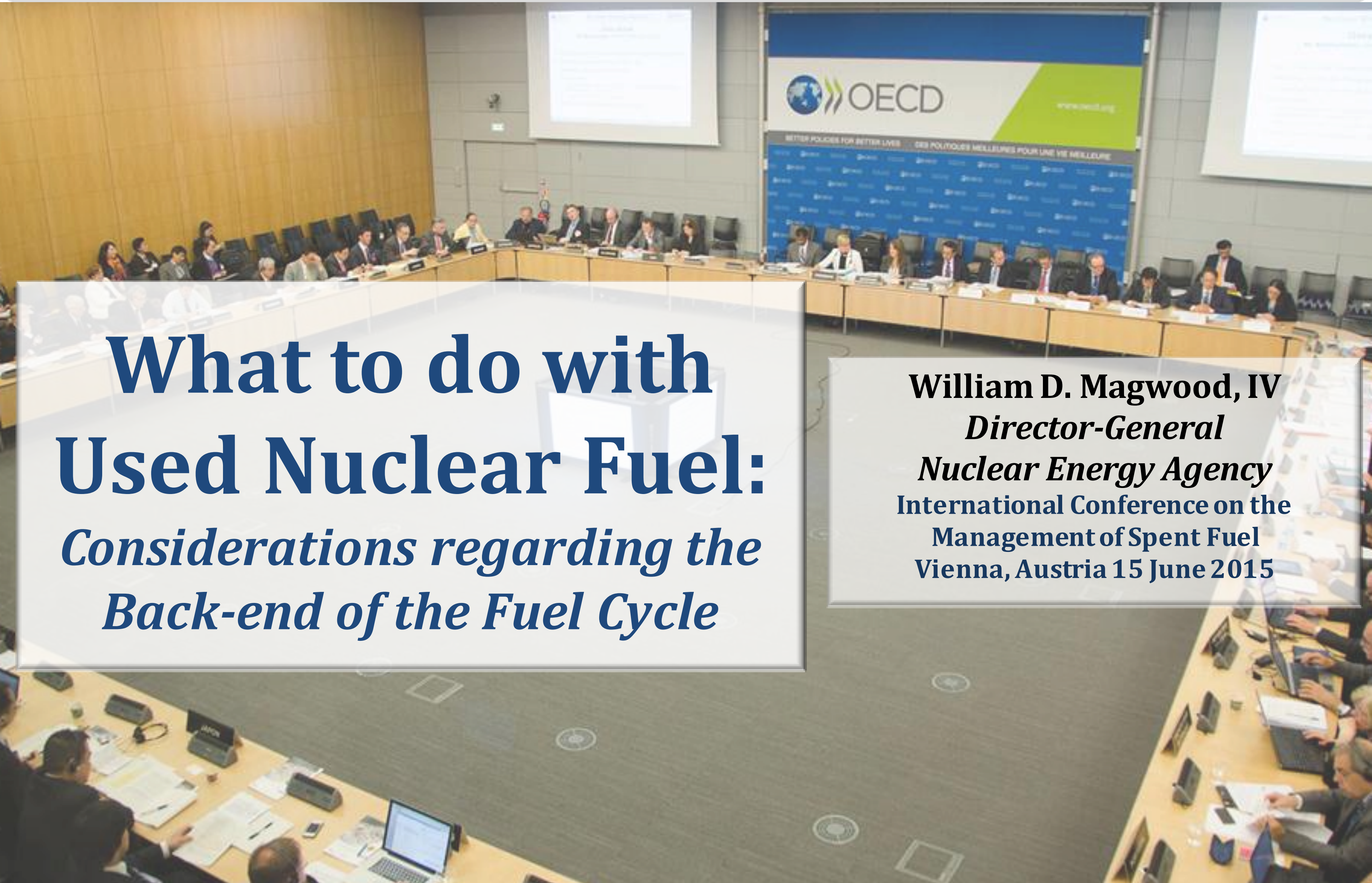


What to do with Used Nuclear Fuel:

Considerations regarding the Back-end of the Fuel Cycle

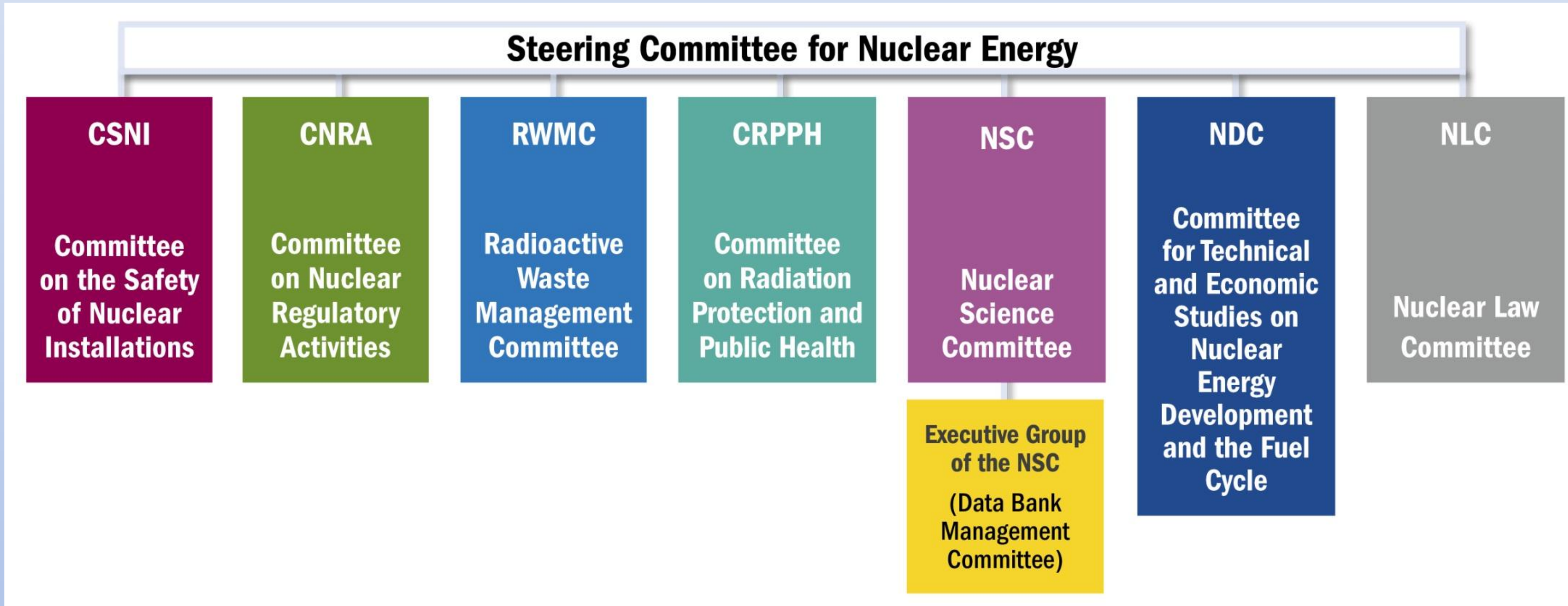
William D. Magwood, IV
Director-General
Nuclear Energy Agency

International Conference on the Management of Spent Fuel
Vienna, Austria 15 June 2015

The NEA: A Forum for International Cooperation for 57 years

- 31 member countries
- 7 standing technical committees
- 75 working parties and expert groups
- 21 international joint projects

NEA Committee Structure



The NEA's committees bring together top governmental officials and technical specialists from NEA member countries and strategic partners to solve difficult problems, establish best practices, and promote international collaboration

Major NEA Separately Funded Activities

Secretariat-Serviced Organisations

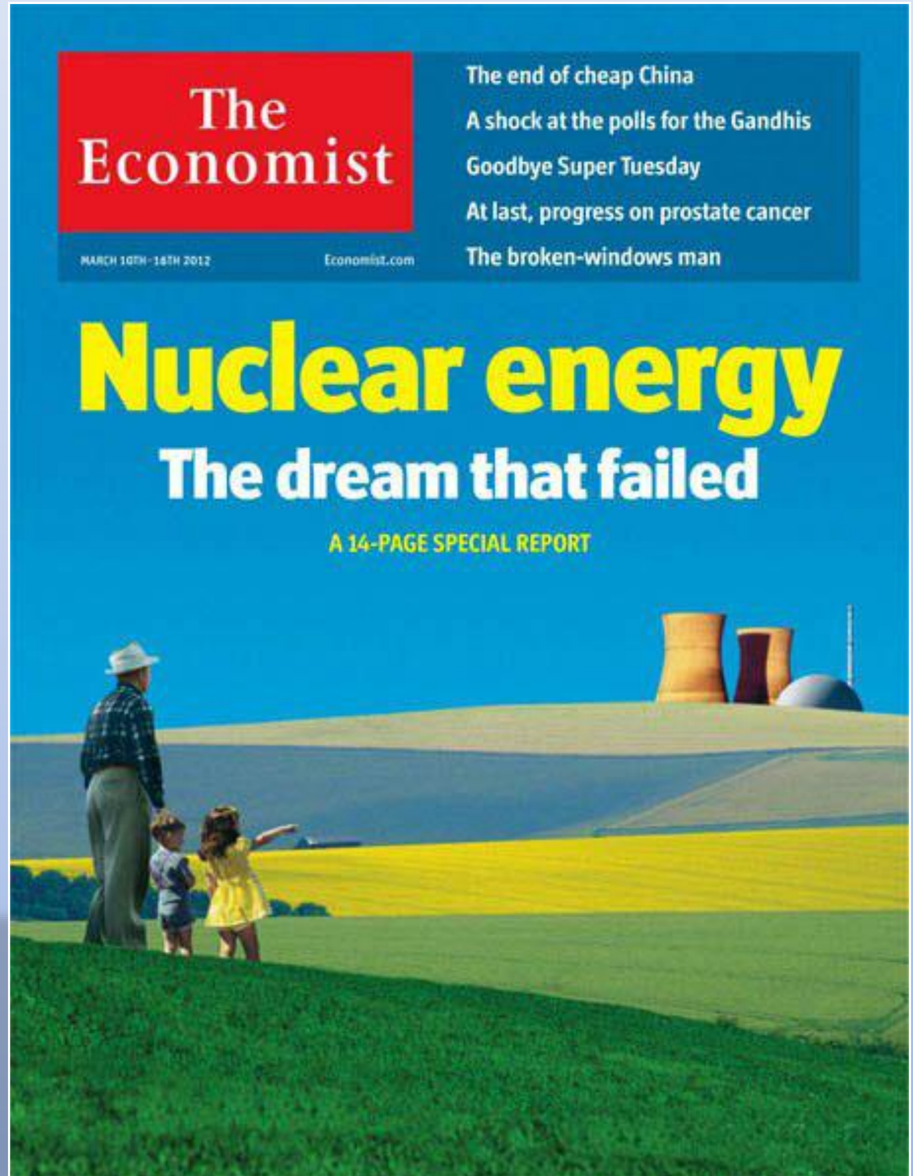
- **Generation IV International Forum (GIF)** with the goal to improve sustainability (including effective fuel utilisation and minimisation of waste), economics, safety and reliability, proliferation resistance and physical protection.
- **Multinational Design Evaluation Programme (MDEP)** initiative by national safety authorities to leverage their resources and knowledge for new reactor design reviews.
- **International Framework for Nuclear Energy Cooperation (IFNEC)** forum for international discussion on wide array of nuclear topics engaging senior officials from both highly experienced nuclear power countries and emerging economies

21 Major Joint Projects

(Involving countries from within and beyond NEA membership)

- **Nuclear safety research** and experimental data (e.g., thermal-hydraulics, fuel behaviour, severe accidents).
- **Nuclear safety databases** (e.g., fire, common-cause failures).
- **Nuclear science** (e.g., thermodynamics of advanced fuels).
- **Radioactive waste management** (e.g., thermochemical database).
- **Radiological protection** (e.g., occupational exposure).


CHERNOBYL & FUKUSHIMA HAVE MADE IT CLEAR
PUT A FULL STOP TO NUCLEAR
ČERNOBYLIAMS– NE
NO TO NUCLEAR..
GREENPEACE
RETIRE VERMONT YANKEE
GREENPEACE
NO NUKES


The Economist
MARCH 10TH-16TH 2012
Economist.com
The end of cheap China
A shock at the polls for the Gandhis
Goodbye Super Tuesday
At last, progress on prostate cancer
The broken-windows man
Nuclear energy
The dream that failed
A 14-PAGE SPECIAL REPORT

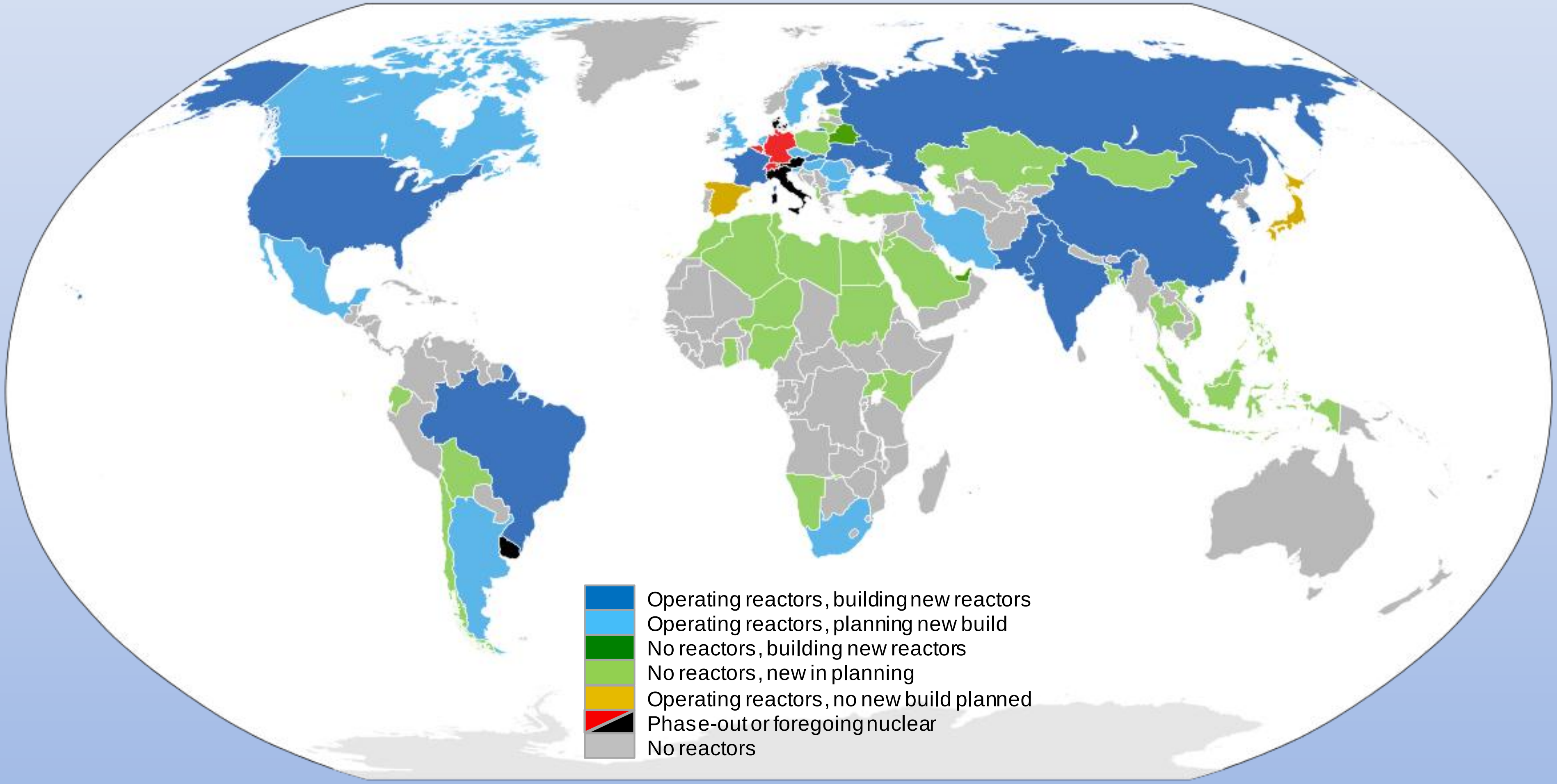
Nuclear Power Plants under Construction

(June 2015)

Location	No. of units	Net capacity (MW)
Argentina	1	25
Belarus	2	2 218
Brazil	1	1 245
China	24	23 738
Finland	1	1 600
France	1	1 630
India	6	3 907
Japan	2	1 325
Korea	4	5 360
Pakistan	2	630
Russia	9	7 371
Slovak Republic	2	880
Ukraine	2	1 900
United Arab Emirates	3	4 035
United States	5	5 633
Other: Chinese Taipei	2	2 600
TOTAL:	**67**	**64 097**

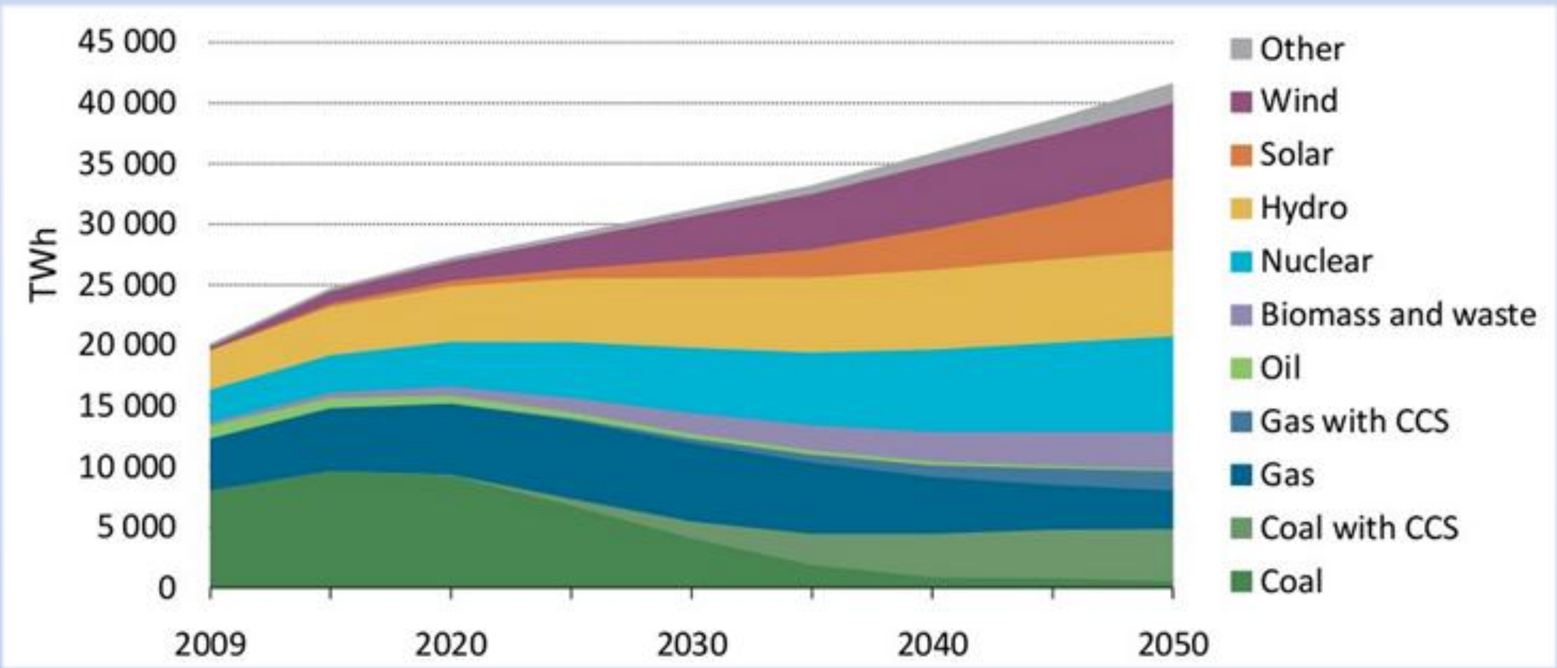
Source: IAEA PRIS

Global View of Nuclear Power Today



Source data: World Nuclear Association
Update 2015

IEA 2°C Scenario: Nuclear is Required to Provide the Largest Contribution to Global Electricity in 2050



2015 NEA/IEA Technology Roadmap

Key Roadmap Recommendations

- **Governments should recognize the value of low-carbon capacity.**
- **R&D is needed to support long-term operation.**
- **Industry needs to optimise constructability of Gen III designs.**
- **Accelerate development of SMRs.**
- **Support development of one or two Gen IV reactors.**
- **Demonstrate nuclear desalination or hydrogen production.**
- **Invest in environmentally sustainable uranium mining.**
- **Continue cooperation and discussions on international fuel services.**
- **Establish policies and sites for long-term storage and disposal.**

2015 NEA/IEA Technology Roadmap

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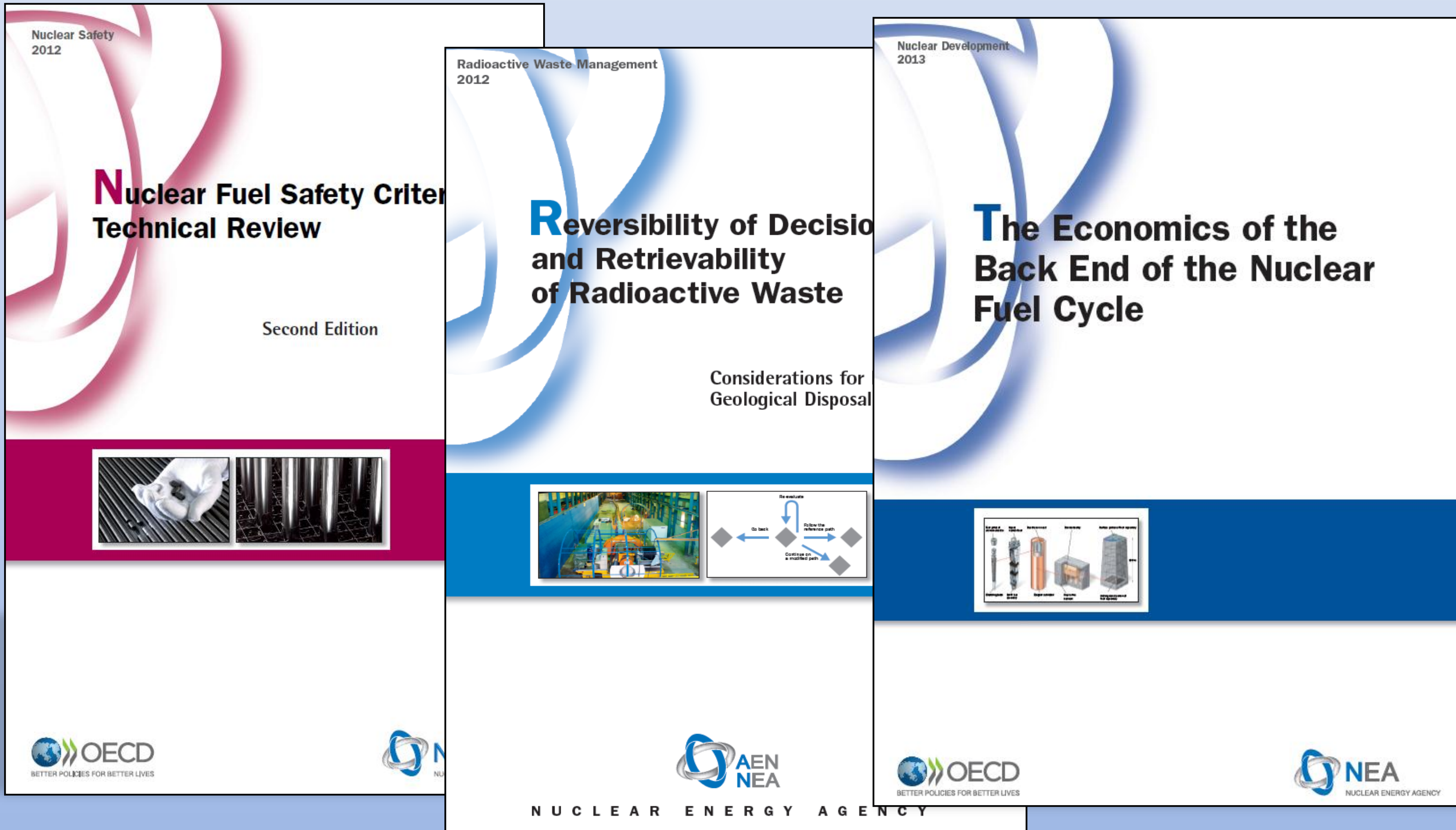
Nuclear Waste:
An Area of Continuing Study



What Are the Options?
Storage

Approach	Current Status	Challenges
Conventional Storage	Use of pools and dry casks (Proven very safe for decades of storage)	Not a long-term solution
Long-Term or Extended Storage	Under consideration by several countries (Generally regarded as an extension of conventional storage)	Questions about stewardship over very long time periods , *i.e.*, 100 years or longer

Extended / Long-term Storage: Challenges and Considerations

- Technical analyses are needed to support regulations for extended storage times — particularly in the area of spent fuel materials.
- Approaches must address uncertainties associated with societal and economic developments over the long-term future.

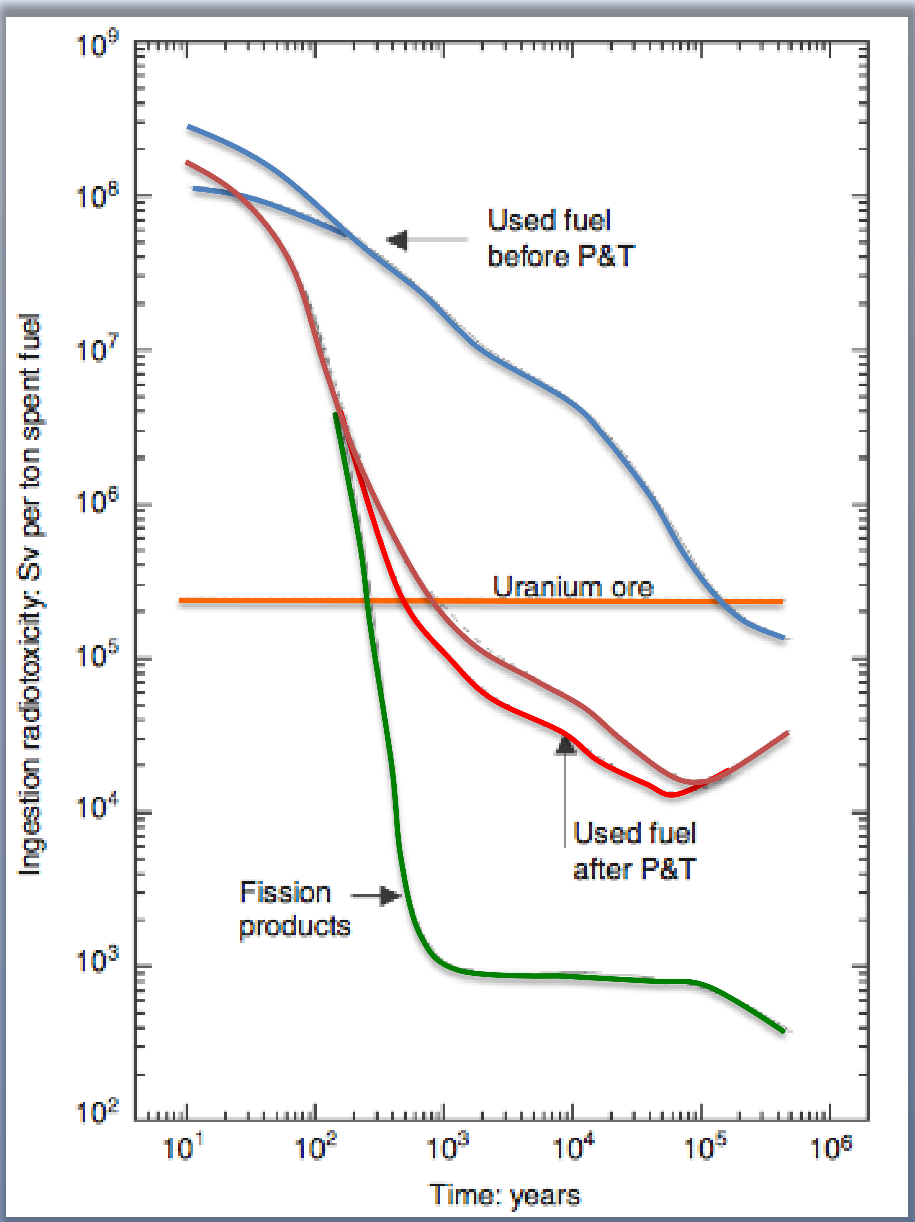
"Castor" (combined transportation and storage casks)
Gorleben site, Germany

Questions to consider:

1. Are new package designs needed to enable safe long term storage?
2. Are new fuel designs necessary to assure long term stability if spent fuel is to stored for very long time periods?
3. Are current storage facilities configured to support reloading operations should it prove necessary in the future?

What Are the Options?
Treatment/Recycling

Approach	Current Status	Challenges
Conventional Reprocessing	In commercial use today (e.g., France, Russia) and pursued by several countries (e.g., China, Japan)	Continuing questions about cost, environmental impact and nonproliferation Does not significantly alter the need for HLW disposal
Advanced Recycling/ Partitioning and Transmutation	Various technologies being explored (Could reduce the long-term environmental risks associated with disposal)	Still in the laboratory; generally requires use of advanced fast reactors — which are not yet available



Radiotoxicity and Spent Fuel Management

Potential of Partitioning and Transmutation (P&T)

Impact limits of partitioning and transmutation scenarios on the radiotoxicity of actinides in radioactive waste*
J. Magill,y V. Berthou,y D. Haas,y J. Galy,y R. Schenkel,y H.-W. Wiese,z G. Heusener,z J. Tommasi} and G. Youinou
Nuclear Energy, 2003, 42, No. 5, Oct., 263–277

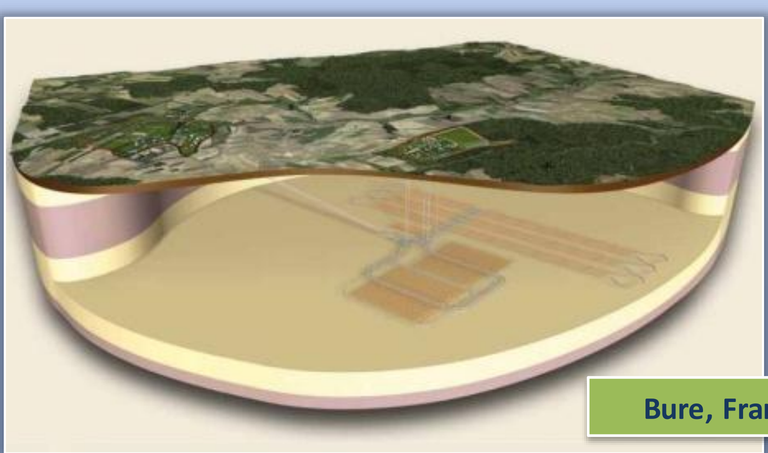
What Are the Options?
Disposition

Approach	Current Status	Challenges
“Exotic” Disposal Concepts	Includes approaches such as delivery of HLW to the moon, deep space, tectonic subduction zones, and the sub-seabed	Most have been rejected in the past; each would require significant R&D; some would violate existing international treaties
Deep Geologic Repositories	A consensus approach of the technical community; under active development in several countries (Generally required as part of any likely waste management strategy)	Siting

Global Leaders in HLW Disposition

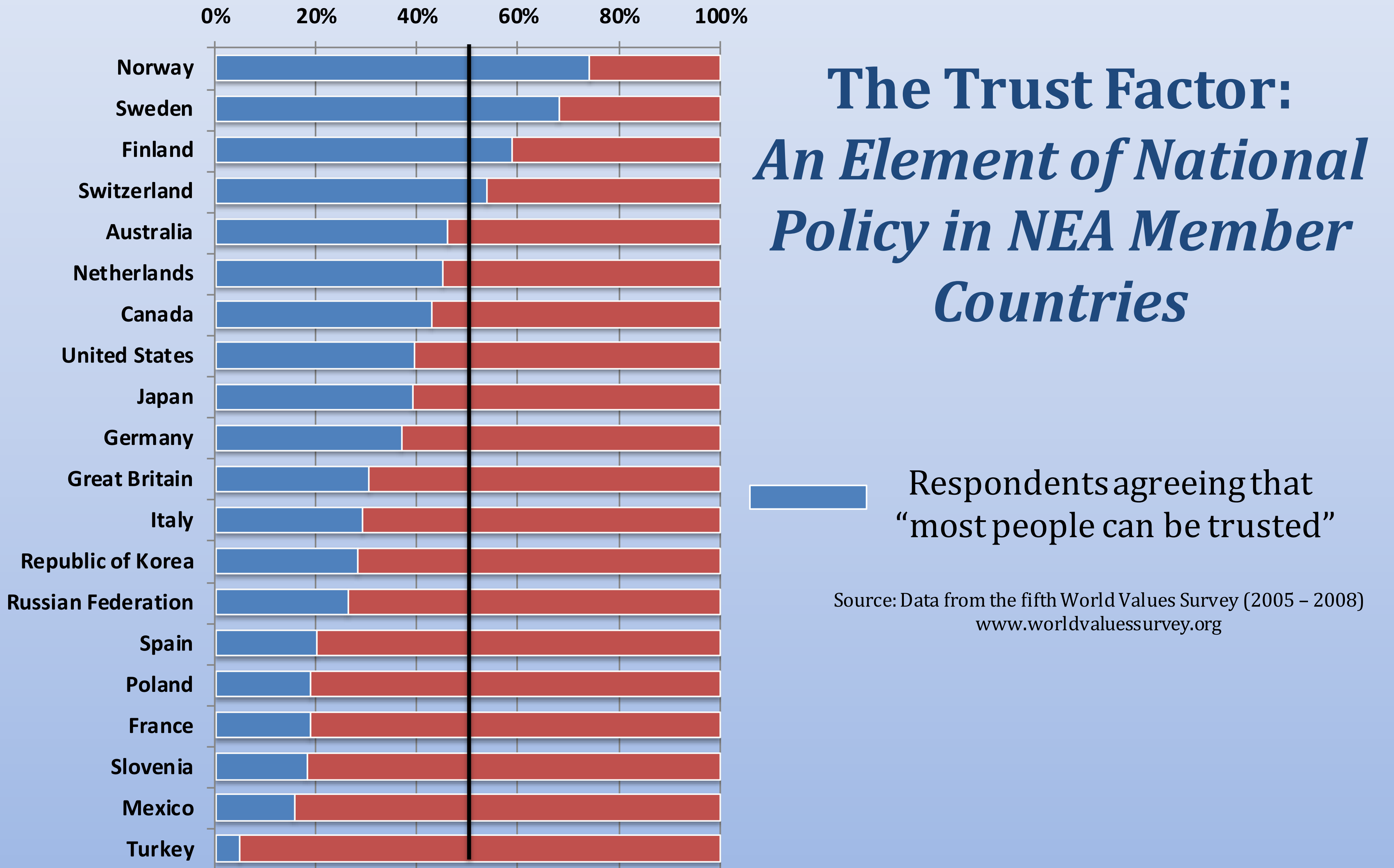
Waste type	Country	Location	Formation	Status	Projected Start of Operations
HLW/SF	Finland	Eurajoki	Crystalline rock	Licence pending	2020
HLW/SF	Sweden	Forsmark	Crystalline rock	Licence pending	2025
HLW/SF	Switzerland	3 potential sites	Opalinus clay	Siting regions identified	~2040
LILW-LL & HLW/SF	France	Region of Bure (URL)	Callovo-Oxfordian Clay	Siting region identified	2025

Forsmark, Sweden



Bure, France

The Trust Factor:
An Element of National Policy in NEA Member Countries



Source: Data from the fifth World Values Survey (2005 – 2008)
www.worldvaluessurvey.org

How to Build Trust:
A Key Challenge for HLW Disposal

NEA Forum on Stakeholder Confidence (FSC)

- Established in 2000 to analyse stakeholder interaction and public participation in decision-making
- Nine "country workshops" conducted thus far
- FSC has produced 14 reports, 11 plain language topical "flyers", 10 Workshop proceedings
- Key Publication 2014:
  - *Local Communities' Expectations and Demands on Monitoring and the Preservation of Records, Knowledge and Memory of a Deep Geologic Repository*

2012 Country Workshop, Czech Republic

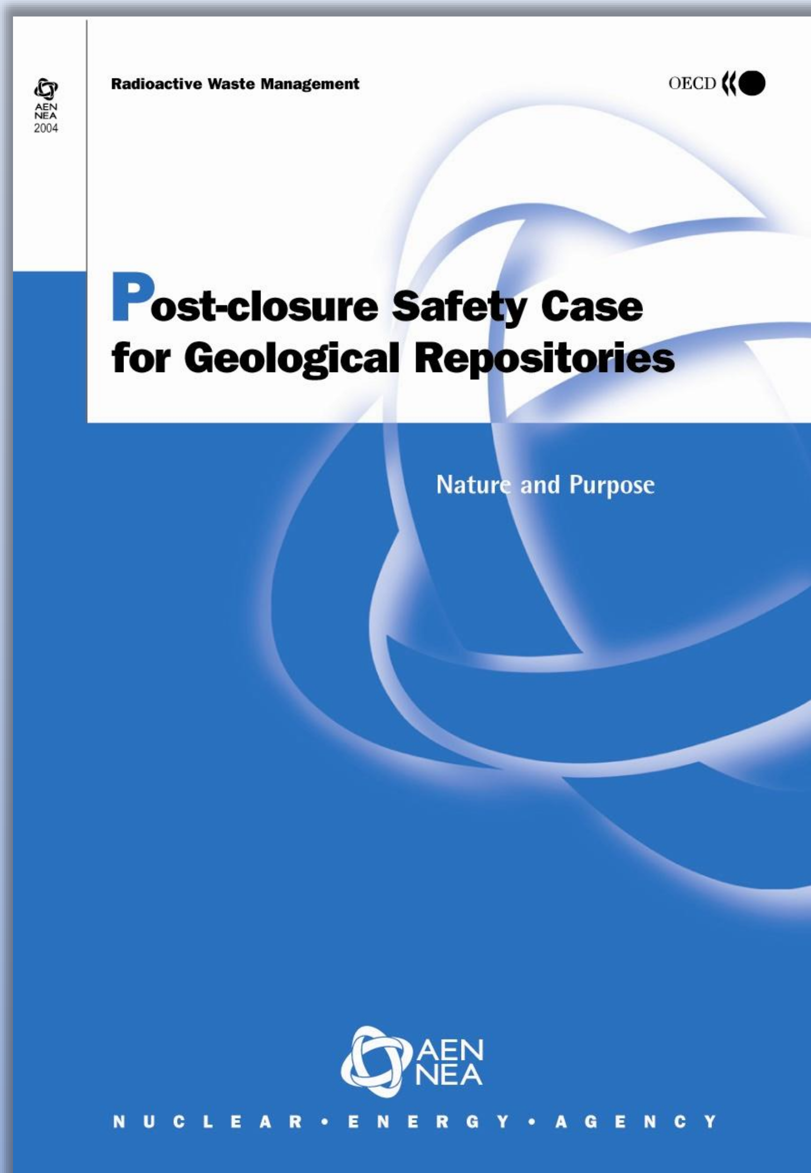
Main Principles:

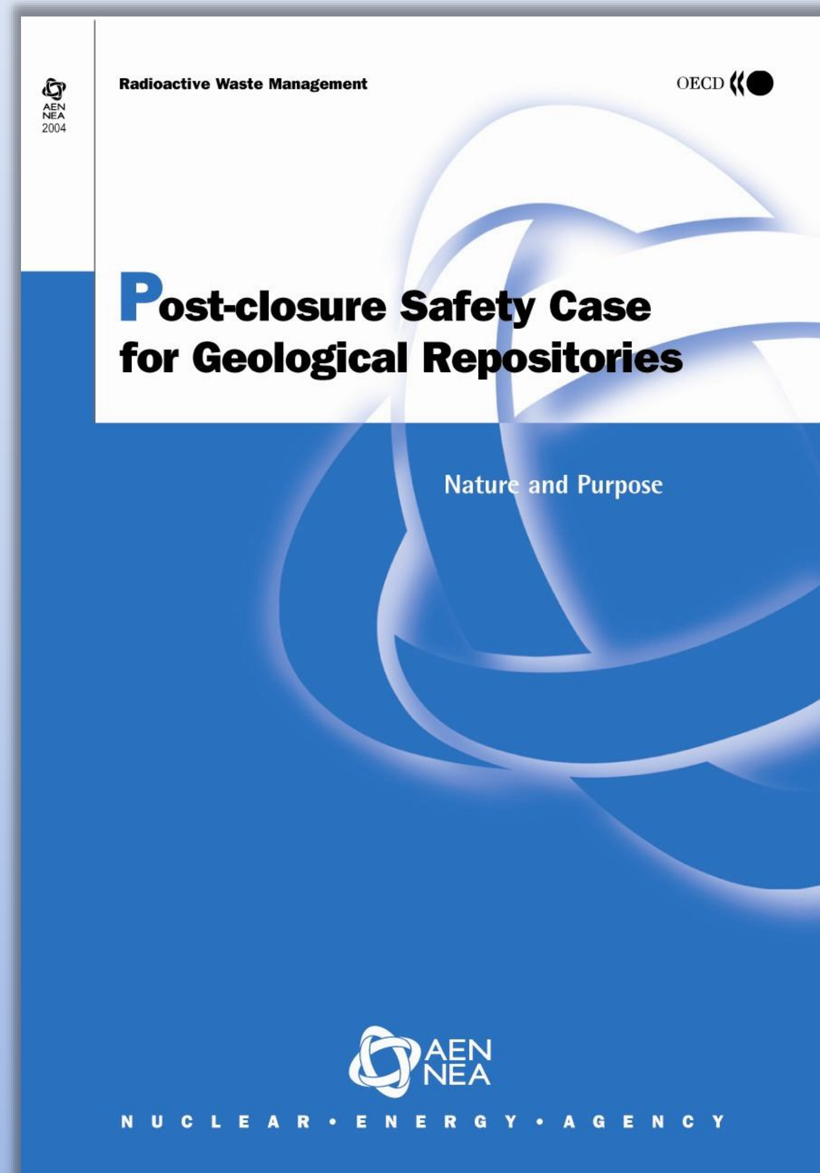
1. Transparency of the process
2. Stepwise decision making and reversibility
3. Partnership approach between all Stakeholders

The Safety Case:
A Global Standard

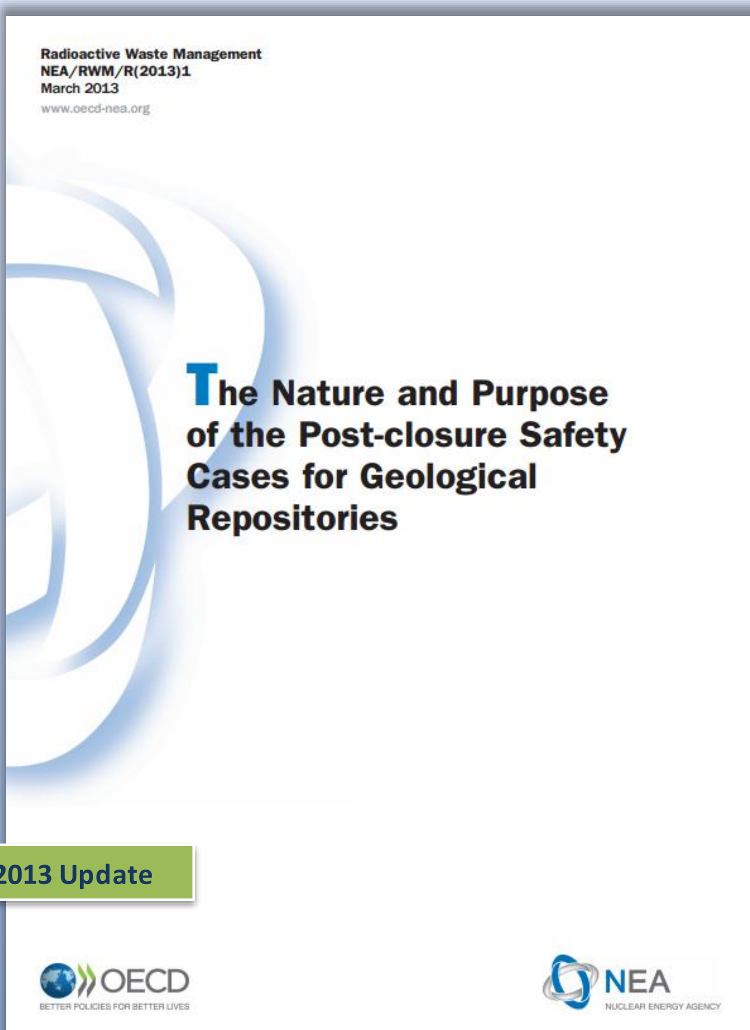
The safety case is a set of arguments and analyses used to justify the conclusion that a specific repository system will be safe.

It includes a presentation of evidence that all relevant regulatory safety criteria can be met.




AEN NEA 2004
Radioactive Waste Management
OECD
Post-closure Safety Case for Geological Repositories
Nature and Purpose
AEN NEA
NUCLEAR • ENERGY • AGENCY

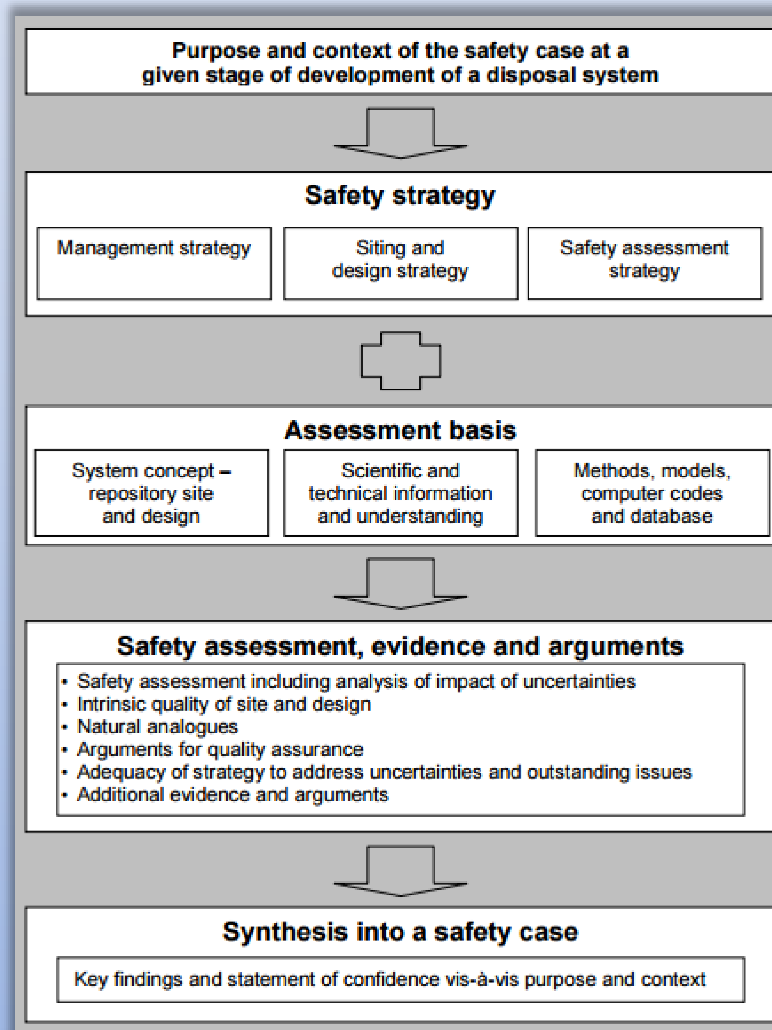
Key Components of the Safety Case


Radioactive Waste Management
NEA/RWM/R(2013)1
March 2013
www.oecd-nea.org

The Nature and Purpose of the Post-closure Safety Cases for Geological Repositories

OECD BETTER POLICIES FOR BETTER LIVES
NEA NUCLEAR ENERGY AGENCY

2013 Update



Regulating Long-term Safety of Geologic Disposal

- Actions and decisions taken today must consider generations in the long-term future.
- Setting a dose limit for the long-term future implies an ability to predict and control, but it's difficult to estimate health impacts thousands of years in the future.
- Limits and constraints in the long-term future have little value in terms of regulatory compliance
- Estimates of dose and risk are used as indicators for the long-term safety and to optimise the disposal concept.

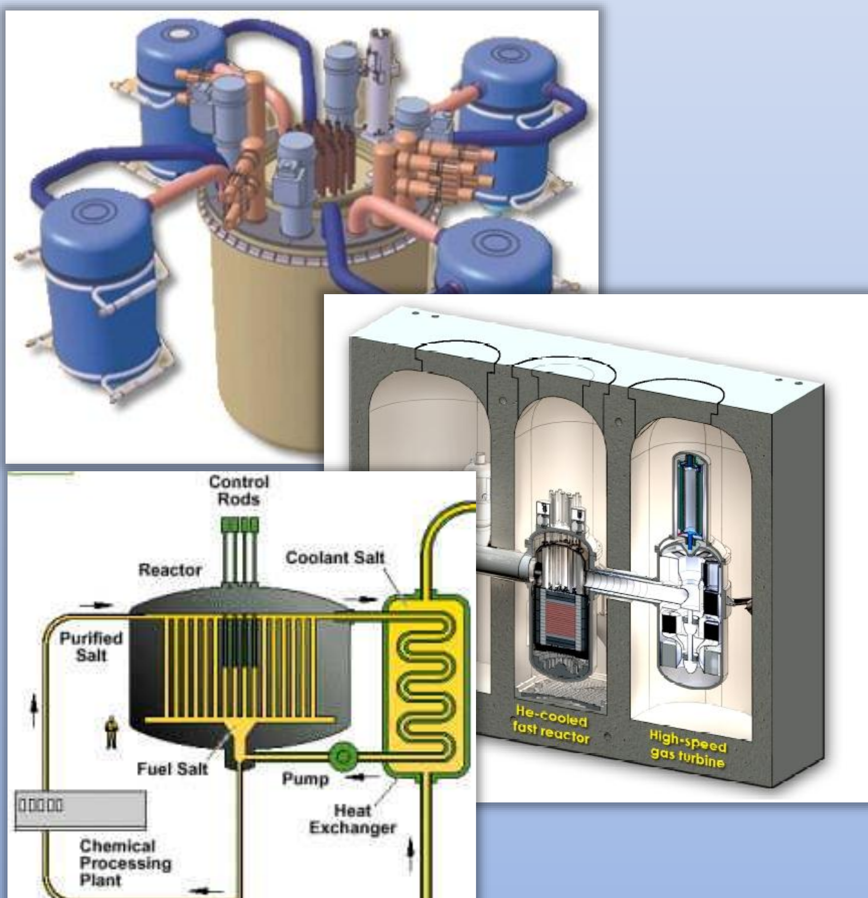
NEA Workshop: *Challenges to the Regulator in Siting, Licensing, Construction and Operation of Waste Repositories*

Helsinki, Finland, 7-11 September 2015

Facilitates the exchange of experiences and expectations between implementers and regulators

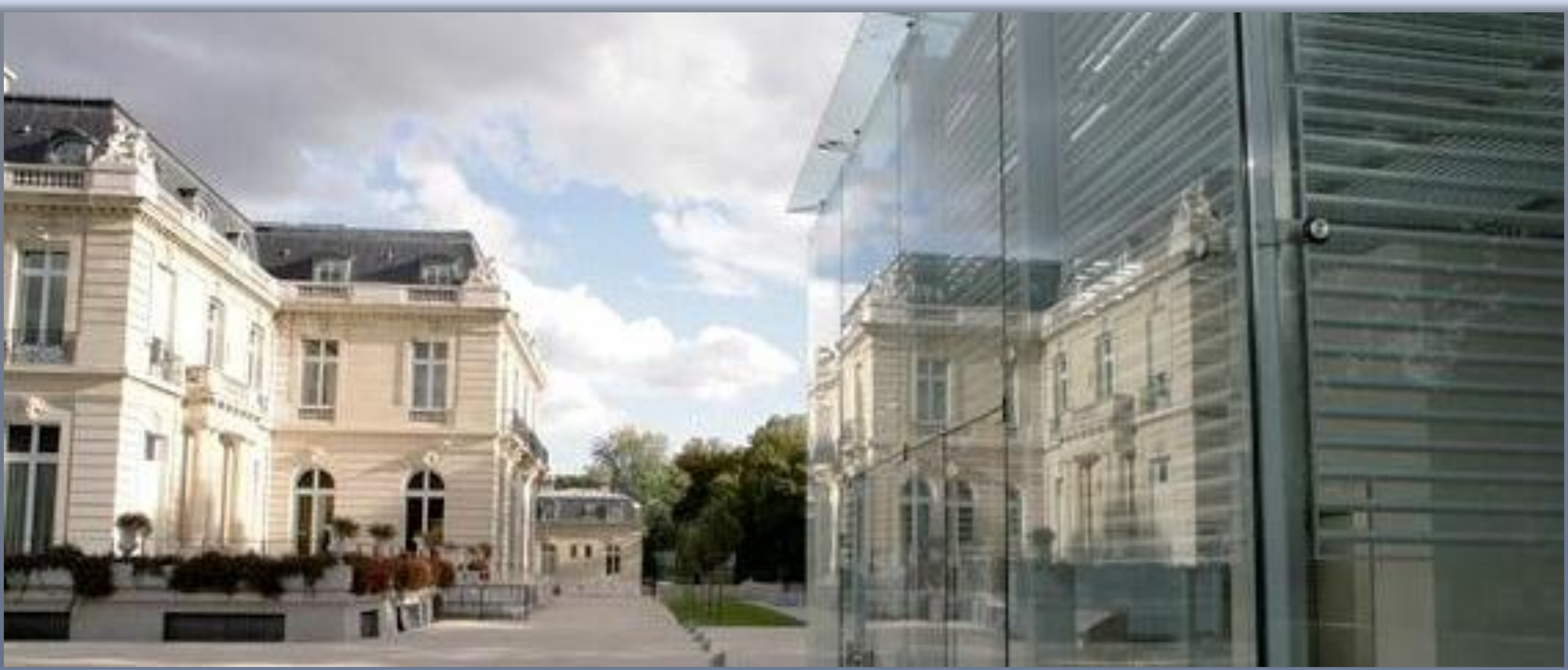
Presentations to be made by Finland, France, Switzerland, Canada, Belgium, Sweden, Korea, Hungary, Spain, UK and USA

« Nuclear Innovation 2050 – A Roadmap for the Future of Nuclear Energy Technology »



- What technologies will be needed in 10 years? 30 years? 50 years?
- What research and development is needed to make these technologies available?
- Is the global community doing the R&D needed to prepare for the future?

Thank you for your attention



More information @ www.oecd-nea.org

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