

# Introduction to the Halden Reactor Project

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Halden – Washington D.C – ca. 6300 km



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## Norway

- **Location:** Northwest in Europe
  - Neighbors to the east: Russia, Finland and Sweden and the Atlantic ocean to the west
  - Halden – South-east corner
- **Area:** about 1/30 of USA
  - Norway has same size as Japan and Italy
- **Population:** 4,7 million
- **Income:** Oil and gas, Shipping, Fish export
  - First Norwegian oil discovery in 1969, since 1971
    - Norway becomes the 8th largest oil & gas producer in the world
    - 3rd biggest exporter



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## Halden – the Gateway to Europe



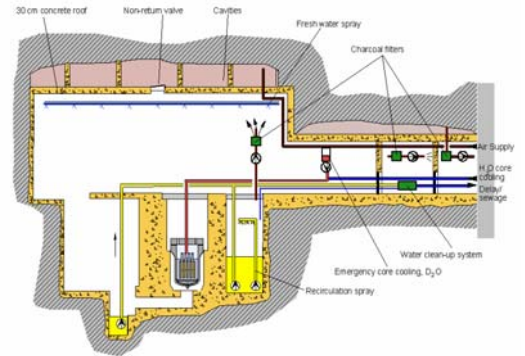
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## Halden & the Halden Reactor site



## HBWR is located in a Mountain Cave



## OECD Halden Reactor Project

- International collaborative research for Safe and Reliable Operation of Nuclear Power Plants
  - affiliated to OECD NEA in Paris
  - located in Halden, Norway
  - operated by [Institute For Energy-technology, IFE](#)
- Halden Agreement first signed in 1958
  - Renewed every 3rd year
  - Current program period from 2009 to 2011
    - (2008: Reached 50 years ->)
  - Countries, through a Signatory organization, signs the Agreement
- Jointly funded by its Members:
  - 18 countries
  - > 100 nuclear organizations world wide
- Participant types
  - Utilities, Vendors, Licensing Authorities and R&D centers



## HRP Members – Signatories and Associated Parties

### Signatory members:

- Norway** – IFE - Institutt for energiteknikk
- Belgium** - SCK/CEN - Belgian Nuclear Research Centre
- Denmark** - Risø DTU
- Finland** - MITI - Finnish Ministry of Trade and Industry, operated by VTT
- France** - EDF - Electricité de France
- Germany** – GRS - Gesellschaft für Anlagen- und Reaktorsicherheit mbH
- Japan** - JNES - Japan Nuclear Energy Safety Organization
- Korea** - KAERI - Korean Atomic Energy Research Institute
- Spain** - CIEMAT - Spanish Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
- Sweden** - SSM - Swedish Radiation Safety Authority
- Switzerland** - HSK - Swiss Federal Nuclear Safety Inspectorate
- UK** - NNLC – National Nuclear Laboratory
- USA** - US NRC - United States Nuclear Regulatory Commission

### Associated Parties:

- USA**
  - GE - Global Nuclear Fuel
  - EPRI - Electric Power Research Inst.
  - Westinghouse Electric Power Company (WEC-LLC)
- Japan**
  - JAEA, CRIEPI, Mitsubishi HI and 11 utilities
- France**
  - IRSN - French Institut de Radioprotection et de Sécurité Nucléaire
- Czech Rep.** - (NRI) Czech Nuclear Research Institute
- Slovakia** - Slovakian VUJE - Nuclear Power Plant Research Institute
- Hungary** - Hungarian Academy of Sciences, KFKI Atomic Energy Res. Inst.
- Russia** - Russian Research Centre "Kurchatov Institute", "TVEL" Co.
- Kazakhstan** – Ulba Manufacturing company

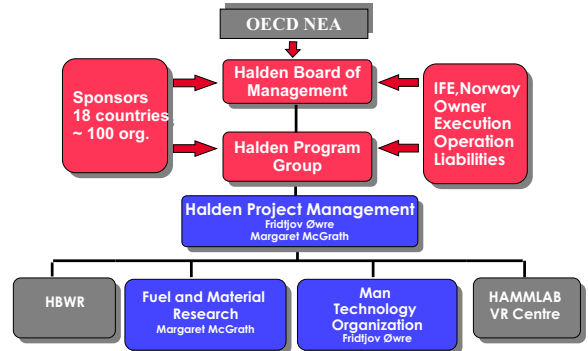


## Possible new Associated Parties to the HRP- work in progress

- DOE – Department of Energy
  - DOE-labs (INL, Oak Ridge and Pacific North West)
- China (CNPEC and CNPRI)
- India (BHARC)
  
- Other possible member candidates
  - Italy (4 EPRs announced 24.02.09)
  - Canada (CNSC, dependant on Bruce Power goes to PWR)
  - Argentine (ARN)
  - Emirates (2 EPRs announced 30.1.09)
  - Mexico
  - South Africa
  - Turkey



## Halden Project Organization

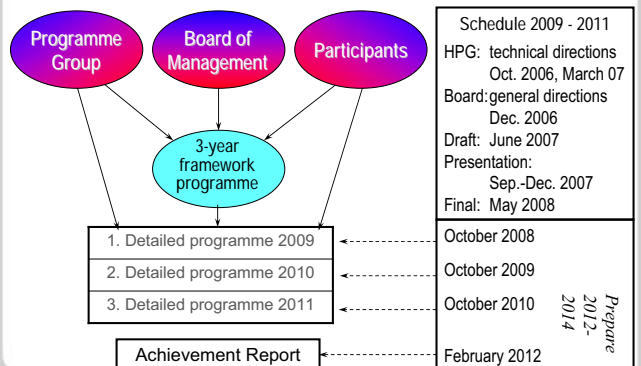


## HRP is also an international collaborative network

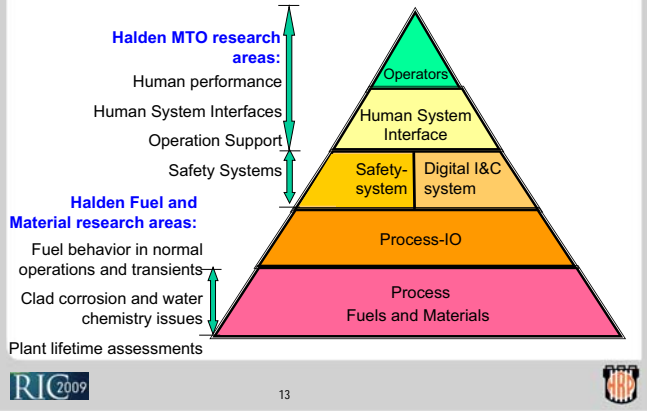
- **Halden Board meetings**
  - Administrative matters - Long term direction - Meets twice per year
  - International network
- **Halden Program Group**
  - Technical Steering committee
  - Decides on program – follow up program progress – have some subcommittees
- **Secondee arrangement**
  - Training – participates in experimental work - link to home organisations
- **Specialist Workshops**
  - Recommend details of research programs
  - Follow-up the programs
- **Enlarged HPG meetings (EHPG)**
  - Conferences to distribute and discuss results
  - Last one at Loen, Norway
    - 18-23th May 2008 - ca. 300 participants, 170 external participants
    - HRP 50 years Anniversary!
    - **Next EHPG in 14-19 March 2010**
      - Storefjell Resort Hotel, Norway [www.storefjell.no](http://www.storefjell.no)
- **Summer schools**
  - **August 2009, Halden: Basic Fuel behaviour**
    - models, experimental approaches and data
  - August 2010: Halden: A MTO topic



## Halden Project Research Programme Definition



### Model illustrating the control-levels of a modern NPP and the Halden Project research areas in this respect

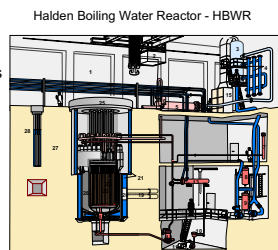


### Fuels and Materials facilities and research areas



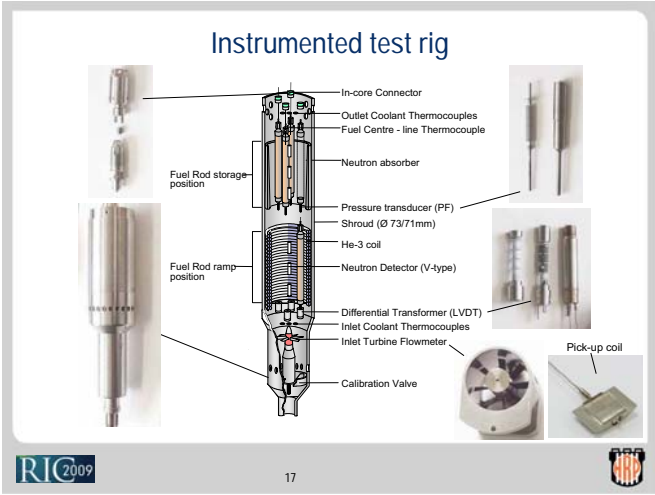
### Fuels and Material research facilities

- HBWR is *only* a test reactor
  - flexible operation cycles
  - +50% availability
  - Capability to implement different modes of operation
- Loop systems
  - Ability to simulate operation conditions of commercial nuclear power stations
- Hot-lab
  - Re-instrumentation capabilities
  - PIE
- **Very important asset:**
  - **Reliable and versatile in-core instrumentation**



### Experiments in the Halden reactor



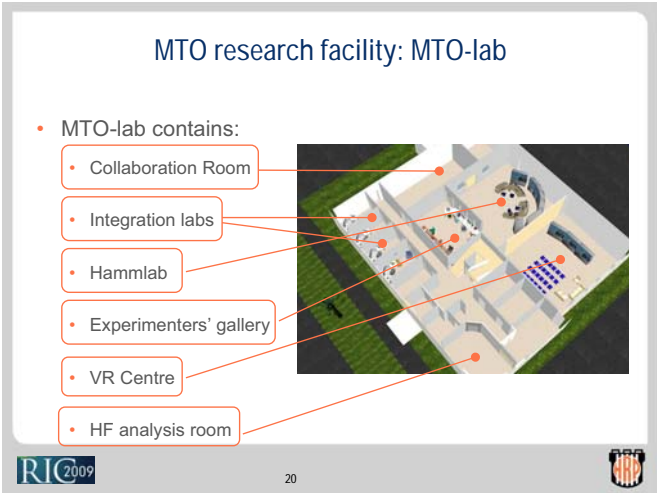


### When everything is in place ... Spectrum of Halden Reactor Fuels & Materials investigations

FUEL	CLAD	Control Materials	Core Comp. Materials
<i>Standard UO<sub>2</sub>, UO<sub>2</sub> + additives, MOX, inert matrix</i> <b>Fission gas release</b> <b>Fuel temperature - conductivity - stored energy</b> <b>Fuel densification</b> <b>Fuel swelling</b>	Rod pressure, lift-off Gap conductance Creep & Growth Axial gaps (clad collapse, power peaks) SCC/PCMI	Zirconium alloys Rod/guide tube bowing IRI Failure Corrosion Crud, AOA	He release, pressure, swelling He release, pressure, swelling He release, pressure, swelling
			Stainless steels Nickel base alloys Crack initiation & Time to failure Crack growth rate (IASCC) Mechanical prop. changes Embrittlement, annealing (RPV)
<del>high burnup, operating conditions</del>		<del>water chemistry</del>	

RIC 2009 18

Man-Technology-Organisation (MTO)  
facility and research areas



## MTO research areas within HRP

- Human Performance
- Design and Evaluation of Human System Interfaces and Control Rooms
- Mixed Reality technologies
- Computerized Operation and Maintenance Support
- Software systems Dependability

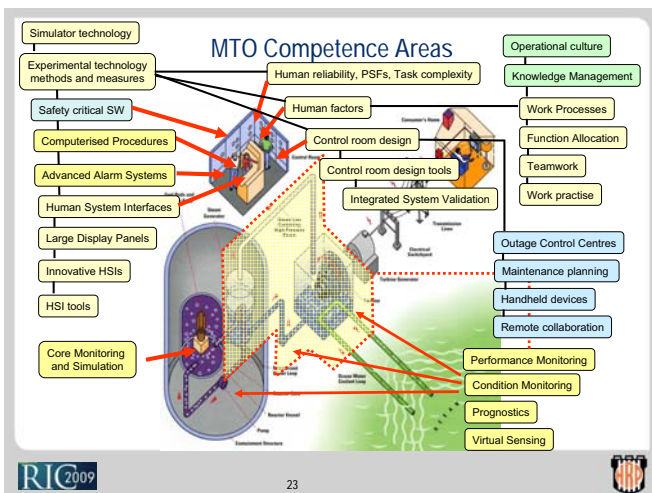


Hammlab 2008

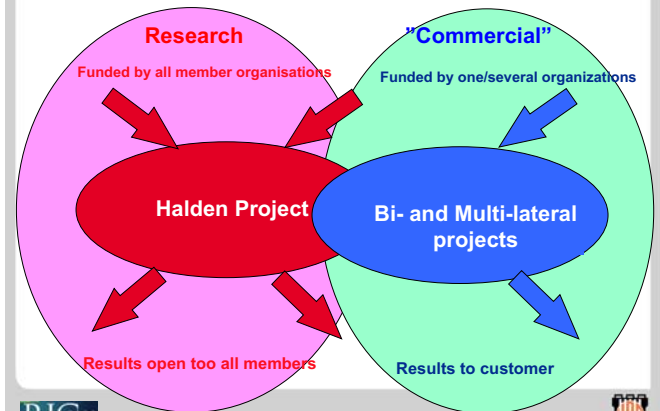


## Human Performance Experiments in Hammlab

- Shift teams – 3 licensed operators from the simulated plant
- Experimenters team - 5-6 persons
- Experiments are difficult scenarios, now often PRA relevant
  - 2009 – Impact of High level of Automation on Operator performance



## Two work areas @ IFE, Halden

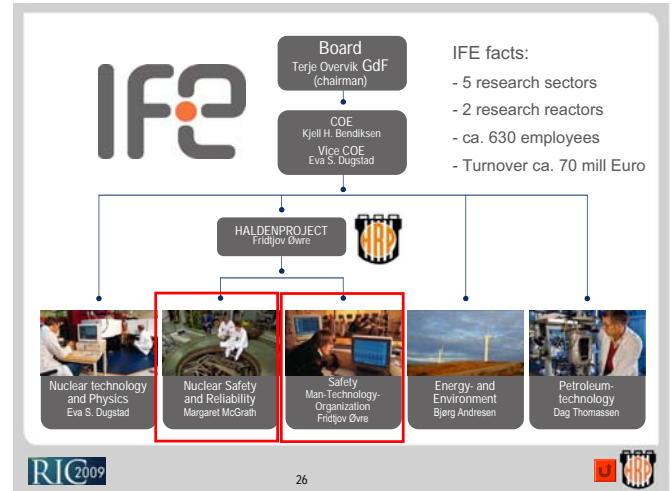




## Summary

- Halden Reactor Project a center for nuclear safety research since 1958
  - 18 countries participate in a jointly funded research program
  - Halden Reactor is one of the most versatile nuclear test reactors in the world
  - Hammlab is a unique test bed in the MTO area

Fredriksten fortress @ Halden: The Nuclear Fortress



## HRP Workshops 2009

- (MTO) Common cause failures in safety critical software
  - Munich 27-28.1.09
  - experimental investigations in Hammlab?
- (MTO) International empirical HRA study
  - Washington 2-5.3.09
  - Finalize phase 1, report on progress phase 2
- (MTO) Integrated System Validation
  - Halden 27-28.4.09
  - Modernisation of old and building new control rooms – how to accept a proposed control room solution from human factors standpoint?
- (Fuels) Loss of Coolant Accidents
  - Results from test 9 and further tests
- (MTO) Structuring of procedures
  - Trnava, Slovakia 13-14.5.09
  - Can procedures be generalized?
- (MTO) Halden On-line Monitoring User Group
  - Loviisa, Finland, 7-9th October 2009
  - HRP and Utilities report on progress and achievements
  - Visit to the Loviisa plant

