PAUL SCHERRER INSTITUT

PSI

Wir schaffen Wissen – heute für morgen

Paul Scherrer Institut

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Research in Switzerland at the Nuclear Energy and Safety division (NES) at PSI

July 7, 2015

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- Priorities for Nuclear Research in Switzerland
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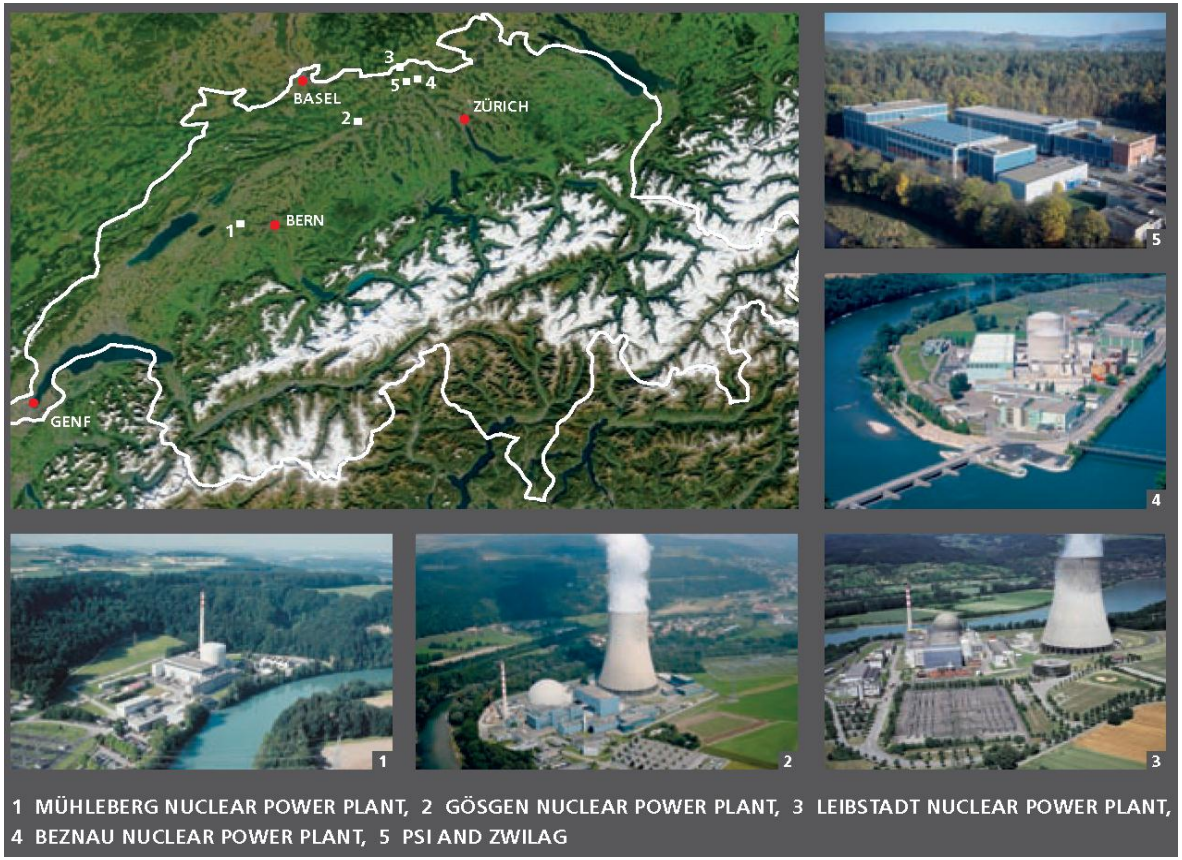
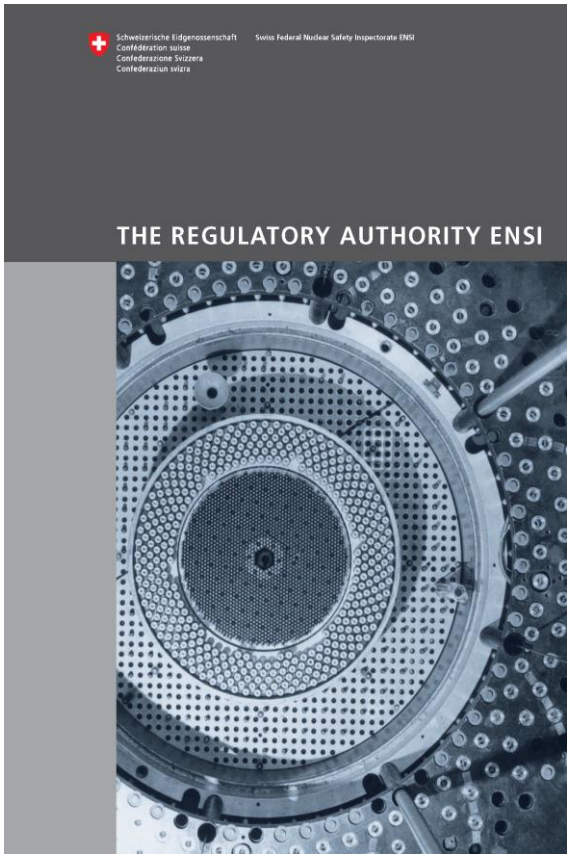
National context: Energy Strategy 2050

- In 2011, the **Federal Council and Parliament decided** that **Switzerland** is **to withdraw from the use of nuclear energy on a step-by-step basis**.
- The existing five nuclear power plants are to be decommissioned when they reach the end of their safe service life, and will not be replaced by new ones.
- As a result of this decision and various other profound changes that have been observed for a number of years, in particular in the international energy arena, the Swiss energy system will require successive restructuring in the period up to 2050.
- In view of this, the Federal Council has developed a long-term energy policy ("**Energy Strategy 2050**") based on the revised energy perspectives. It has produced an initial package of measures aimed at securing the country's energy supply over the long term.

Swiss Federal Office of Energy, May 29, 2015

National context: NPPs in Switzerland





NPP	Type	Shut down	50 yrs	60 yrs	Net Elect. Power
Beznau I	PWR		2019	2029	365 [MWe]
Beznau II	PWR		2021	2031	365 [MWe]
Mühleberg	BWR	2019	-	-	373 [MWe]
Gösgen	PWR		2029	2039	1010 [MWe]
Leibstadt	BWR		2034	2044	1220 [MWe]

National context: Nuclear research to continue

Nuclear research will continue despite the decision to not build new reactors:

- Reactors will operate for many more years to come
- Waste repository work will be required as well
- Monitoring of the nuclear technologies is a mandate

The Swiss competence center for nuclear research is the Nuclear Energy and Safety Division (NES) at PSI.

Challenge: Maintain nuclear competence

Priorities for Nuclear Research in CH (I)

Nuclear research focuses on

- LWR safety : Understanding and simulation of relevant phenomena
  - It covers phenomena from Normal Operation ⋯ Severe Accidents
    - Fuel, reactor core, primary system, (BOP), containment
  - It addresses (barrier) integrity of structure and components and considers aging phenomena (also at micro-structural scale)
- For some topics, PSI/NES assumes the TSO function for the national regulator

Priorities for Nuclear Research in CH (II)

Nuclear energy related research focuses on

- Waste Management
  - Multiscale reactive transport of radio-isotopes
  - Geochemical modelling of in situ conditions in energy-related subsurface systems
- Monitoring of new nuclear technologies with participation
  - in GIF with contributions to HT-Materials and (in future) to MSR and via bilateral cooperations
  - Irradation programs in relation spallation source materials (→ESS), ATF, modern fuel concepts
- Analysis and comparisons of energy systems

Nuclear Education

- ETHZ and EPFL together with PSI offer a nuclear master program
  PSI senior scientists serve as lecturers
- MSc and PhD thesis are offered in the framework of NES research programs
- Training programs for “newcomer” to the nuclear industry are co-organized

Past and recent research initiatives (I) in CH

PSI/NES bases the development of its research capabilities on continuously integrating new elements into the subject fields mentioned before

Past and recent innovation initiatives

- Larger scale
  - Small heating reactor
  - SBWR TH-tests (→ PANDA facility)
  - Several large experimental reactor physics programs:
    - GCFR, HTR, FDWR, several LWR campaigns

Past and recent research initiatives (II) in CH

Recent innovation initiatives

- Smaller scale
  - High temperature materials (→ Gen-IV)
  - Fast reactor analysis (→ Gen-IV)
  - Atomistic modeling of nuclear fuels
  - Dynamic event trees
  - STIP irradiation program
  - Two phase CFD: mechanistic boiling process
  - New detectors for TH-applications
  - Fast neutron tomography
  - GEN-III safety research (abandoned after Fuku)

Past and recent research initiatives (III) in CH

- Integration of advanced experimental techniques into the study of wide range of materials behaviour
  - PSI large user facilities (SLS, SINQ, SμS)
    - LWR fuel investigations (requires micro-sampling of active materials)
  - Similar facilities abroad
- Nuclear Cross Section Data measurements

Research perspectives in CH (I)

LWR Safety:

- Improving simulation methodologies for reactor physics, thermal-hydraulics, thermo-mechanics, structural mechanics
  - Integrating uncertainty quantification into these fields
  - Special interest: nuclear data variance / covariance generation using a nuclear model code (TENDL)
- Fuel and cask behavior in relation of intermediate storage
  - RIA/LOCA related work may continue at a reduced level
- Radiation damage
- Basic studies in relation to structural integrity
- Develop new methodologies for HRA

Research perspectives in CH (II)

Application of nuclear techniques into other fields:

- Neutron activation for decommissioning
- Fast neutron tomography
- Medical application

Advanced reactor related work (Gen IV):

- Contributions to MSR (Th cycle → reduced waste, reduced risk)
- Some work in relation to HTR safety
- High temperature materials
- Irradiation and radiation damage of spallation source material
- ATF

Waste management:

- Experimental validation of multiscale reactive transport for the application to deep geological repository applications
- Applications for geothermal energy or general waste repositories?

Research perspectives in CH (III)

Energy system modeling:

- Development of time-resolved and technology-rich regional (cross boundary) energy-systems engineering model

Trends:

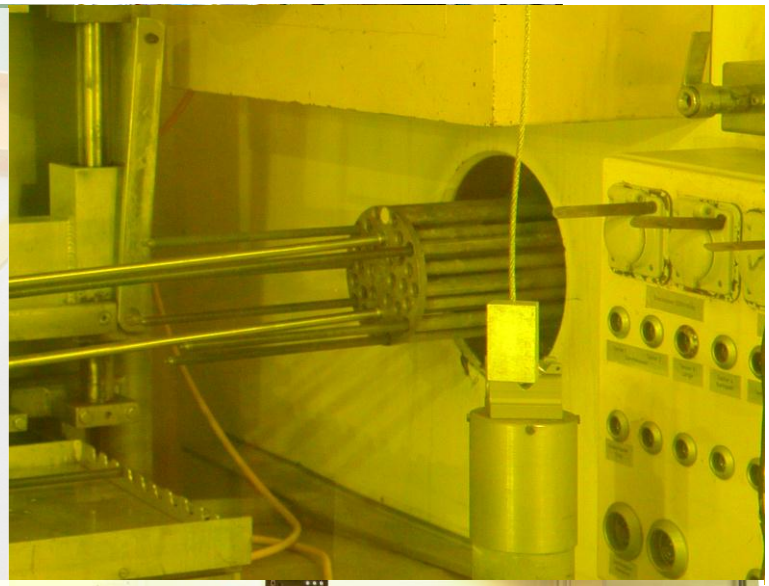
- Resolving safety issues requires contributions from different technical fields
  - Ability for cooperation across “disciplinary boundaries” becomes increasingly a pre-requisite for success
- Stronger usage of basic computational approaches that frequently require HPC
- Experimental facilities of increasingly smaller scale (budgetary constraints)

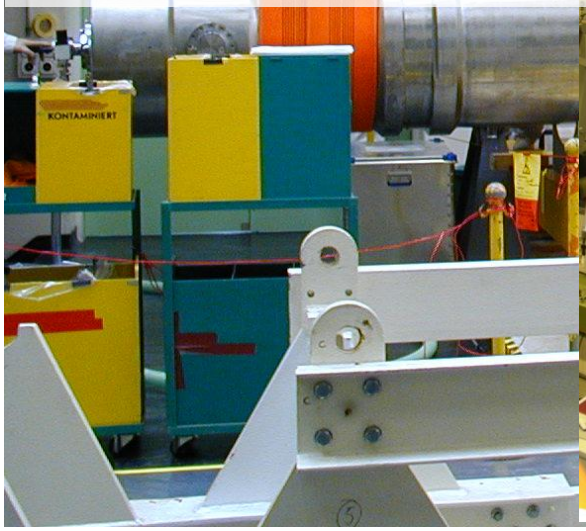
Research Infrastructures: Hotlab

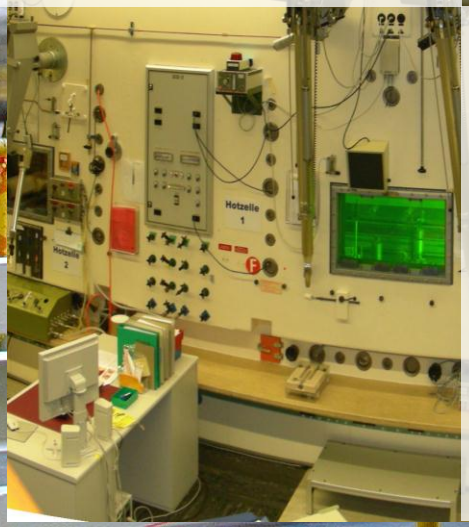
Status

Capability of handling active materials constitutive element of nuclear competence

- Keep PSI hot laboratory operational (main regulatory challenge: earthquake resistance)
- Key for exploiting large advanced user facilities at PSI and abroad because micro-samples of the active material need to be prepared







Perspectives

- Good prospects to keep the hotlab operational and to keep the measurement techniques at state-of-the-art
- Embedding in international cooperation framework?

Research Infrastructures: PANDA facility

Large-scale experimental facility PANDA

Status

Features extensive instrumentation

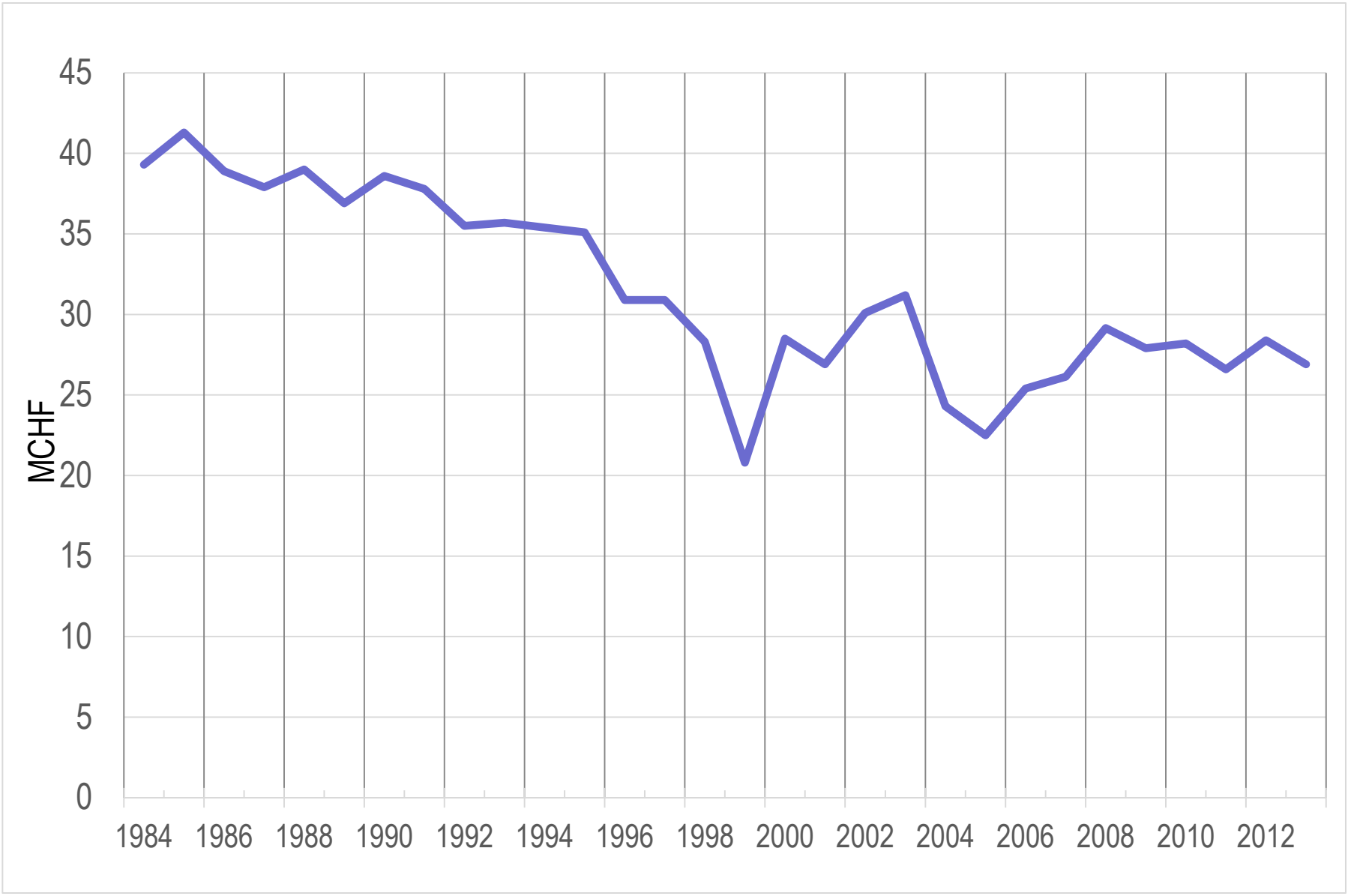
- Temperatures
- Pressures
- Gas concentrations (mass spectrometer)
- Particle Image Velocimetry (PIV)
- Wire mesh sensor

Current program:
HYMERES (OECD)

Perspectives

Maintain large experimental TH-facility (PANDA) operational as long as cooperative safety relevant projects find international interest

Past evolution of nuclear fission research budget



International cooperation

- EU: H2020
  (uncertain status of relationship EC – Switzerland after 2016)
  - Switzerland is currently actively involved in 6 H2020 R&D programs

- OECD
  - Switzerland is active in this domain, intends to continue at that level
  - Participation in OECD projects (e.g. Halden, several TH-programs)

- Bilateral cooperation with peer R&D organizations
  - In- and outside of Europe


HORIZON 2020
Switzerland's participation 2014–2016
Excellent Science (EUR 24.4bn)
European Research Council EUR 13.1bn
Future and Emerging Technologies EUR 2.7bn
Marie-Sklodowska-Curie Actions EUR 6.1bn
Research Infrastructures EUR 2.5bn
Industrial Leadership (EUR 17bn)
LEIT = Leadership in enabling and industrial technologies
• ICT
• Nano, new materials
• Biotechnology
• manufacturing and processing
• Space
EUR 13.5bn
Access to Risk Finance EUR 2.9bn
Innovation in SMEs EUR 0.6bn
Societal Challenges (EUR 29.7bn)
Health EUR 7.5bn
Food EUR 3.9bn
Energy EUR 6bn
Transport EUR 6.3bn
Climate EUR 3bn
Inclusive Societies EUR 1.3bn
Security EUR 1.7bn
Spreading Excellence (EUR 0.8bn)
Science for Society (EUR 0.5bn)
European Institute of Innovation and Technology (EIT) EUR 2.7bn
Joint Research Centre (JRC) EUR 1.9bn
Euratom EUR 1.6bn
Switzerland's participation in Horizon 2020 (As of: 15.09.2014)
CH Association (Sept. 2014 -Dec. 2016)
CH participation as third country
No CH participation