Fuel Innovation:
What does it take?

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The Fuel

Uranium-based (or heavy fissile actinide) design to:

- Generated **heat or neutrons** by fission reaction
- Be able to conduct the heat generate out
- Safely hold most of the fission products in its matrix (**first safety barrier**)

Example of materials: UO_2, MOX, U_3O_8, U_3Si_2, U-metal, U-Mo, UN, UC, UF_4, etc…

Design variables: Composition, geometry, %U-235, density, microstructure, etc…

The Cladding

Alloy or composite material design to:

- ❑ Hold the nuclear fuel in **position** up to high temperatures
- ❑ Protect fuel from the coolant environment
- ❑ Need be "transparent" to neutrons to not compromise the fission reaction
- ❑ Safety hold most of the fission products that leaves the fuel matrix (**second safety barrier**)

Example of materials: Zircaloy, Al, Al-alloys, SiC-SiC, FeCrAl, etc..

Design variables: Composition, geometry, mechanical properties, microstructure, etc…

The Coolant

A fluid material design to:

- **Extract** the heat generated in the fuel
- **Transfer heat** to electricity generator
- **Moderate** (slow down) neutrons to maintain the rate of the fission reaction

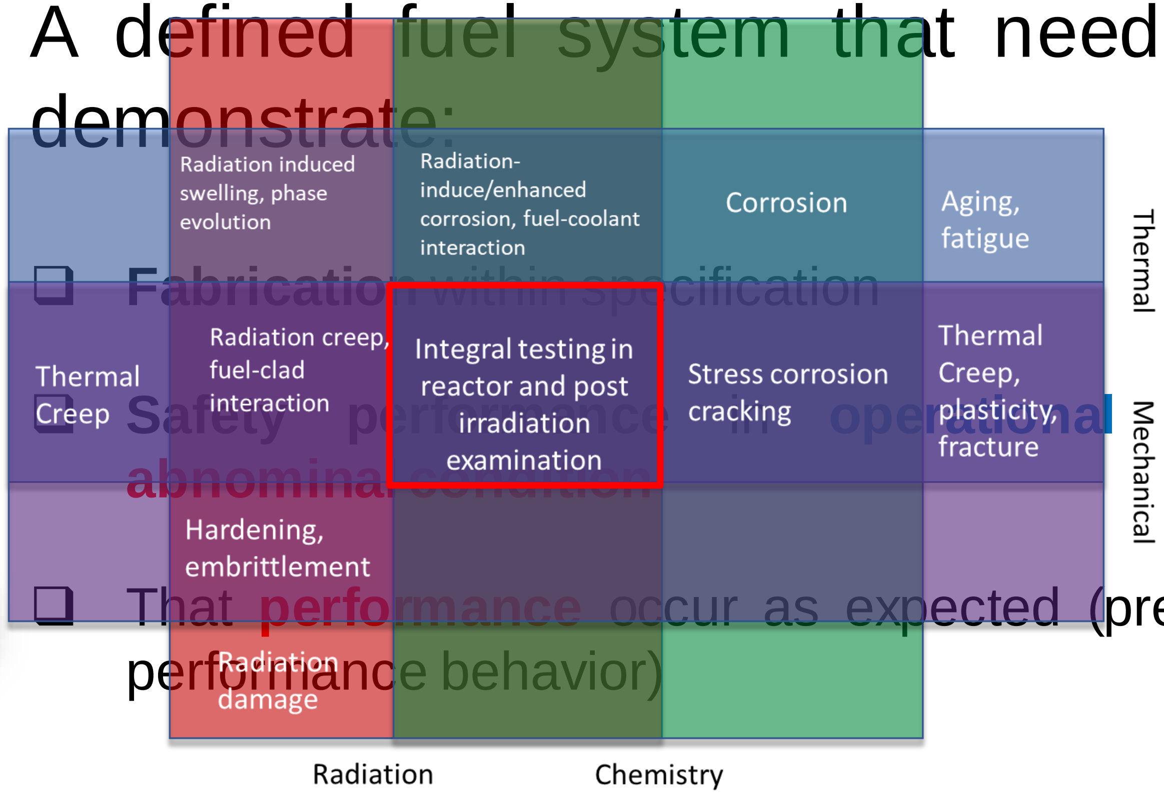
Example of materials: H_2O, D_2O, H_2O-steam, Pb, Pb-Bb, Na, Li, Na-Li, etc..

Design variables: Composition, pressure, speed, etc…

Fuel Qualification

A defined fuel system that need to demonstrate:

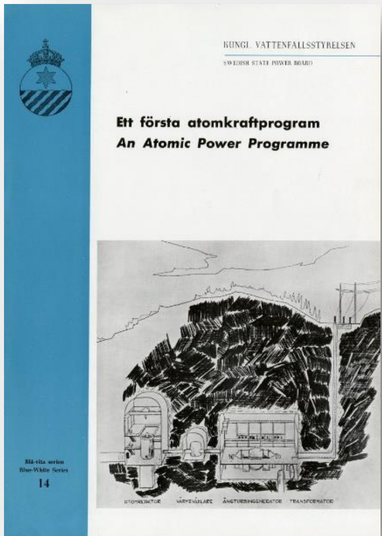
- ❑ Fabrication within specification
- ❑ Safety performance in operational and abnominal condition
- ❑ That performance occur as expected (predict performance behavior)



Each country has its own Regulatory Commission, and **license** needs to be obtained **per country**

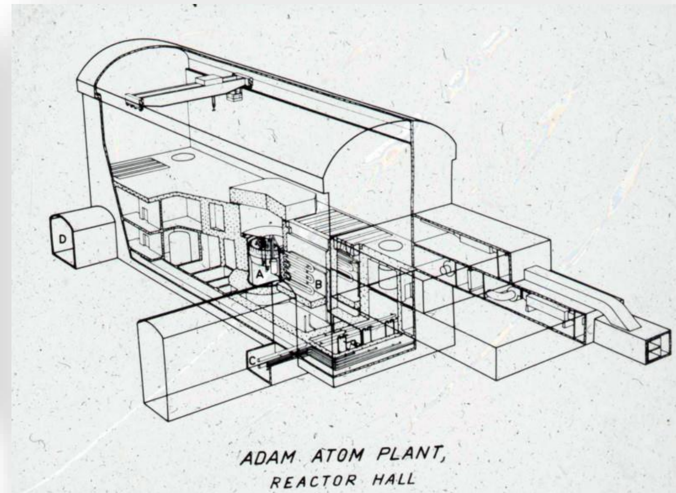
Fuel Qualification: An example from the past

1947- AB Atomenergi



1954-R1

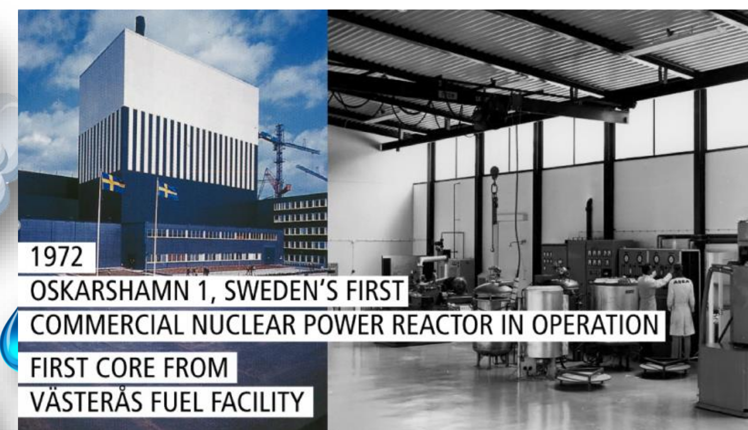
1964-R3 Ågesta



1966-Fuel Factory

1969-ASEA Atom

1972-First Commercial Reactor



Over 20 year for UO_2 fuel system

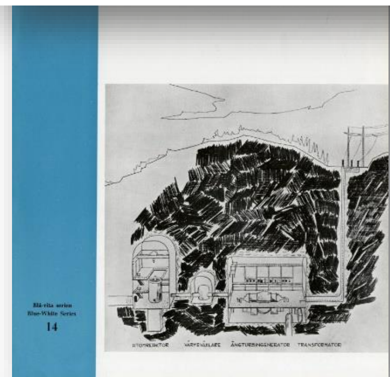
Fuel Qualification: Legacy in Sweden

KTH VETENSKAP OCH KONST

SUNRISE Sustainable Nuclear Energy Research in Sweden

1947- AB Atomenergi

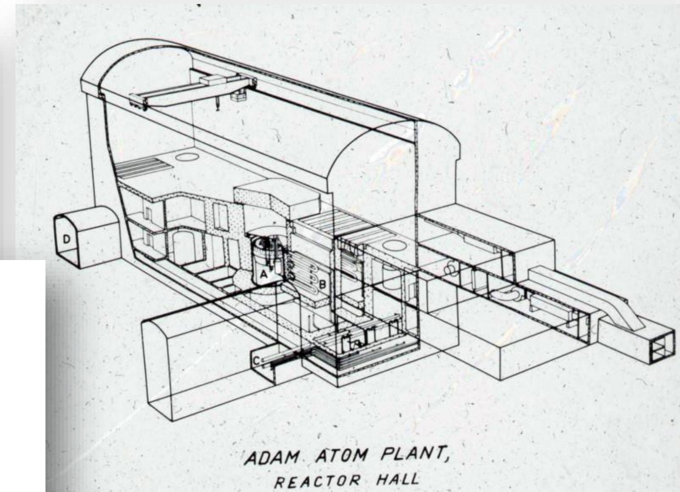
Studsvik



1954-R1

Strål säkerhets myndigheten
Swedish Radiation Safety Authority

1964-R3 Ågesta



1966-Fuel Factory

Westinghouse

SANDVIK

1972-First Commercial Reactor

VATTENFALL

uniper

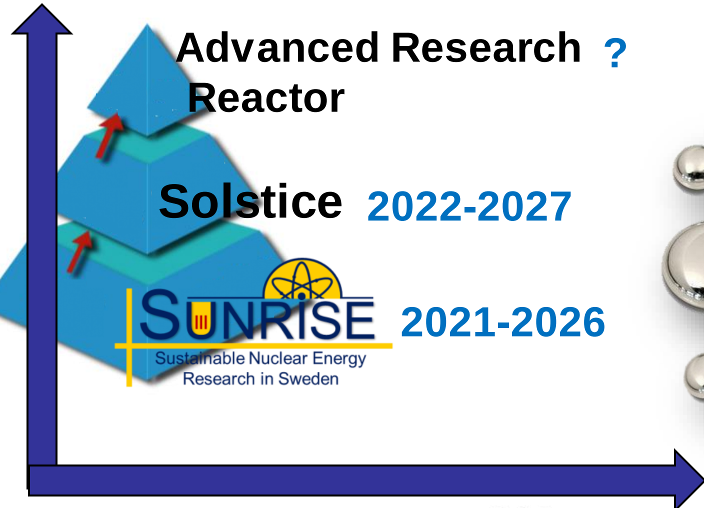
okg
- part of the energy business Uniper

Main parts are still activity today

Significant level of export products from Sweden

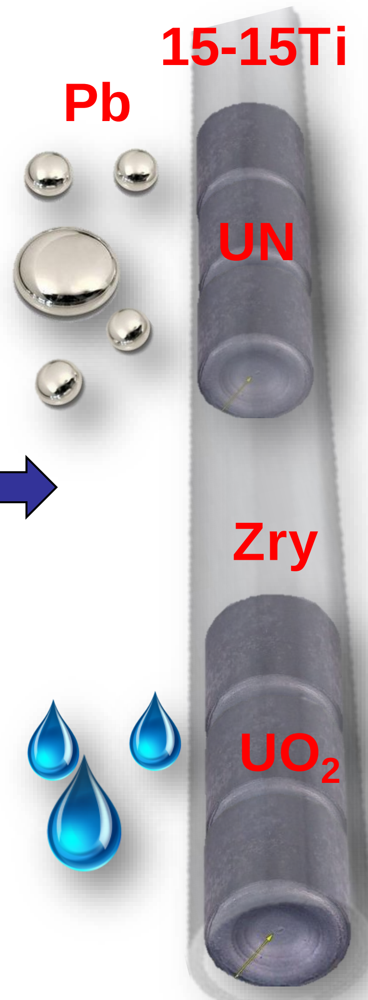
Fuel Qualification: View of Future and what is different now

SUNRISE Sustainable Nuclear Energy Research in Sweden

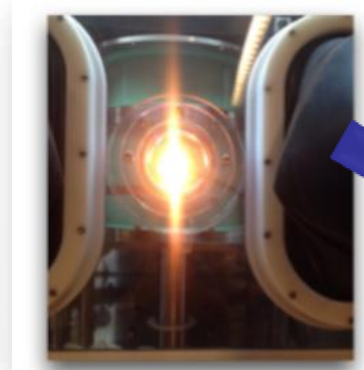


ANItA

2022-2027

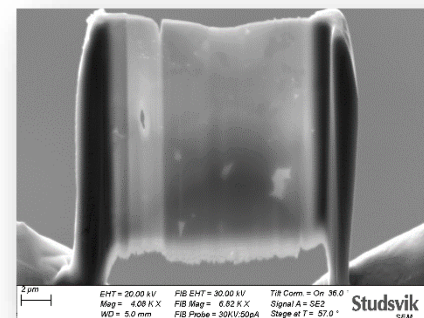


Advanced Fabrication



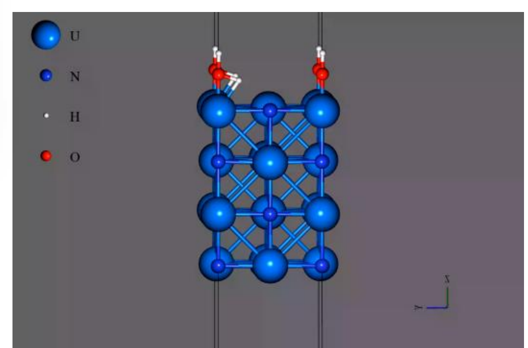
Separate effect test

Advanced Characterization



Accelerated Fuel Qualification

Advanced Modeling



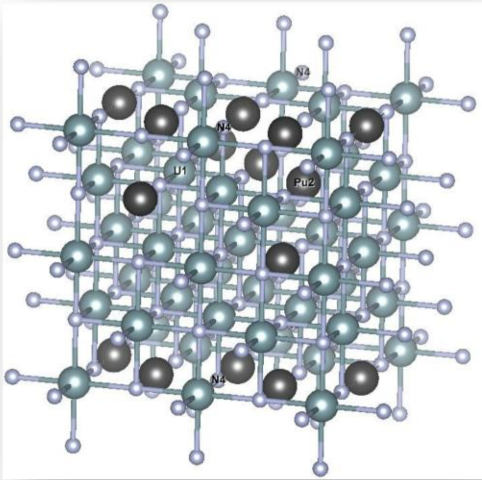
Goal to do faster, more efficient and in a safer way

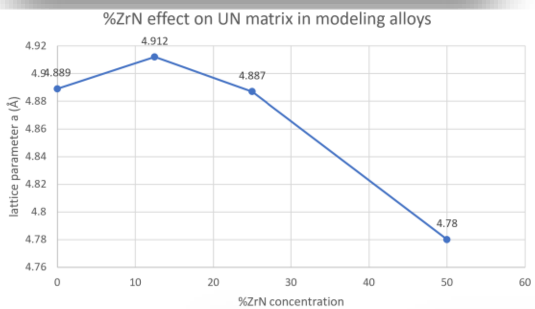
Fuel Qualification: SUNRISE results

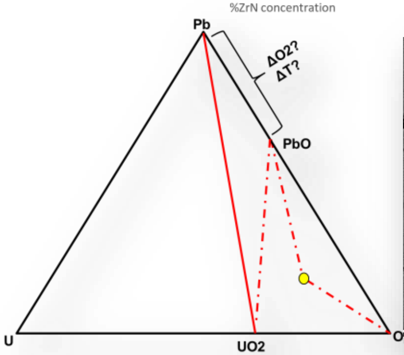
SUNRISE
Sustainable Nuclear Energy Research in Sweden

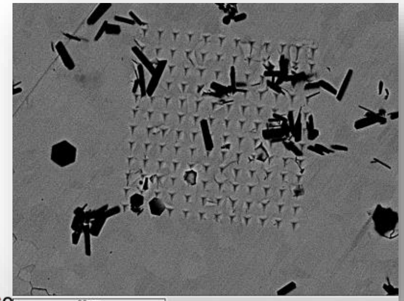
UN doped with Fission Product

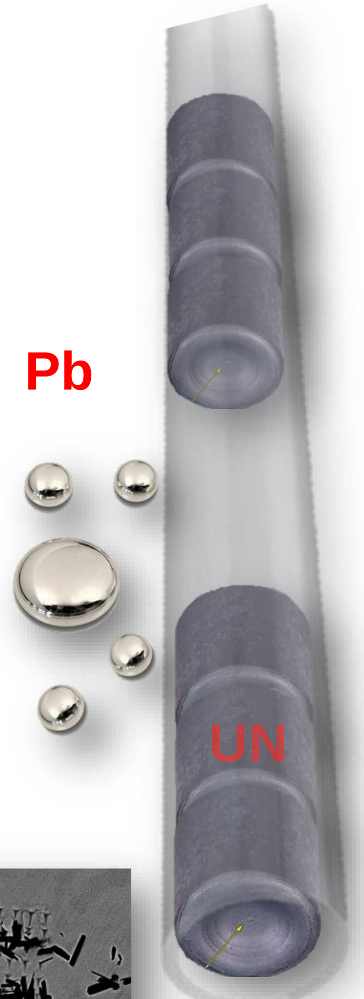
Advanced Modeling



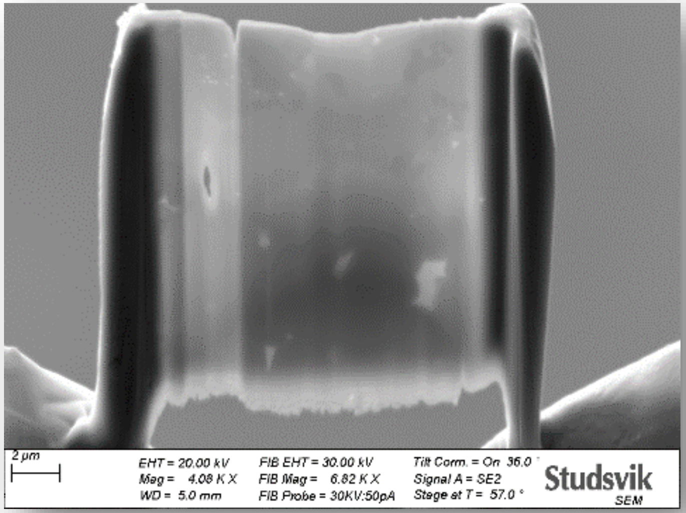


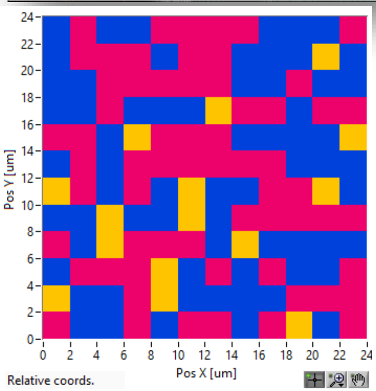


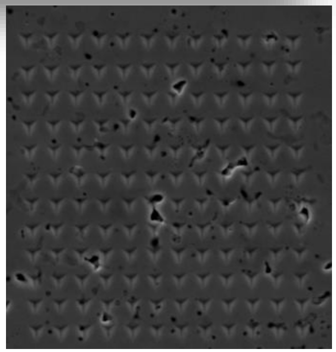




Advanced Characterization







Some achievements in SUNRISE fuel WP

So… what does it take?

Technical

- Infrastructure for **advanced testing**, including:
  - Facilities for irradiation under prototypic/nonprototypic conditions
  - Active laboratories for post irradiation examination
  - Post-test and operational waste handling
- Infrastructure for pilot scale **manufacturing**
- Infractucture for pilot scale **operation**
- Infrastructure for **advanced computing** to build up predictive capacity to accelerate licensing
- Transport solutions if intersite logistics are required

Strategical/Political

- A concerted **national strategy**
- **Inventory** of existing and required infrastructure required for realization
- **Systematic** ways of **funding** (decreased risk) of company's initiative
- Politics to **close gap** between Universities/Companies/State parts
- **Regulation change** for establishment of new reactors where necessary

Questions