NEA NI2050 Initiative

Global Survey Outcomes

Marc Deffrennes, Danielle Zayani, Byungho Jung

ADV PANEL and NDC Meetings
September 2017
ELEMENTS of the SURVEY

- Discussed and agreed at the NI2050 Launch Conf in 07/2015
- Objective: picture of actual state of nuclear research
- Technical and Budgets (Public + Private (*not successful*))
- By country, via a nominated contact point (through NDC)
- Period 2010-2015 (6 years)
- 9 Categories (and subcategories)
- Survey sent out September 2015
- Initial deadline November 2015

Comments:
- Many delays, large variety of returns (both in scope and budgets)
- Comparison with IEA yearly surveys since 1975 – using other categories
- Request from AP to look at trends – done using IEA 2000-2015
GLOBAL: ALL Energy R&D Public BUDGETS

## POST COP21 Mission Innovation: R&D x 2

<table>
<thead>
<tr>
<th>INDUSTRY &amp; BUILDINGS</th>
<th>VEHICLES &amp; OTHER TRANSPORTATION</th>
<th>BIO-BASED FUELS &amp; ENERGY</th>
<th>SOLAR, WIND &amp; OTHER RENEWABLES</th>
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<th>HYDROGEN &amp; FUEL CELLS</th>
<th>CLEANER FOSSIL ENERGY</th>
<th>CO2 CAPTURE, UTILIZATION &amp; STORAGE</th>
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Indicators are for key areas of R&D investment, but do not imply a comprehensive representation of a country's full R&D portfolio.

Source: Mission Innovation
NI2050 SURVEY: Consolidation of BUDGET Numbers

- Large Excel Tables containing all numbers from the survey, per year, categories/subcategories, subtotals and totals,…
- Manual calcs needed
- Conversion National Currencies to yearly USD, using official OECD conversion rates
- Large set of graphs
- We may provide the excel tables if desired for own use
USA: Total Budget Categories 1-9 2010-2015

- 1. R&I Programmes on Energy Scenarios and role of nuclear
- 2. R&I Programmes on Reactor Technology
- 3. R&I Programmes on Fuel Cycle
- 4. R&I Programmes on Waste Management and Decommissioning
- 5. Crosscutting R&I Programmes
- 6. R&I Programmes for Non Electricity Applications
- 7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
- 8. Large Research Infrastructures
- 9. Fusion
Korea: Total Budget Categories 1-9 2010-2015

- 1. R&I Programmes on Energy Scenarios and role of nuclear
- 2. R&I Programmes on Reactor Technology
- 3. R&I Programmes on Fuel Cycle
- 4. R&I Programmes on Waste Management and Decommissioning
- 5. Crosscutting R&I Programmes
- 6. R&I Programmes for Non Electricity Applications
- 7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
- 8. Large Research Infrastructures
- 9. Fusion
UK: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion
EURATOM: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion
EURATOM:
Total Fission Budget 2010-2015

Total Fusion Budget 2007-2018

- Total EURATOM Budget (incl. national contributions) 2010-2015
- Total European Commission Budget 2010-2015
- Total EURATOM Budget 2007-2018
- Total European Commission Budget 2007-2018
Japan: Total Budget Categories 1-9 2010-2015

- 1. R&I Programmes on Energy Scenarios and role of nuclear
- 2. R&I Programmes on Reactor Technology
- 3. R&I Programmes on Fuel Cycle
- 4. R&I Programmes on Waste Management and Decommissioning
- 5. Crosscutting R&I Programmes
- 6. R&I Programmes for Non Electricity Applications
- 7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
- 8. Large Research Infrastructures
- 9. Fusion

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<th>Category</th>
<th>Budget</th>
<th>Percentage</th>
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<td>168.12M$</td>
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<td>2. R&amp;I Programmes on Reactor Technology</td>
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<td>6. R&amp;I Programmes for Non Electricity Applications</td>
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<td>0%</td>
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<td>7. E&amp;T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research</td>
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<td>8. Large Research Infrastructures</td>
<td>0M$</td>
<td>0%</td>
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<tr>
<td>9. Fusion</td>
<td>168.12M$</td>
<td>3%</td>
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</tbody>
</table>
Canada: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
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2. R&I Programmes on Reactor Technology
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5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion
Netherlands: Total Budget Categories 1-9 2010-2015

- 1. R&I Programmes on Energy Scenarios and role of nuclear
- 2. R&I Programmes on Reactor Technology
- 3. R&I Programmes on Fuel Cycle
- 4. R&I Programmes on Waste Management and Decommissioning
- 5. Crosscutting R&I Programmes
- 6. R&I Programmes for Non Electricity Applications
- 7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
- 8. Large Research Infrastructures
- 9. Fusion

- 193.64M$, 69%
- 23.69M$, 9%
- 14.12M$, 5%
- 11.22M$, 4%
- 16.47M$, 6%
- 17.46M$, 6%
- 0.79M$, 0%
- 0.72M$, 0%
- 3.6M$, 1%
Spain: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion
Germany: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion

170M$, 100%
Finland: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion

- 28.8M$, 18%
- 32.36M$, 21%
- 1.77M$, 1%
- 1.55M$, 1%
- 0.96M$, 1%
- 1.93M$, 1%
- 10.57M$, 7%
- 78.39M$, 50%
- 0M$, 0%
Poland: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion
1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion
Italy: Total Budget Categories 1-9 2010-2015

1. R&I Programmes on Energy Scenarios and role of nuclear
2. R&I Programmes on Reactor Technology
3. R&I Programmes on Fuel Cycle
4. R&I Programmes on Waste Management and Decommissioning
5. Crosscutting R&I Programmes
6. R&I Programmes for Non Electricity Applications
7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
8. Large Research Infrastructures
9. Fusion
Austria: Total Budget Categories 1-9 2010-2015

- 1. R&I Programmes on Energy Scenarios and role of nuclear
- 2. R&I Programmes on Reactor Technology
- 3. R&I Programmes on Fuel Cycle
- 4. R&I Programmes on Waste Management and Decommissioning
- 5. Crosscutting R&I Programmes
- 6. R&I Programmes for Non Electricity Applications
- 7. E&T Knowledge Management, Human Resources Management and Public Relations Programmes in Relation with Research
- 8. Large Research Infrastructures

12.24 M$, 100%
### France

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<td>5. 6 &amp; 8 Cross cutting, Non Electricity Application and Large Research Infrastructure</td>
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<td>207.23</td>
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<td><strong>418.97</strong></td>
<td><strong>474.23</strong></td>
<td><strong>542.50</strong></td>
<td><strong>513.56</strong></td>
<td><strong>482.21</strong></td>
<td><strong>454.79</strong></td>
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#### Somme de 2010-2015

- **Unallocated, 36%**
- **2. R&I Programmes on Reactor Technology, 28%**
- **3. R&I Programmes on Fuel Cycle, 13%**
- **4. R&I Programmes on WMD, 4%**
- **5, 6 & 8 Cross cutting, Non Electricity Application and Large Research Infrastructure**
- **9. Fusion, 7%**
- **Unallocated**
Total Fission and Fusion Budget 2010-2015

France:
Total Fission: 3,469.43 M$, Total Fusion: 268.69 M$
Category 1: R&I Programmes on Energy Scenarios and Role of Nuclear

- Japan: 23.01 M$
- USA: 0 M$
- Korea: 3.74 M$
- Canada: 0 M$
- EURATOM: 0 M$
- UK: 5.07 M$
- Czech Republic: 0.79 M$
- Netherlands: 10.17 M$
- Spain: 0.24 M$
- Germany: 170 M$
- Finland: 0 M$
- Poland: 0 M$
- Slovenia: 0 M$
- Italy: 0 M$
- Austria: 0 M$

Total Budget 2010-2015
Category 3: R&I Programmes on Fuel Cycle

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<th>Budget 2010-2015 (M$)</th>
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<td>886.4</td>
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<td>Japan</td>
<td>168.12</td>
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<td>Korea</td>
<td>246.53</td>
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<td>Canada</td>
<td>150.1</td>
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<td>UK</td>
<td>78.43</td>
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<td>Czech Republic</td>
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<td>1.51</td>
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<td>Austria</td>
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Total Budget 2010-2015
Category 4: R&I Programmes on Waste Management and Decommissioning

- **Japan**: $4,489.15
- **USA**: $179.3
- **Korea**: $137.95
- **Canada**: $121.7
- **EURATOM**: $160.59
- **UK**: $79.6
- **Czech Republic**: $26.26
- **Netherlands**: $16.47
- **Spain**: $41.67
- **Germany**: $32.36
- **Finland**: $3.15
- **Poland**: $0
- **Slovenia**: $0
- **Italy**: $0
- **Austria**: $0

Total Budget 2010-2015
Category 5: Crosscutting R&I Programmes

- **Canada**: 708.15 M$
- **Euroatom**: 265 M$
- **UK**: 164.3 M$
- **Czech Republic**: 25.71 M$
- **Spain**: 45.34 M$
- **Finland**: 10.57 M$
- **Poland**: 0.9 M$
- **Slovenia**: 1.42 M$
- **Italy**: 2.08 M$
- **Austria**: 0 M$

Total Budget 2010-2015
Category 6: R&I Programmes for Non Electricity Applications

Total Budget 2010-2015

- Korea: 133.09 M$
- Canada: 33.18 M$
- Euratom: 36.64 M$
- UK: 7.29 M$
- Japan: 30.43 M$
- Czech Republic: 0 M$
- Netherlands: 0 M$
- Spain: 0 M$
- Germany: 0 M$
- Finland: 1.93 M$
- Poland: 0.17 M$
- Slovenia: 0 M$
- Italy: 0 M$
- Austria: 0 M$

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Category 7: E&T, Knowledge Management, Human Resources Management and Public Awareness Programmes in relation with Research

Total Budget 2010-2015

<table>
<thead>
<tr>
<th>Country</th>
<th>Budget (M$)</th>
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<tr>
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<tr>
<td>USA</td>
<td>92.1</td>
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<td>EURATOM</td>
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<td>UK</td>
<td>116.48</td>
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<td>Czech Republic</td>
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<td>Germany</td>
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</tr>
<tr>
<td>Finland</td>
<td>0.96</td>
</tr>
<tr>
<td>Poland</td>
<td>0.12</td>
</tr>
<tr>
<td>Slovenia</td>
<td>5.07</td>
</tr>
<tr>
<td>Italy</td>
<td>0.08</td>
</tr>
<tr>
<td>Austria</td>
<td>0</td>
</tr>
</tbody>
</table>
Category 8: Large Research Infrastructures

Total Budget 2010-2015
Category 9: Fusion

Total Budget 2010-2015

- Japan: 0 M$
- USA: 2525.2 M$
- Korea: 847.66 M$
- Canada: 68.57 M$
- EURATOM: 9697.33 M$
- UK: 137.59 M$
- Czech Republic: 4.77 M$
- Netherlands: 23.69 M$
- Spain: 0 M$
- Germany: 0 M$
- Finland: 28.8 M$
- Poland: 2.52 M$
- Slovenia: 12.43 M$
- Italy: 47.97 M$
- Austria: 0 M$

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## NEA SURVEY vs IEA ??? Over 2010-2015
### Suggestions for Category Consolidation

<table>
<thead>
<tr>
<th>NI2050 Survey</th>
<th>IEA RD&amp;D Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category 2:</strong> R&amp;I Programmes on Reactor Technology</td>
<td></td>
</tr>
<tr>
<td>2.1 Large GEN II and III Reactors and SMRs</td>
<td>411 LWRs</td>
</tr>
<tr>
<td>2.2 GEN IV Reactors and Advanced SMRs</td>
<td></td>
</tr>
<tr>
<td>2.3 Advanced Power Conversion Systems</td>
<td>412 Other Converter Reactors + 412 Unallocated</td>
</tr>
<tr>
<td><strong>Category 3:</strong> R&amp;I Programmes on Fuel Cycle &amp; Reactor Technology</td>
<td></td>
</tr>
<tr>
<td><strong>Category 4:</strong> Programmes on Waste Management and Decommissioning</td>
<td></td>
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<tr>
<td><strong>Category 5:</strong> Crosscutting R&amp;I Programmes</td>
<td></td>
</tr>
<tr>
<td><strong>Category 6:</strong> R&amp;I Programmes on for Non Electricity Applications</td>
<td></td>
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<tr>
<td><strong>Category 8:</strong> Large Research Infrastructures</td>
<td></td>
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<tr>
<td><strong>Category 9:</strong> Fusion</td>
<td></td>
</tr>
<tr>
<td><strong>Unallocated: Categories 1 &amp; 7</strong></td>
<td><strong>Unallocated: 413, 414, 41, 4</strong></td>
</tr>
</tbody>
</table>

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NI2050 SURVEY: Consolidation of TECHNICAL Scope

- Report per country and following the 9 categories of the survey

- Selection of 10 countries: US, CAN, KR, EC, JP, RF, FR, CZ, FI, NL

- Wide variation in coverage/content of the survey returns

- Report contains most of the information from the survey COMPLEMENTED by additional information from open sources (*in Italic*), providing some level of consistency between the reports

- Sources are cited and numerous weblinks are given

- “State of Play”

- Possibility for further consolidation on infrastructures (category 8)
NI2050 SURVEY: Consolidation of TECHNICAL Scope

1. R&D Programmes on Energy Scenarios and role of nuclear

The Ministry of Trade, Industry and Energy (MOTIE) released a Second Energy Master Plan in 2014 to determine its national energy policy until 2035. It aimed at reducing fossil energy consumption by 33% by 2035, with six basic directions: conversion to demand management policies, establishment of distributed generation system, balance with the environment and safety, enhancement of energy security and stable energy supply, stable supply system of each energy source, and energy policy reflecting public opinion.

Nuclear energy in Korea has been as the big contributor to the nation’s economic growth as well as Low Carbon Green Growth. In 2004, Nuclear Technology Roadmap (NTR) was established, which provides the systematic chains from needs-driven R&D activities, through innovation and industrial performance, to eventual commercialization in the society. In 2008, “Long-term Development Plan of Future Nuclear Energy System” was established to secure the solutions for the front- and back-end of the fuel cycle. Sodium-cooled Fast Reactor (SFR) coupled with zero-recycling is expected to provide long-term solution for spent nuclear fuel (SNF) management in Korea. Very high Temperature Reactor (VHTR) is expected to contribute to clean and safe energy with a wide range of applications such as hydrogen production.

A number of studies on the economics of nuclear energy are performed including a SMART (System-integrated Modular Advanced Reactor) SFR, and research reactors for export.

More information:
Ministry of Trade, Industry and Energy (http://enplus.motie.go.kr/www/motieatx)

2. R&D Programmes on Reactor Technology

2.1. Large GEN II and III reactors and SFRs

As a near-term reactor option, the Korean Next Generation Reactor, which is the Advanced Power Reactor (APR1400), Generation III PWR – 1400 MW(e), has been developed and is under construction. Building on the APR1400, the Advanced Power Reactor Plus (APR+) – Generation IV PWR – 1250 MW(e) with improved economy, efficiency and safety, is under development. It is expected to be ten times safer than APR1400. The standard design of the APR+ was confirmed by the Korean regulatory agency in 2014.

In the field of research-reactors, the Korean Atomic Energy Research Institute (KAERI) seeks to develop the Safety and Performance Analysis Code (SPACE) that is the best estimate system analysis code to be used for Ramping PWBR design, in collaboration with several research institutions. KAERI is in charge of the development of the physical models, calculational packages, and code verification & validation (V&V), including integral effect tests and separate effect tests for model development and code validation.

For the design optimisation and performance improvement of Generation IV reactor, the APR+ R&D project focuses on revisiting the reactor design and validating the advanced safety system such as Direct Vessel Injection Plus (DVIP), Fluidic Device Flow (FD), Passive Auxiliary Water System (PAWS), and Control Element Drive Mechanism (CEDM).

Integral and separate effect tests were performed to verify the reactor system response and local thermal hydraulic phenomena by using FD, PAWS and CEDM. In 2012, the pilot experiment on the Hybrid Safety Injection System (HSIS) test was launched. HSIS is a novel safety injection system to make the reactor coolant during the anticipated Design Basis Accident (DBA) and beyond Design Basis Accidents (BDBAs) such as Station Black-Out (SBO) in PWR system.

Additionally, for the seismic risk assessment, KAERI is developing the performance formats of seismic isolation systems and seismic design of nuclear is defined as the interface crossing over between the seismically isolated and non-isolated structures of nuclear power plants (NPPs).

For the Beyond Design Basis Safety Analysis, technology development for safe operation of NPPs against man-made events and natural disaster are being pursued and is being reflected to APR1400 and APR+. Safety enhancement technologies including passive hydrogen removal systems, exhaust and decompression equipment, and coastal barrier were developed. In addition, several methodologies are under development, such as the development of the Integrated Risk Assessment Technology for Multiple Units, the Base Technology for Integrated Severe Accident Management and Emergency Preparedness, and the Risk Evaluation Methodologies for Extreme External Events.

For the development of Small Modular Reactor (SMR), KAERI is developing the System-integrated Modular Advanced Reactor (SMART) which is a 300 MW(t) PWR with integral system generator and advanced passive safety systems.

6. Large Research Infrastructures

6.1. Critical Zero Power Facilities

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6.2. Research Reactors

The research reactors mentioned below are selected based on the survey provided by Republic of Korea and high utilisation rate reactors (≥300%F) from IEA Research Reactor Database.

- High-flux Advanced Neutron Application Reactor (HANARO) – KAERI, Daejeon
High-flux Advanced Neutron Application Reactor (HANARO) is a 30 MW(e) open-pool type research reactor that has been operated since 1995. HANARO is widely utilised in the fields of neutronics science, irradiation test, radiobiology (RF) production, and neutron transmutation doping. HANARO is also equipped with a neutron beam facility.

More information:

- Kijung Research Reactor (KRR, to be built) – KAERI, Busan
Kijung Research Reactor (KRR) is the open-tank-in-pool type research reactor, 15 MW(e), using high density, low-enriched U-Mo fuel for R&D production, which is the first of its kind application, of which qualification test is being performed in cooperation with Engineering National Laboratory. Present under construction. It is expected to start operation by early 2020.

Related documents:
OVERVIEW OF KRR DESIGN FEATURES

6.3. Large Demonstration/Prototype

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8.4. Accelerators

- Proton Linear Accelerator – KAERI, Daejeon
It is 100 MeV, 20 mA Proton Linear Accelerator at Korea Multi-purpose Accelerator Complex (KOMAC), KAERI, Daejeon

The facilities mentioned in this report only cover results from survey and NI2050 meeting presentations. For more information on large research infrastructures, please refer to the following websites.

NRI Research and Test Facilities Database (http://www.nri.re.kr/main/0600/searchMain.do?Option=1)
IEA Fast Irradiation Examination Facilities Database (https://neutronics.org/sites/default/files/2016-02/)

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NI2050 SURVEY: Consolidation of TECHNICAL Scope

- Selection criteria of infrastructure

Research reactor: Survey, IAEA Research Reactor Database (with high utilisation rate*)

* Effective Weeks (7days*24hrs of operation per year) ≥ 20 EW

Others: Survey, AP presentations

- Results: Non-exhaustive lists
  ex) Discrepancy between reports and templates: Korea infrastructure – “HELIOS” (LBE thermal hydraulics) from Dr. Kamide’s template

- MC (NDC rep/Adv Panel) until end November to review and provide comments/updates/additions – ia on infrastructures…
NI2050 SURVEY:
Trends using IEA 2000-2015 data

- For all IEA countries we got all figures per year – all energies, including split nuclear fission and fusion – Excel tables

- Graphs:
  1/ Total cumulative budget per country for the 15 years, and share between different energies
  2/ For « top ten » - per country, trend in budget (total and per energy type (in actual USD and USD2014)
  3/ For nuclear – total and split FI/FU per country for the 15 years
  4/ Where possible – per country, trend in budget (total nuclear, and FI/FU)
Total Budget 2000-2014 (USD 2014)

- **Italy**: $1,212 (Energy Efficiency), $828 (Fossil Fuels), $1,430 (Renewable Energy Sources), $1,902 (Nuclear), $250 (Hydrogen and Fuel Cells), $1,590 (Other Power and Storage Technologies), $643 (Other Cross-Cutting Technologies/Research)
- **Canada**: $1,534 (Energy Efficiency), $3,959 (Fossil Fuels), $1,427 (Renewable Energy Sources), $2,431 (Nuclear), $483 (Hydrogen and Fuel Cells), $780 (Other Power and Storage Technologies), $483 (Other Cross-Cutting Technologies/Research)
- **Germany**: $1,552 (Energy Efficiency), $473 (Fossil Fuels), $3,081 (Renewable Energy Sources), $3,782 (Nuclear), $417 (Hydrogen and Fuel Cells), $586 (Other Power and Storage Technologies), $1,292 (Other Cross-Cutting Technologies/Research)
- **France**: $2,448 (Energy Efficiency), $2,851 (Fossil Fuels), $1,896 (Renewable Energy Sources), $10,921 (Nuclear), $825 (Hydrogen and Fuel Cells), $555 (Other Power and Storage Technologies), $2,114 (Other Cross-Cutting Technologies/Research)
- **Japan**: $8,879 (Energy Efficiency), $5,921 (Fossil Fuels), $6,562 (Renewable Energy Sources), $46,308 (Nuclear), $2,237 (Hydrogen and Fuel Cells), $1,227 (Other Power and Storage Technologies)
- **United States**: $14,899 (Energy Efficiency), $11,124 (Fossil Fuels), $12,291 (Renewable Energy Sources), $11,932 (Nuclear), $3,223 (Hydrogen and Fuel Cells), $3,803 (Other Power and Storage Technologies), $23,307 (Other Cross-Cutting Technologies/Research)
Total Budget 2000-2014 (USD 2014)

- Belgium: $342 (Energy Efficiency), $133 (Fossil Fuels), $585 (Renewable Energy Sources), $7 (Nuclear), $106 (Other Power and Storage Technologies)
- Austria: $598 (Energy Efficiency), $33 (Fossil Fuels), $433 (Renewable Energy Sources), $66 (Nuclear), $56 (Other Power and Storage Technologies), $217 (Other Cross-Cutting Technologies)
- Spain: $274 (Energy Efficiency), $81 (Fossil Fuels), $1,011 (Renewable Energy Sources), $411 (Nuclear), $69 (Other Power and Storage Technologies), $173 (Other Cross-Cutting Technologies)
- Denmark: $325 (Energy Efficiency), $62 (Fossil Fuels), $936 (Renewable Energy Sources), $54 (Nuclear), $345 (Other Power and Storage Technologies), $216 (Other Cross-Cutting Technologies)
- Sweden: $987 (Energy Efficiency), $9 (Fossil Fuels), $859 (Renewable Energy Sources), $114 (Nuclear), $224 (Other Power and Storage Technologies), $291 (Other Cross-Cutting Technologies)
- Switzerland: $580 (Energy Efficiency), $200 (Fossil Fuels), $776 (Renewable Energy Sources), $801 (Nuclear), $222 (Other Power and Storage Technologies), $350 (Other Cross-Cutting Technologies)
Total Budget 2000-2014

Category 1: ENERGY EFFICIENCY
Category 2: FOSSIL FUELS
Category 3: RENEWABLE ENERGY SOURCES
Category 4: NUCLEAR
Category 5: HYDROGEN AND FUEL CELLS
Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
Nuclear Energy Agency

Total Budget 2000-2014 (USD 2014)

- **Slovak Republic**
  - Category 1: ENERGY EFFICIENCY: $15
  - Category 2: FOSSIL FUELS: $8
  - Category 3: RENEWABLE ENERGY SOURCES: $92
  - Category 4: NUCLEAR: $48
  - Category 5: HYDROGEN AND FUEL CELLS: $6
  - Category 6: OTHER POWER AND STORAGE TECHNOLOGIES: $16
  - Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH: $24

- **New Zealand**
  - Category 1: ENERGY EFFICIENCY: $19
  - Category 2: FOSSIL FUELS: $57
  - Category 3: RENEWABLE ENERGY SOURCES: $110
  - Category 4: NUCLEAR: $13
  - Category 5: HYDROGEN AND FUEL CELLS: $25
  - Category 6: OTHER POWER AND STORAGE TECHNOLOGIES: $9

- **Czech Republic**
  - Category 1: ENERGY EFFICIENCY: $52
  - Category 2: FOSSIL FUELS: $32
  - Category 3: RENEWABLE ENERGY SOURCES: $73
  - Category 4: NUCLEAR: $178
  - Category 5: HYDROGEN AND FUEL CELLS: $7
  - Category 6: OTHER POWER AND STORAGE TECHNOLOGIES: $65
  - Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH: $26

- **Ireland**
  - Category 1: ENERGY EFFICIENCY: $235
  - Category 2: FOSSIL FUELS: $5
  - Category 3: RENEWABLE ENERGY SOURCES: $172
  - Category 4: NUCLEAR: $1
  - Category 5: HYDROGEN AND FUEL CELLS: $47
  - Category 6: OTHER POWER AND STORAGE TECHNOLOGIES: $60

- **Hungary**
  - Category 1: ENERGY EFFICIENCY: $826
  - Category 2: FOSSIL FUELS: $8
  - Category 3: RENEWABLE ENERGY SOURCES: $64
  - Category 4: NUCLEAR: $11

- **Poland**
  - Category 1: ENERGY EFFICIENCY: $296
  - Category 2: FOSSIL FUELS: $261
  - Category 3: RENEWABLE ENERGY SOURCES: $161
  - Category 4: NUCLEAR: $42
  - Category 5: HYDROGEN AND FUEL CELLS: $33
  - Category 6: OTHER POWER AND STORAGE TECHNOLOGIES: $127
  - Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH: $8

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Total Budget 2000-2014

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
- Category 3: RENEWABLE ENERGY SOURCES
- Category 4: NUCLEAR
- Category 5: HYDROGEN AND FUEL CELLS
- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH

Countries: Luxembourg, Turkey, Greece, Portugal, Estonia

USD 2014 Budget
Total Budget 2000-2014 (USD 2014)

- **Estonia**
  - Category 1: $1
  - Category 2: $4
  - Category 3: $8
  - Category 4: $0.60
  - Category 5: $1
  - Category 6: $4
  - Category 7: $0.18

- **Portugal**
  - Category 1: $11
  - Category 2: $6
  - Category 3: $27
  - Category 4: $12
  - Category 5: $2
  - Category 6: $1
  - Category 7: $3

- **Greece**
  - Category 1: $12
  - Category 2: $5
  - Category 3: $38
  - Category 4: $4
  - Category 5: $1
  - Category 6: $18
  - Category 7: $14

- **Turkey**
  - Category 1: $23
  - Category 2: $23
  - Category 3: $32
  - Category 4: $1
  - Category 5: $14
  - Category 6: $22
  - Category 7: $3

- **Luxembourg**
  - Category 1: $111
  - Category 2: $6
  - Category 3: $3
  - Category 4: $1
  - Category 5: $5
  - Category 6: $3
  - Category 7: $3

Legend:

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
- Category 3: RENEWABLE ENERGY SOURCES
- Category 4: NUCLEAR
- Category 5: HYDROGEN AND FUEL CELLS
- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
France

USD 2014

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
- Category 3: RENEWABLE ENERGY SOURCES
- Category 4: NUCLEAR
- Category 5: HYDROGEN AND FUEL CELLS
- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH

Total Budget
United States

USD 2014

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
- Category 3: RENEWABLE ENERGY SOURCES
- Category 4: NUCLEAR
- Category 5: HYDROGEN AND FUEL CELLS
- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
- Total Budget

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Germany

USD Yearly

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
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- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
- Total Budget
Germany

USD 2014

- Category 1: ENERGY EFFICIENCY
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- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
- Total Budget

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Canada

Category 1: ENERGY EFFICIENCY
Category 2: FOSSIL FUELS
Category 3: RENEWABLE ENERGY SOURCES
Category 4: NUCLEAR
Category 5: HYDROGEN AND FUEL CELLS
Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
Total Budget
Italy

USD Yearly

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
- Category 3: RENEWABLE ENERGY SOURCES
- Category 4: NUCLEAR
- Category 5: HYDROGEN AND FUEL CELLS
- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
- Total Budget

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Korea

USD Yearly

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
- Category 3: RENEWABLE ENERGY SOURCES
- Category 4: NUCLEAR
- Category 5: HYDROGEN AND FUEL CELLS
- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
- Total Budget

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Korea

USD 2014


Category 1: ENERGY EFFICIENCY
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Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
Total Budget
United Kingdom

USD 2014

- Category 1: ENERGY EFFICIENCY
- Category 2: FOSSIL FUELS
- Category 3: RENEWABLE ENERGY SOURCES
- Category 4: NUCLEAR
- Category 5: HYDROGEN AND FUEL CELLS
- Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
- Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH

Total Budget
Norway

USD Yearly

Category 1: ENERGY EFFICIENCY
Category 2: FOSSIL FUELS
Category 3: RENEWABLE ENERGY SOURCES
Category 4: NUCLEAR
Category 5: HYDROGEN AND FUEL CELLS
Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
Total Budget

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Norway

Category 1: ENERGY EFFICIENCY
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Category 4: NUCLEAR
Category 5: HYDROGEN AND FUEL CELLS
Category 6: OTHER POWER AND STORAGE TECHNOLOGIES
Category 7: OTHER CROSS-CUTTING TECHS/RESEARCH
Total Budget
Nuclear Energy Agency

Nuclear Fission/Fusion Split 2000-2014

USD 2014

Japan: $42,566.79
  - Fusion: $3,696.98
  - Fission: $38,869.81
France: $1,818.47
  - Fusion: $810.58
  - Fission: $1,007.89
US: $11,828.75
  - Fusion: $5,990.75
  - Fission: $5,838.00
Germany: $3,296.14
  - Fusion: $2,796.14
  - Fission: $500.00

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Nuclear Energy Agency

Nuclear Fission/Fusion Split 2000-2014

- Netherlands: $203.64 (Fission) + $124.69 (Fusion) = $328.33
- Finland: $214.49 (Fission) + $54.97 (Fusion) = $269.46
- Norway: $207.67 (Fission) + $0 (Fusion) = $207.67
- Spain: $149.37 (Fission) + $261.83 (Fusion) = $411.19
- Sweden: $81.53 (Fission) + $32.95 (Fusion) = $114.48

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France: Nuclear Budget 2000-2014

- Fission
- Fusion
- Total Nuclear

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Finland: Nuclear Budget 2000-2014

USD 2014

- Fission
- Fusion
- Total Nuclear
Germany: Nuclear Budget 2000-2014

USD 2014

Fission
Fusion
Total Nuclear

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Japan: Nuclear Budget 2000-2014
Spain: Nuclear Budget 2000-2014

- Fission
- Fusion
- Total Nuclear
Sweden: Nuclear Budget 2000-2014

USD 2014

- Fission
- Fusion
- Total Nuclear

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NI2050 SURVEY: Conclusions

- Great variety of survey returns
- Private budgets basically not available or relevant
- Limited comparison with IEA data
- Some questions also on IEA data
- Countries should reflect on how to improve their inputs

NI2050 Survey Report:
- Background and Questionnaire
- Graphs and country reports
- Short general analysis based on the IEA tends 1975-2015
- Graphs not to be modified anymore
- Country reports – comments/updates/additions via NDC contact person – strict deadline end November 2017
- Publication early 2018