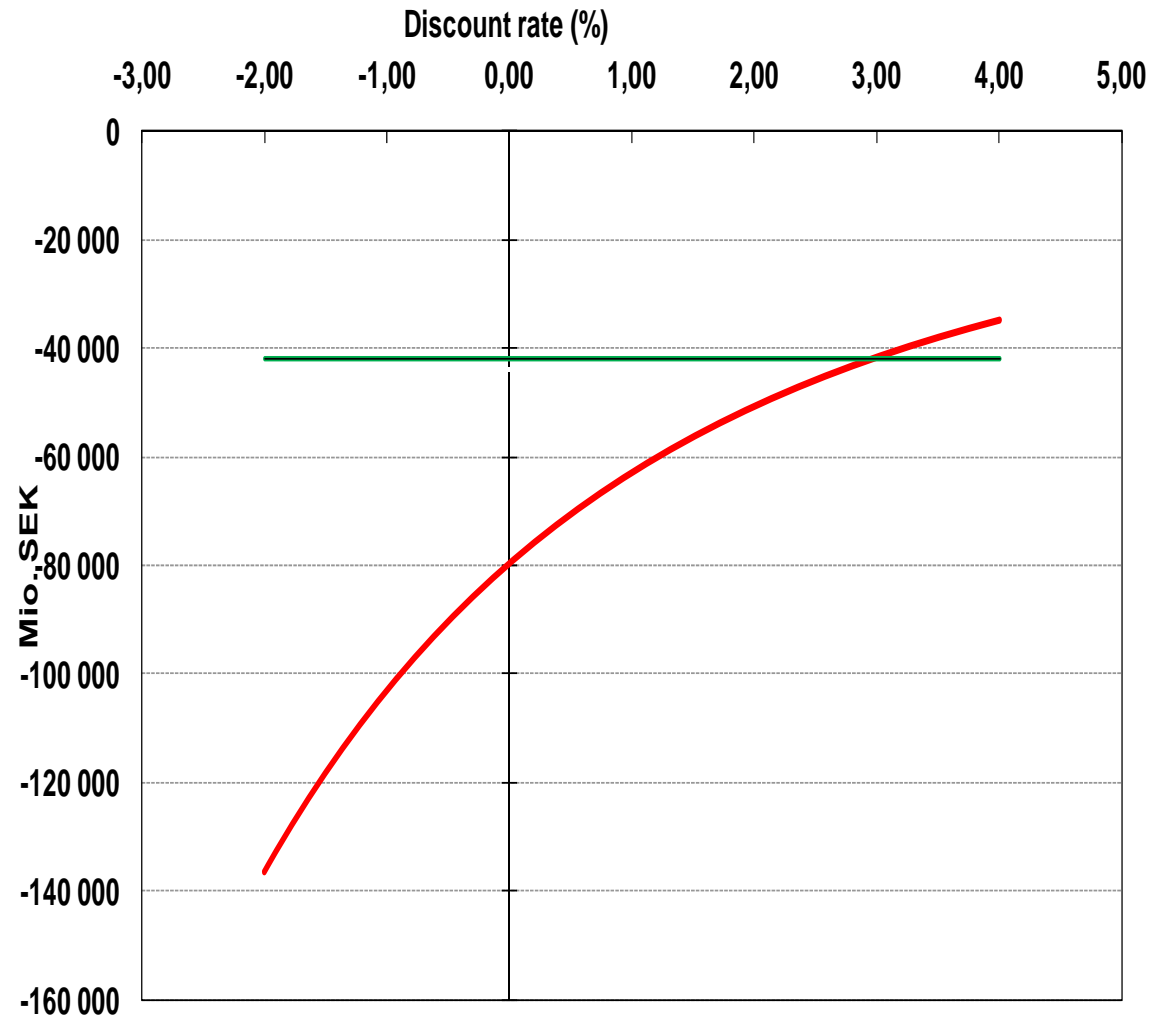
# Productivity

- Productivity is difficult to measure (at least for the production of services)
- Data available from the National Accounts, i.e. macro economics
- However, the annual average increase in productivity is 0.3 per cent in the construction sector
- Another important question: What is the relationship between productivity in a sector or the economy as a whole and a specific project?
- SSM has worked with consultants in order to analyse this area in more depth. But no useful answers yet (if ever)
- Further research is needed especially on productivity in projects. Also, we probably need to establish a way of dealing with the problem if the research turns out inconclusive



# Rate of Return

- When calculating the NPV of expected cash flow, one single rate has be used.
- Assumptions on the discount rate have a major impact on the need for additional funding.
- At a discount rate of 3 per cent, no additional funding is needed.

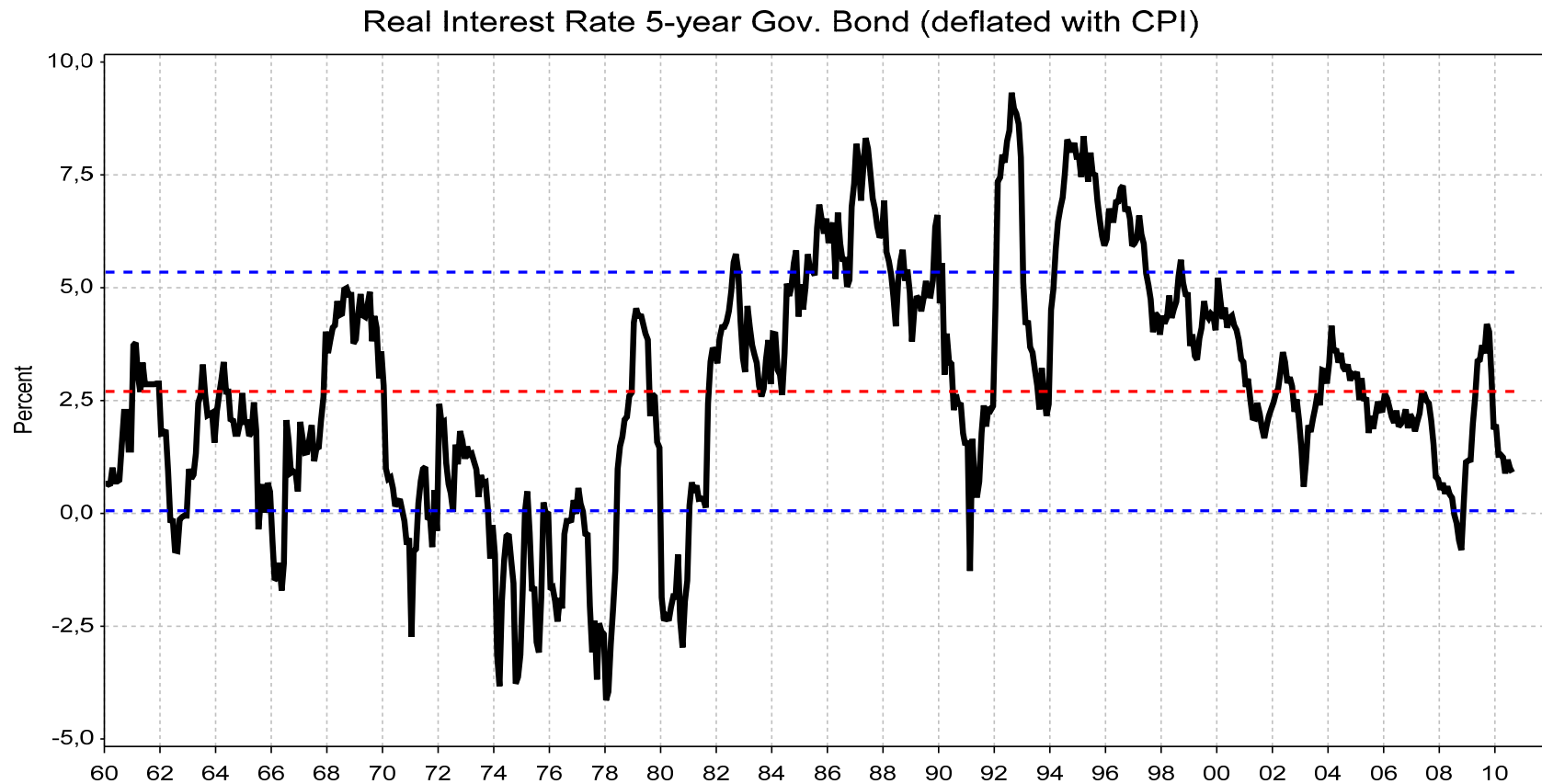




# Rate of Return

➔ In this model: Two issues need to be addressed

1. What is the appropriate level of the real long term interest rate?
2. How to deal with variations over time (volatility).



Source: Reuters EcoWin



# Rate of Return

- SSM has worked with consultants in this area as well.
- Long term level: Economic theory is inconclusive. The Fisher Golden Rule still seems to be the best guess. For Sweden, this could mean a level of 1.5-2.5 per cent.
- The volatility is a problem. The historical data shows a mean of 2.5 percent, but the standard deviation is also 2.5 per cent.
- In the last proposal of fees, the average (2.5) was reduced by a risk premium of 0.5 per cent.
- However, we believe that this method is insufficient. Another problem is a mismatch to the asset side in the system. The market value of the fund is calculated using a term structure reflecting the actual portfolio of bonds.



# A Balance Sheet for the System

- A project has been launched to investigate if it is possible to use the same term structure on both the asset and liability sides.
- The project will also address the volatility and how to deal with risks in the rate of return.

Assets	Liabilities
Assets in the Nuclear Waste Fund	Net Present Value of Expected Cash Flow
Not yet financed costs Gap to be covered by fees	



## In summary: Complexity in this project

- ➔ The key complexity?
- ➔ Candidates:
  1. The design – many stakeholders, different agendas. The overall responsibility.
  2. The long time span. Projections are hard (or even impossible to do).
  3. A variety of factors, internal as well as external, influences the outcome.

## **Risk management/how to deal with complexity**

- ➔ A first step is to adequately estimate the risks and their potential impact on the estimated costs using a broad perspective.
- ➔ Started the work in this area.
- ➔ The fee is set every three years.
- ➔ Guarantees provided by the owners of the generating companies
- ➔ Sufficient?





## In summary:

- ➔ New legislation has broadened SSM's responsibilities.
- ➔ Research and development work in a number of areas.
- ➔ Some problems are specific to this programme, but many of them are generic.
- ➔ We are striving to benchmark our methods and the methods used by industry.
- ➔ Experiences from other sectors and other countries are very valuable to us.



Thank you! Questions and comments?



