OECD NEA
Halden HTO
Project

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HALDEN PROJECT
HTO

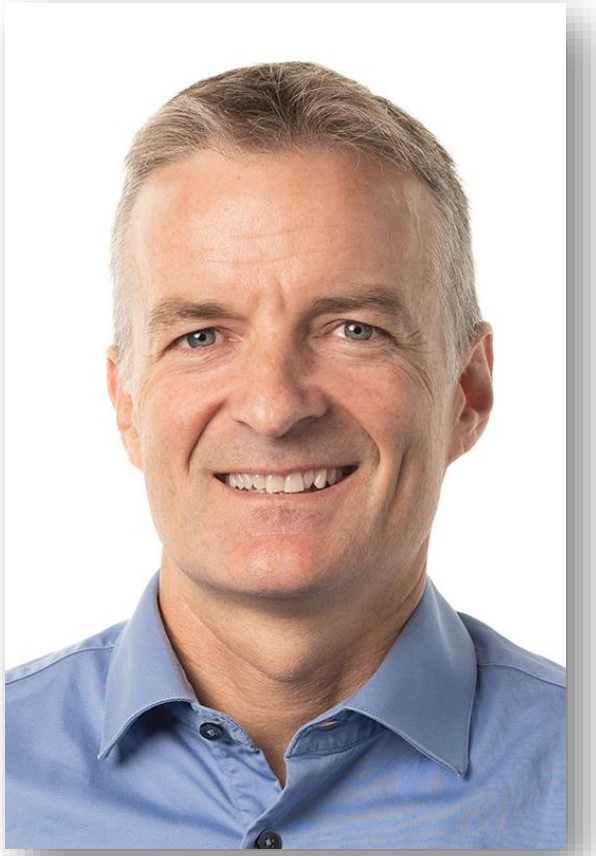
IFE Kjernekraft

Andreas Bye
Chief Scientist, IFE
Programme Manager OECD Nuclear Energy Agency Halden Human-Technology-Organisation (HTO) Project

Hvem er jeg?

Andreas Bye

- Sjefsforsker ved Institutt for energiteknikk, IFE
- Programleder, OECD NEA Halden Human – Technology – Organisation (HTO) Project
- Norges representant i Nuclear Energy Agency's (NEA) Committee on the Safety of Nuclear Installations (CSNI)
- Medlem i European Atomic Energy Society
- Jobbet med atomsikkerhet for IFE siden 1989



Stiftelsen IFE

Divisjoner

FoU Energi

FoU Kjernekraft

Teknologi og Eiendom

Nukleær drift og sikkerhet

Datterselskap

Agilera Pharma AS

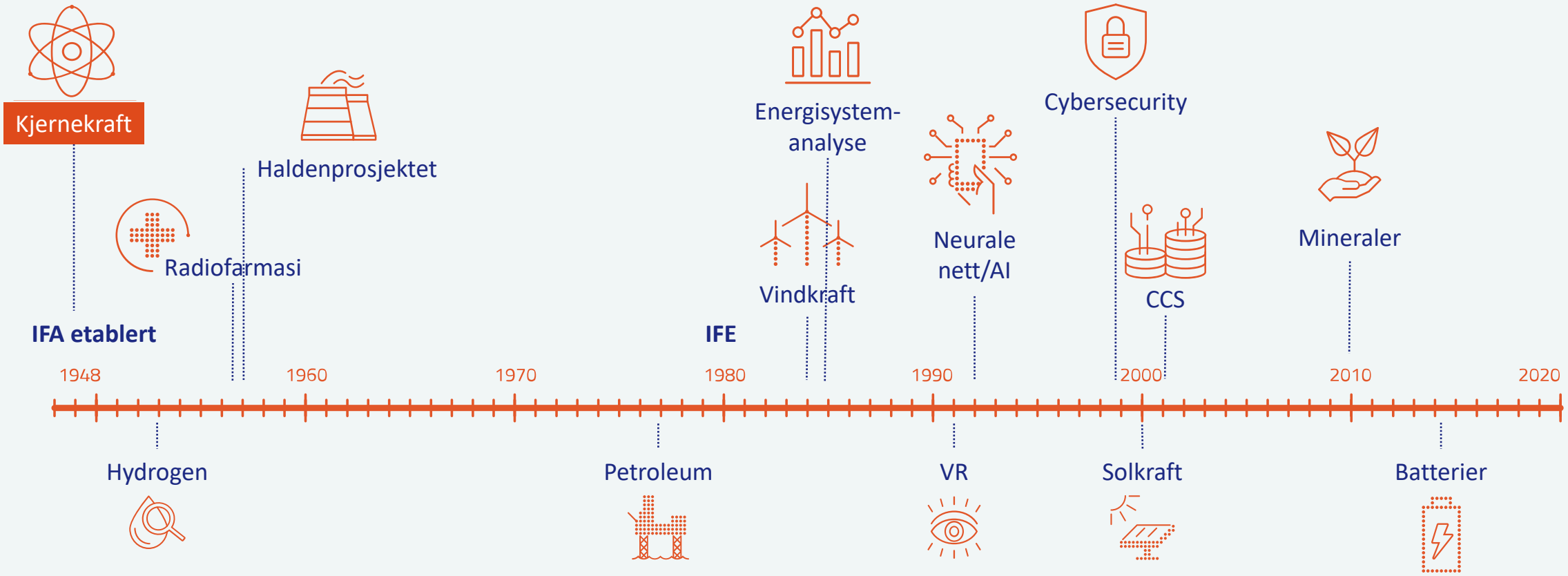
49%

IFE Invest AS

100%

IFE har vært i forkant av utviklingen i 70 år og har spilt en nøkkelrolle i utviklingen av energinasjonen Norge

ÅPEN
4



Reaktorer:

1951: JEEP I — 1967

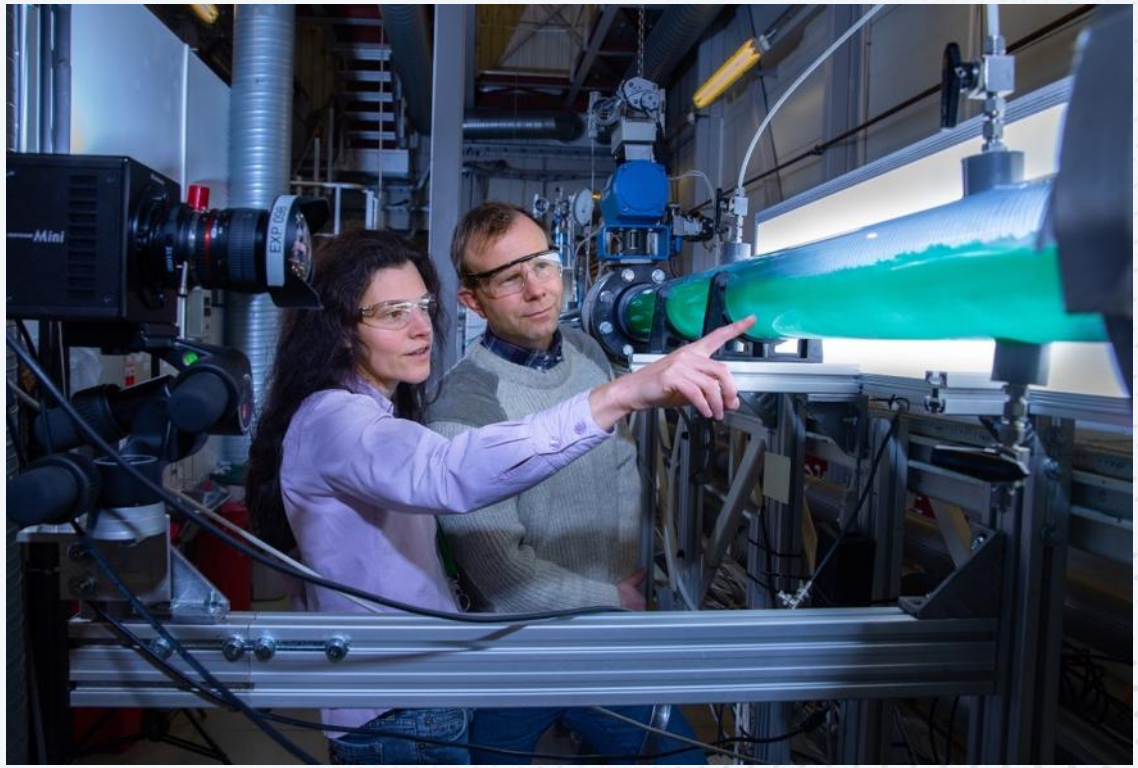
1959: Haldenreaktoren — 2018

1961: Nora — 1968

1967: JEEP II — 2019

Forskning og innovasjon fra IFE har skapt store verdier for samfunnet

- **OLGA:**
  - «Norges viktigste innovasjon siden 1980» (Aftenposten 2012).
  - Spart oljeselskapene på norsk sokkel for mer enn 200 mrd. kr.
  - Starten på det store subsea-eventyret.
- **Integrated Operations, IO-centre:**
  - 2007–2014, Norges største SFI, 340 mill. kr. totalt, med 70 % finansiering fra bedriftspartnerne
  - IFE, NTNU og SINTEF. IFE bidro med kompetanse bygd opp i Haldenprosjektet
- **Kontrollromsteknologi:**
  - IFE har laget storskjermsbilder for en rekke oljeplatformer og landanlegg i petroleumsindustrien, jernbane
  - Sikkerhetsanalyser og metoder for oljeindustrien, jernbane og luftfart



Forskning og utvikling

340 ansatte

600 mill kr i omsetning

To divisjoner:

- Energi (Kjeller)
- Kjernekraft (Halden)

Anvendt forskning i nært samarbeid med industripartnere

4000 kvm laboratorier

- 24 avanserte laboratorier i Halden og på Kjeller
- 9 laboratorier er nasjonal forskningsinfrastruktur

Vertskap for flere forskningssentre:

- FME Solar
- FME Battery
- Haldenprosjektet (OECD/NEA)
- Nukleært digitalt dekommisjoneringssenter (IAEA)

ISO 9001 og 14001-sertifisert

Achilles-sertifisert

IFEs batterilab på Kjeller

Strategiske satsingsområder for Divisjon Energi

- Batteriteknologi
- Hydrogenteknologi
- Solenergi
- Energisystemer
- CCS
- Kritiske mineraler
- Nukleærteknologi

IFEs sollab på Kjeller

IFE NUCLEAR

From Sensor to decisions

with 7 Departments:

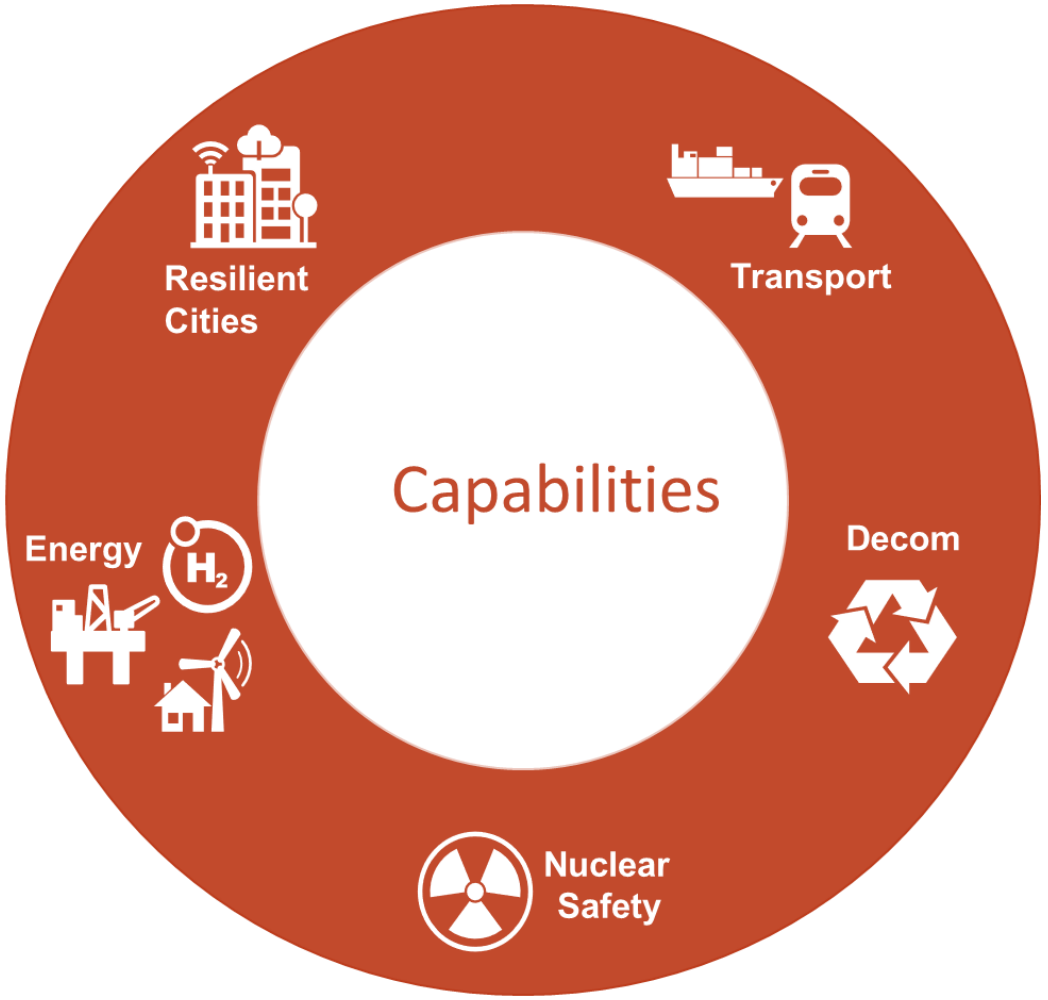
- Control Room & Interaction Design
- Virtual & Augmented Reality
- Applied Data Science
- Human and Organisational Factors
- Risk and Safety
- Risk and Security
- Applied Physical Science

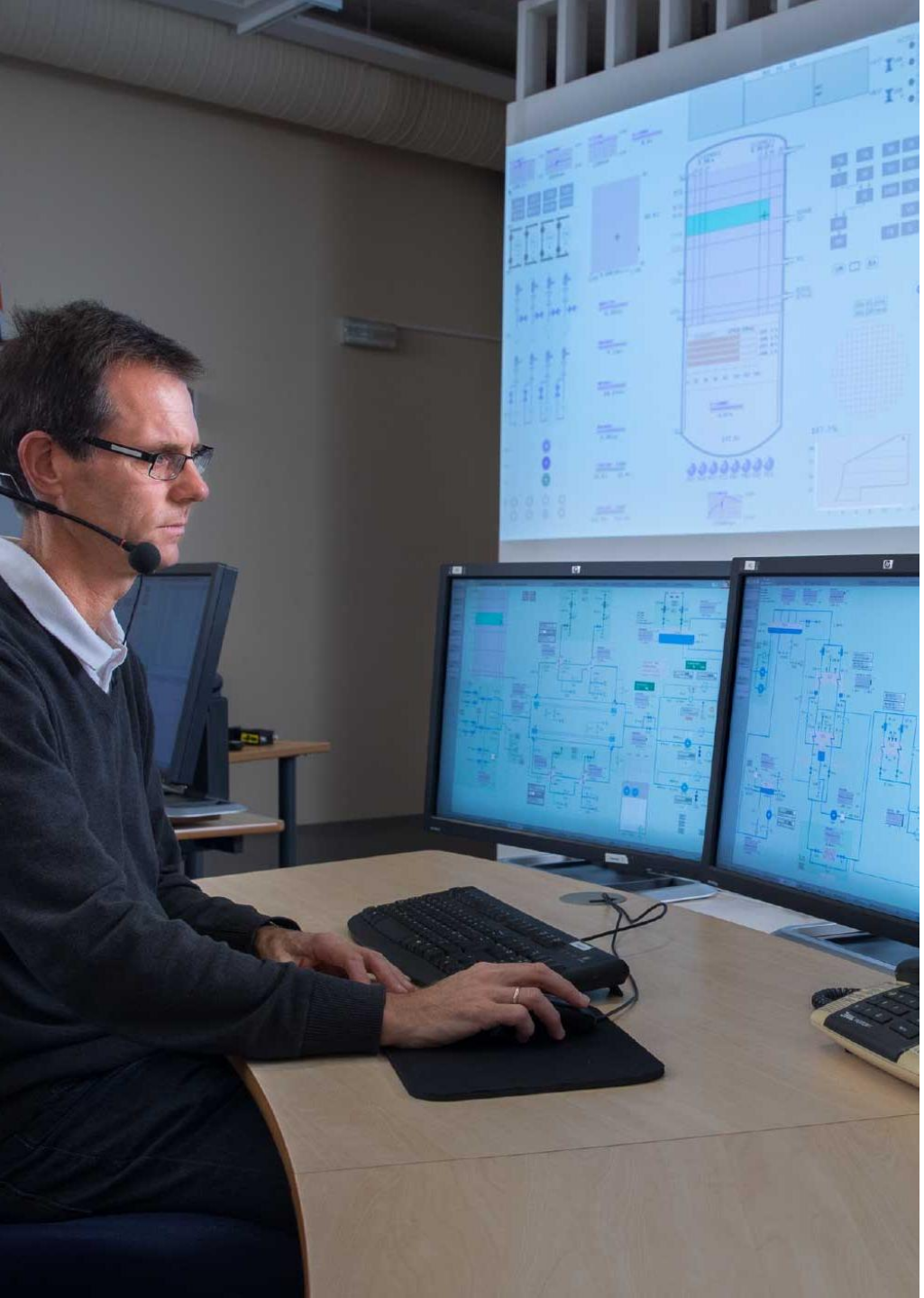
11 Labs

2 research centres

~ 100 employees

Our Business Areas





IFE er Norges nukleære forskningsinstitutt

- Forskning som andre norske forskningsmiljøer ikke har kompetanse eller infrastruktur til å drive
- Stort internasjonalt nettverk innen kjernekraft-industri, myndigheter, regulatorer, internasjonale organisasjoner og forskningsmiljøer
- IFEs posisjon innen kjernekraft:
  - Bidrar med fakta og erfaring fra 75 år med drift av forskningsreaktorer + forskning på nukleærteknologi og atomsikkerhet
  - Tar ikke stilling til om kjernekraft skal utbygges i Norge eller ikke – det er et politisk spørsmål

IFEs forskning anvendes på SMR-konsepter

- **Teknologiutvikling**
  - Forstå reaktor- og SMR-designkonsepter
  - Designutvikling av SMR
- **Menneskelige faktorer**
  - Identifisere menneskelige faktorer, ytelsesutfordringer og muligheter
  - Analyse av driftserfaring på tvers av bransjer
- **Empirisk datainnsamling**
  - SMR-simulator i Halden-laboratoriene
  - Simulatoreksperimenter for å teste menneskelig ytelse med erfarne kjernekraftverk operatører i ulike operasjonelle situasjoner

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Norsk Nukleært Forskningssenter

Norsk Nukleært Forskningssenter
Norwegian Nuclear Research Centre

NNRC Consortium & Associates

Academia

UiO
NTNU
Universitetet i Stavanger
Høgskulen på Vestlandet
CHALMERS
Berkeley
iThemba LABS

Research & Application Sector

IFE
SYKLOTRON
BAYER
NORSAR
Norwegian Meteorological Institute
SINTEF
FFI Forsvarets forskningsinstitutt
NILU

Other

Fagskolen i Viken
NND, Halden Municipality, ...

NNRC Connections

IAEA
Institute for Energy Technology (IFE)
IAEA Collaborating Centre
NCNR
HALDEN PROJECT
HTO
DECOM
decommissioning and repurposing
ELINDER
dScience
Senter for data- og beregningsvitenskap
Digi DECOM'22
CCSE
INTPART

Other international partners & networks ...

IFE og Haldenprosjektene

Institutt for atomenergi

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Dekommisjonering

Menneske, Teknologi & Organisasjon

Brensel & Material

1948 1951 **1958** 1967 1970 2018 **2021**

OECD Halden Reactor Project

Halden HTO-prosjektet, 2024-2026

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OECD OECD-NEA drevet medlemsskap IFE Vert

Norge

Canada

Kina

Tsjekkia

Tyskland

Japan

Korea

Nederland

Sverige

Forente Arabiske Emirater

Storbritannia

USA

OECD NEA Halden HTO Project

- **International collaborative research for the safe and reliable operation of Nuclear Power Plants, focusing on Human-Technology-Organisation**
  - OECD Nuclear Energy Agency (NEA)
    - Division of Radiological Protection and Human Aspects of Nuclear Safety (RP-HANS)
  - Operating agent: IFE (Institute for Energy Technology) in Norway
  - 3-yearly joint research program
- **Jointly funded by the membership**
  - Agreement signed by 21 Parties in 12 countries
  - 47 organisations pre-approved Third Parties (Regulators, Utilities, Vendors, TSOs, R&D centres)
  - Budget for 2024-2026 is 170 MNOK (14.8 MEUR)
    - Budget for 2021-2023 was 148 MNOK (13.8 MEUR)

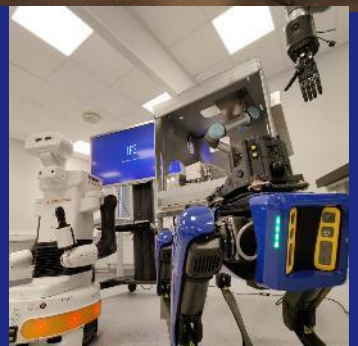
Why Halden HTO

- Human-Technology-Organisation (HTO) is about operational safety
- The importance of Human Aspects of Nuclear Safety and science based safety
- Human aspects are often unexpected and cannot always be predicted
- Empirical research is necessary
- Halden has kept an empirical focus with a focus on operational laboratories
  - HAlden huMan Machine LABoratory (HAMMLAB)
  - VR-lab (and AR, XR)
  - Cybersecurity lab
  - SMR simulator
  - Robotics lab
- Interdisciplinary research
  - Psychologists
  - NPP operations experts
  - Engineers, computer scientists
- Quantitative and qualitative methods

Members and Networking

- 21 Parties in 12 countries
- 47 organisations pre-approved Third Parties
- Regulators, Utilities, Vendors, TSOs, R&D centres
- Collaboration arenas:
  - 2 conferences per 3 years (Enlarged Halden Program Review Group Meeting (EHPRG))
  - Summer schools
  - Workshops
    - Physical
    - Virtual and hybrid workshops and meetings
- Norwegian consortium
  - Equinor and Kongsberg Maritime have signed
  - How to apply results in current Norwegian industry
  - Future nuclear in Norway

HTO-labs



HTO Topics 2024-2026

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01	Human Performance
02	Digital I&C - Safety Assurance
03	Control Room Design & Evaluation
04	Human-Automation Collaboration and Multi-Unit Operation
05	Digital Systems for Operations and Maintenance
06	Sustainable Decommissioning and Asset Lifecycle Management
07	Cyber Security for Main Control Rooms

HAMMLAB, Halden human-machine laboratory

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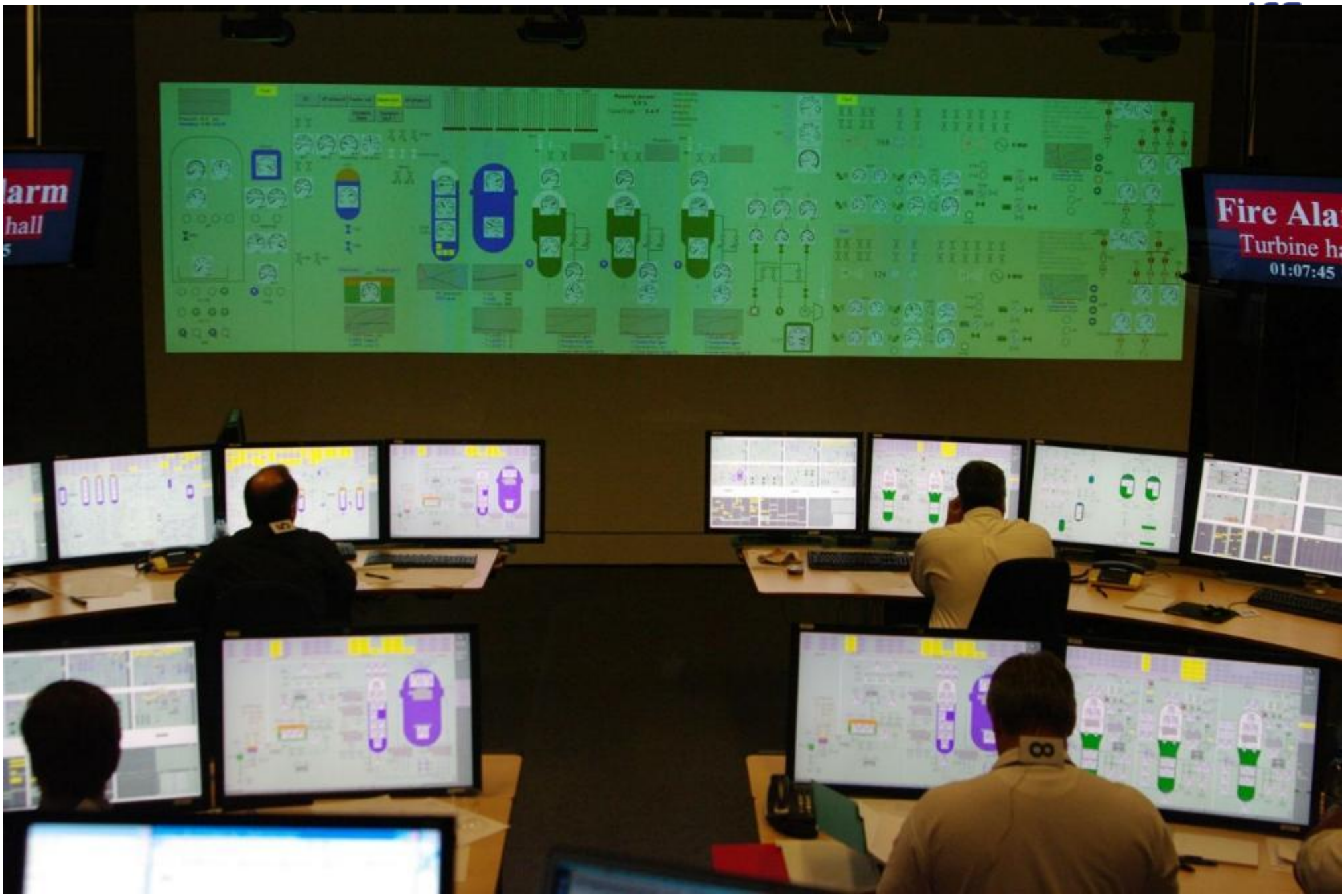
Licensed crew at work in HAMMLAB

Picture taken through gallery window



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HAMMLAB with SMR simulator

Installed August 2022

Halden Virtual Reality Centre

Cybersecurity Centre

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Robotics Lab, HADRON

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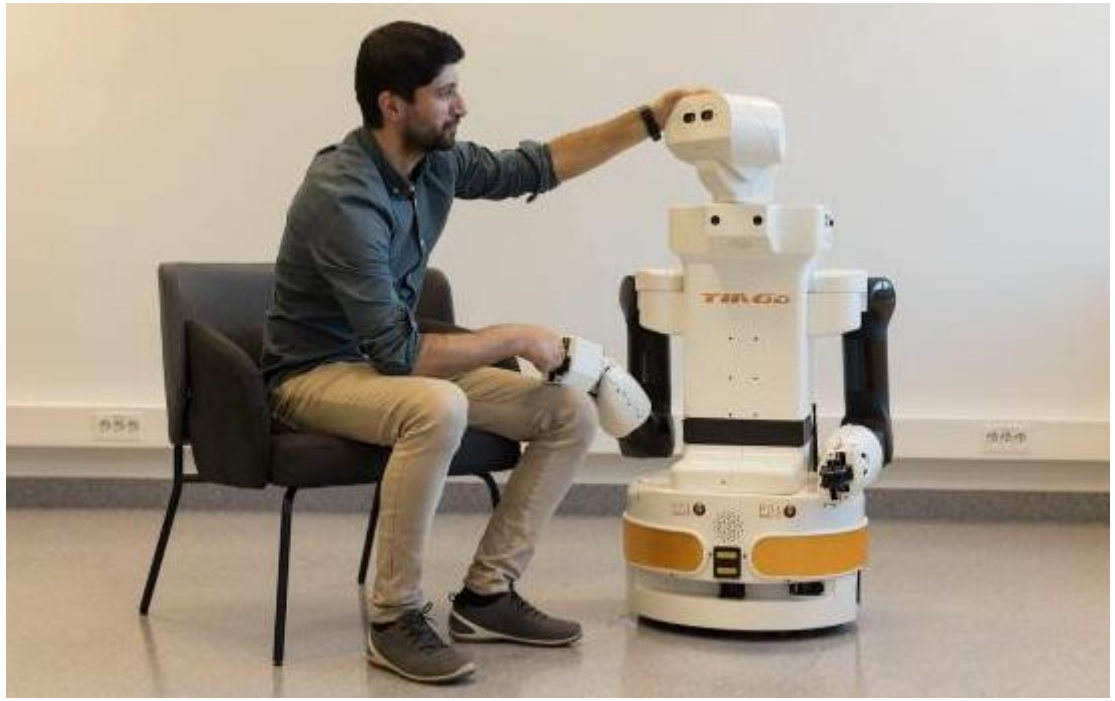
Human-Automation Lab



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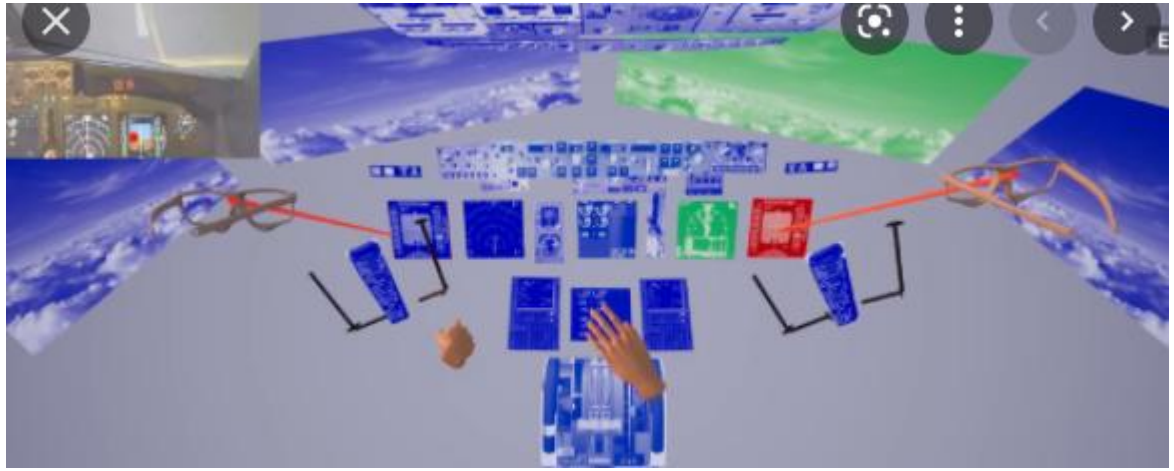
Biometrics lab, Remote lab

- SYNOPTICON
- SYNQUESTICON
- ECG, EEG, EKG
- Eye-trackers



Remote lab

- Data collection in a training simulator in the U.S.

Utfordringer i framtida (forskningsspørsmål)

- Mer automatisering
  - Markedsført som sikkerhet
  - Er det virkelig det? Hvordan behandles samhandlingen mellom automatiseringen og mennesket?
  - Er passive systemer en type automatisering for operatørene?
- Multi-enhets overvåkning
- Fjernstyring
- Uforutsette tilfeller
  - Boeing Max8 ulykkene

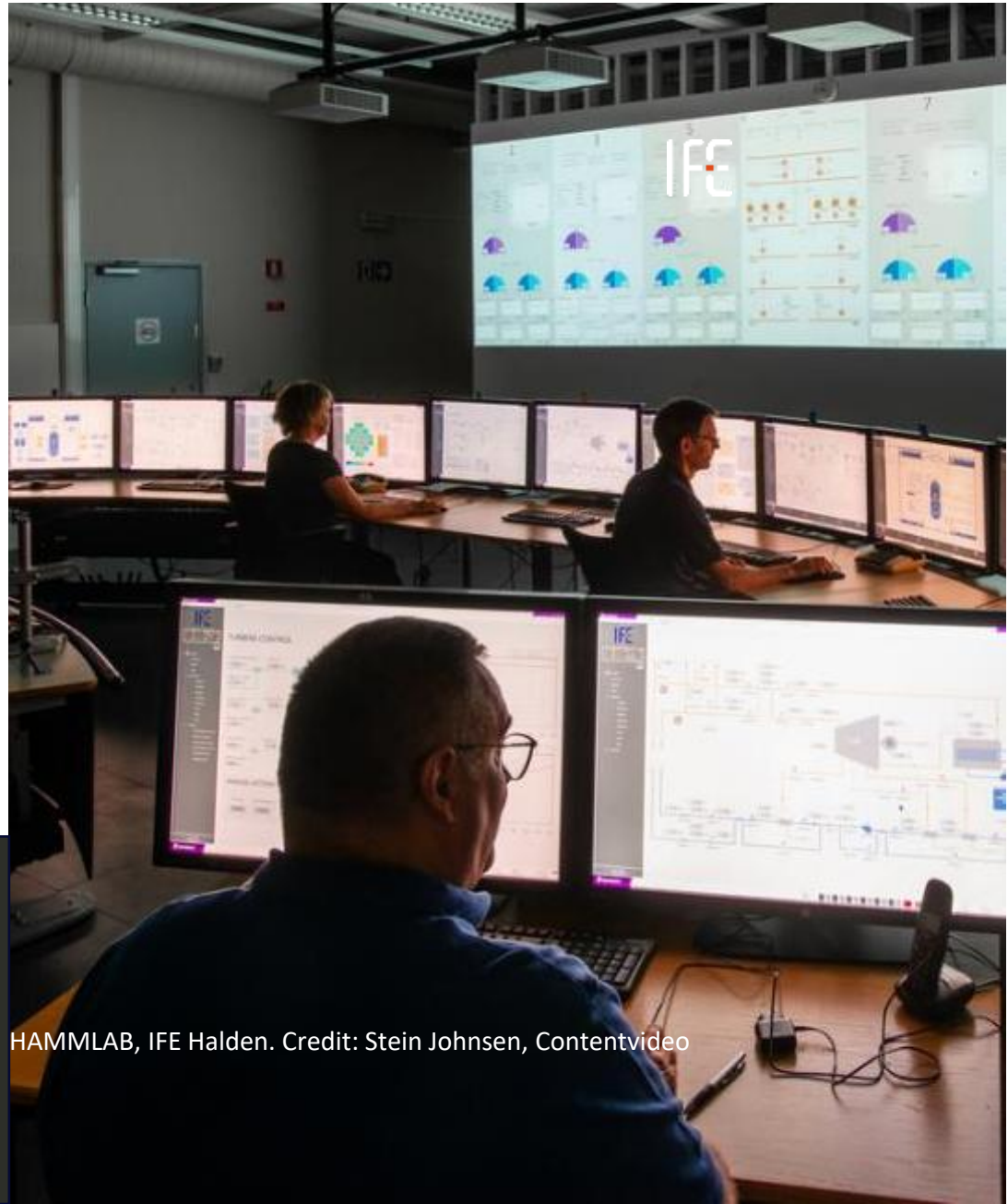
SMR simulator and services

One of a kind: Our facility offers independence, facilitating objective research crucial for advancing the field.

- Platform for research, evaluation, and training
- HSMR capabilities:
  - **Flexible Simulation:** Simulate 1 to 12 integrated pressurized water reactors (iPWR), with each unit operating independently but sharing a common electric system and ultimate heat sink.
  - **Advanced Features:** Advanced automation and state-based deviation detection and alarming for operational efficiency.
  - **Customizable HSI Deployment:** Empower operators with customizable Human System Interfaces (HSIs) across multiple screens, enabling operators to monitor and control all or specific subsets of units, whether locally or remotely over web

We offer a comprehensive suite of services aimed at enhancing the safety and efficiency of Small Modular Reactor (SMR) operation.

- Human Factors Studies
- Scenario Development
- Testing of Operational Concepts
- Control Room Systems Design
- Control Room Design and evaluation
- Support tool for Operator Training (STEAMS)
- Integrated System Validation (ISV)
- Performance Measurements
- Situational Awareness Assessments
- Cognitive Workload Assessment



HAMMLAB, IFE Halden. Credit: Stein Johnsen, Contentvideo

Our Secret Sauce

- Many organizations work with digitalization and with AI, VR, Cyber, etc.

We differ:

- We combine digital technology with human factor and human interaction. This is the key to adopting new technology to improve efficiency and safety.
- We focused on these topics (that recently become hot in Norway and EU) since 1970 funded by almost every nuclear country for the last 50 years to increase nuclear safety.
- Relevant Labs (mostly funded by other countries)

We are often referred to as the world leader in our field

Tusen takk!

Andreas.Bye@ife.no