

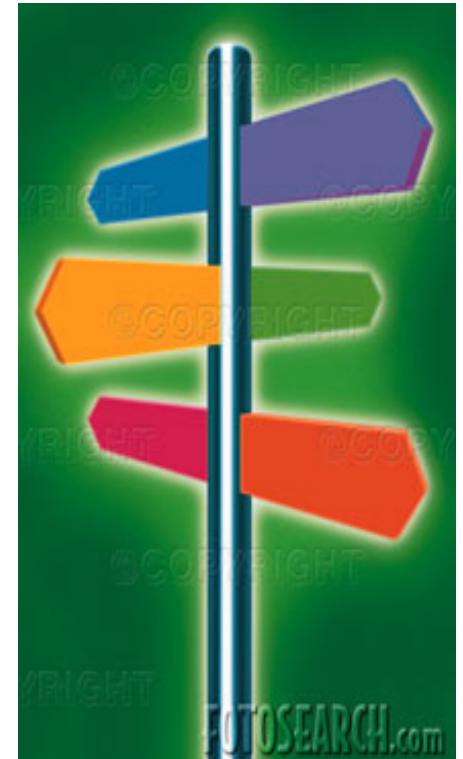


Waste management options in Europe

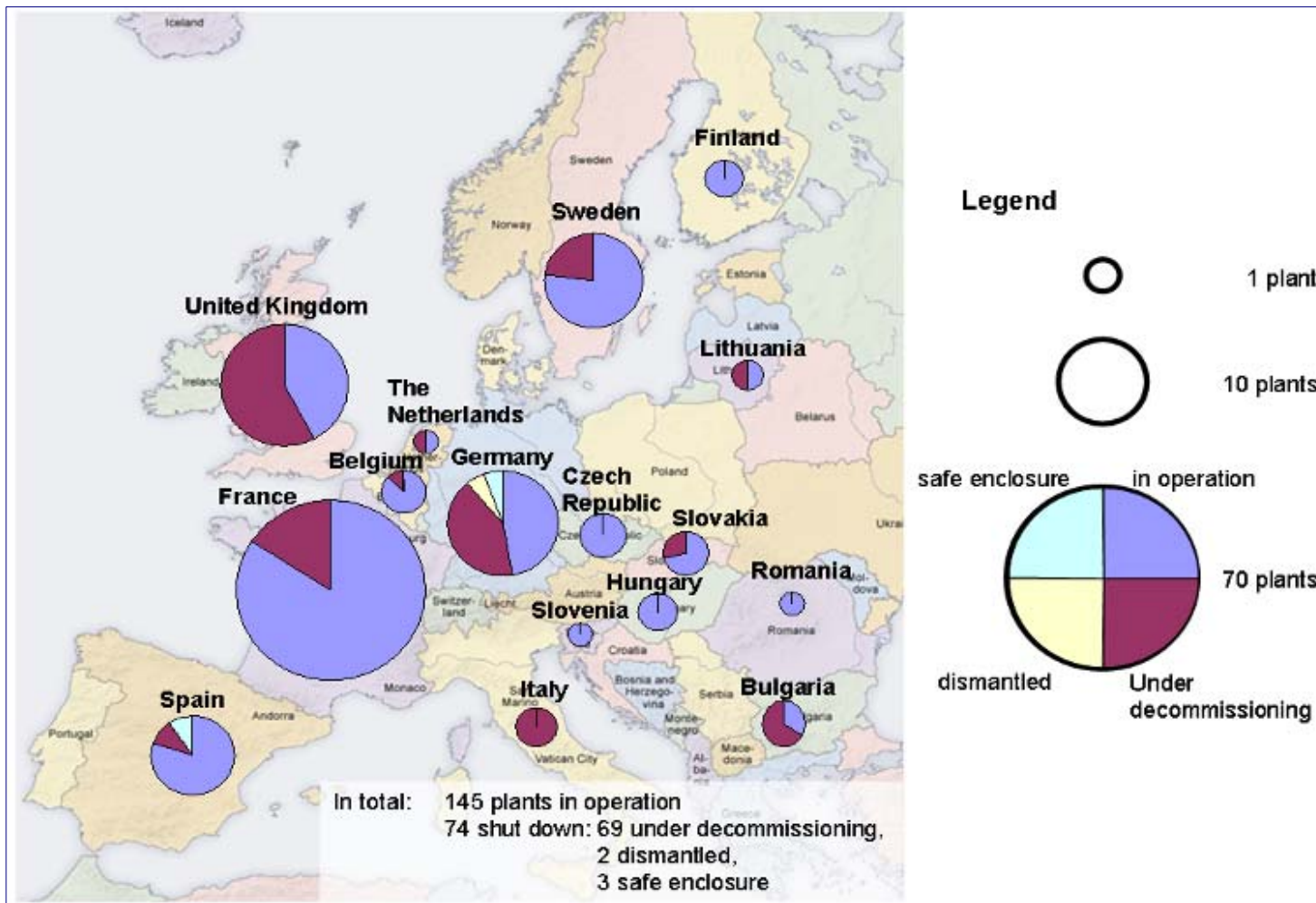
Dr. Roland Schenkel

Director-General
European Commission, Joint Research Centre
'Robust science for policy-making'

1. **Setting the scene** → the importance of the waste issue on public acceptance
2. **Low and intermediate Level Waste** → industrial solutions are in place
3. **Spent Fuel management** → two main tracks are being followed
4. **Geological Disposal** → needed in any case - implementation is under way
5. **The role of research** → increasing confidence in long-term analysis and reducing uncertainties
6. **Take-home message** → solutions for nuclear waste management are implemented or progressing



Nuclear power provides about 50% of Europe's base load electricity



KEY FACTS

- EU 27: 145 reactors (2007) in operation (133 GWe) in 15 countries
- 8 new reactors are under construction
- 31% of total electricity production in Europe is via nuclear
- Reactor life-extension requests have been made in France, Sweden, Finland & Hungary
- Phasing out of reactors is planned in Germany and Spain

- Legacy of waste✓
- Legacy of public opinion✓
- Survey on the level of support of EU citizens to nuclear energy:

Waste Eurobarometer 2008

62% of EU citizens interviewed would favour nuclear energy if safe solutions for waste are implemented

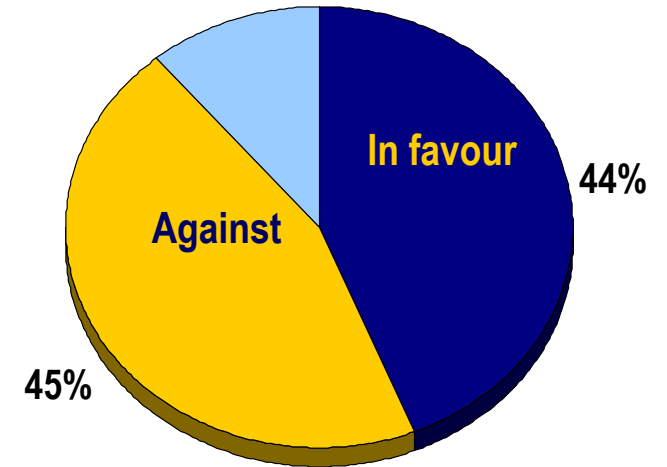
93% of EU citizens want urgent implementation of long term management of highly radioactive waste

43% believe that deep underground disposal presents the most appropriate solution



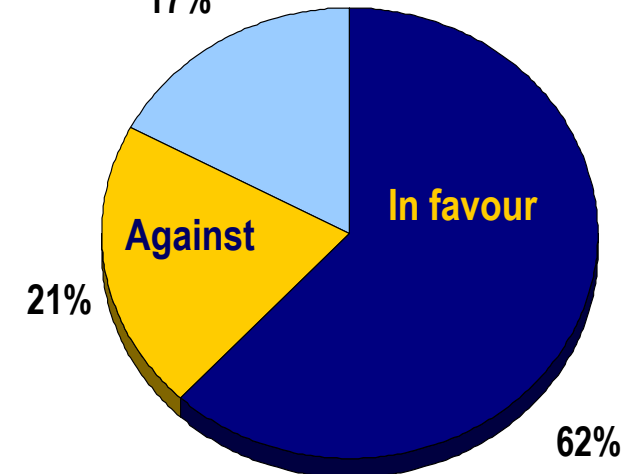
Current Opinion

11% Don't know



If waste issue was solved

17% Don't know



Low and medium active waste: *Solutions are in place*

Country	Site	Period
UK	Drigg Dounreay	1959 - 1957
France	Centre la Manche Centre de l'Aube Morvilliers	1969 - 1994 1992 - 2003 -
Germany	Morsleben	1981 - 1999
Sweden	Forsmark	1988 -
Finland	Olkiluoto Loviisa	1992 - 1998 -
Spain	El Cabril	1992 -
Czech rep.	Dukovany	1994 -
Norway	Himdalen	1998 -
Slovak rep.	Mochovche	2000 -



Simple shallow-land disposal

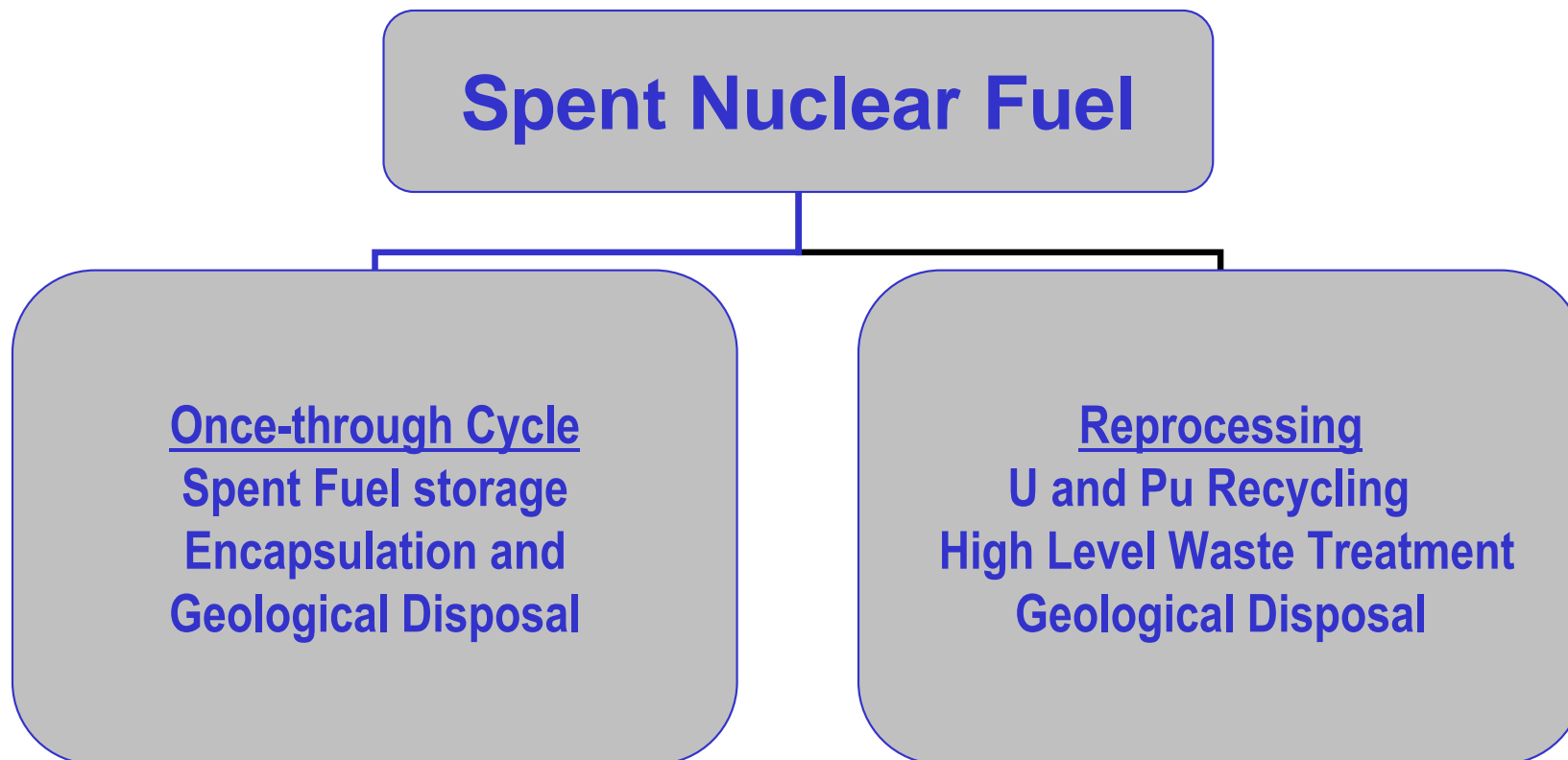


Engineered near-surface disposal



Mined rock cavity

Decision tree for Spent Nuclear Fuel strategy selection in Europe



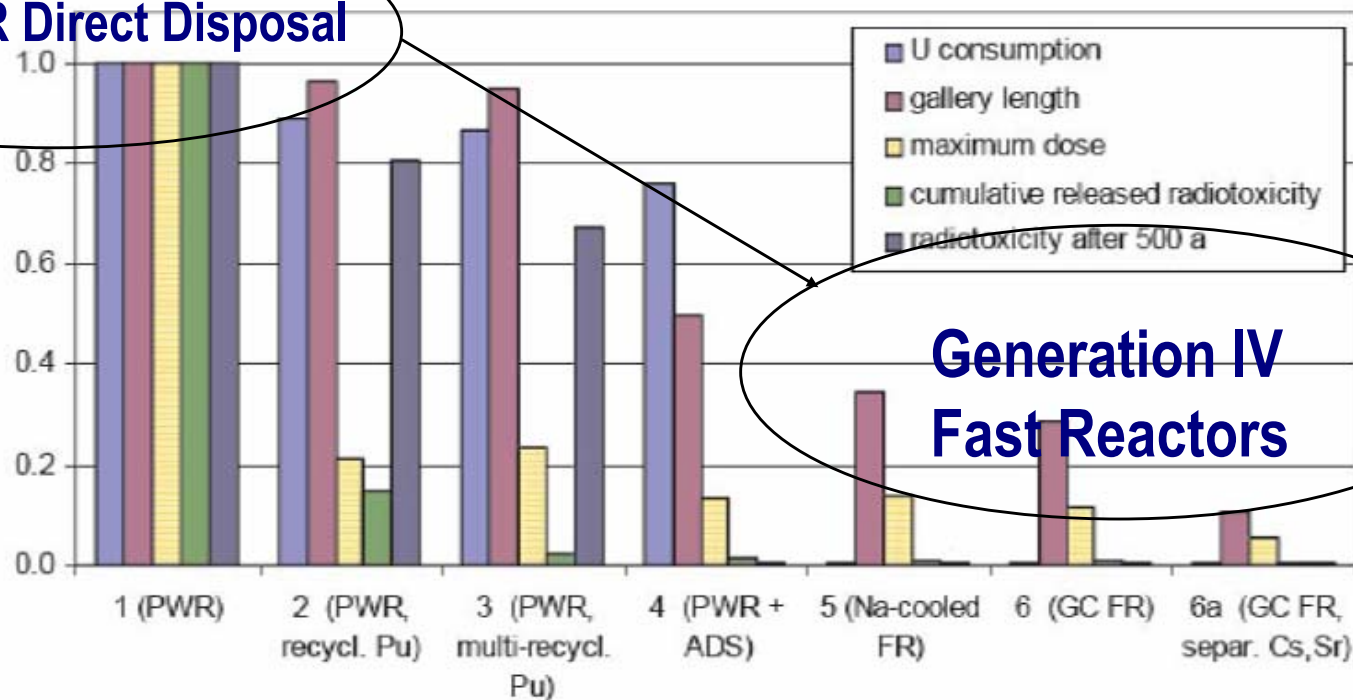
Geological Disposal is needed in each case

Will reduce U consumption, as well as overall waste volume and waste toxicity in geological repository



Comparison of different fuel cycle strategies in terms of radiological and disposal aspects

GEN 2 PWR Direct Disposal



Generation IV Fast Reactors



Highly active waste: *Solutions* are being refined

- Reprocessing and vitrification of fission products plus minor actinides (France, UK)

Status: implemented, glass storage facility

- Direct interim storage of spent fuel

**Status: technical solutions exist;
implemented interim store facilities**



- Geological repository of vitrified glass / spent fuel

Status: technical solutions exist / under test

- Partitioning and transmutation of long lived actinides

Status: feasibility demonstration at laboratory scale





Vitrified waste canister being inspected in the R7 vitrification facility in the Cogema UP2-800 waste-reprocessing plant at La Hague (Manche département).
Sidney Jezeque/Cogema



*10,622 canisters produced end 2002
Source ANDRA
Occupies a volume of 1639 m³
Contains 96% of total radioactivity

Vitrified Waste Canister

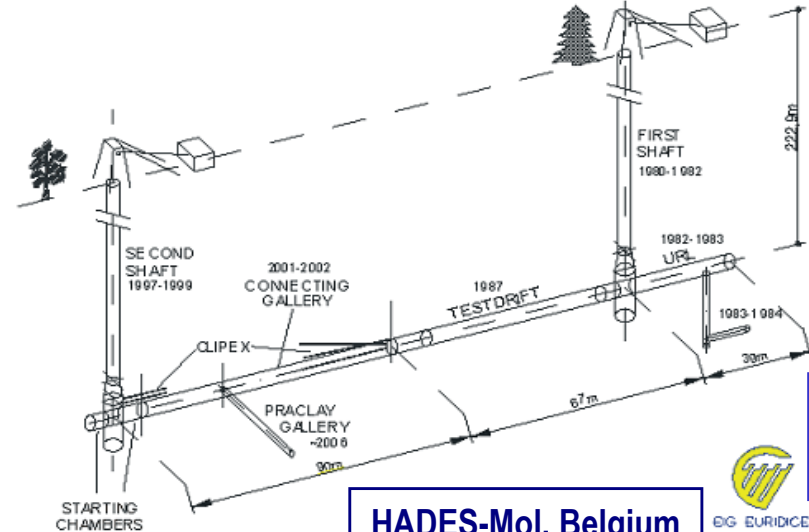
Highly active waste: *Real solutions are underway*



ONKALO Test Site, Finland
Final repository in Olkiluoto in 2020

Crystalline rock
Since 2004

UNDERGROUND RESEARCH FACILITY HADES



HADES-Mol, Belgium

Boom clay
Since 1984



Grimsel, Switzerland

Granite
Since 1983

Cost of Geological disposal: the example of Finland

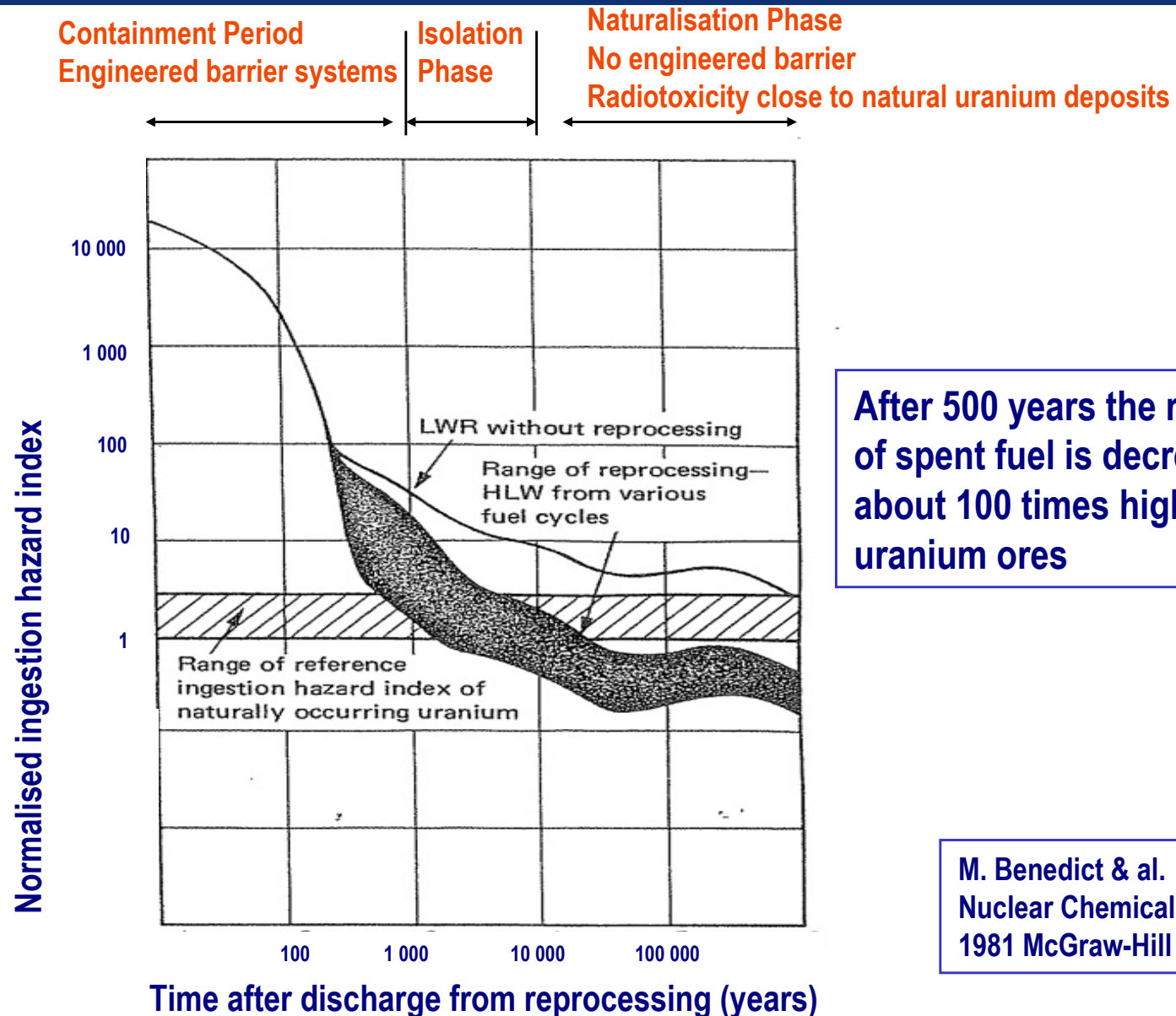
Spent fuel disposal cost breakdown (Million Euro Dec 2006)
5,500 tU of spent fuel from 5 reactors operating up to 60 years

<u>Construction</u>		630 M€
- above ground facilities	150	
- repository	480	
<u>Site Operation (100 years)</u>		2,140 M€
- encapsulation plant	1,120	
- canisters	530	
- repository	470	
- transports	20	
<u>Decommissioning and sealing</u>		240 M€
- dismantling and waste management	10	
- repository closure and sealing	230	
Total		3,010 M€

Waste management and disposal costs represent 5% of the total electricity production price

0.16 c€/kWh
(1,000 tU produce 400 million kWh).
Same order as other projects:
UK, USA, Spain, Sweden

Range of Ingestion Hazard of HLW vs Naturally Occuring Uranium



After 500 years the radiotoxicity of spent fuel is decreased to about 100 times higher than uranium ores

M. Benedict & al.
Nuclear Chemical Engineering
1981 McGraw-Hill

Containment period:

engineered barrier systems (cladding tubes and containers) are still intact

- analysis of degradation of engineered barriers due to groundwater (e.g. corrosion) or due to waste (swelling)
- only limited releases of mobile radionuclides (e.g. by diffusion through cracks)
- lasts typically 500-1000 years



lasts
500-1000
years

Isolation phase:

after degradation of engineered barrier

- Barrier functions of the geological disposal site are important
- Main safety functions:
 - limited solubility of radionuclide and sorption on EBS materials
 - slow groundwater flow and sorption on/diffusion into bentonite clay / bedrock



lasts
several
1000 years

Naturalisation phase:

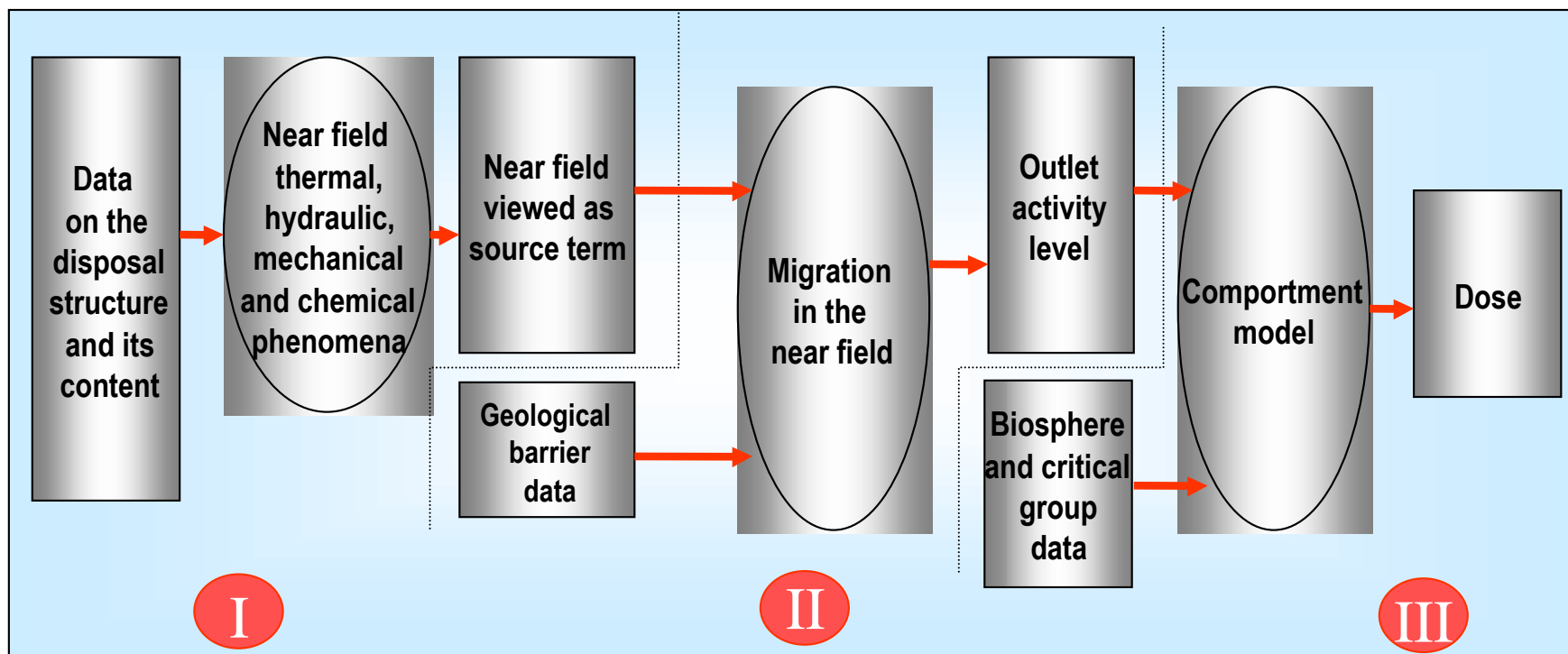
- no engineered barrier systems safety functions
- radiotoxicity close to natural uranium deposit



lasts
> 10000
years

Particular focus of RD&D:

- Waste properties including mobilisation and retention of radionuclides
- Evolution of host rock due to thermal and mechanical loads
- Long-term performance of geological barrier
- Evolution of the engineered barrier system and its interaction with the rock
- Ability of the engineered barrier system and the surrounding rock to retard radionuclides
- Plugging and sealing
- Biosphere and climate conditions



- **Waste management and disposal is in the EU a technical reality as far as low and medium active nuclear waste is concerned**
- **For High Active Waste, technical solutions exist and are processed; encapsulated spent fuel or vitrified glass containers are stored in surface interim stores; new developments (transmutation) continue**
- **First geological repositories will go in operation around 2025 (Finland, Sweden and France)**
- **Current cost estimates suggest that waste management and disposal account for about 5% of the electricity price per KWh**
- **The role of research will continue to address particular effects in view of reducing uncertainties in performance safety analyses and increasing confidence in models**