Nuclear power today & tomorrow

A view from Poland …

Vogtle Plant License Approval Highlights Nuclear Renaissance

February 13, 2012

The approval of the two new reactors at the Vogtle Plant is the first in three decades.

THEMA

Katastrophe in Japan 2011

Alle Artikel und Hintergründe

Im Ausnahmezustand

Nach dem schwersten Erdbeben in der Geschichte Japans überflutete am 11. März 2011 ein Tsunami weite Teile der Nordostküste. Die Wassermassen rissen fast 20.000 Menschen in den Tod. Im Atomkraftwerk Fukushima Daiichi kam es zum Super-GAU; die Region um die Unglücksreaktoren musste evakuiert werden.

Atomkatastrophe in Japan

Tausende Soldaten suchen nach Opfern

Vier Wochen nach dem Erdbeben versuchen Soldaten in einer großangelegten Suche erneut, Vermisste im Katastrophengebiet zu finden.

Knapp einen Monat nach dem Mega-Erdbeben und dem Tsnumai in Japan suchen Soldaten in der Katastrophenregion unter Trümmern und auf dem Meeresboden nach fast 15.000 Vermissten. Rund 22.000 Soldaten der japanischen Streitkräfte und des US-Militärs durchkämmten den Nordosten der Hauptinsel Honshu, berichteten japanische Medien.

Rauchende Trümmer

Bild: © *dpa.de*

Nach dem Tsunami droht Japan eine Atomkatastrophe

Tokio (dpa) - Ein katastrophales Erdbeben mit Tsunami hat in Japan womöglich mehr als 1000 Menschen in den Tod gerissen und einen gefährlichen Atomunfall ausgelöst. Nach dem schwersten Beben in der Geschichte des Landes mit der Stärke 8,9 rief die Regierung Atomalarm aus.

Experten und Politiker sprachen von der Möglichkeit einer drohenden Kernschmelze im Kraftwerk Fukushima. Zuvor hatte eine Riesenwelle an der Küste Gebäude, Menschen und Fahrzeuge weggespült. Heftige Nachbeben sorgten für Angst. In vielen Ländern rund um den Pazifik brachten sich die Leute aus...

zum Artikel

Meist finden die Helfer jedoch nur noch Tote - die Zahl der geborgenen Leichen liegt inzwischen bei 3676. Die Behörden gehen davon aus, dass das Erdbeben und der anschließende Tsunami bis zu 11.000 Opfer gefordert hat.

Lessons from Fukushima earthquake

Public (mis)perception:

- „Nuclear disaster" happened in Fukushima
- There was a danger of nuclear explosion
- Release of radioactivity threatened the lives of thousands of people

⇒ Nuclear power plants can explode any time

⇒ We better get rid of them all together, at any cost

Facts:

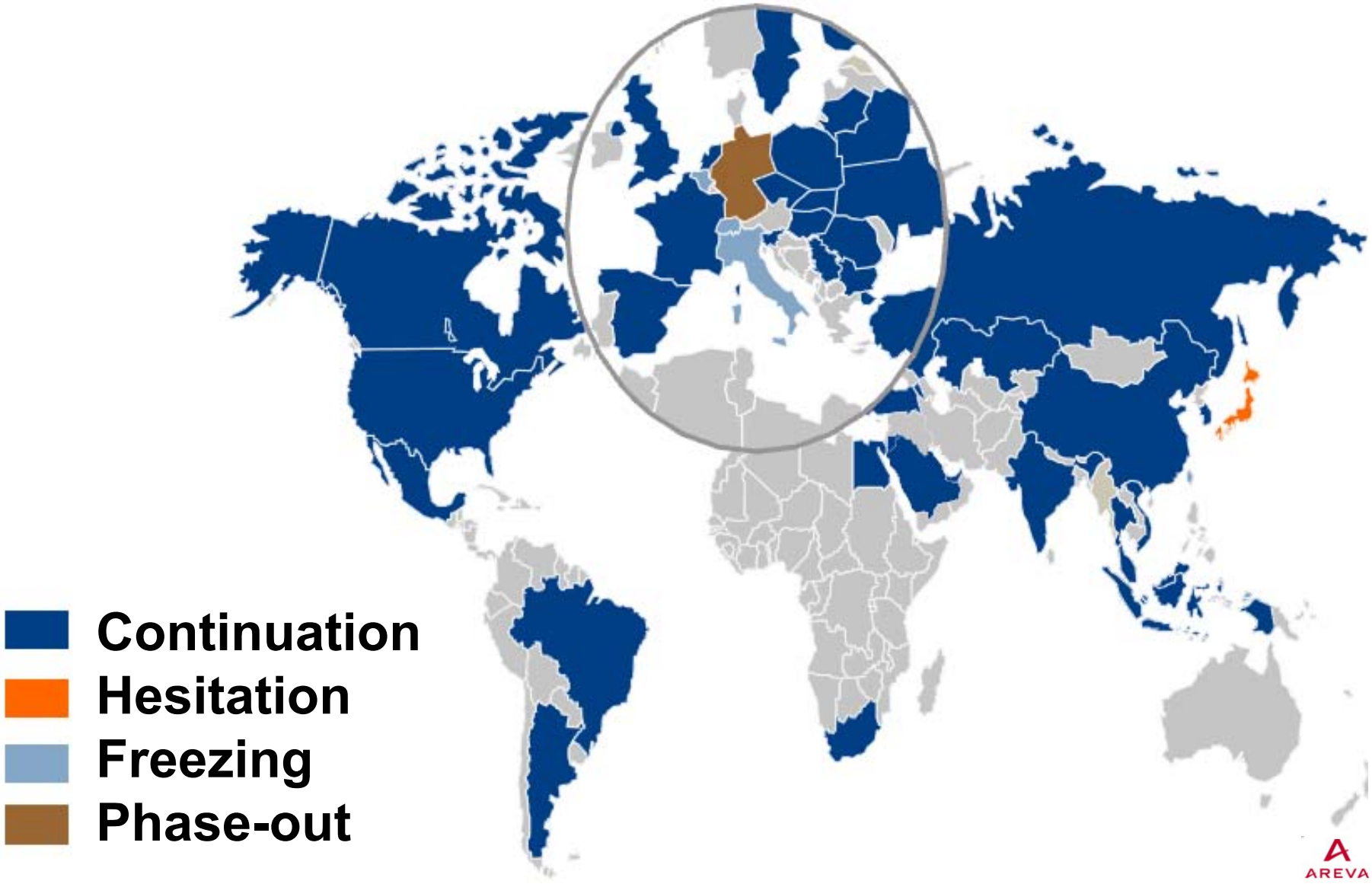
- In spite of terrible natural disasters which lead to damage of 6 reactors, no one was seriously hurt
- 40 reactors provided electricity while other type of plants could not

⇒ It was „experimental" proof of nuclear safety

⇒ Stress tests checked gen. II reactors

⇒ Safety features already implemented in gen. III

Nuclear power plans



Asia

China

- Constructions continue
- Licensing of new reactors suspended
- Debate on exclusion of II gen. newbuilds

India

- Independent regulatory created
- Jaitapur – continuation

South Korea

- More independendent regulator

South-east Asia

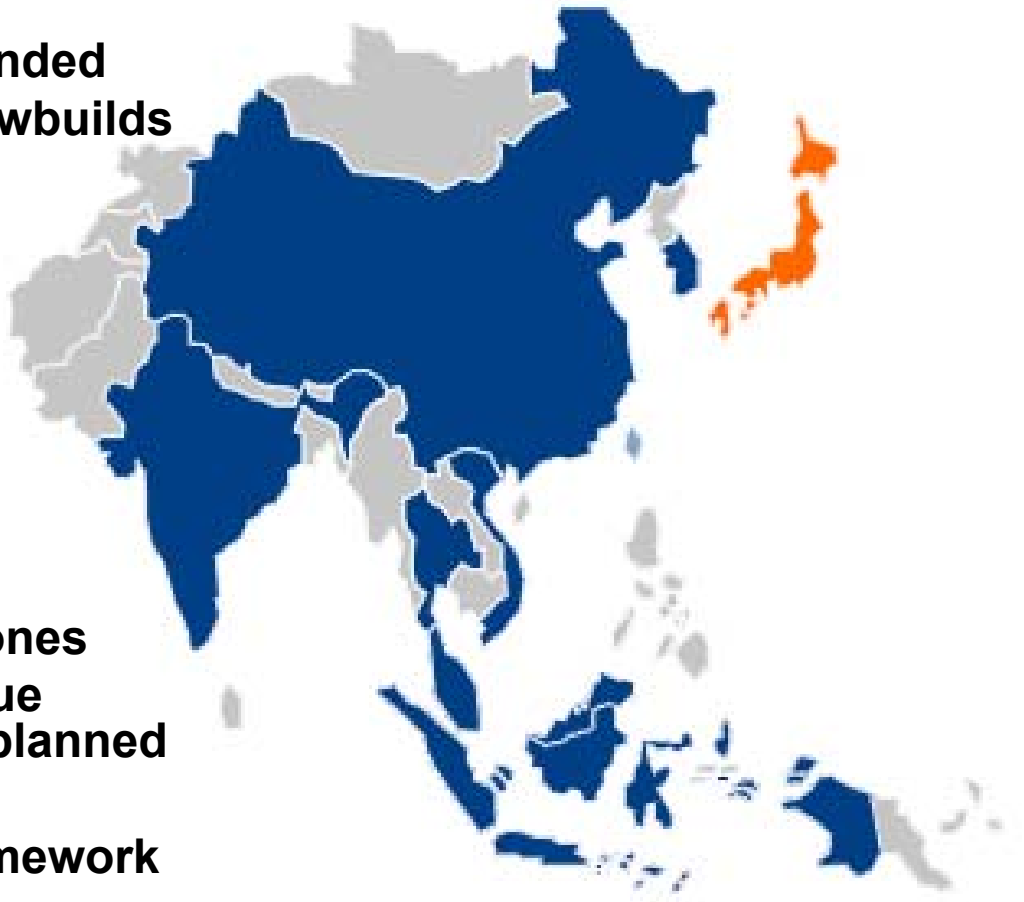
- Continuation of the programs

Taiwan

- No lifetime prolongation for old ones
- Government commited to continue construction, but referendum is planned

Japan

- Reorganisation of regulatory framework
- Constructions suspended
- Extensive review of existing reactors
- 50 „operational”, but only one is on



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Americas

Canada

- Construction programs continued

USA

- 2 licenses issued
- 24 projects investigated by US NRC
- 6 suspended by investors
- Discussion about stronger requirement
- Big push for Small Modular Reactors

Mexico

- Continuation, in spite of divided opinions in the government

Brasil

- Construction programs continued

Argentina

- Construction programs continued

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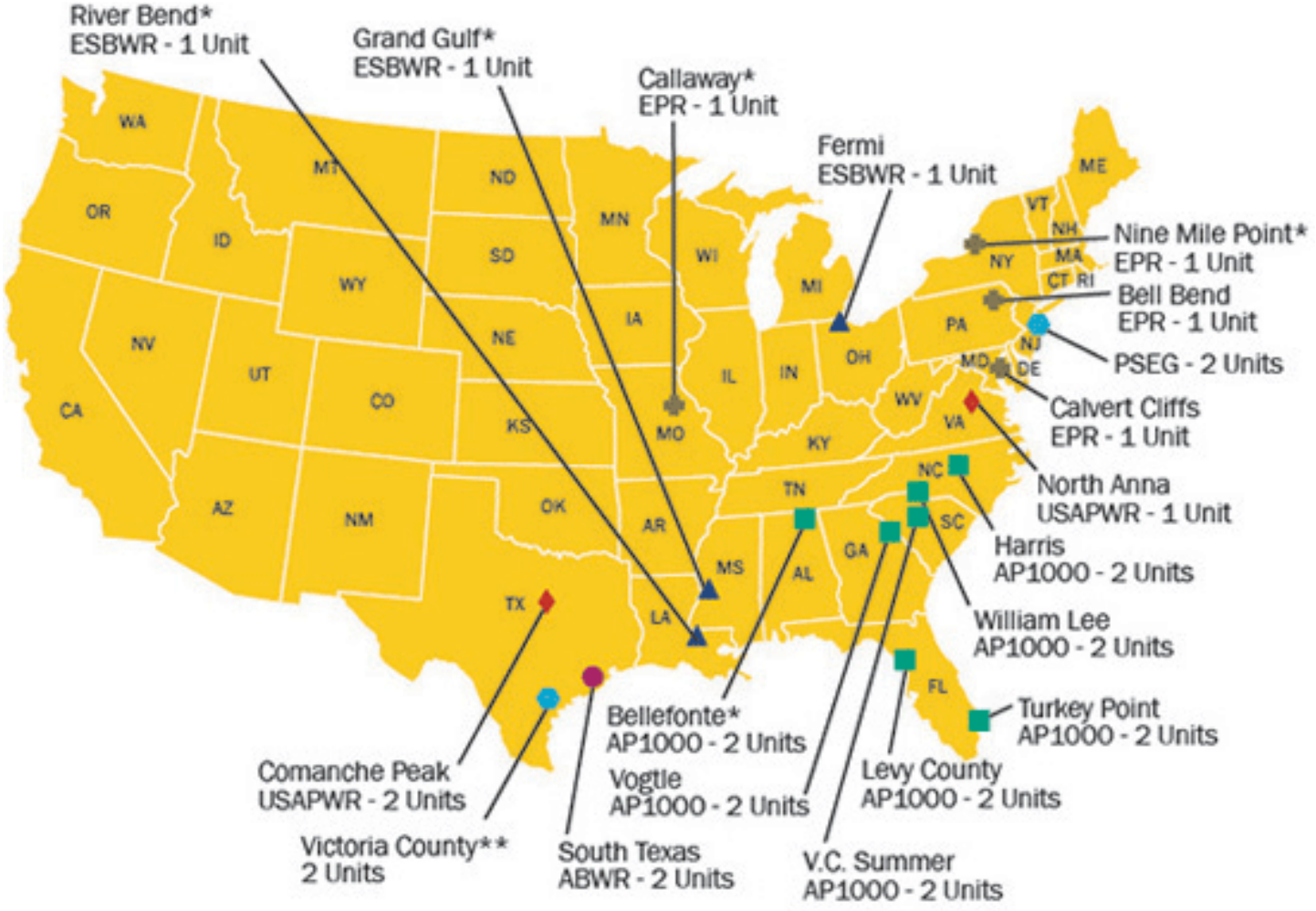
Projects submitted to US NRC



*Review Suspended by Applicant

** COL Application Amended by Applicant to ESP on 03/25/2010

Africa, Middle East, etc.

South Africa
- Continuation confirmed

Saudi Arabia
- Construction programs continued
- 16 bloków do 2030

United Arab Emirates
- Construction programs continued

Jordan
- Construction programs continued

Egypt
- Construction programs continued

Turkey
- Contracts for 2 plans signed, 3rd ongoing
  - 4 ATMEA 1200 MW reactors
  - 4 VVER 1200 MW reactors

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Europe

UK +19GW, Czech R., Poland, Finland, Netherland, Slovakia

- **Construction programs continued**

Hungary, Lithuania, Slovenia

- **Plans for newbuilds**

Switzerland

- **Decision not to build new plants**
- **Extended licese for Muhleberg**

Italy

- **94% against newbuilds**

Belgium

- **Declaration of phase-out if new sources available**
- **Strong R&D effort** (MYRRHA project)

Germany

- **8 reactors permanently shut down**
- **Complete phase-out by 2022**

Still 1/3 of electric energy in Europe comes from nuclear power

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Reactors shut down 3.2011-9.2013

- FUKUSHIMA-DAIICHI-1234 (439+3x730 MW(e), BWR, JAPAN) on 19 May 2011
- OLDBURY-A2 (217 MW(e), GCR, UK) on 30 June 2011
- BIBLIS-A (KWB A) (1167 MW(e), PWR, GERMANY) on 6 August 2011
- BIBLIS-B (KWB B) (1240 MW(e), PWR, GERMANY) on 6 August 2011
- BRUNSBUETTEL (KKB) (771 MW(e), BWR, GERMANY) on 6 August 2011
- ISAR-1 (KKI 1) (878 MW(e), BWR, GERMANY) on 6 August 2011
- KRUEMMEL (KKK) (1346 MW(e), BWR, GERMANY) on 6 August 2011
- NECKARWESTHEIM-1 (GKN 1) (785 MW(e), PWR, GERMANY) on 6 August
- PHILIPPSBURG-1 (KKP 1) (890 MW(e), BWR, GERMANY) on 6 August 2011
- UNTERWESER (KKU) (1345 MW(e), PWR, GERMANY) on 6 August 2011
- OLDBURY-A1 (217 MW(e), GCR, UK) on 29 February 2012
- WYLFA 2 (490 MW(e), GCR, UK) on 25 April 2012
- GENTILLY-2 (635 MW(e), PHWR, CANADA) on 28 December 2012
- CRYSTAL RIVER-3 (860 MW(e), PWR, USA) on 5 February 2013
- KEWAUNEE (566 MW(e), PWR, USA) on 7 May 2013
- SAN ONOFRE-2&3 (1070+1080 MW(e), PWR, USA) on 7 June

Germany 8, Japan 4, UK 3, USA 4, Canada 1, TOTAL 20

Connected to grid 3.2011-9.2013

- CHASNUPP 2 (300 MW(e), PWR, PAKISTAN) on 14 March 2011
- LING AO 4 (1000 MW(e), PWR, CHINA) on 3 May 2011
- CEFR (20 MW(e), FBR, CHINA) on 21 July 2011
- BUSHEHR 1 (915 MW(e), PWR, IRAN,ISL.REP) on 3 September 2011
- KALININ-4 (950 MW(e), PWR, RUSSIA) on 24 November 2011
- QINSHAN 2-4 (610 MW(e), PWR, CHINA) on 25 November 2011
- SHIN-WOLSONG-1 (997 MW(e), PWR, KOREA REP.) on 27 January 2012
- SHIN-KORI-2 (960 MW(e), PWR, KOREA REP.) on 28 January 2012
- NINGDE 1 (1000 MW(e), PWR, CHINA) on 28 December 2012
- HONGYANHE 1 (1000 MW(e), PWR, CHINA) on 18 February 2013

China 5, South Korea 2, Iran 1, Pakistan 1, Russia 1, TOTAL 10

Construction started 3.2011-9.2013

- CHASNUPP 3 (315 MW(e), PWR, PAKISTAN) on 28 May 2011
- RAJASTHAN-7 (630 MW(e), PHWR, INDIA) on 18 July 2011
- RAJASTHAN-8 (630 MW(e), PHWR, INDIA) on 30 September 2011
- CHASNUPP 4 (315 MW(e), PWR, PAKISTAN) on 18 December 2011
- BALTIC-1 (1082 MW(e), PWR, RUSSIA) on 22 February 2012
- SHIN-ULCHIN-1 (1340 MW(e), PWR, KOREA REP.) on 10 July 2012
- BARAKAH 1 (1345 MW(e), PWR, UAE) on 18 July 2012
- FUQING 4 (1000 MW(e), PWR, CHINA) on 17 November 2012
- YANGJIANG 4 (1000 MW(e), PWR, CHINA) on 17 November 2012
- SHIDAO BAY 1 (200 MW(e), HTGR, CHINA) on 9 December 2012
- TIANWAN 3 (933 MW(e), PWR, CHINA) on 27 December 2012
- VIRGIL C. SUMMER-2 (1117 MW(e), PWR, USA) on 9 March 2013
- VOGTLE-3 (1117 MW(e), PWR, USA) on 12 March 2013
- SHIN-HANUL-2 (1340 MW(e), PWR, KOREA REP.) on 19 June 2013

China 4, India 2, South Korea 2, Pakistan 2, USA 2, Arab Emirates 1, Russia 1, TOTAL 14

Currently 69 reactors under constrution all over the world

Why the world still attached to NP?

Physics constraints (independent off technology):

Uranium (nuclear power) – huge energy density

Gas, oil, biomass (chemical en.) – medium density

Wind, solar – very low energy density

Fuel for GW/year (1 big power plant) needs: Poland 36 GW, Slovenia 2 GW, EU27 650 GW		
Biomass	**2 000 km^2 fields**	
Wind	**486 km^2 area**	**2700 windmills of 1,5 MW**
Solar	**23 km^2 panels at equator**	**2555 football fields**
Biogas	**20 000 000 pigs**	
Natural gas 45 MJ/kg	**1,2 km^3**	
Oil 46 MJ/kg	**1 400 000 tons**	**10 000 000 barrels**
Coal 10-30 MJ/kg	**2 500 000 tons**	**26 260 rail cars** **= 2 trains / day**
Uranim 500 000 MJ/kg	**35 tons of UO_2**	**a few trucks**

Nuclear, windmills or gas?

- **Common perception: nuclear plants in Germany are to be replaced with „renewable" energy sources, maily winmills.**
- **But wind blows on average 20% of the time. At least 80% of the nominal windmill's power must be backed up with gas power plants.**
- **Nominal power of 1000 MW in windmills means 200 MW from wind & 800 MW from gas**
- **In fact, the nuclear power plants in Germany will be in >80% replaced by gas-fired plants**

Nuclear vs gas

- **There is strong competition between nuclear and gas industry**
- **They have very different business models**
  - **Gas-fired plat can be quickly built for relatively low cost, electricity cost dominated by gas prices**
    - weak point: profit depends on gas price & availability
  - **Nuclear plant construction is expensive, but fuel cost is only ~5% of the overall cost.**
    - weak point: large investment needed at the beginning

Reasons behind German phase-out

Recent decision announced 30.05.2011

- 3 months after Fukushima earthquake (11.03.2011)
  - >6R earthquakes & tsunami never happen in Germany
- 3 weaks after finishing the first pipeline of NordStream (4.05.2011)
  - NordStream throughtput would not be justified without nuclear phase-out

Phase-out decision taken already in 2002

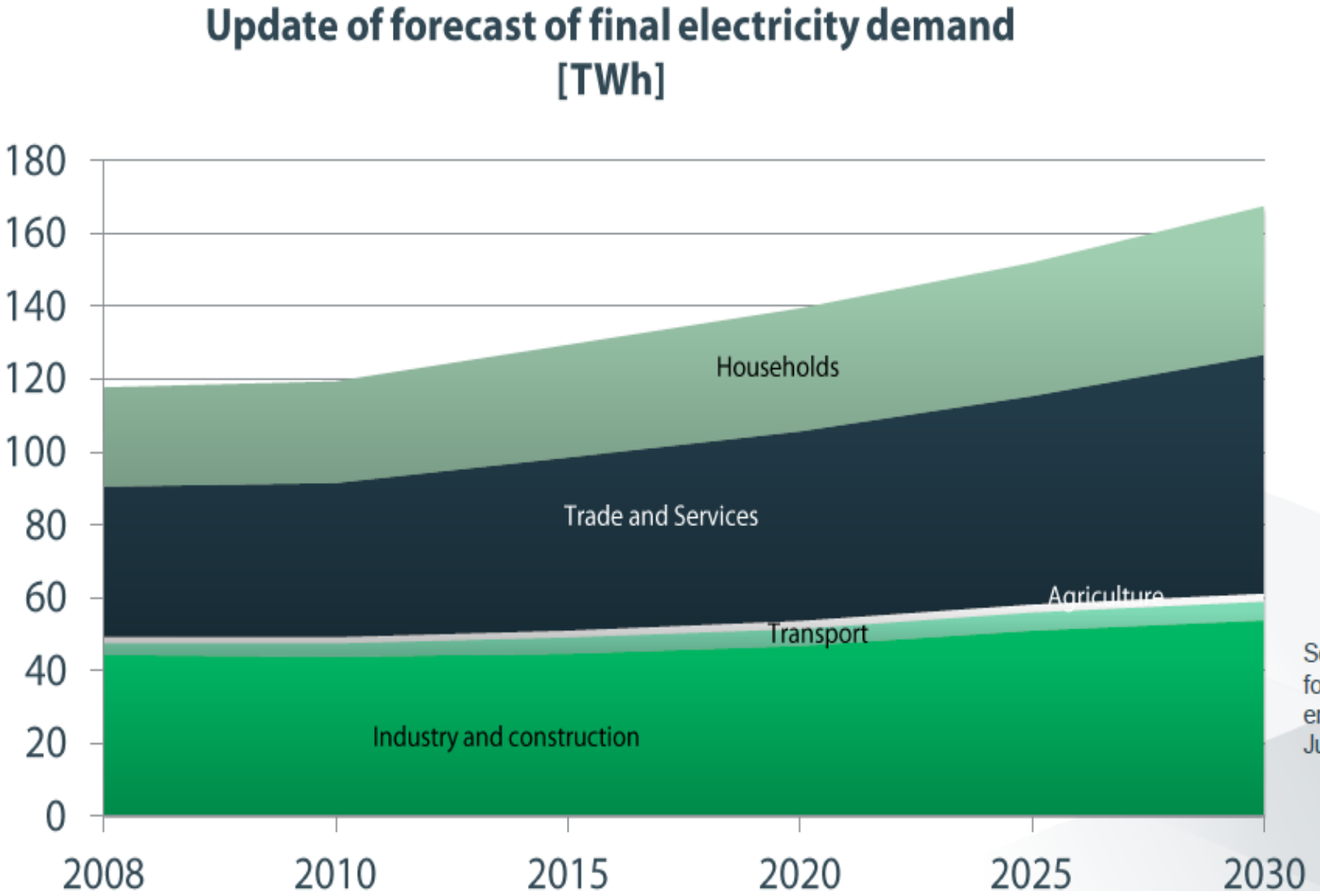
  - Several times delayed, but never canceled
  - Taken by Schröder, who became head of Nordstream shareholder's committee 3 months after signing Nordstream agreement as the Chancellor of Germany

Energy policy of Poland

Let's make a joke to Poles and place them between Germany & Russia

- **Today, electricity production in Poland is ~100% based on domestic sources** (mainly coal)
- **Security of supply remains the priority for future policies**

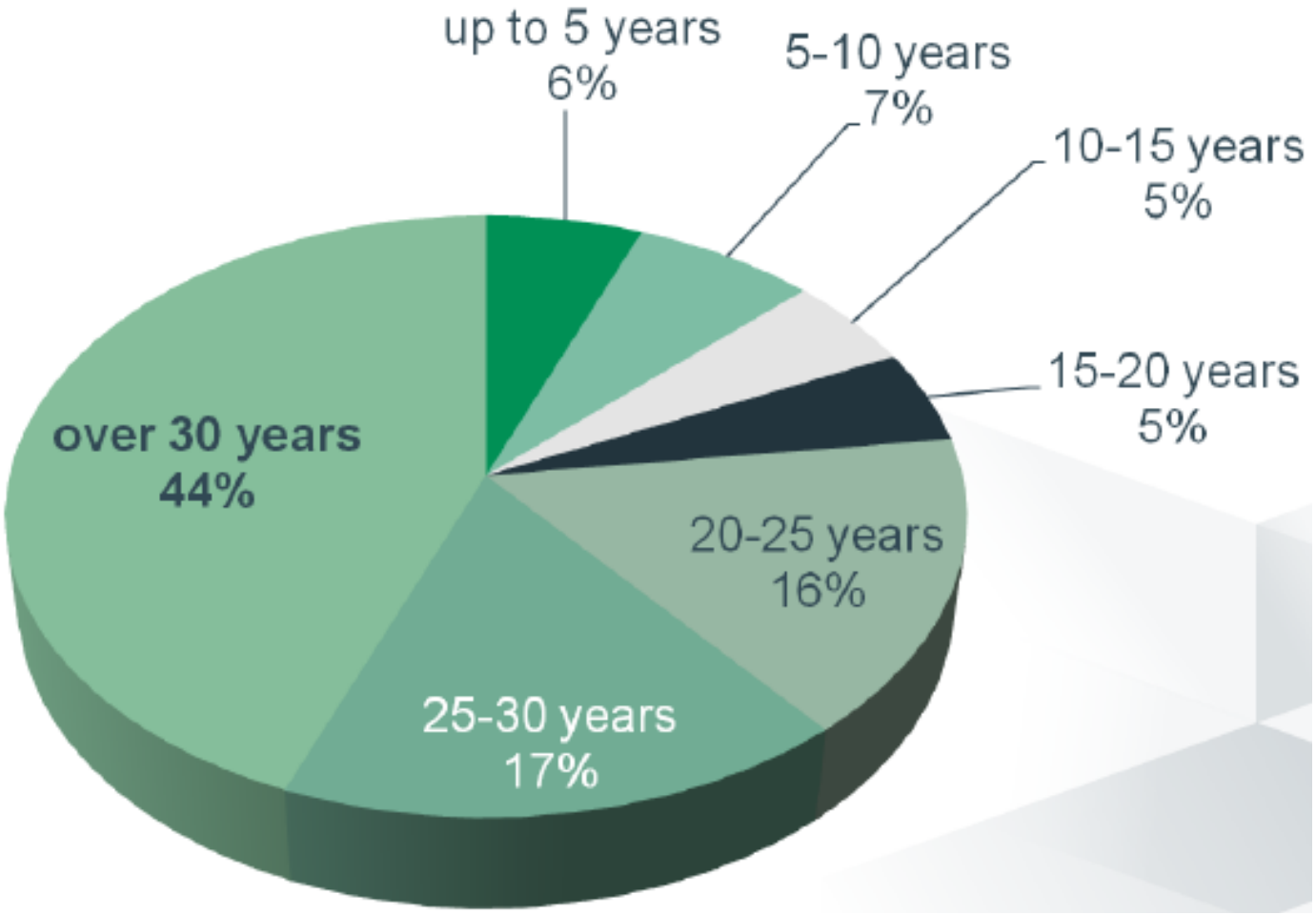
Electricity demand in Poland will grow



MINISTRY of ECONOMY

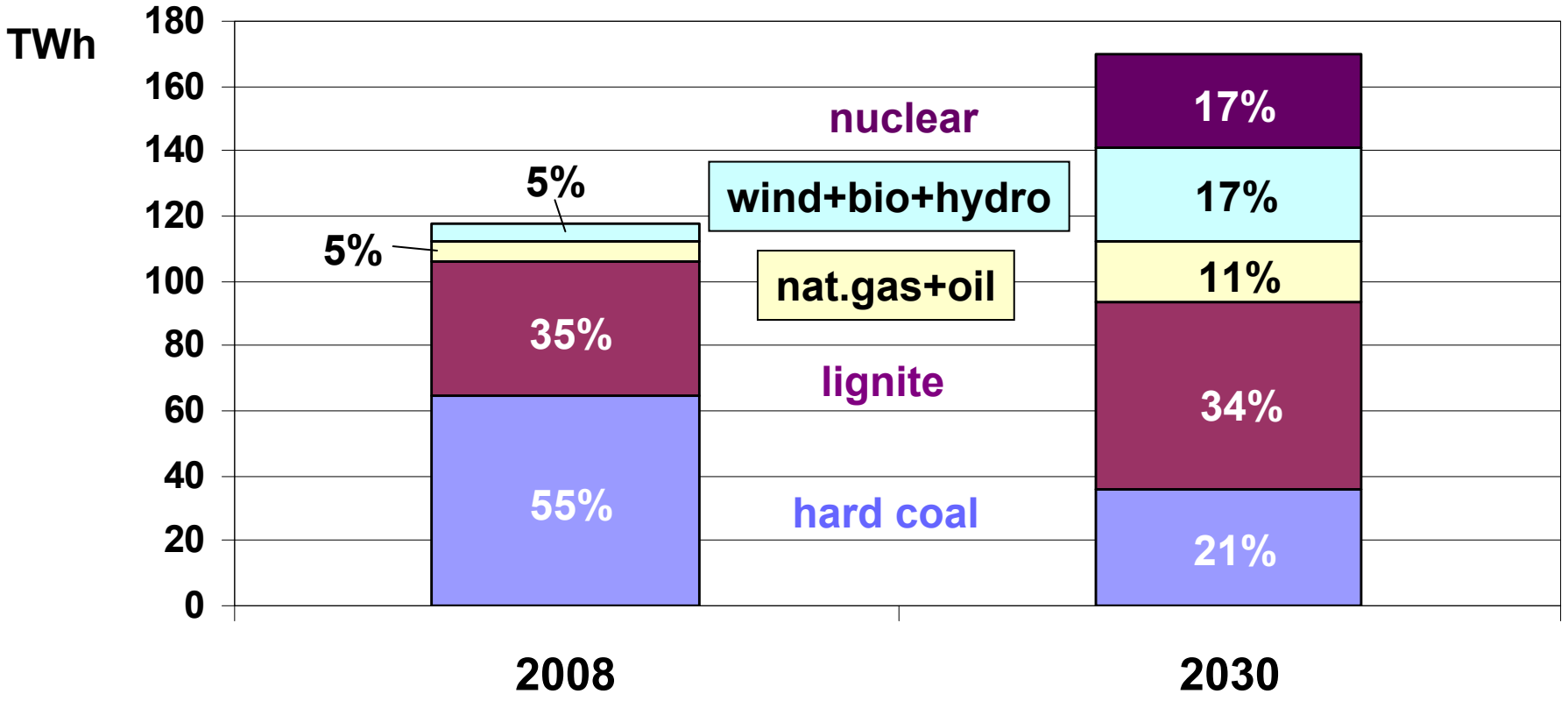
Source: Updated forecast of fuels and energy demand, EMA, July 2011

Age structure of power plants in Poland



MINISTRY OF ECONOMY

Electric energy mix in Poland



Energy mix fixed ±5% by available resources

- **Keep coal ~constant: new plants to replace old,**
  - **more lignite, less hard coal**
- **Match increase of demand by more gas, wind & nuclear**

Alternative for nuclear energy in Poland?

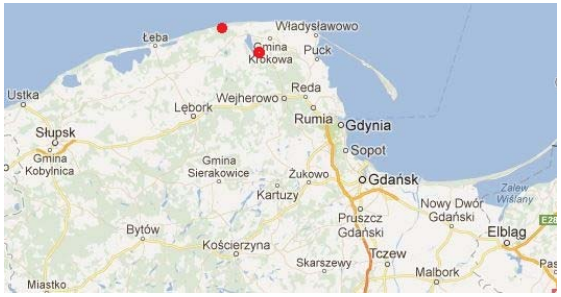
Yes, imported nuclear energy.

Units 300 km from Polish border:

- 23 in operation
- 6 in construction
- 9 planned

All neighbours by 2020 will have nuclear plants

First unit in Poland by 2024



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 2024**

Current plan for the first unit:

- **2015 – technology choice**
- **2016 – request for permit**
- **2018 – licence issued**
- **2024 – in operation**

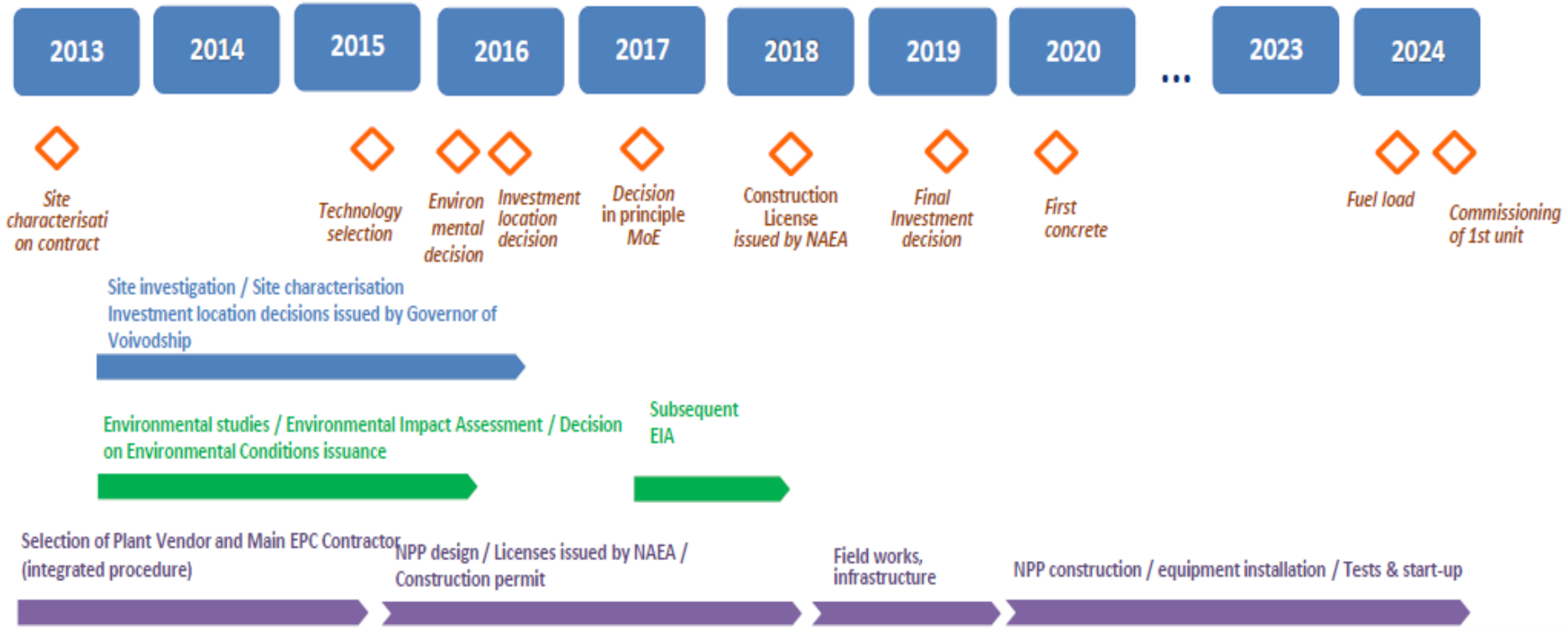
PGE

Polska Grupa Energetyczna

PGE schedule for the first unit

Framework schedule for the commissioning of first Polish NPP unit encompassing the integrated procedure (selected elements)

- Launch of site characterization works – 1st half of 2013
- Conclusion of the integrated proceedings – 1st half of 2015
- Launch of construction activities – 2d half of 2018 (first nuclear concrete – 1st half of 2020)
- Launch of operations of the first NPP unit – 2d half of 2024



Current status of PGE EJ1 activities

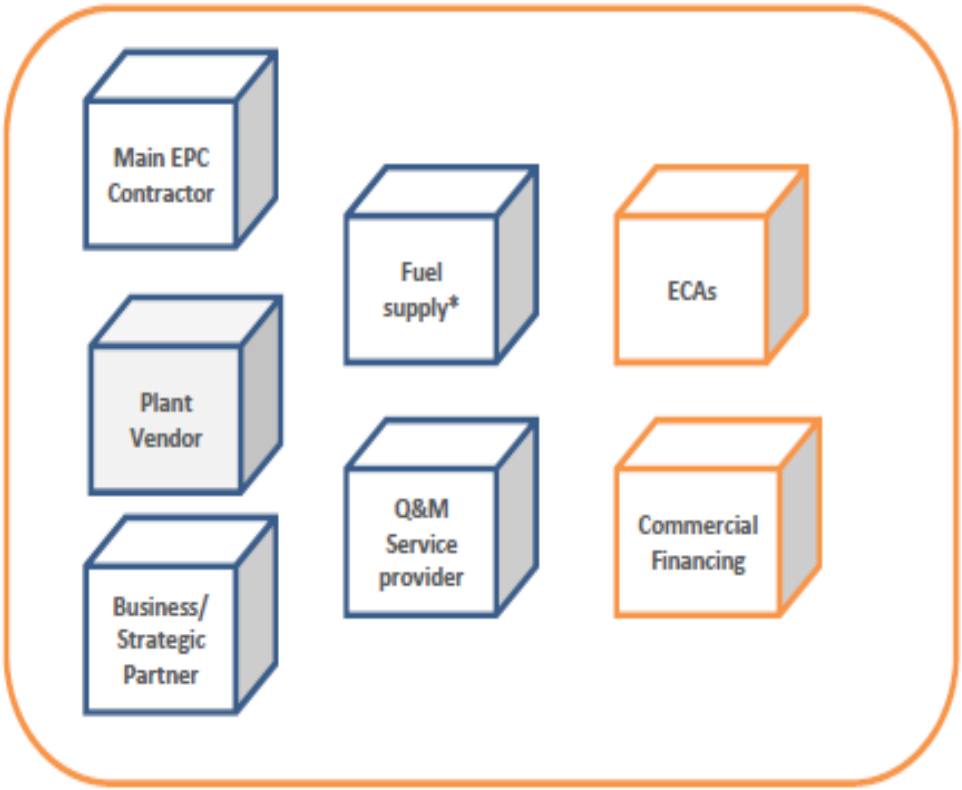
- **Two nearby potential sites selected:**
  - **Żarnowiec (lake side)**
  - **Choczewo (sea side)**
- **WorleyParsons contracted for site surveys**
- **Tender for Owner's Engineer published**
- **Decision taken on integrated procedure:**
  - **Single contract with a consortium for:**
    - reactor technology and construction
    - maintenance & operation
    - fuel supply
    - financing
  - **Dialog with consortia started 18.04.2013**

Tender for vendor+O&M+fuel+financing

Integrated procedure

Under integrated procedure, the potential vendors will be required to include the following in their tender offers:

- Nuclear technology for an NPP of 3000 MWE installed capacity – 2 or 3 units based on a gen. III/III+ technology, together with main EPC services delivery
- O&M support services, together with the knowledge transfer program to benefit PGE EJ 1 (O&M)
- Strategic Partner's equity interest and energy off-take
- Declaration of intent to provide debt financing by ECAs and commercial banks (letters of intent and preliminary financing arrangements at the technology selection stage)
- Fuel supply
- Recent development: **commencement of the initial dialog with consortiums on 18th April**



*The question of embedding fuel supply in the integrated proceedings is subject to further analyses

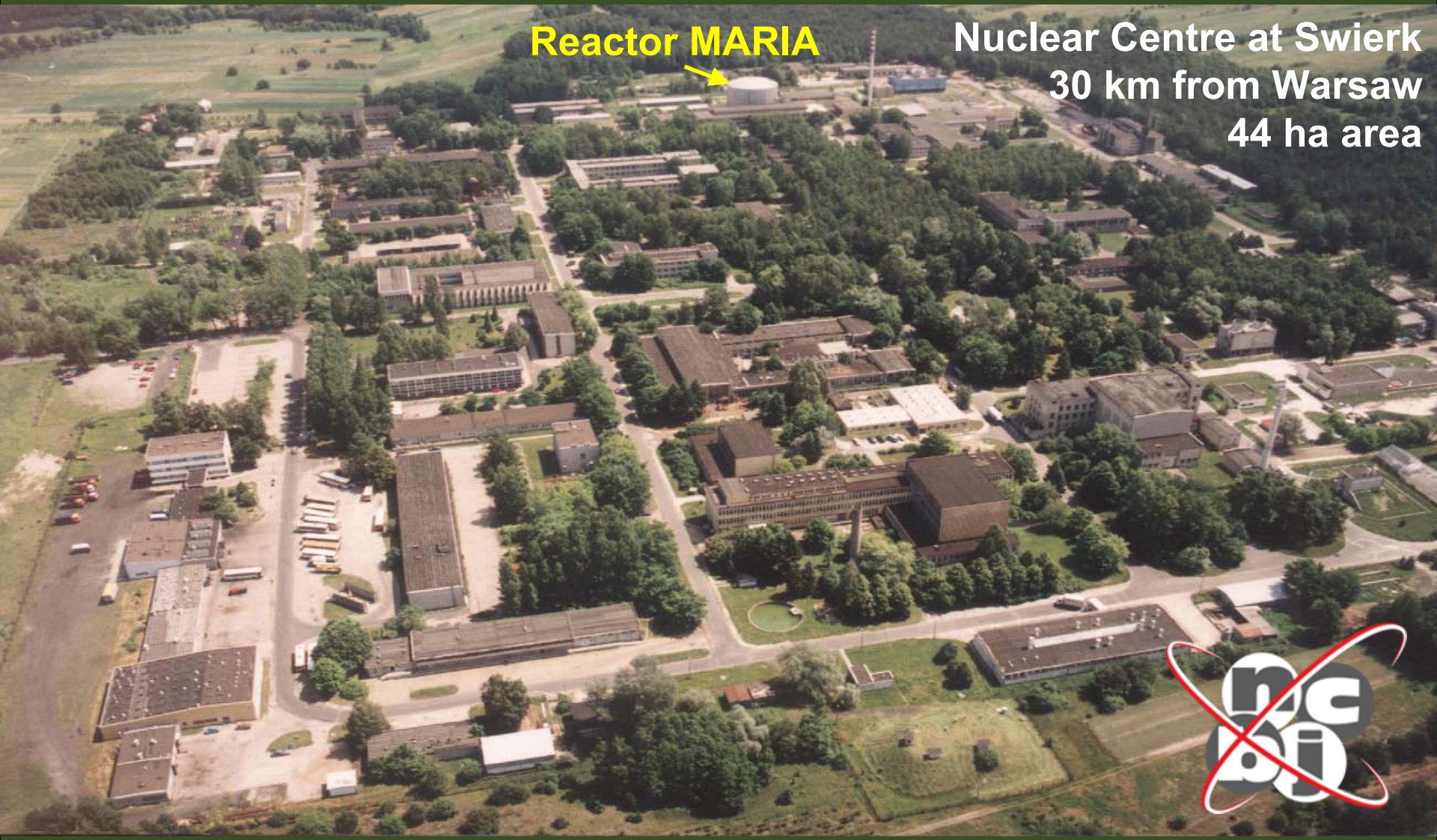
Polish nuclear institutes

Institute	site	staff	supervised	funded
National Centre for Nuclear Research (**NCBJ**)	Świerk, Łódź, Warsaw	1073	Ministry of Economy	Ministry of Science & Higher Education
Inst. of Nuclear Chemistry & Technology (**IChTJ**)	Warsaw	241		
Central Lab. for Radiological Protection (**CLOR**)	Warsaw	53		
Institute of Nuclear Physics (**IFJ**) Polish Academy of Sciences	Cracow	486	Ministry of Science & Higher Education	

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, + …

National Centre for Nuclear Research



ncbj@ncbj.gov.pl

www.ncbj.gov.pl

National Centre for Nuclear Research

- **The largest research institute in Poland**
  - **1073 employees, inc. 56 prof. & 117 PhD**
- **Mission:**
  - **Conduct basic and applied research in international cooperation**
  - **Provide research infrastructure for Poland and international community**
  - **Develop nuclear technologies and products for various applications**
  - **Support Polish nuclear power programme**
- **Incomes:**
  - **statutory fund ~20%, grants/projects ~30%**
  - **commercial activities ~50%**

Commercial activities

Accelerators & detectors for medicine, science & industry

Radioisotopes to 75 countries

National Centre for Nuclear Research

Scientific Council

Director
Grzegorz Wrochna

RESEARCH SECTOR

Scientific Director
Ewa Rondio

Deputy for Research Infrastructure
Krzysztof Wieteska

Director of DEJ
Grzegorz Krzysztoszek
Nuclear Energy Department
MARIA Reactor

Director DBP
Grzegorz Wilk
Department of Fundamental Research

Director of DFM
Jacek Jagielski
Material Physics Department
Material Research Laboratory

Director of DTJ
Agnieszka Syntfeld-Każuch
Department of Nuclear Techni-ques & Equipment
Division of Nuclear Equipment HITEC

FUNCTIONAL SECTOR

Director's Office
Director supervised units

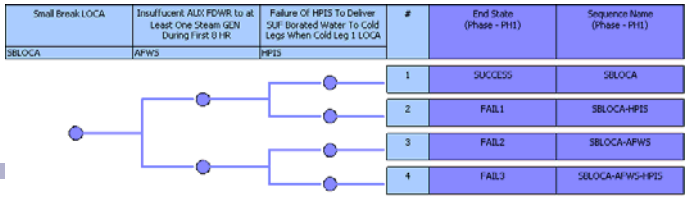
Scientific Secretary
Krzysztof Kurek
Department of Information & Education

Deputy for Nucl. Safety & Radiolog. Protection
Jerzy Kozieł
Department of Nucl. Safety & Health Care

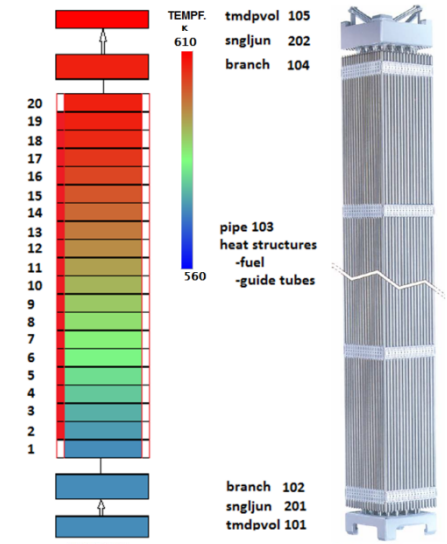
Deputy for Economy & Development
Zbigniew Gołębiewski
Department of Economy & Development
Radioisotope Centre POLATOM

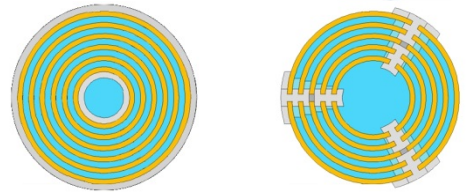
Administrative & Technical Deputy
Marek Juszczyk
Administration & Technical Department
Division of Transport

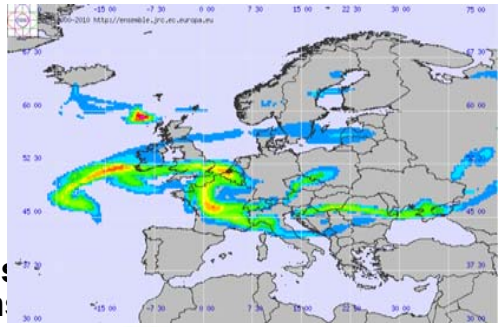
Nuclear Energy Division



- **Safety Analyses:**
  - **DSA (Currently used codes: CATHARE 2 v25_2 mod8.1, RELAP5 – projects made in collaboration with** IAEA **and** CEA **experts)**
  - **PSA (work done for** NAEA**)**
- **New Reactor Technologies:**
  - **Polish projects:** HTR PL**;**
  - **International projects:** Allegro, NC2I-R **(*Nuclear Cogeneration Industrial Initiative)*;**
- **Reactor Core Neutronic Analyses:**
  - **Calculation done for** polish research reactor MARIA**;**
  - **Validation of neutronic calcultaion in collaboration with** Argonne National Laboratory;
- **Nuclear Fuel Cycle;**
  - **Participation in Thorium project;**
  - **Transmutation of a nuclear wastes – collaboration with JINR Dubna;**
    - Use of ADS and fast reactors;
- **Radiochemistry and Environmental Analyses:**
  - **Spectrometrical Laboratory**
    - Nuclear fuel composition measurement
    - Environmental tests
    - Detection of composition of archeological objects and geological materials
  - **Participation in radiological waste repository planning and design program**
  - IPPA Project
- **Centre of Excellence MANHAZ;**
  - **Modelling of the weather, atmospheric releases of hazardous substances** (RODOS system**) and radioactive ground contamination, CFD calculations**
- **CIŚ – high performance computing centre;**







Codes for reactor simulation & safety analysis

DSA used:

- CATHARE2 v25_2 mod8.1 – thermal-hydraulic; CEA code;
- RELAP5/MOD 3.2 – thermal-hydraulic;
- RELAP5/SCDAPSIM – thermal-hydraulic and core degradation;
- Dragon 4 – core neutronics;
- Serpent – core neutronics;
- URANIE 2.3.0-NGI – senivity and uncerteinty study, CEA code;

DSA planned:

- MELCOR – sever accident;
- TRACE – thermal-hydraulic;
- PARCS – reactor kinetics;
- ASTEC – sever accident;
- CATHARE3 - thermal-hydraulic;
- Draccar – thermo-mechanical;
- ATHLET - thermal-hydraulic;

PSA used:

- Saphire;
- COSYMA;

CFD used:

- ANSYS Fluent;
- OpenFOAM;
- TRIO_U – CEA code;

CDF planed:

- NEPTUNE_CFD

CORE NEUTRONICS used:

- MCNP, SERPENT - Reactor core characteristics;
- REBUS, WIMS - Diffusion burn-up calculations; transport lattice calculations;
- WIMS-GNOMER - Core simulator for PWR reactor (in progress);
- MCNP - Validation of diffusion and transport models;
- APOLLO 2.8-3E, CRONOS 210, TRIPOLI 4 – CEA codes;

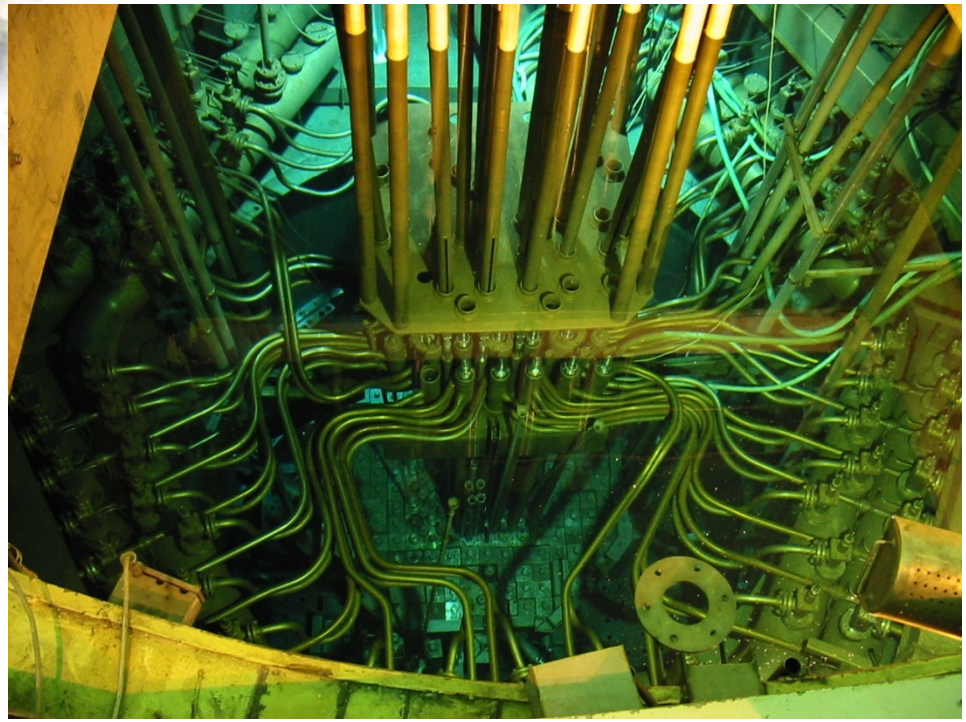
International collaboration

- **IAEA:**
  - Participation in trainings, courses and conferences;
  - Participation in TSO Forum and Advisory Meetings;
- **NEA OECD**
  - Representation of Poland in different Committees and Working Groups;
- **Participation in NUGENIA and SNETP;**
- **Participation in SARNET project;**
- **Participation in EURATOM/FP7 projects:**
  - PRACE, EXASCALE - mass calculations;
  - ASGARD with IChTJ – management and transmutation of the spent fuel;
  - FIRST with IGT – geological disposal of the spent fuel;
  - PELGRIMM with IChTJ – comparison of different transmutation methods of the spent fuel;
  - NURESAFE – creation of a platform of a Best Estimate Codes for nuclear industry;
  - ASAMPSA_E: Advanced Safety Assessment Methodologies: Extended PSA
  - ESNII - European Sustainable Nuclear Industrial Initiative;
  - NC2I-R - Nuclear Cogeneration Industrial Initiative **– coordinated by NCBJ**
  - ALLIANCE part of the ALLEGRO project;
- **CEA:**
  - Training for performing calculations with CEA codes;
  - Maria reactor and JHR collaboration;
- **GE-Hitachi and Westinghouse – bilateral agreements;**

Research reactor MARIA at Świerk

- neutron beam research, material irradiation, radioisotope production
- ^{99}Mo for medical use
  18% of world production
- 1 week of Maria irradiation =
  100 000 medical procedures

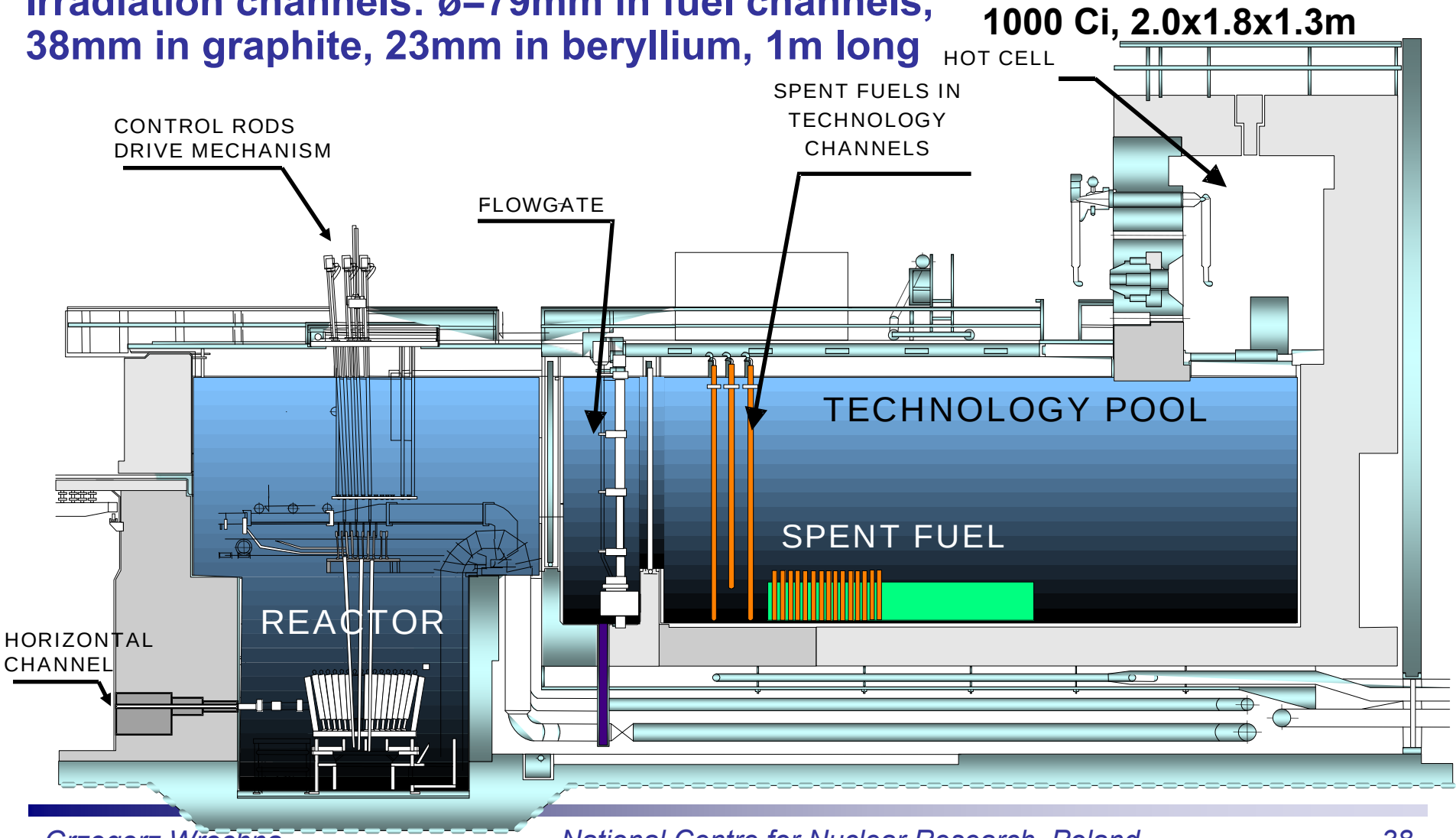
- built 1974, upgrade 1992
- pool type
- H_2O, Be moderated
- 30 MW thermal power
- neutron flux:
  - thermal $4 \cdot 10^{14}$ n/cm^{2}s
  - fast $2 \cdot 10^{14}$ n/cm^{2}s



Maria research reactor

Each channel is individually connected to the primary cooling circuit

Irradiation channels: ø=79mm in fuel channels, 38mm in graphite, 23mm in beryllium, 1m long



What could we offer to next generations?

- 8000 high schools student in NCBJ each year
- Physics competitions, science festivals, …

… to make nuclear attractive for the young generation

Sustainable development

- **Sustainable development is more than just environment protection.**
- **It is our duty to provide for next generations the means to live better life without degradation of the planet.**
- **This includes the means to produce energy with minimal impact on the environment, to avoid:**
  - **air pollution**
  - **waste production**
  - **biosphere damage**
  - **land degradation**

Developing nuclear energy technologies

SNETP
Sustainable Nuclear Energy Technology Platform

Grown from 35 to >100 EU organisations

Industry:

Research / Engineering:

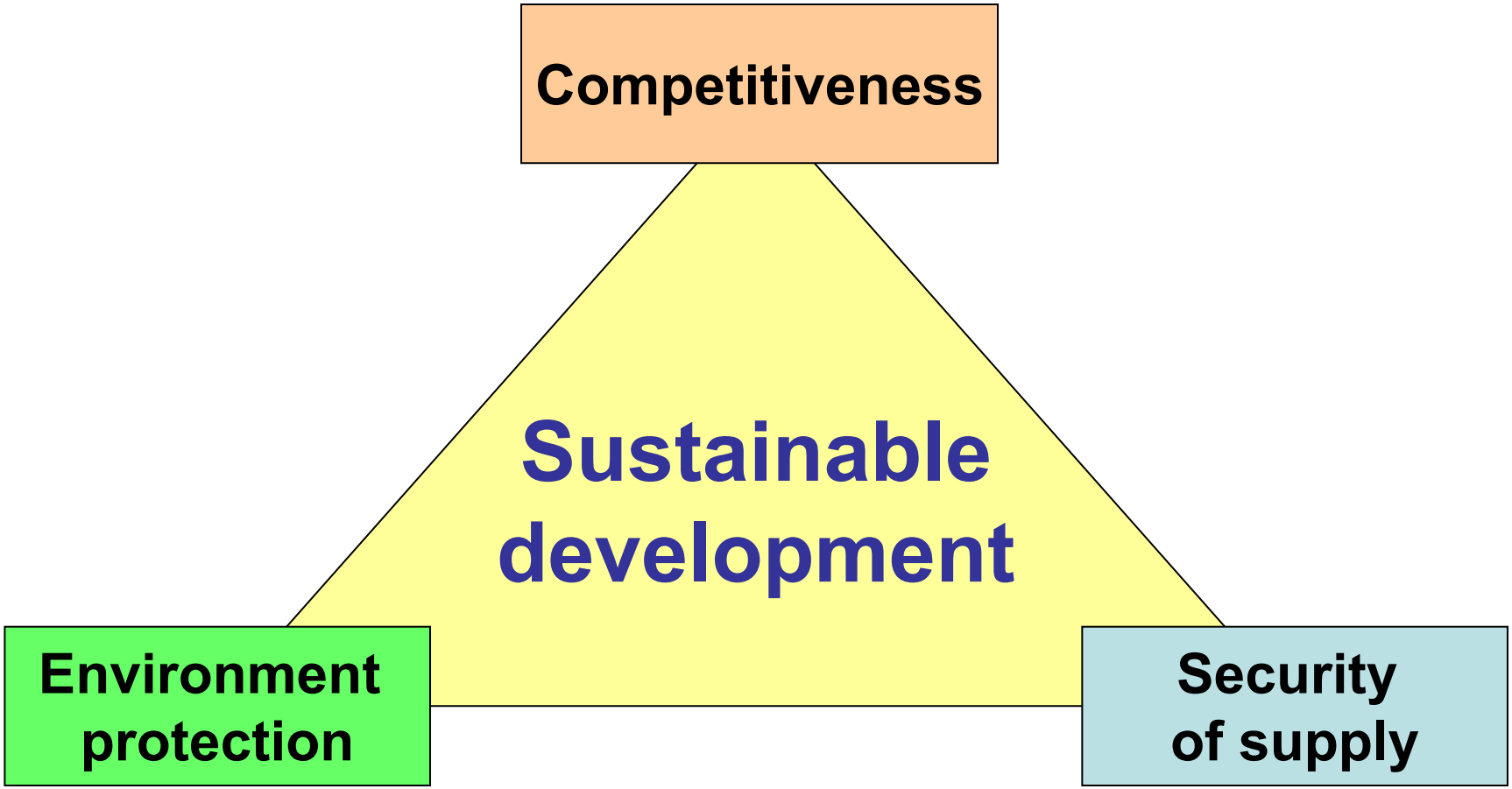
Academia:

Technical Safety Organisations:

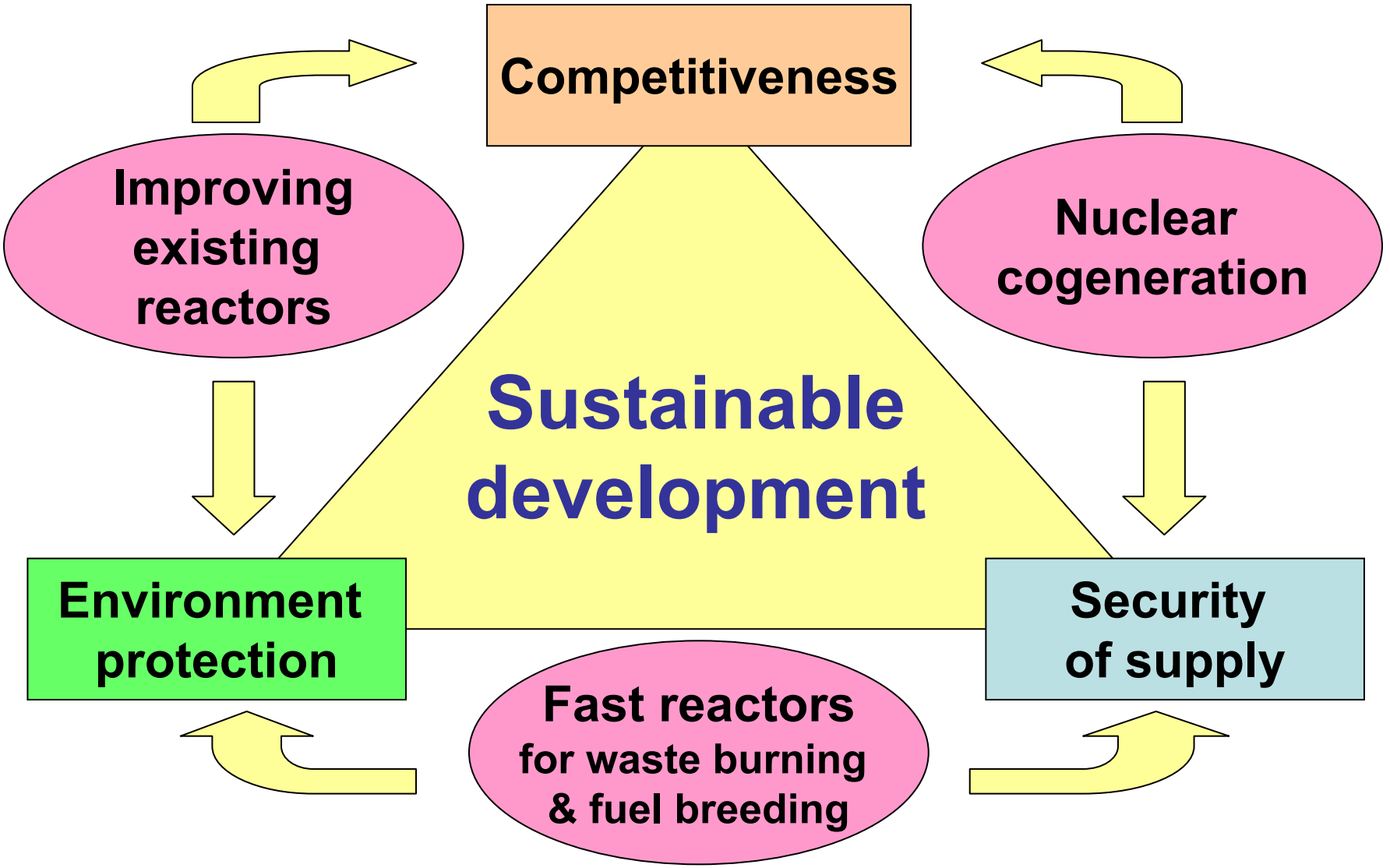
Non-governmental Organisations:

Others:

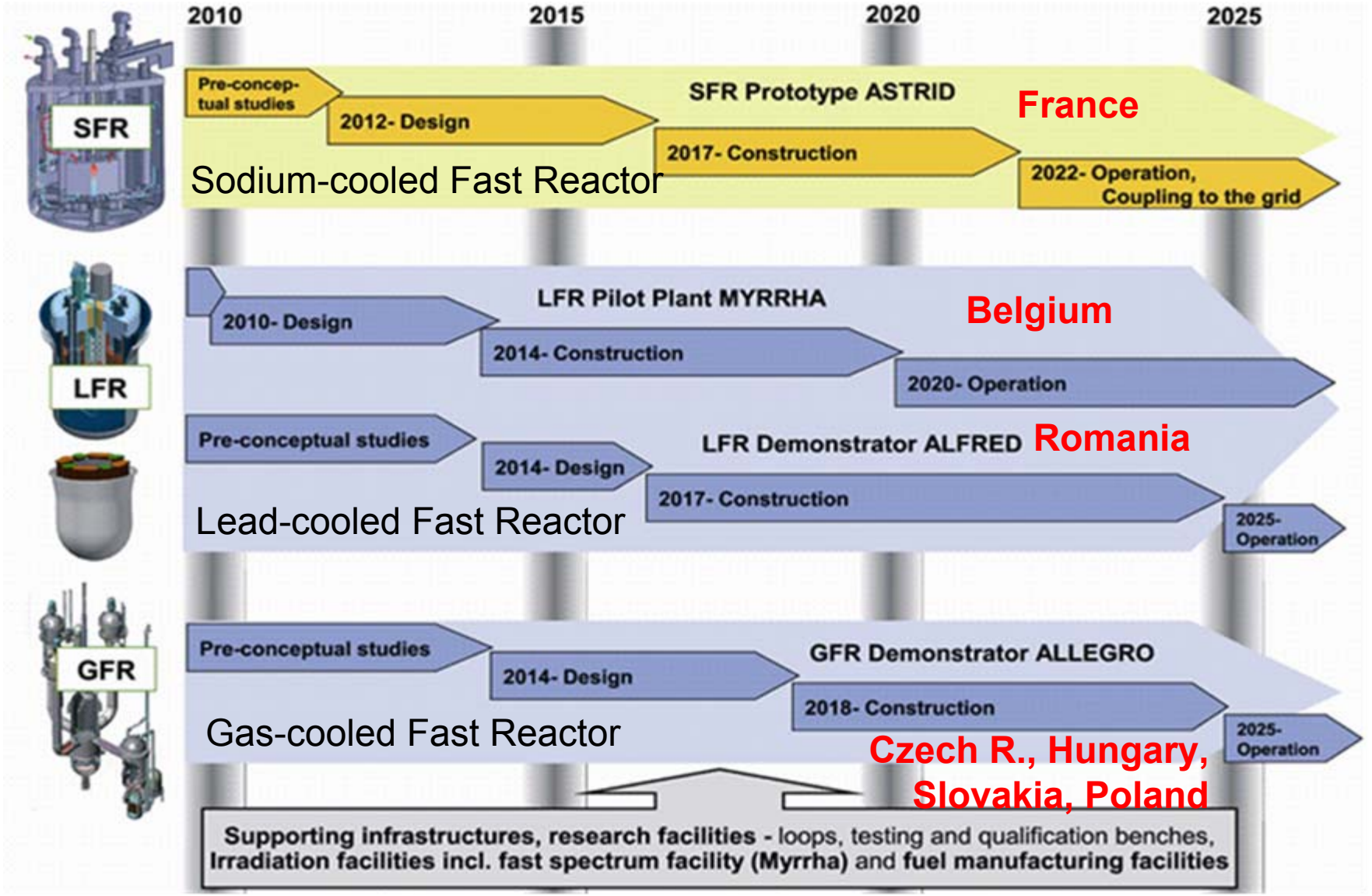
Development triangle



Sustainable Nuclear Energy Technology Platform



2040: Target for the deployment of Gen-IV Fast Neutron Reactors with Closed Fuel Cycle



Visegrad-4 for Generation-4 reactors

association created 15.08.2013

V4G4

phase I

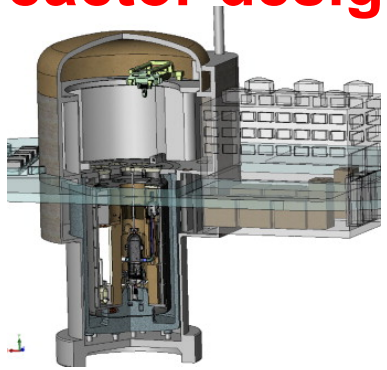
capacity building

know-how **infrastructure**

Allegro

phase II

reactor design



other projects

France: **Technology input**

Slovakia: **Reactor design & safety**

- safety concept, design basis, simulation and numerical analysis

Chech R: **Research laboratory on technology related experiments**

- thermophysics, aerodynamics, helium technology, reactor physics, etc.

Hungary: **Laboratory on the closed fuel cycle and fuel issues**

- PIE of ceramic fuels, separation of minor actinides, fuel fabrication, etc.

Poland: **Material research laboratory**

- irradiation by reactor & accelerators, structural & functional material analysis

Conclusions

- **Nuclear power remains one of the dominant electric energy sources worldwide**
- **New generation of reactors is needed for better use of U, reduction of waste & for cogeneration**
- **Europe needs to reinforce its position in the world nuclear power sector**
- **Structural funds in some coutries are available for this effort**
- **Regional cooperation between new EU member states is essential**

In the nuclear world we have common goals