Overview of Worldwide Nuclear Decommissioning

Patrick O’Sullivan
International Atomic Energy Agency

12th December 2014
International Seminar

Nuclear decommissioning : an opportunity for global and sustainable development

Milan, Italy
Agenda

- Global Statistics on NPPs
- Some Examples of Good Progress in Europe
- IAEA Activities to Advance Decommissioning Programmes
  - CIDER Project
  - New International Project on Accident Damaged Facilities
  - International Conference on Decommissioning and Environmental Remediation
Operational Reactors Worldwide – by country

Total Number of Reactors: 438

Country Name:
- UNITED STATES OF AMERICA
- FRANCE
- JAPAN
- RUSSIA
- CHINA
- KOREA, REPUBLIC OF
- INDIA
- CANADA
- UNITED KINGDOM
- UKRAINE
- SWEDEN
- GERMANY
- BELGIUM
- SPAIN
- CZECH REPUBLIC
- SWITZERLAND
- FINLAND
- HUNGARY
- SLOVAKIA
- ARGENTINA
- PAKISTAN
- BRAZIL
- BULGARIA
- MEXICO
- ROMANIA
- SOUTH AFRICA
- ARMENIA
- IRAN, ISLAMIC REPUBLIC OF
- NETHERLANDS
- SLOVENIA

Number of Reactors:

Number of Reactors
Operational Reactors Worldwide – by age

Total Number of Reactors: 438

Number of Reactors

Years

Number of Reactors

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
Operational Reactors Worldwide – by region
Operational Reactors Worldwide - by type

![Bar chart showing the total number of reactors by type.

- PWR: 250 reactors
- BWR: 100 reactors
- PHWR: 50 reactors
- GCR: 10 reactors
- LWGR: 10 reactors
- FBR: 1 reactor

Total Number of Reactors: 438]
Nuclear Share of Electricity – by country
Construction of Reactors Worldwide – by country

Total Number of Reactors: 71

- China: 25
- Russia: 11
- India: 8
- Korea, Republic of: 7
- United States of America: 6
- United Arab Emirates: 5
- Belarus: 4
- Japan: 4
- Pakistan: 4
- Slovakia: 3
- Ukraine: 3
- Argentina: 3
- Brazil: 3
- Finland: 3
- France: 3

Number of Reactors
Construction Reactors Worldwide – by region

![Bar chart showing the total number of reactors worldwide by region. Asia - Far East has the highest number, followed by Europe - Central and Eastern, Asia - Middle East and South, America - Northern, America - Latin, and Europe - Western.]

Total Number of Reactors: 71

- Asia - Far East
- Europe - Central and Eastern
- Asia - Middle East and South
- America - Northern
- America - Latin
- Europe - Western

Number of Reactors
Construction Reactors Worldwide – by type

- PWR: 60 reactors
- BWR: 5 reactors
- PHWR: 4 reactors
- FBR: 2 reactors
- HTGR: 0 reactors

Total Number of Reactors: 71
Permanently Shutdown Reactors Worldwide – by country

Total Number of Reactors: 149

Country Name

- UNITED STATES OF AMERICA
- UNITED KINGDOM
- GERMANY
- FRANCE
- JAPAN
- CANADA
- RUSSIA
- BULGARIA
- ITALY
- UKRAINE
- SLOVAKIA
- SWEDEN
- LITHUANIA
- SPAIN
- ARMENIA
- BELGIUM
- KAZAKHSTAN
- NETHERLANDS
- SWITZERLAND

Number of Reactors
Permanently Shutdown Reactors Worldwide – by region

- **Europe - Western**: 80
- **America - Northern**: 40
- **Europe - Central and Eastern**: 20
- **Asia - Far East**: 10

Total Number of Reactors: 149
Permanently Shutdown Reactors Worldwide – by type

![Bar chart showing the total number of reactors by type. The chart indicates that PWR has the highest number of reactors, followed by GCR, BWR, and so on. The total number of reactors is 149.]
## Research Reactors Worldwide

<table>
<thead>
<tr>
<th>Status</th>
<th>Developed Countries</th>
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</table>
Current Status of Nuclear Power Plants in Japan
[from K. Takahashi, JAEA, IDN-2014, Vienna]

- In operation
- Under construction (2)
- Under decommissioning (10)
- Under review by Nuclear Regulation Authority (NRA)

Sendai 1st & 2nd got the first permission in September.
# Schedule (José Cabrera NPP Decommissioning)

*from E. Garcia Neri, ENRESA, IDN-2014, Vienna*

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64% progress
Work Areas
[from E. Garcia Neri, IDN-2014, Vienna]

Reactor Building: 80%

Auxiliary Building: 75%

Electrical Building: 100%

Decom.Auxiliary Building (EAD) 100% (other uses)
Major Primary Circuit Components
[from E. Garcia Neri, ENRESA, IDN-2014, Vienna]
CEA’s Grenoble Nuclear Facilities
[from J-G Nokhamzon, CEA, IDN-2014, Vienna]

6 Basic Nuclear Installations

- **Siloé**
  - 1963-1997

- **Siloëtte**
  - 1964-2002
  - Delicensing mi 2007

- **STED (2BNI)**
  - 1964 & 1972 - 2002

- **Mélusine**
  - 1958-1988
  - Delicensing end 2011

- **LAMA**
  - 1961-2002
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<th>Year</th>
<th>SILOETTE BNI 21</th>
<th>MELUSINE BNI 19</th>
<th>SILOE BNI 20</th>
<th>LAMA BNI 61</th>
<th>STED BNI 36-79</th>
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<td>Operation &amp; wastes management</td>
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<td>2015</td>
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*Schedule Management–Grenoble Research Facilities [from J-G Nokhamzon, CEA, IDN-2014, Vienna]*
34 years operation (1963 to 1997)
Nominal power 35 MW\textsubscript{th}
Wide range of activities:
- research on crystalline structures using neutron beams,
- scientific support to French nuclear fleet,
- behaviour studies on future nuclear fuels,
- radionuclide production for medical purposes,
- doped silicium production for micro electronics industries.
Siloé building internal structures demolition (2010)
[from J-G Nokhamzon, CEA, IDN-2014, Vienna]
Siloé: Summary of Main Stages
[from J-G Nokhamzon, CEA, IDN-2014, Vienna]

- Reactor shutdown
  - 1997

- Pond emptied
  - 2005

- Liner removal remotely
  - 2007

- Blg internal structures demolished
  - 2010

- Reactor hall demolition
  - 2013

- Final end state
  - 2014
IAEA Responsibilities re. Decommissioning

IAEA Statute:

1. Develop safety standards
2. To (support) practical development and practical application of atomic energy
3. To foster the exchange of scientific and technical information on peaceful uses of atomic energy
4. To encourage the exchange and training of scientists and experts

- Nuclear safety
- Radiation Safety
- Waste Safety
- Transport Safety

- Peer reviews
- Technical cooperation
- Research and development
- Training
- Exchange of information (networks)
The overarching objective of the CIDER project is to improve current levels of performance on decommissioning and environmental remediation projects, by

- Raising awareness at a policy level and promoting greater cooperation amongst IAEA Member States dealing with the decommissioning and remediation of disused nuclear facilities and sites, and with national and international organizations involved in the development of aspects pertaining to their management, decommissioning and remediation and regulatory oversight;
- Developing a baseline report for use by policy makers and other involved parties
- Establishing a plan of action that proposes specific actions and associated timeframes to address constraints to progress.
Objectives of the Baseline Report (CIDER)

• Discusses specific barriers impeding implementation (Phase 1, 2013-15)

• Provides recommendations on how these barriers might be overcome (Phase 1)

• Provides a detailed overview of global liabilities for decommissioning and remediation (Phase 2, 2015-)
Overcoming Barriers to Implementing Decommissioning and Environmental Remediation Projects

- **Barriers to Implementation**
  - National policy and legal & regulatory framework
  - Finance
  - Technology and infrastructure constraints (esp. for waste management)
  - Stakeholder and political challenges
Overcoming Barriers to Implementing Decommissioning and Environmental Remediation Projects

- **Strategies for Overcoming Barriers**

  - Lifecycle planning, project management & risk management (role of characterization)
  - Funding sources (primary and complementary sources)
  - Management and organizational culture change (‘project’ rather than ‘process’)
  - Using an affordable and graded approach (infrastructure commensurate to the liability)
  - Risk-based prioritization (efficient allocation of resources)
  - Clear identification of roles (government, regulator, implementer)
  - Value of independent review (sharing good practice)
  - Communication and stakeholder engagement (ownership/sustainability of the solution)
  - Management of political influences (risk of political changes)
International Project on Decommissioning of Accident Damaged Facilities – 19-23 January 2015

- Purpose: Learn and benefit from the experiences derived from the challenges associated with D&ER of these facilities, in particular relating to: regulatory issues; technical issues and strategic planning (three working groups)

- Case Studies
  - Fukushima
  - Three Mile Island
  - Chernobyl
  - A1 (Slovakia)
  - Kyshtym (Russian Federation)
  - Windscale (UK)
Future International Conference on Advancing Decommissioning & Environmental Remediation

- Planned date: 23-27 May 2016
- Successor Conference to Athens 2006 (D&D) and Astana 2009 (ER)
- Mainly technical but also aimed at political decision makers
- Invited papers with contributed posters
Future International Conference on Advancing Decommissioning & Environmental Remediation

- Lifecycle planning and risk management at different stages of the lifecycle;
- Regulatory frameworks for D&ER;
- Societal considerations/ decision making end selection;
- Characterization techniques and development of inventory databases;
- Optimization of the waste management strategies associated with the decommissioning or remediation work;
- Project management costing and financing of D&ER projects / contracting strategies and supply chain management;
- Technology selection and deployment for D&ER, including new technology developments following the Fukushima accident.