Looking Forward: *Nuclear Energy Issues and Opportunities*

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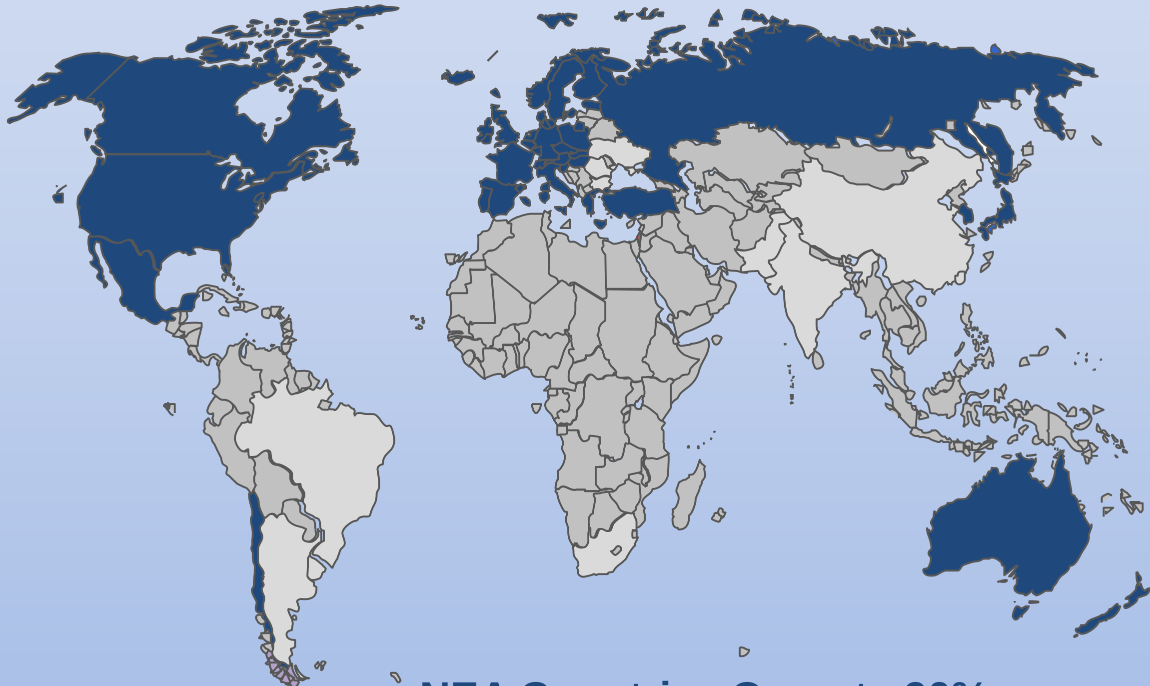
Director-General
Nuclear Energy Agency

2017 ISOE International Symposium
Fort Lauderdale, Florida
9 January 2017

NEA: Bringing Advanced Countries Together to Address Global Challenges

The Role of the NEA is to:

- Foster international co-operation to develop the scientific, technological and legal bases required for nuclear and radiological safety.
- Develop authoritative assessments and forge common understandings on key issues as input to government decisions on nuclear technology policy
- Conduct multinational research into challenging scientific and technological issues.

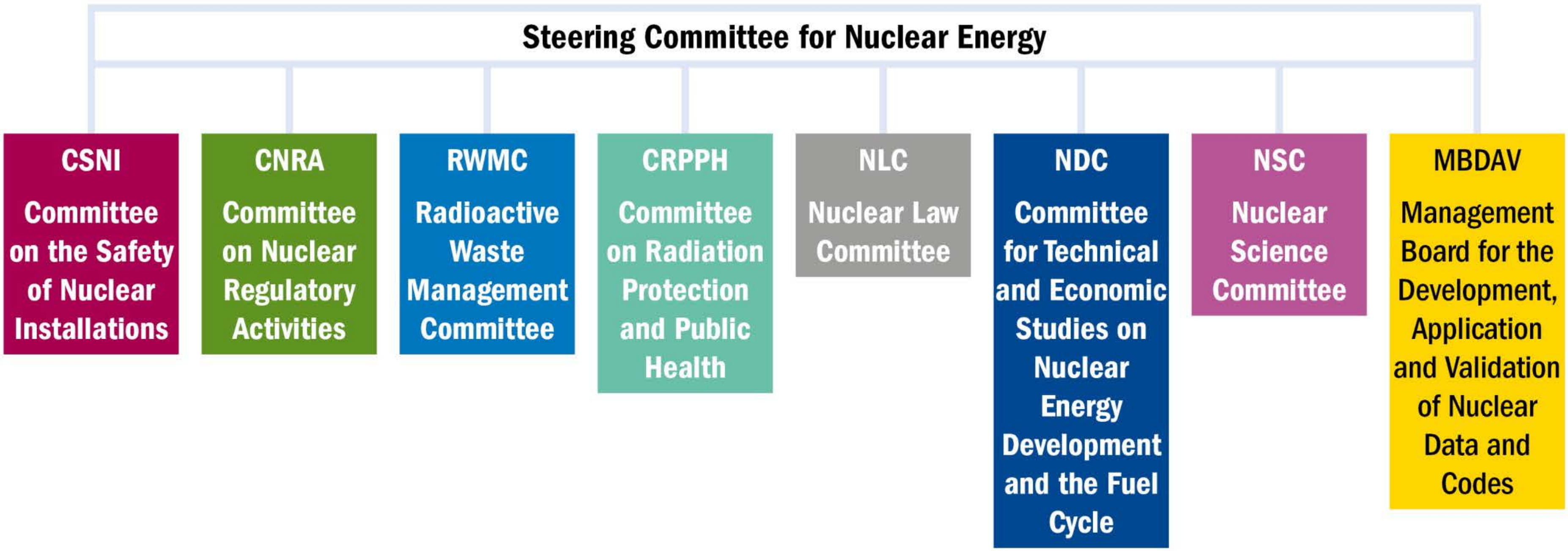


NEA Countries Operate 90% of the World's Installed Nuclear Capacity

The NEA: 31 Countries Seeking Excellence in Nuclear Safety, Technology, and Policy

- **31 member countries w/ and wo/nuclear technology + key partners (e.g., China)**
- **7 standing committees and 75 working parties and expert groups**
- **The NEA Data Bank - providing nuclear data, code, and verification services**
- **21 international joint projects (e.g., the Halden Reactor Project in Norway)**

NEA Standing Technical Committees



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 to promote international collaboration.

Committee on Radiation Protection and Public Health (CRPPH)

Chair: Mr Mike Boyd, USA
Lead Staff: Dr Ted Lazo

Joint Undertakings

Information System on Occupational Exposure (ISOE)

- Collect and analyse occupational exposure data from NPPs,
- Share exposure management experience

Working Group on Data Analysis (WGDA)

- Analyse ISOE data for trends

Working Group on Radiological Protection Aspects of Decommissioning Activities at Nuclear Power Plants (WGDECOM)

- Occupational exposure management experience and good practice for units in decommissioning

Working Party on Nuclear Emergency Matters (WPNEM)

Develop and implement CRPPH programmes in emergency management

International Nuclear Emergency Exercises (INEX-5)

Develop, implement and analyse INEX exercises

Expert Group on Lessons Learnt from Non-Nuclear Events (EGNE)

Draw experience from chemical and natural disaster

Expert Group on the Implications of Recommendations (EGIR)

- Regulatory input to draft ICRP and IAEA documents

Expert Group on Exclusion from Paris Convention (EGPC)

- Development of RP criteria for exclusion from the Convention

Expert Group on the Radiological Protection Aspects of the Fukushima Accident (EGRPF)

- CRPPH Programmes on Fukushima

Expert Group on Legacy Management (EGLM)

- Develop practical recommendations for regulators

Major Int'l Workshops

Workshop on Post-Accident Food Safety Science

(Fukushima, JAPAN, 8-10 November 2016)

Workshop on Management of Non-Nuclear Waste

(Legnaro, ITALY, May 2017)

New Activities Under Development

International School of Radiological Protection (ISRP)

- **Sharing Social Media Experience**
- **Evacuation Decisions**
- **Building Human capital in RP**

NEA and ISOE: A Success Story

- **Since 1993 ISOE has produced 34 technical reports, including landmark publications such as *Occupational Radiation Protection in Severe Accident Management* (2014)**
- **ISOE has many significant achievements, including:**
  - Establishing an effective platform for exchanging data, good practices and experience in the area of occupational exposure reduction at NPPs;
  - Continuous improvement of the occupational exposure database; and
  - Development of the ISOE Network website providing one-stop access and retrieval of ISOE data and information.

Major NEA Separately Funded Activities

NEA 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 involving both developed 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., ISOE).
- **Halden Reactor Project** (fuels and materials, human factors research, etc.)

Major NEA Separately Funded Activities

Secretariat-Serviced Organisations

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21 Major Joint Projects

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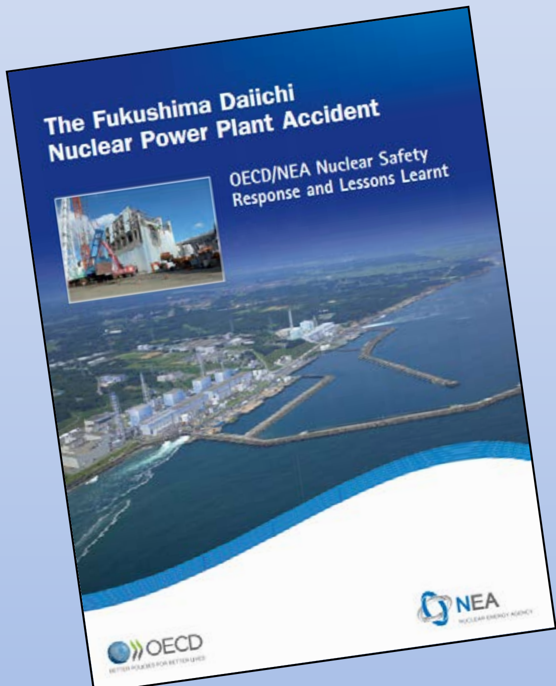
A Current Joint Project

BSAF: *The Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Plant* – applying the scientific information gained from the Fukushima Daiichi accident to test and improve nuclear safety analysis tools and to use those tools to support cleanup of the damaged Fukushima reactor cores.

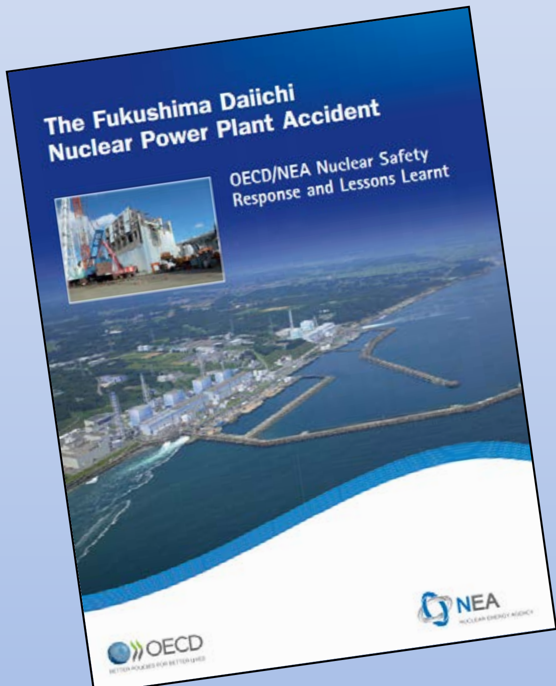
Fukushima Daiichi:
Learning the Lessons and Moving Forward

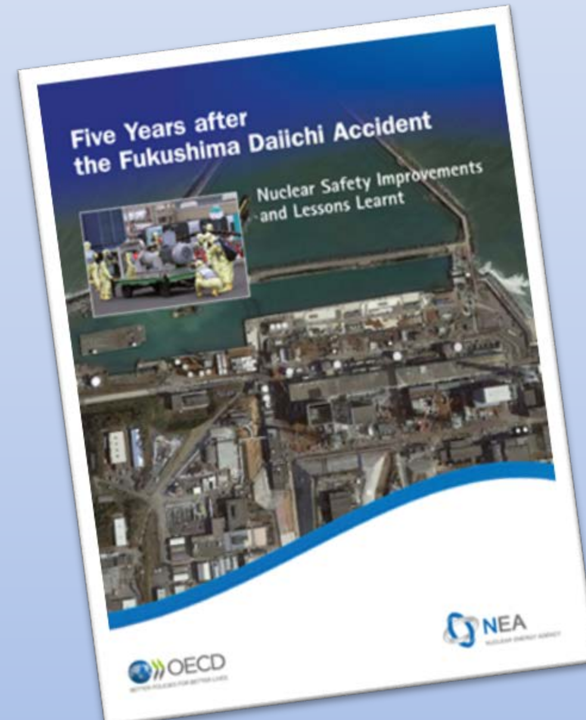
Fukushima Daiichi:
Key NEA Conclusions After the Accident



- NEA member countries determined that their reactors were **safe to continue operation**.
- New safety enhancements related to **extreme events** and severe accidents should be implemented.
- The Fukushima Daiichi NPP accident revealed **significant human, organisational and cultural challenges.**

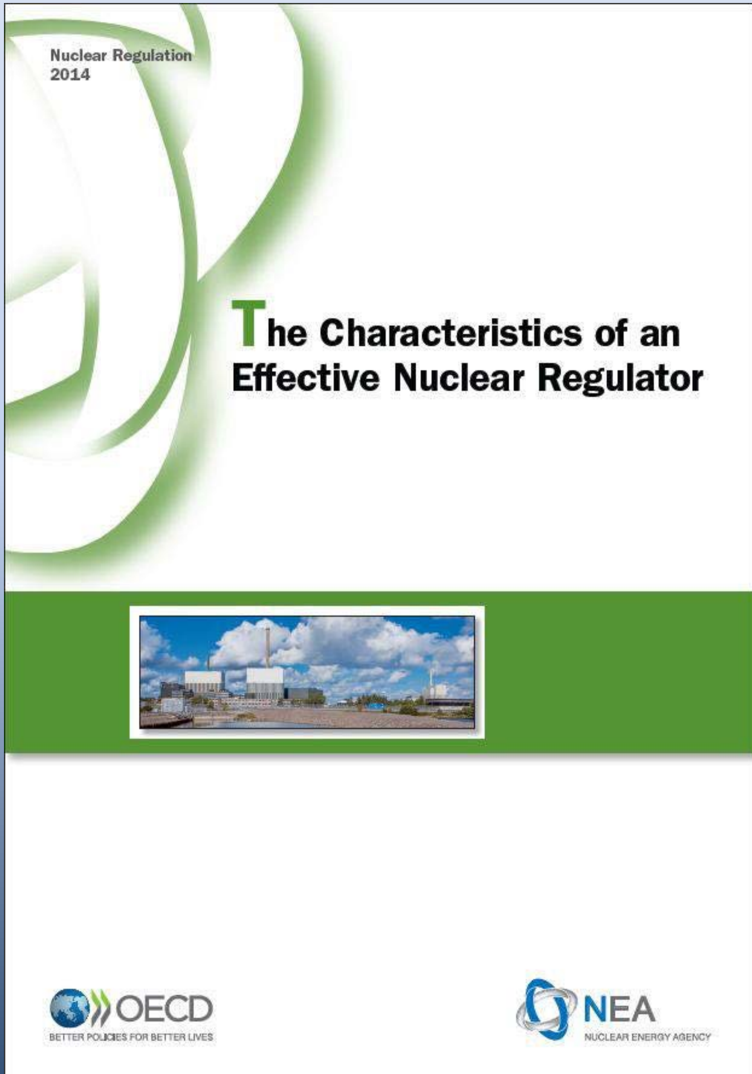
Fukushima Daiichi:
Five Years Later





Examples of Safety Enhancements

- External hazard reassessments
- Reinforcing flood protection measures
- Mobile systems to cool cores and SFPs
- More robust electrical power supplies
- Portable electric power supplies and enhanced battery capacity
- Improved training for severe accident management
- Filtered vent and filtering strategies
- Consideration of safety culture characteristics and organisational factors in decision making processes



The Characteristics of an Effective Nuclear Regulator

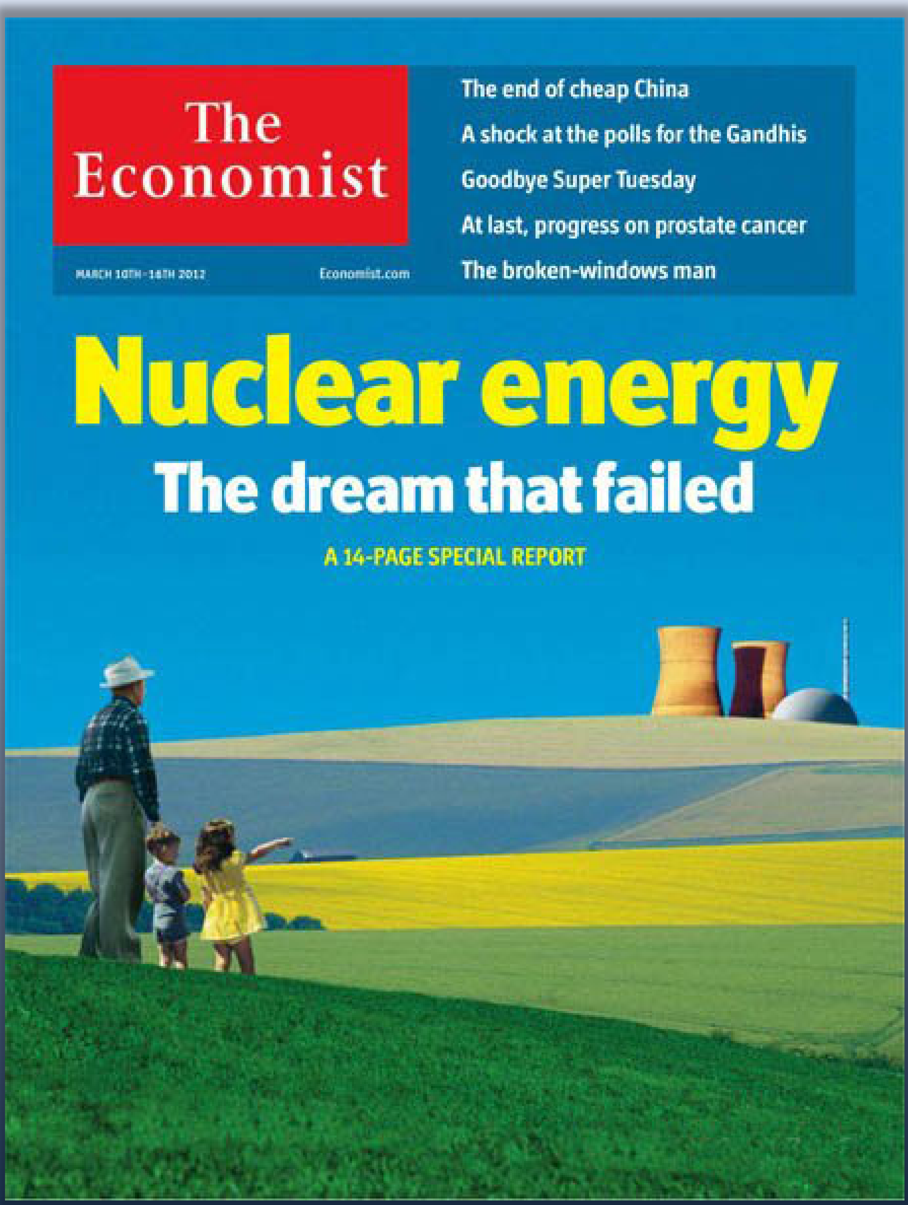
NEA Regulatory Guidance Booklets
Volume 16, 2014, NEA/CNRA/R(2014)3

Fukushima Stakeholder Dialogues
A Good Model for Engagement

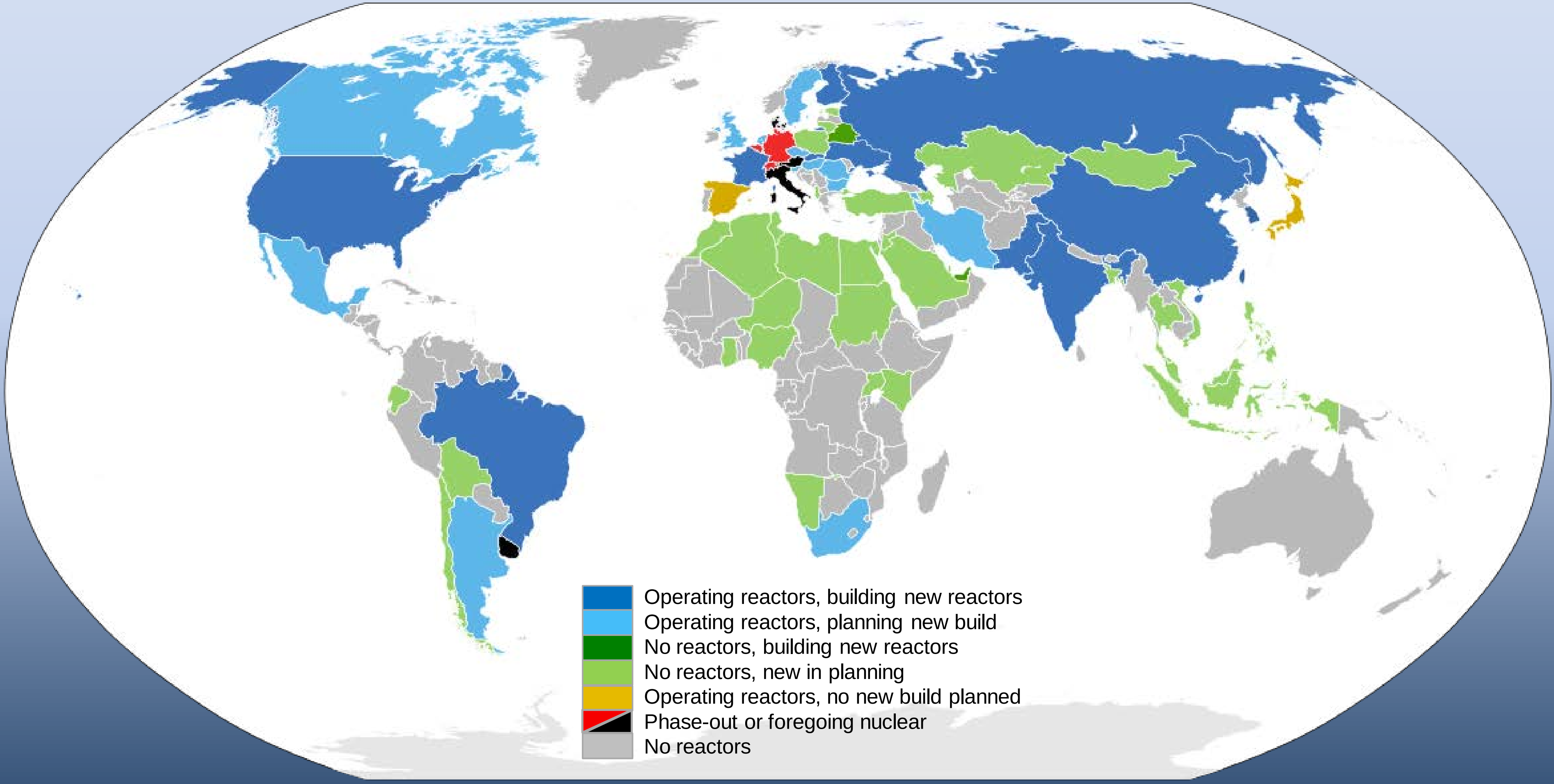
NEA supported 12 dialogue sessions organised by ICRP between 2011 and 2015, with stakeholders from affected areas of Fukushima Prefecture

- Addressed many stakeholder concerns regarding radiological safety
- Reflected desire of residents to regain control of their lives and to return to normality
- Important message from those who evacuated and have not returned: "We may return, but only if the site is safe."


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


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

Global View of Nuclear Power Today



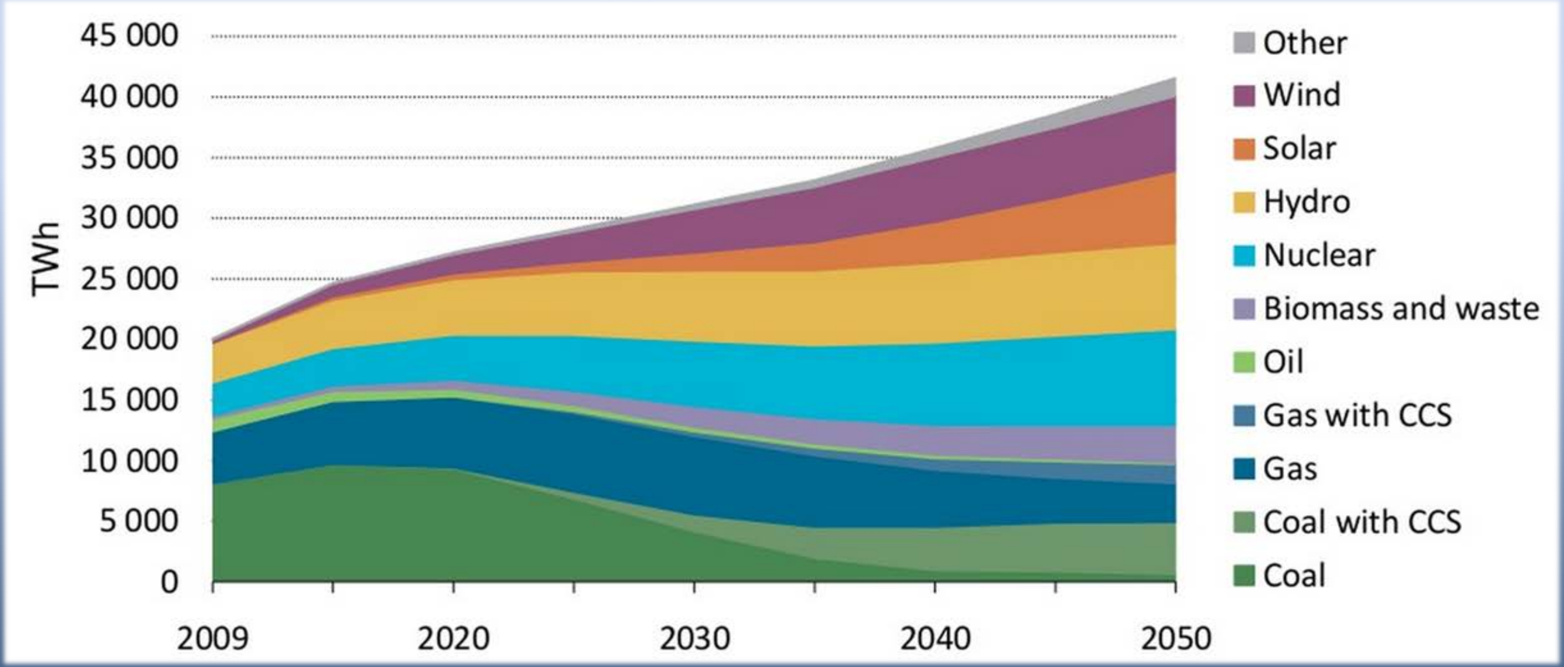
Source data: World Nuclear Association
Update 2015

Nuclear Power Plants under Construction (August 2016)

Location	No. of units	Net capacity (MW)
Argentina	1	25
Belarus	2	2 218
Brazil	1	1 245
China	20	20 500
Finland	1	1 600
France	1	1 630
India	5	2 990
Japan	2	2 650
Korea	3	4 020
Pakistan	3	1 644
Russia	7	5 468
Slovak Republic	2	880
Ukraine	2	1 900
United Arab Emirates	4	5 380
United States	4	4 468
***Other:* Chinese Taipei**	2	2 600
TOTAL:	**60**	**59 218**

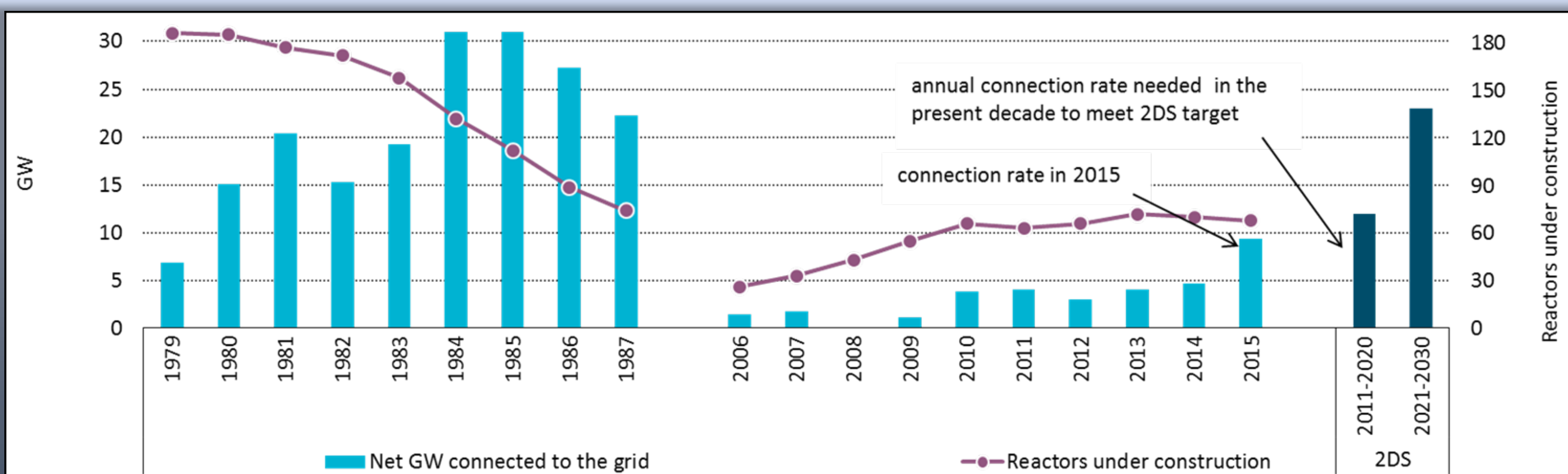
Source: WNA

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



Source: IEA

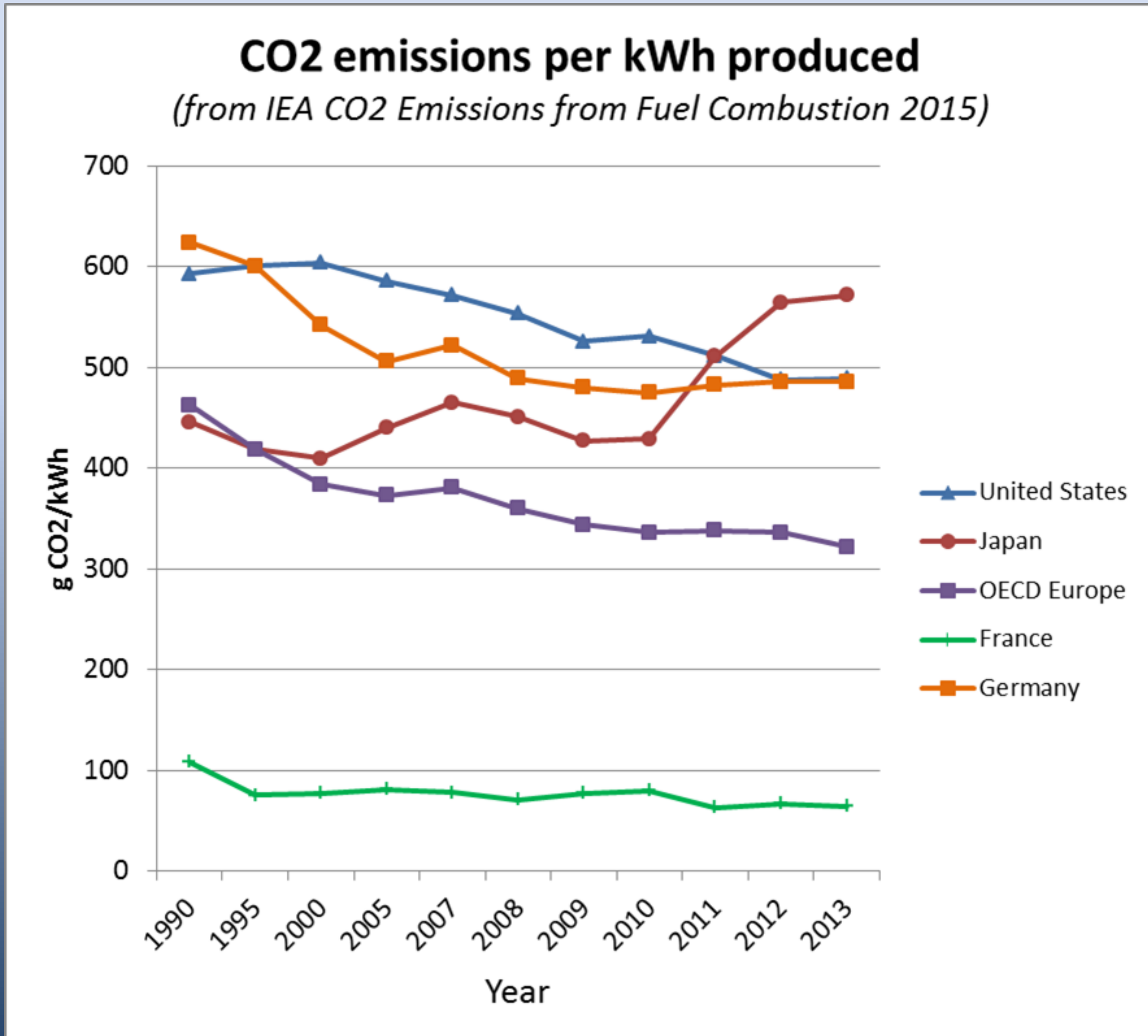
At Least 12 GWe/Year of New Nuclear Would Be Needed to Meet 2°C Scenario



2015: 8 construction starts, 8.5 GW net connected

Electricity Mix and Carbon Footprint

(g CO_2 per kWh produced)



<u>Main trends:</u>

- US: coal to gas switch, ↗ RES
- Japan: nuclear ↘↘↘, fossil ↗↗↗
- France: fossil ↘, RES ↗
- Germany: nuclear ↘↘, RES ↗↗

<u>Source:</u> IEA, data

Current Headwinds

1) Economic pressures are forcing some plants to shut down before the end of their licences.

2) Operational costs have risen significantly, particularly as post-Fukushima regulatory changes are implemented.

3) Some countries have suspended their new build programs in the face of large construction costs and problematic experiences in other countries.

4) Globally and in the US, the regulatory, economic, and political landscapes are evolving and uncertain.

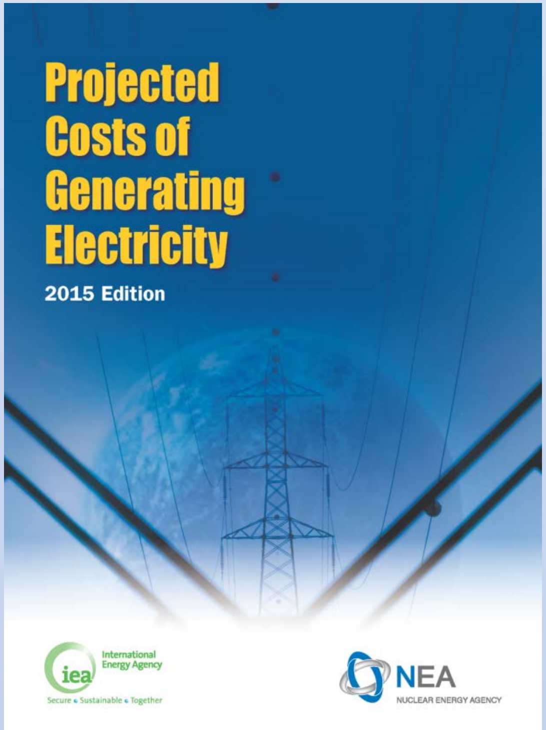
"Projected Costs of Generating Electricity" *Key Conclusions*

1) Financing:

- Electricity price risk introduces bias against high-capital-cost, low-carbon technologies.
- In new build, shareholders not bondholders are most exposed to project risks.

2) Project Management:

- Nuclear industry should advance convergence and standardisation of engineering codes and quality standards.
- Explicit change management regimes are essential.
- "Soft issues" such as project leadership, team building, experience, incentives and trust are very important to large projects and require investment.



APT

ALIGNING POLICIES FOR THE TRANSITION TO A LOW-CARBON ECONOMY

"In May 2014, ministers and representatives of OECD member countries and the European Union gathered at the Ministerial Council Meeting invited the OECD to work with the International Energy Agency (IEA), the Nuclear Energy Agency (NEA) and the International Transport Forum (ITF) "to continue to support the UNFCCC negotiations and to examine how to better align policies across different areas for a successful economic transition of all countries to sustainable low-carbon and climate-resilient economies and report to the 2015 OECD Ministerial Council Meeting (3-5 June)."

A Major Challenge:
Market Design and Failures

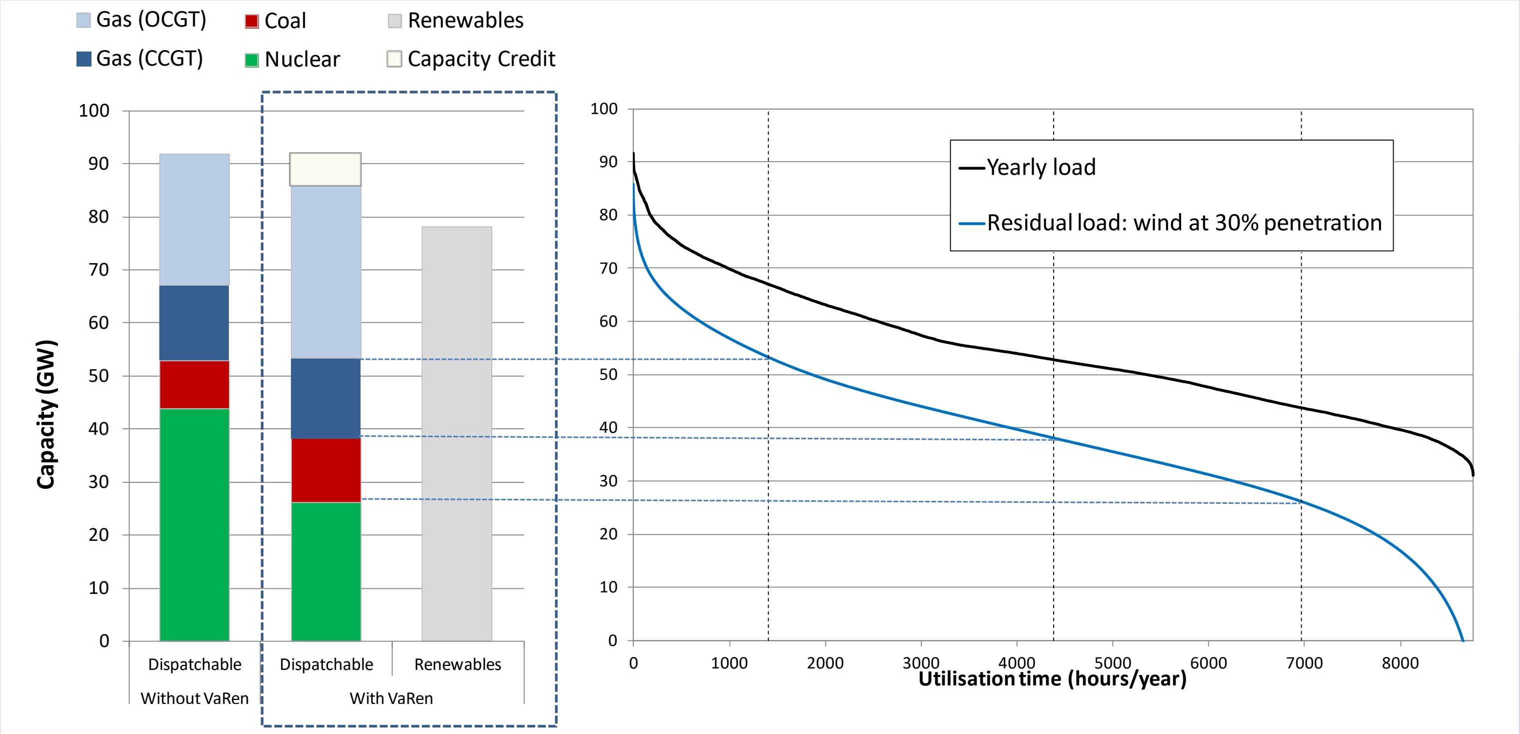
"Current designs of wholesale electricity markets in many OECD countries are not strategically aligned with the low-carbon transition"

APT Report – June 2015

Electricity market design operating in most OECD countries brings challenges for low-carbon investment:

- Entry of renewables depresses average electricity prices
- Electricity price risk due to scarcity pricing affects real value of revenues and profits
- CO_2 prices are not providing sufficient incentives for low carbon investments
- Out of market financing of variable renewables such as wind and solar creates overcapacity but contributes little to security of supply due to variability and absence of dispatchability

VREs Restructure the Residual Mix with Uncertain Impacts on CO_2 Emissions



- Due to lower load hours, dispatchable technologies with high fixed costs (e.g., nuclear) will be displaced by technologies with low fixed costs (e.g., gas).
- The resulting system may well become **more carbon-intensive** with uncertain impacts on overall emissions as well as **more expensive due to system costs.**

Source: NEA

2015 NEA/IEA Technology Roadmap

What Are the Barriers to Large Global Expansion?

- **Distortions and failures in electricity markets that impact financial competitiveness of baseload plants**
- **Persistent questions about long-term operation of current plants and constructability of Gen III/Gen III+ plants**
- **Unanswered questions about technology, cost, and regulatory issues regarding SMRs, Gen IV reactors, and other advanced technologies**
- **In some countries, public acceptance concerns about safety in the aftermath of the Fukushima accident**
- **Continuing international concerns about non-proliferation associated with expanded use of civilian nuclear power**
- **Ongoing challenges in many countries regarding long-term high level waste storage and disposal**

Public Views of Nuclear Waste

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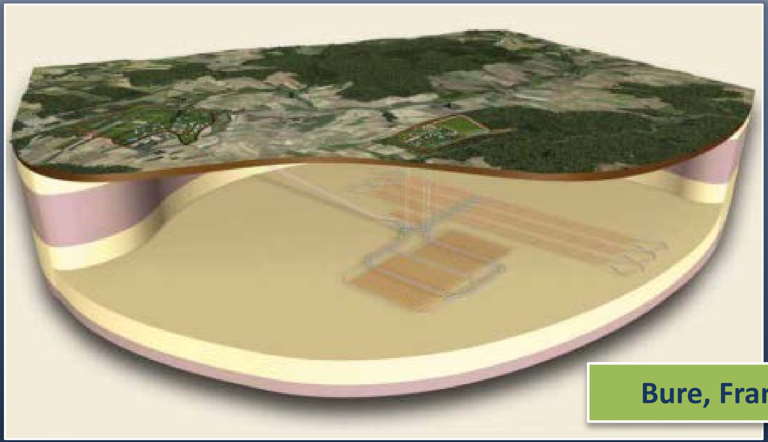
Global Progress in HLW Disposition

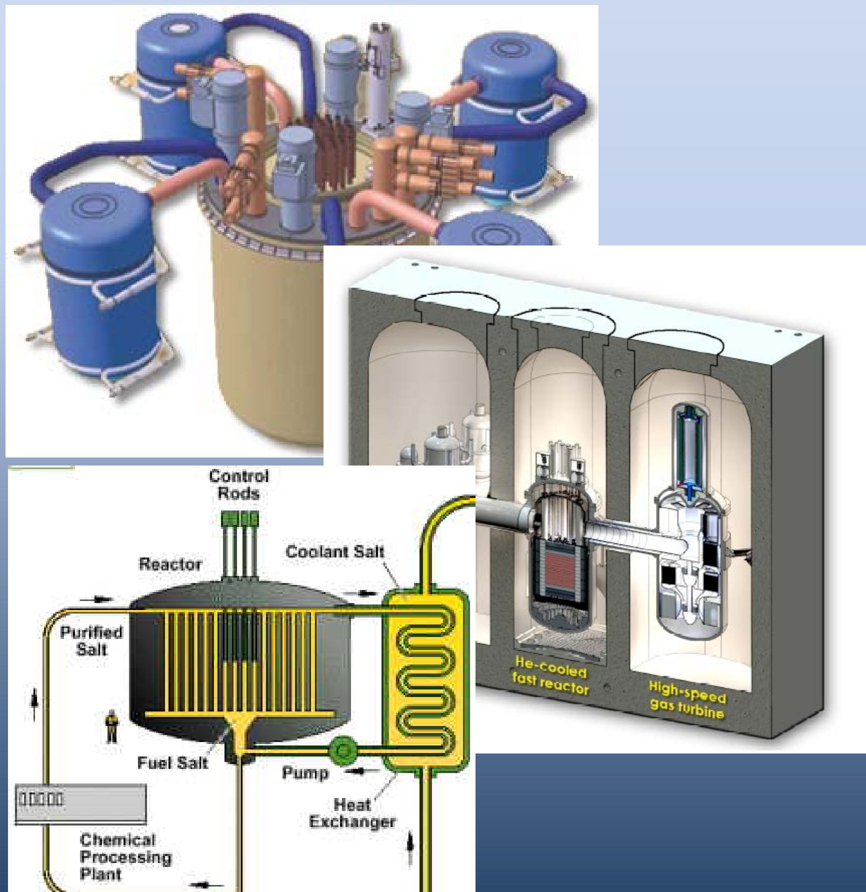
Waste type	Country	Location	Formation	Status	Projected Start of Operations
HLW/SF	Finland	Eurajoki	Crystalline rock	Licence pending	2020
HLW/SF	Sweden	Forsmark	Crystalline rock	Licence pending	2025
HLW/SF	Switzerland	3 potential sites	Opalinus clay	Siting regions identified	~2040
LILW-LL & HLW/SF	France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

Forsmark, Sweden



Bure, France

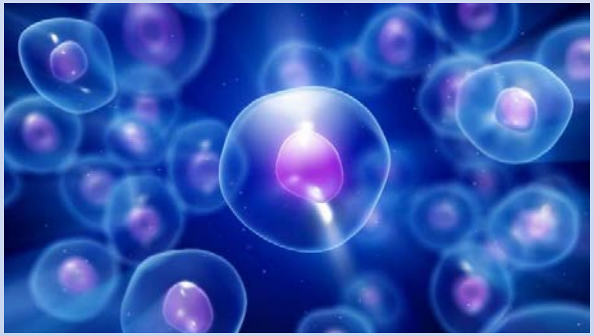
Nuclear Innovation 2050:
Pursuing Global Agreement on the Nuclear R&D Needs for the Future



- What technologies will be needed in 10 years? 30 years? 50 years?
- What R&D is needed to make these technologies available?
- Is the global community doing the R&D needed to prepare for the future?
- Can we cooperate to do more?

There is More to be Done in RP Science

- **Identifying the biological pathway(s) from cancerous cells to healthy cells**
- **Explaining of how radiation initiates or accelerates the process in which cells becoming cancerous**
- **Determining whether the effects of chronic exposure differ from acute exposure**
- **Finding the bio-markers for radiation-induced cancer**
- **Determining whether there is a threshold below which there is no risk of radiation-induced cancer**


NEA and ISOE: Looking Forward

- **NEA encourages ISOE to:**
  - continue to explore approaches to maintain worker doses ALARA, while considering, as appropriate, economics;
  - support the extension of the Programme to newcomer countries;
  - give attention to further developing new analytical tools;
  - develop collaborative efforts with other appropriate networks; and
  - open doors to new participants, specifically those involved in decommissioning activities.

Thank you for your attention

More information @ www.oecd-nea.org

All NEA reports are available for download free of charge.

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