Poland: non-nuclear country?

Countries with nuclear power plants

- in operation
- under construction
Poland: nuclear for 57 years

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ewa</td>
<td>1958</td>
<td>2 MW</td>
</tr>
<tr>
<td>Anna</td>
<td>1963</td>
<td>10 kW</td>
</tr>
<tr>
<td>Maryla</td>
<td>1963</td>
<td>100 kW</td>
</tr>
<tr>
<td>Agata</td>
<td>1973</td>
<td>10 kW</td>
</tr>
<tr>
<td>Wanda</td>
<td>1985</td>
<td>100 kW</td>
</tr>
<tr>
<td>Maria</td>
<td>1974</td>
<td>30 MW</td>
</tr>
</tbody>
</table>
Polish Nuclear Power Programme

- The first attempt ~1970: VVR400 in Żarnowiec
- Abandoned after constructing 44% of the plant
Polish Nuclear Power Programme

Decision taken 13.01.2009:

- PGE indicated as the first investor
  - largest Polish energy company
- 2 plants, 3000 MW each, by 2030
  - the first unit by 2020, now delayed to 2025

Program approved 28.01.2014:

Plan for the first unit:

- 2016 – technology choice
- 2017 – request for permit
- 2019 – licence issued
- 2025 – in operation

Some delay is expected
# Polish nuclear institutes

<table>
<thead>
<tr>
<th>Institute</th>
<th>site</th>
<th>staff</th>
<th>supervised</th>
<th>funded</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Centre for Nuclear Research (NCBJ)</td>
<td>Świerk, Warsaw</td>
<td>1114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inst. of Nuclear Chemistry &amp; Technology (IChTJ)</td>
<td>Warsaw</td>
<td>262</td>
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<tr>
<td>Central Lab. for Radiological Protection (CLOR)</td>
<td>Warsaw</td>
<td>53</td>
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<tr>
<td>Institute for Plasma Physics &amp; Laser Microfusion (IFPiLM)</td>
<td>Warsaw</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute of Nuclear Physics (IFJ) Polish Academy of Sciences</td>
<td>Cracow</td>
<td>486</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Universities with some nuclear research and education:
- AGH Technical University in Cracow,
- Warsaw University of Technology, University of Warsaw,
- Technical University in Gdańsk, Silesian University of Technology,
- Wrocław Technical University, + …
Radiochemistry laboratories

Accelerators

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Nuclear research infrastructure in Poland
Institute of Nuclear Physics, Cracow

230 MeV proton cyclotron for research & proton therapy
National Centre for Nuclear Research

Nuclear Centre at Swierk
30 km from Warsaw

www.ncbj.gov.pl
research ⇒ apparatus ⇒ products

- Nuclear & particle physics
- Astrophysics & cosmology
- Fusion & plasma physics
- Material research

Apparatus for
- LHC/CERN, XFEL/DESY
- W7X, ESS, JHR?

Accelerator & detectors for
- healthcare, industry, security
Research reactor MARIA at Świerk

- neutron beam research, material irradiation, radioisotope production + R&D
- $^{99}\text{Mo}$ for medical use - 20 weeks in 2013
- 1 week of Maria irradiation = 100,000 medical procedures

- built 1974, upgraded 1992
- pool type
- $\text{H}_2\text{O}$, Be moderated
- 30 MW thermal power
- neutron flux:
  - thermal $4 \times 10^{14}$ n/cm$^2$s
  - fast $3 \times 10^{13}$ n/cm$^2$s
Maria research reactor

Each channel is individually connected to the primary cooling circuit.

Irradiation channels: $\phi=79\text{mm}$ in fuel channels, $38\text{mm}$ in graphite, $23\text{mm}$ in beryllium, $1\text{m}$ long.

- 1000 Ci, $2.0\times1.8\times1.3\text{m}$
- HOT CELL

In the diagram:
- CONTROL RODS DRIVE MECHANISM
- FLOWGATE
- SPENT FUELS IN TECHNOLOGY CHANNELS
- TECHNOLOGY POOL
- SPENT FUEL
Material Testing Laboratory

- Hot cells, mechanical tests, structural analysis
POLATOM radioisotope centre

• Research on production methods and medical applications
• Production: ~80 products to 80 countries
Radioisotope products of NCBJ

PRODUCTS FOR NUCLEAR MEDICINE

Radiopharmaceuticals for diagnostic and therapy
• MIBG – 131I for diagnostic use
• MIBG – 131I for therapeutic use
• MIBG – 123I for injection
• Sodium iodide, Na 131I for injection
• Sodium iodide, Na 131I capsules for diagnostics
• Sodium iodide, Na 131I capsules for therapy
• Sodium orthophosphate, Na2H32PO4 for injection
• Hipuran – 131I for injection
• Strontium chloride, 89SrCl2

Kits for labelling with 99mTc
• PoltechColloid, 0,17 mg
• PoltechDMSA, 1 mg
• PoltechDTPA, 13,25 mg
• PoltechMBrIDA, 20 mg
• PoltechMDP, 5 mg
• PoltechMIBI, 1 mg
• PoltechRBC, 14,40 mg
• 99mTc-Tektotryd

Radiochemicals (pharmaceutical grade)
• Sodium chromate, Na251CrO4 for injection
• 64CuCl2 as cupric (II) chloride
• 59Fe as Iron (III) citrate, FeC6H5O7
• 51Cr as 51Cr-EDTA for injection

Precursors for labelling
• LutaPol 177Lu, 90Y
• ItraPol

Radionuclide generators
• 99mMo/99mTc generator
• 188W/188Re generator

Accessories for Nuclear Medicine Department

PRODUCTS FOR RESEARCH AND DEVELOPMENT

Radiochemicals reagents
• Antimony 124Sb
• Arsenic 76As
• Barium 131Ba
• Barium 133Ba
• Bromine 82Br
• Cadmium 109Cd
• Cadmium 115mCD
• Caesium 131Cs
• Caesium 134Cs
• Caesium 137Cs
• Calcium 45Ca
• Chromium 51Cr
• Cobalt 58Co
• Cobalt 60Co
• Copper 64Cu
• Europium 152Eu
• Europium 152+154Eu
• Gold 198Au
• Holmium 166Ho
• Iodine 131I
• Indium 114mIn
• Iridium 192Ir
• Iron 59Fe
• Lanthanum 140La
• Lutetium 177Lu
• Neodymium 147Nd
• Phosphorus 32P
• Rhenium 186Re
• Rubidium 86RB
• Samarium 153Sm
• Scandium 46Sc
• Selenium 75Se
• Silver 110mAg
• Sodium 24Na
• Strontium 85Sr
• Strontium 89Sr
• Strontium 90Sr
• Sulphur 35S
• Terbium 166Tb
• Thallium 204Tl
• Thulium 170Tm
• Tin 113Sn

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Nuclear research infrastructure in Poland

POLATOM
Project CERAD (40 mln €)

Center of Design & Synthesis of Radiopharmaceuticals for Molecular Targeting

@ Polish RI Roadmap, applying for structural funds

Specialized laboratories

Widdening the range of radionuclides:

\[ ^{11}\text{C}, \, ^{13}\text{N}, \, ^{15}\text{O}, \, ^{18}\text{F}, \, ^{22}\text{Na}, \, ^{44}\text{Sc}, \, ^{47}\text{Sc}, \, ^{74}\text{As}, \, ^{64}\text{Cu}, \, ^{67}\text{Cu}, \, ^{67}\text{Ga}, \, ^{68}\text{Ge}, \, ^{81}\text{Rb}, \, ^{82}\text{Sr}, \, ^{86}\text{Y}, \, ^{89}\text{Zr}, \, ^{94m}\text{Tc}, \, ^{99m}\text{Tc}, \, ^{109}\text{Cd}, \, ^{111}\text{In}, \, ^{123}\text{I}, \, ^{124}\text{I}, \, ^{201}\text{Tl}, \, ^{211}\text{At}, \, ^{225}\text{Ac} \]

Novel imaging techniques:
Multimodality scanners, chemical synthesis and biochemical laboratories
Financing nuclear R&D infrastructure

- **NCBJ incomes (2014):** 50 M€
  - 13%: Ministry of Science
  - 2%: Ministry of Economy
  - 22%: grants (PL+EU+US)
  - 63%: commercial (radioisotopes, accelerators)

- **IChTJ ~10 M€, IFJ ~40 M€** (more grants, less commercial)
- Hardly enough to maintain existing infrastructure

- **New infrastructure only from EU structural funds**
  - 35+20 M€ - IFJ Cracow 230 MeV cyclotron+gantry
  - 24 M€ - NCBJ computing centre (500 TFLOPS, 4PB)
  - 10 M€ - IChTJ laboratories
Access to research infrastructures

• Bilateral agreements
  ○ Cooperation with CEA: Osiris → Maria → JHR
    – $\gamma$-heating, Be ageing, Melodi(?) experiments in Maria
    – H2020: POLARIC proposal (to be resubmitted in 2017)
  ○ HZB BER-II n spectro-, diffractometers moving to Maria

• Regional alliances
  ○ Visegrad-group (CZ, HU, SK, PL) – see Hungarian pres.
    – Euratom: VINCO project (coordinated by NCBJ)
  ○ Baltic countries (LT, LV, ET, PL, SE)
    – Euratom: BRILLIANT project

• SNETP activities
  ○ Nuclear Cogeneration Industrial Initiative
    – Euratom: NC2I-R project (coordinated by NCBJ)
Local problems:

- Relatively small power systems & no justification for autonomous handling of nuclear wastes
- Basic technical level of heavy industry & diminishing number of qualified workers
- Poor nuclear research infrastructure & competence gap between old and new nuclear programs

Towards regional solutions:

- Analysis of electric power systems
- Regional cooperation on nuclear waste and fuel cycle
- Macroeconomic impact of nuclear programs
- Nuclear R&D capacity building
Large & small research infrastructures

- System with large R.I. in only a few countries (ESFRI only) is not sustainable
- Researchers from other countries must have possibility to make careers & educate new generations at home
- Otherwise, it is just brain-drain. We must reverse it!

- Small (0-10 MW) reactors necessary for research, education, training and developing safety culture!