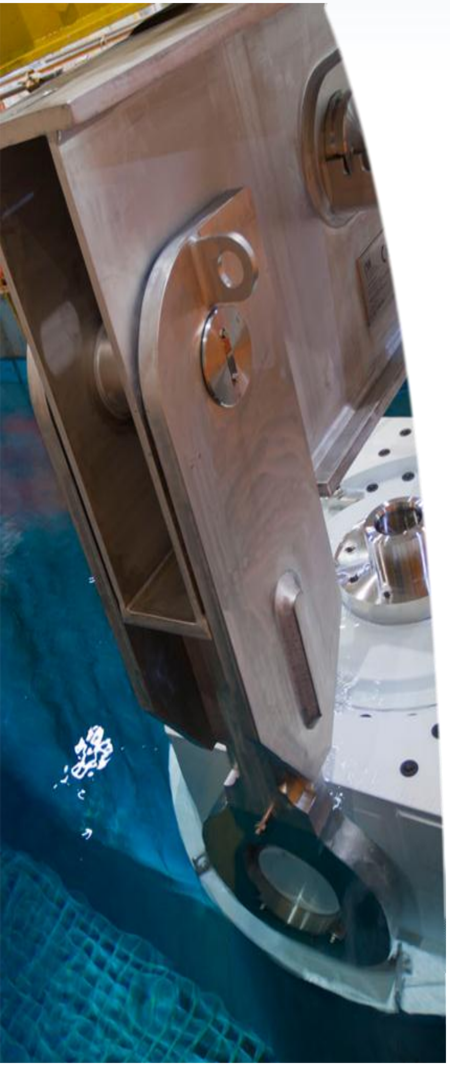
Il quadro e le opportunità di decommissioning oggi e nei prossimi anni

Genova, 15 Gennaio 2014

Decommissioning: what does it really mean?



The term **decommissioning** is used to describe all the management and technical actions associated with ceasing operation of a nuclear licensed installation and its subsequent dismantling to facilitate its removal from regulatory control (de-licensing)

These actions involve decontamination of structures and components, dismantling of components and demolition of buildings, remediation of any contaminated ground and removal of the resulting waste

Decommissioning activities are concluded when the site reaches a condition (end state) pre-established that may be "green field" or "brown field"

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Decommissioning has a long story

Decommissioning is an industrial activity that has been proved to be mature by the several project successfully completed

R-I research reactor, Idaho, USA
First decommissioning: 1964

Shippingport, Pennsylvania, USA
First commercial nuclear plant decommissioned: 1984-1989

Fuel Manufacturing Facility at Winfrith, UK
The first green field decommissioning of a major plutonium facility in UK: 1996 - 1999

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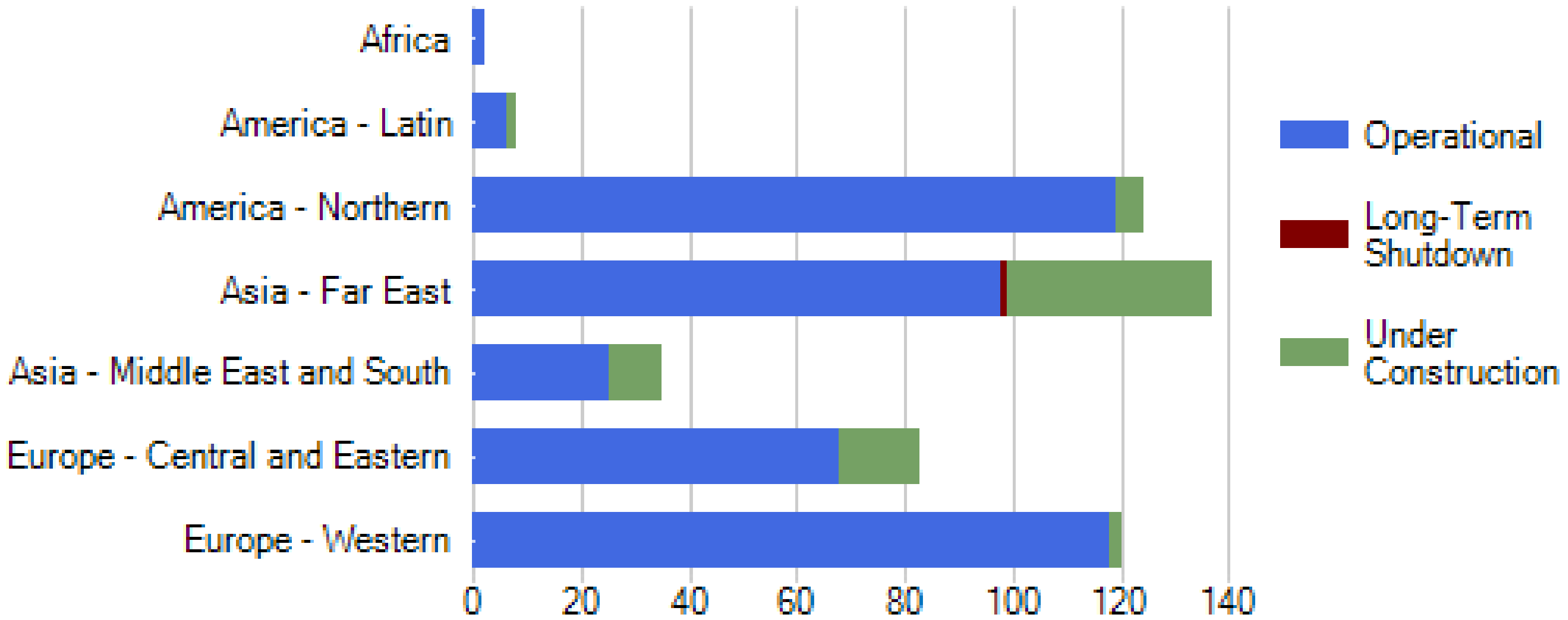
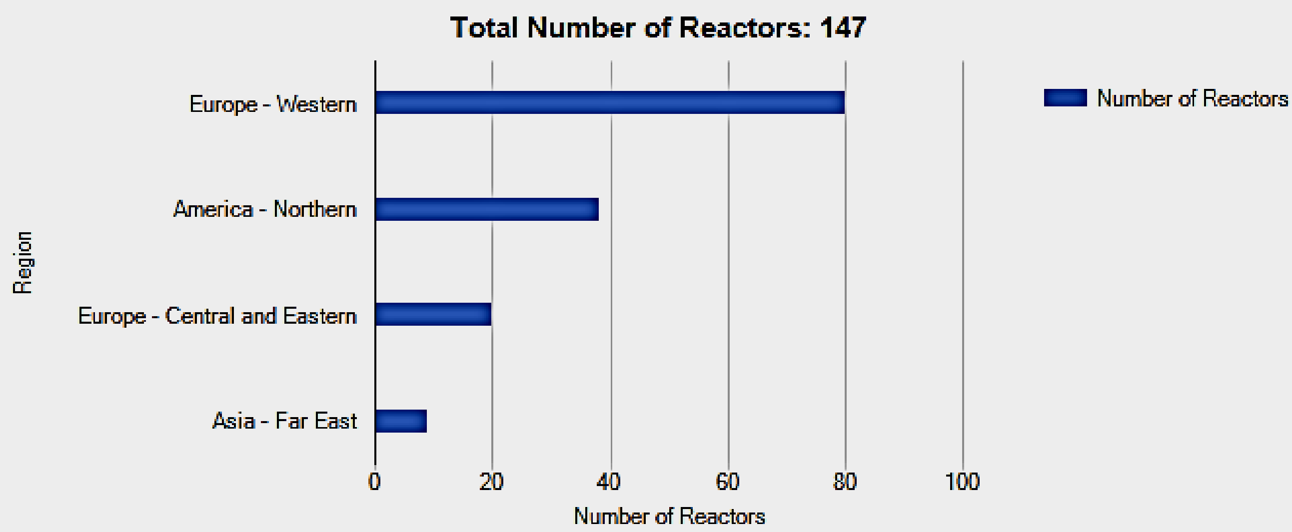
Nuclear Power in the world (IAEA 12/2013)



436	NUCLEAR POWER REACTORS IN OPERATION
1	NUCLEAR POWER REACTORS IN LONG-TERM SHUTDOWN
72	NUCLEAR POWER REACTORS UNDER CONSTRUCTION

Nuclear Power in the world (IAEA 12/2013)

PERMANENT SHUTDOWN REACTORS



Region	Number of Reactors	Total Net Electrical Capacity [MW]
America - Northern	38	15483
Asia - Far East	9	4337
Europe - Central and Eastern	20	9640
Europe - Western	80	25640
Total	**147**	**55100**

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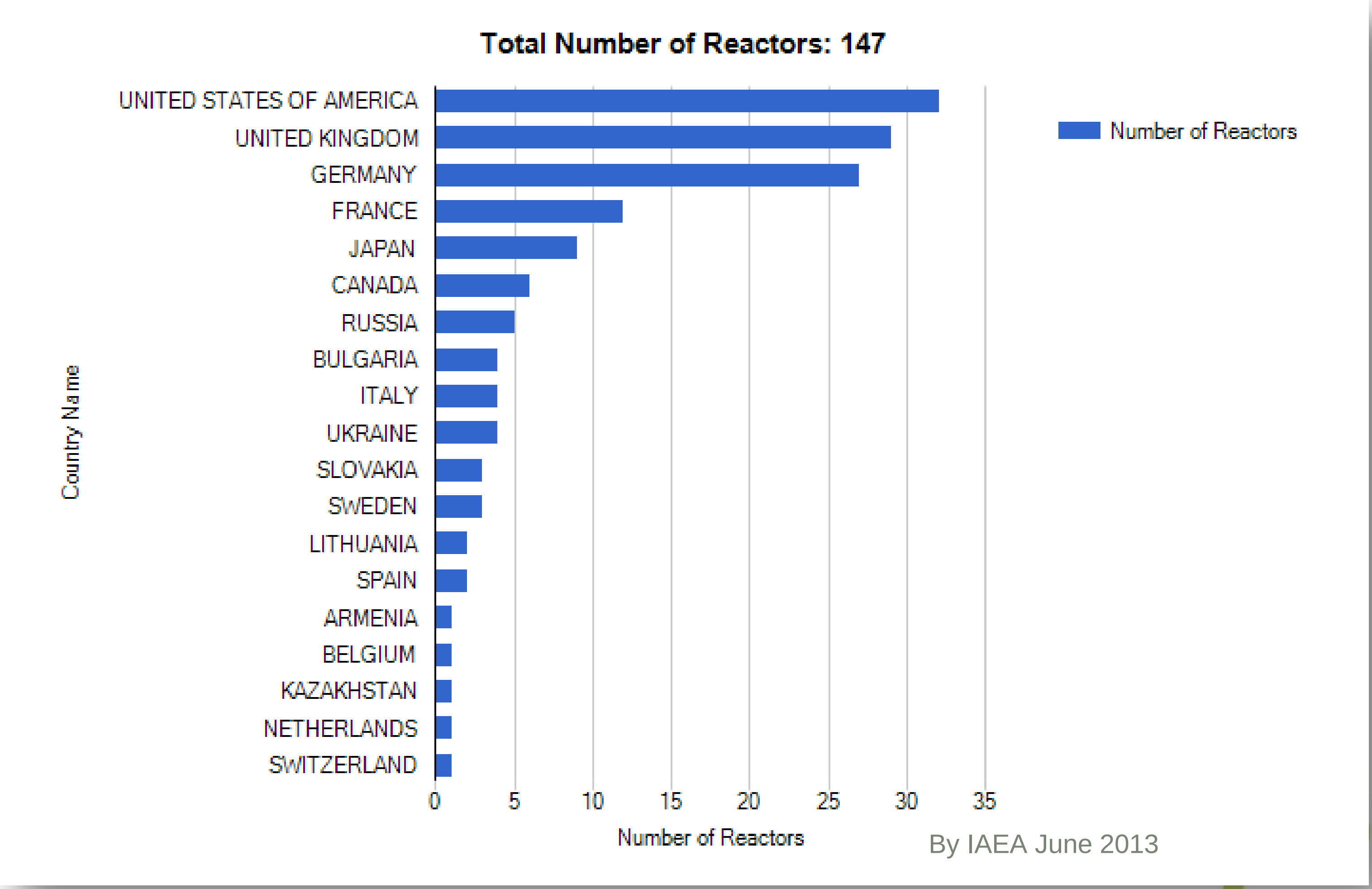
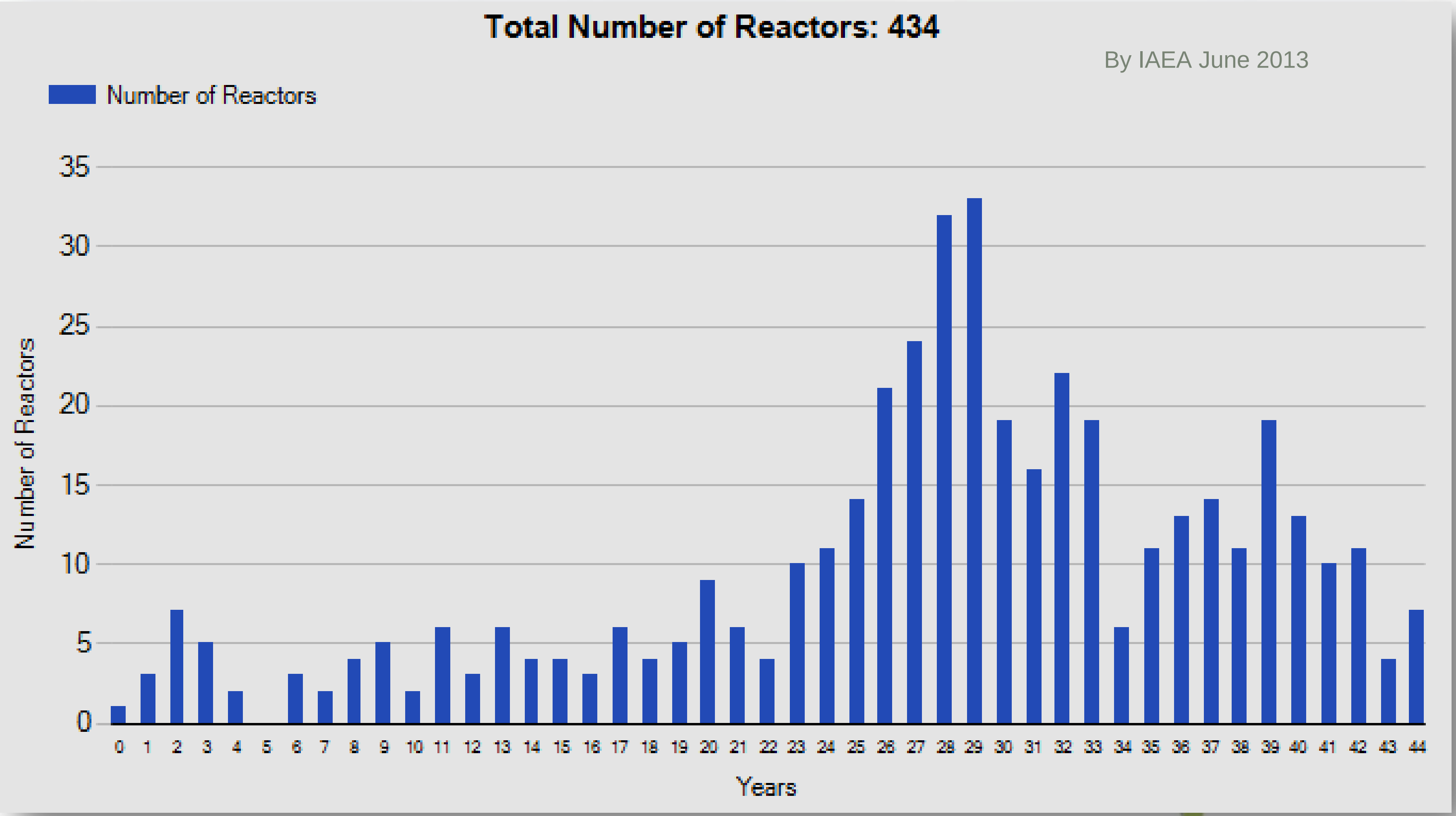
Worldwide NPP's in decommissioning by country



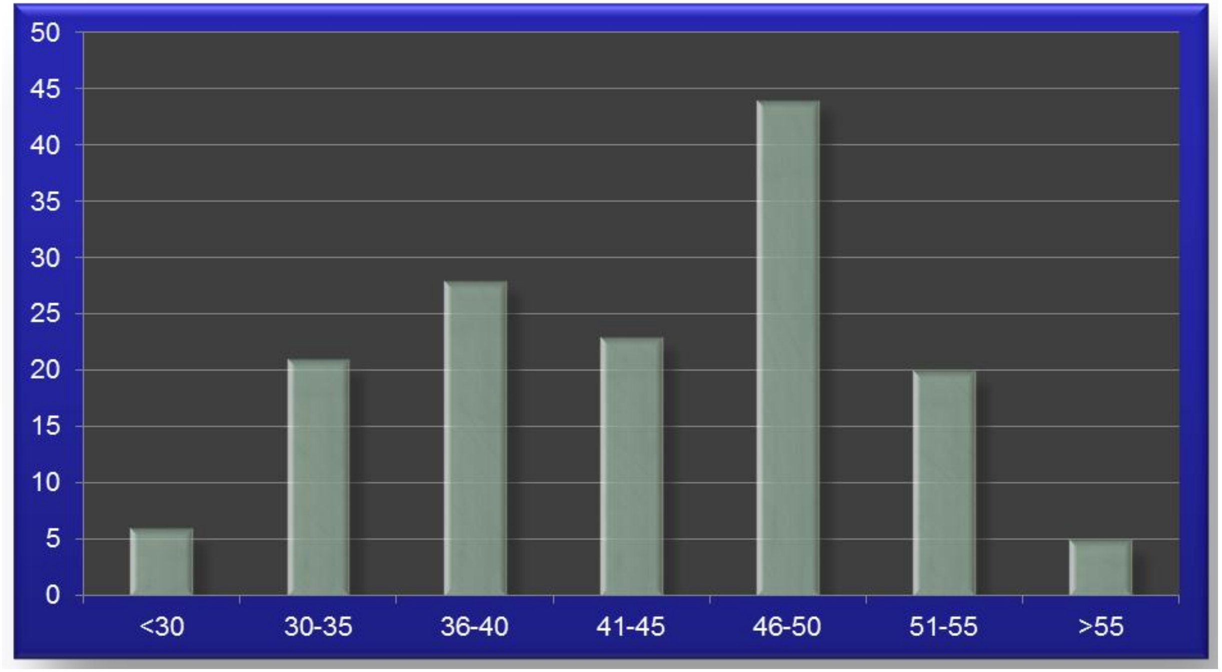
By IAEA June 2013

A look into the future - Age of operating reactors



Decommissioning by age

The hystogram below shows the age of reactors who entered so far in decommissioning



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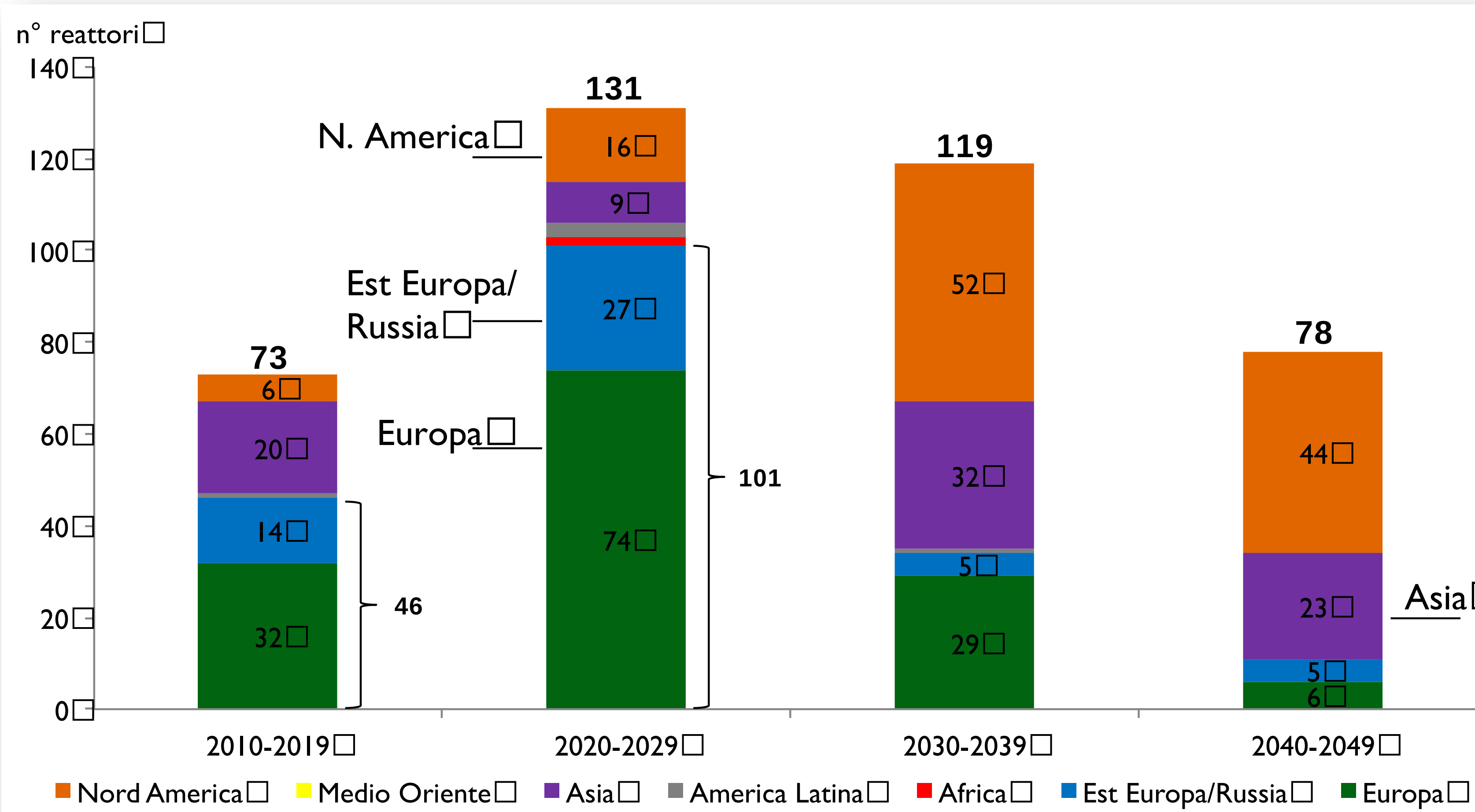
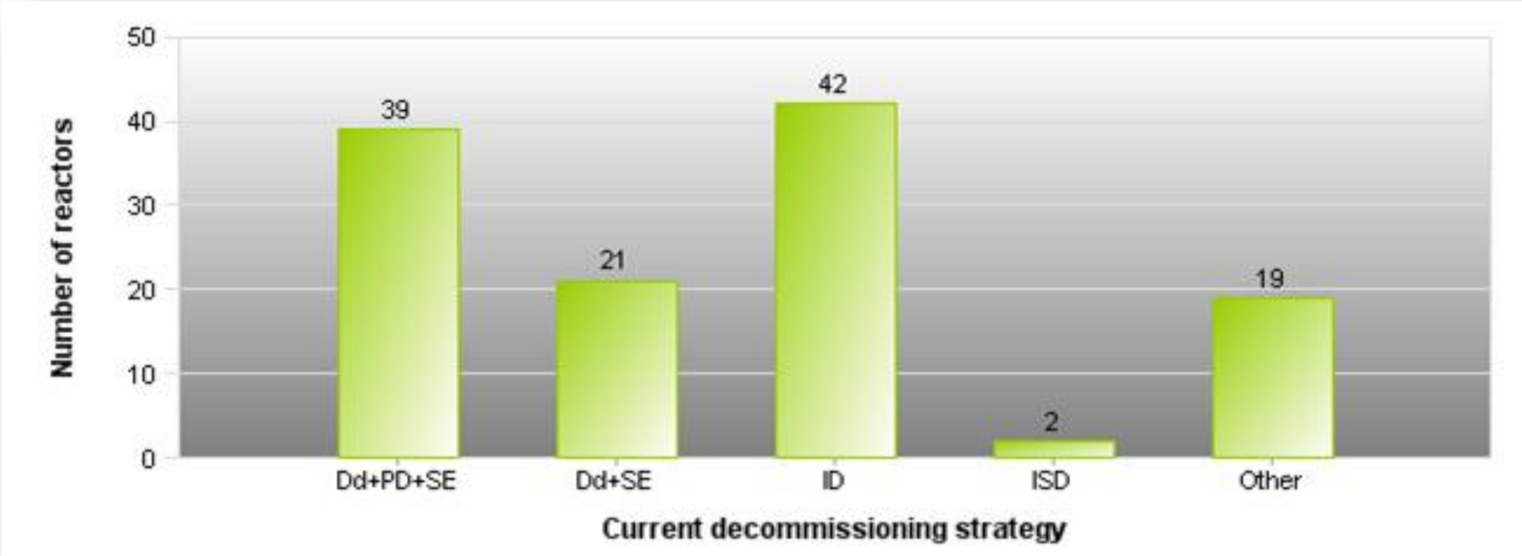
Projections of additional NPP's in decomm. by region



Decommissioning strategies today

By IAEA June 2013



Strategy	Description
Dd+PD+SE	Deferred dismantling, including partial dismantling and placing remaining radiological areas into safe enclosure
Dd+SE	Deferred dismantling, placing all radiological areas into safe enclosure
ID	Immediate dismantling and removal of all radioactive materials
ISD	In situ disposal, involving encapsulation of radioactive materials and subsequent restriction of access
Other	None of the above

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Decommissioning of other nuclear installations

Decommissioning industry will not take care only of NPP’s, but also of a large number of other nuclear facilities or radiologically contaminated sites, that in some case are even more complex and challenging

	Total 2000-2050 Billion US$
Nuclear Power Plants	185
Fuel Cycle Facilities	71
Research Reactors	6.3
Research Facilities	3.4
Industrial Facilities	0.04
Cold War Legacy	640

Facility type	Estimated decommissioning cost (US $$10^6$ in 2003)
Power reactors	350
Research reactors	1/MW
Uranium conversion	150
Uranium enrichment	600
Fuel fabrication	250
Fuel reprocessing	800
Industrial facilities	0.200
Particle accelerators	0.100

Ref. IAEA 2006

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Military installations (ex. Nuclear submarines)

Source: UK Mod public consultation

In Service	Out of Service	Disposed
USA		
72	117	100
Russia		
29	274	180*
UK		
12	17	0
France		
10	6	3*

*Reactor compartments removed, not dismantled

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Business Expansion by Geographical Areas

Nuclear power reactors in the first decade (60'ties) were primarily built in Europe (UK, Italy, France, being this region more eager of energy for the post-war reconstruction

A consequence is that Western Europe is the first area where decommissioning started and will expand more vigorously in the first phase

Central-East Europe is following partially for the obsolescence of the first generation Russian design reactors and partially for the pressures by the European Union

USA will come with some delay, especially because the life extention process is particularly efficient, even for older plants

Asia introduced massively nuclear power somewhat later and therefore is expected to contribute progressively to the decommissioning market

Necessary specialized competences

Investigation & Evaluations

- Plant status and data collecting
- Background radiological characterization (plant structure and waste)
- Classification of plant structures, systems and components and radioactive waste (inventory)
- Environmental survey (measurement and monitoring)
- Environmental Impact study

Strategy and Planning

- Definition of decommissioning strategy
- Preliminary safety analysis
- Scope, Time and Cost Planning

Licensing

- Development of licensing documentation
- Application for decommissioning license, environmental authorisation and local permits

Decommiss.

- Project management (implementation phase)
- Preparatory activities to bring the site in safe conditions (e.g. fuel removal)
- Detailed radiological characterization
- Material and structure Decontamination
- Dismantling and removal of structure, systems and components
- Monitoring and material release

Waste Management

- Radioactive waste characterization and sorting
- Treatment, conditioning and packaging
- Interim storage
- Radioactive waste transport
- Shipment to national repository

Site Release

- Final characterisation of the site
- Monitoring and release of the site

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The Nuclear Expert Factor

Shortage of nuclear experts is expected worldwide

In Europe the European Commission estimates that 40.000 nuclear experts will be hired by 2020 to cope with the expected activities and the retirement of aged employees

Of those about 10.000 will be involved in decommissioning and waste management activities

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The Issue of Technology Innovation

To be a key player in the current and future markets, innovative and competitive technologies are needed

Decommissioning is a relatively mature industry, but innovation is necessary

Main points:

- «Nuclearization» of conventional techniques
- Flexibility to cope with special challenges and in some cases severe challenges after an accident
- Minimization of primary, secondary and tertiary waste
- Predictability of schedules and costs

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Fukushima challenges

Unprecedented efforts are required to implement the decommissioning plan at the 4 Fukushima Daichii reactors. Progress of R&D technology for each challenge

- ✓ Treatment of very large amounts of contaminated water
- ✓ Soil remediation in a large territory
- ✓ Long term corrosion control and inhibition
- ✓ Remote decontamination
- ✓ Torus inspection & repair by remote technologies
- ✓ Inspection of the inside of the PCV
- ✓ fuel debris & in-core structures removal
- ✓ Integrity evaluation techniques for RPV/PCV
- ✓ Processing & disposal of solid radioactive waste

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OECD/NEA Major R&D areas

A very recent OECD work under the guidance of the Working Party on Decommissioning and Dismantling (WPDD) presented important consensus elements on the major innovations needed by the decommissioning industry

- Characterization and survey prior to dismantling
- Technologies for segmentation and dismantling
- Decontamination and remediation
- Material and waste management
- Site characterization and environmental monitoring

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OECD/NEA Major R&D areas
Characterization and survey prior to dismantling

Physical and radiological measurements of facilities and materials (inside the facility) prior to dismantling, undertaken for purposes of planning the dismantling and material management. This includes:

- ✓ Plant history analysis,
- ✓ Radiological mapping,
- ✓ Chemical and physical measurements of materials and structures,
- ✓ Non-destructive and destructive sampling and laboratory analysis,
- ✓ Modeling.

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OECD/NEA Major R&D areas
Characterization and survey prior to dismantling

Current and future areas to be investigated

- R&D on Statistical Modeling and Sampling
- Development of method and hardware for characterizing Contamination Intrusion Along Concrete Cracks
- Detect and quantify Hard-To-Measure radionuclides in solid samples without dissolution
- Development of technologies for rapid Alpha and beta non destructive measurements in structures before dismantling
- Development of an international approach or standard for estimating the level of impurities in metals and concrete, especially for new reactors

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OECD/NEA Major R&D areas
Technologies for Segmentation/dismantling

Metal component cutting and filtration of air/water for reduction of secondary waste

Current and future areas to be investigated

- Improvements in efficiency by use of remote systems and/or innovative technologies
  - ✓ E.g. underwater laser cutting
- Reduction in secondary waste generation
  - ✓ Including mobile waste management treatment/conditioning

OECD/NEA Major R&D areas – Decontamination and remediation

Decontamination of components (including concrete and metals; remediation of soils, limiting the spread of contamination in groundwater (fixing the contamination to avoid groundwater contamination).

Current and future areas to be investigated

- New Physical Processes and Chemical Processes or Decontamination
- Concrete remediation, regeneration
- Bulk soil remediation including bio-remediation and engineered barriers
- Suite of robotic and/or remote technologies (platforms and tools) for efficient operations in high radiation or contaminated areas
- Methods for decontaminating high volumes of water or chemical contaminated to low levels
- Surface treatment and removal of contamination; surface polishing
- Heels and residues (e.g. from process fuels/fuel cycle reprocessing)
- Optimizing the use of robotics

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OECD/NEA Major R&D areas – Materials and waste management

Treatment at the facility, conditioning, handling, transport, interim storage, treatment for recycling, disposal and material clearance, entombment

Current and future areas to be investigated

- Management of problematic wastes - chemical (PCB, asbestos etc.) and mixed waste
- Treatment/removal (including mineralization) of organic materials (bituminized waste, resins, oils, nitrates), activated sodium
- Conditioning of waste (different grouts, concrete foam, etc.; improving waste incorporation)
- Long-term performance of waste-forms (e.g. concrete, impact of superplasticisers on radionuclide migration)
- Treatment of reactive metals (high temperature processes, melting) and managing gas generation
- Monitoring of waste packages during interim storage
- Clearance and recycling of low contaminated materials.

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OECD/NEA Major R&D areas – Site characterization and enviromental monitoring

Characterization, modeling, and clearance assays to support and verify conceptual site models and to demonstrate compliance with license termination criteria

Current and future areas to be investigated

- Identification of reliable and adequate characterization techniques to identify subsurface radionuclide contamination and assess long-term transport via environmental media with minimal intrusive characterization
- Selection, evaluation, and bench-marking of contaminant transport codes and models in consideration of potential long-term environmental impacts (e.g.; 1000 years or more)
- Proper assessment of the source-terms, considering lack of data, and selection of appropriate statistical methods and models using a probabilistic approach
- Establishing appropriate realistic scenarios for receptors (e.g., a representative
- person), considering land use for a specific performance period.

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Conclusions

- ✓ Decommissioning has gained focus nationally and internationally
- ✓ Decommissioning can and has been done. A lot of experience is available. Challenges do remain!
- ✓ Decommissioning is a long term project management and engineering issue
- ✓ Regulations must be proportionate and deliverable
- ✓ New reactors need to consider decommissioning needs (this may also improve plant maintenance)

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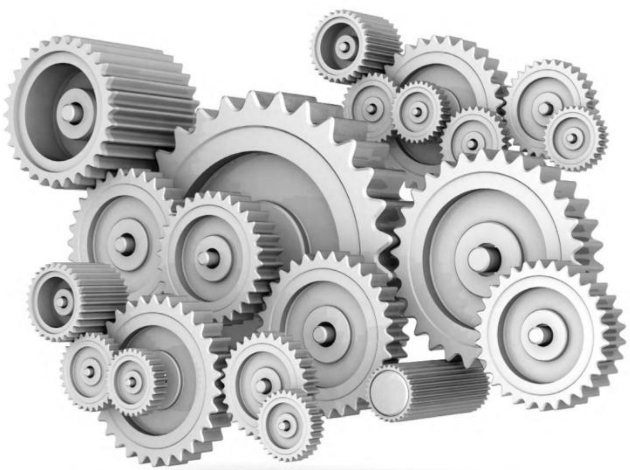
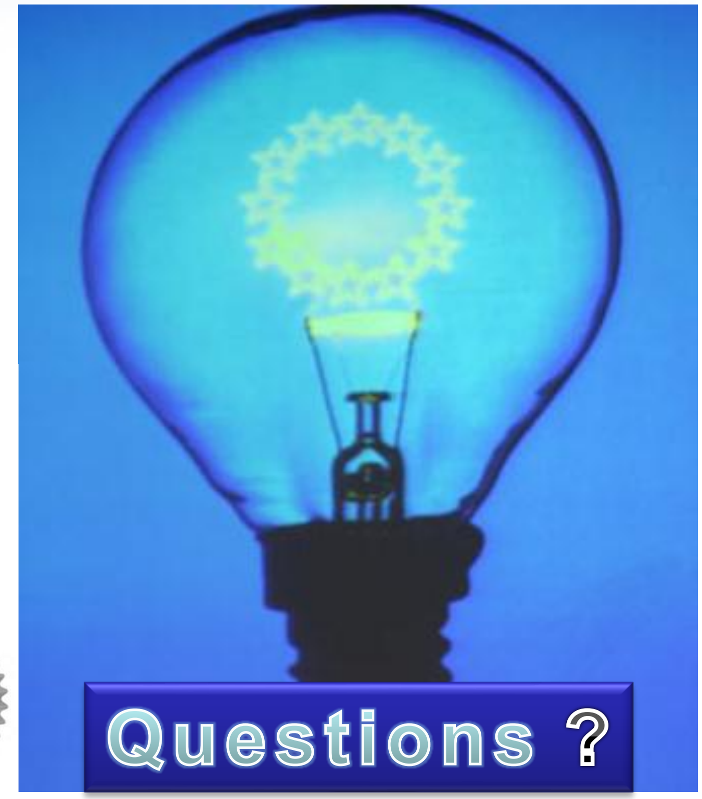
Conclusions

- ✓ A lot of good decommissioning techniques are available but R&D/Innovation is still important
- ✓ Comparability of costs is an issue on which progress is being made
- ✓ Public shows much interest in decommissioning and becomes more an active player of the game

Thank you for your attention!!!





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