INVAP perspectives and initiatives for proliferation resistance as research reactor's designer

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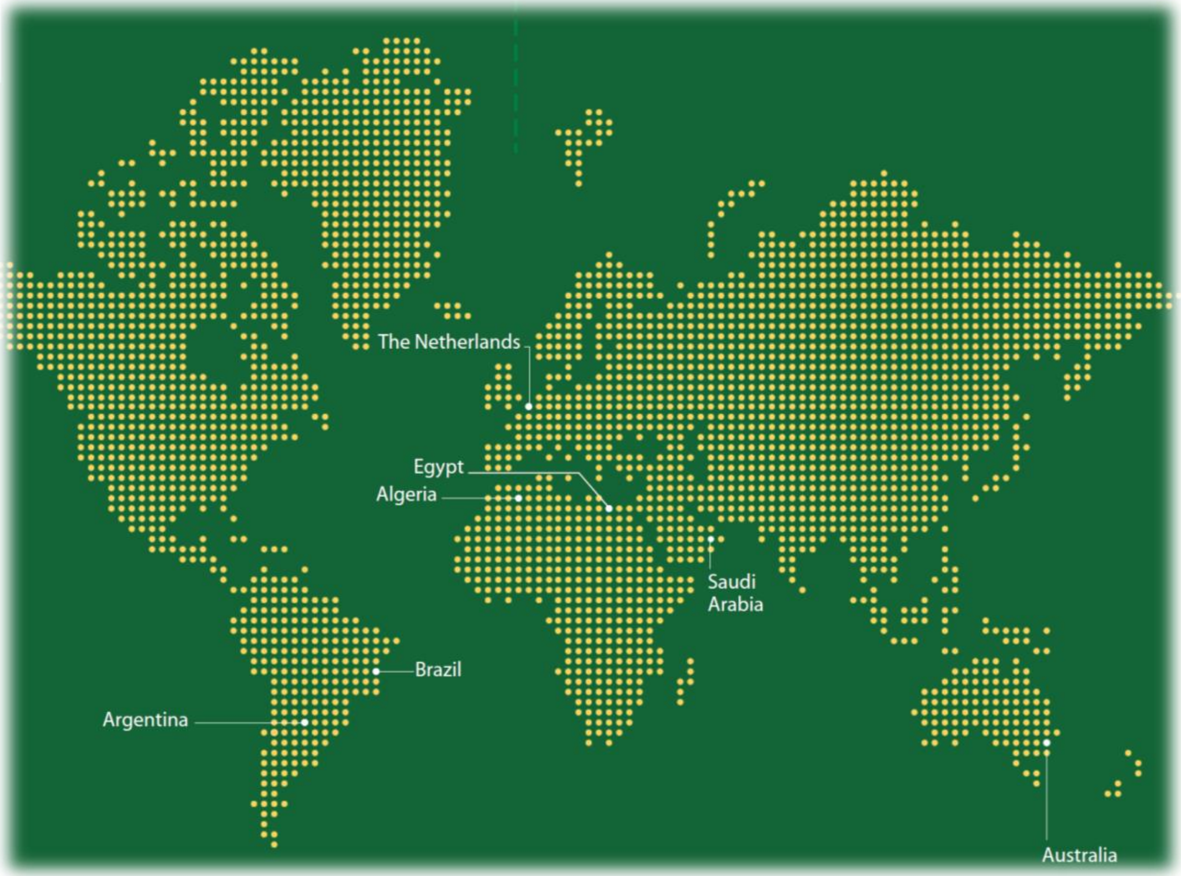
1- Introduction: INVAP nuclear projects

- INVAP's core nuclear business is mainly related to research reactor technology.
- Several successful and on-going projects worldwide: design, construction, commissioning, training and uprating of research reactors.



+ <u>Associated facilities:</u>
    i. Radioisotope production (Mainly ^{99}Mo)
    ii. Fuel production facilities.
    iii. Waste storage.
+ I&C.
+ Specific tailored devices (e.g. CNS).
+ Consultancy.
+ ...

2.1 Main grounds of INVAP's reactor designs:

The philosophy behind our reactor designs

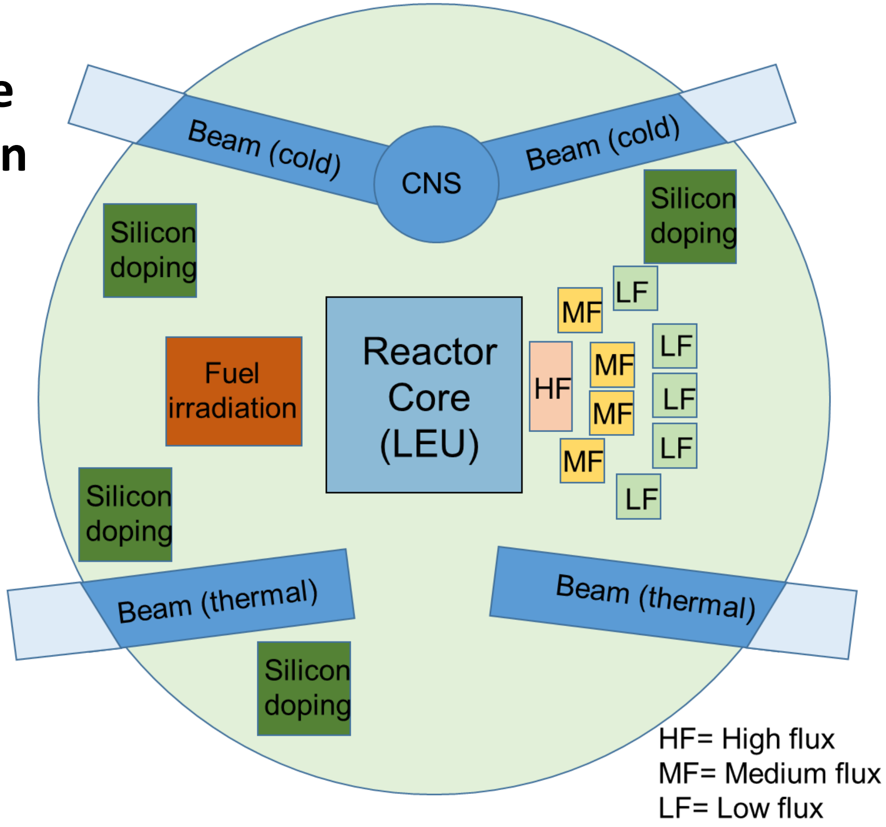
INVAP approach in the design is based on a series of principles:

- ✓ Always consider **Nuclear Safety** as priority.
- ✓ Develop a **customized design**, tailored to client's requirements and capabilities.
- ✓ Involve **peer-review and international experts from early engineering stages** (e.g. IAEA, regulatory bodies, TSO, ad-hoc consultants, etc.).
- ✓ Enhance visibility and integration with research reactors community.

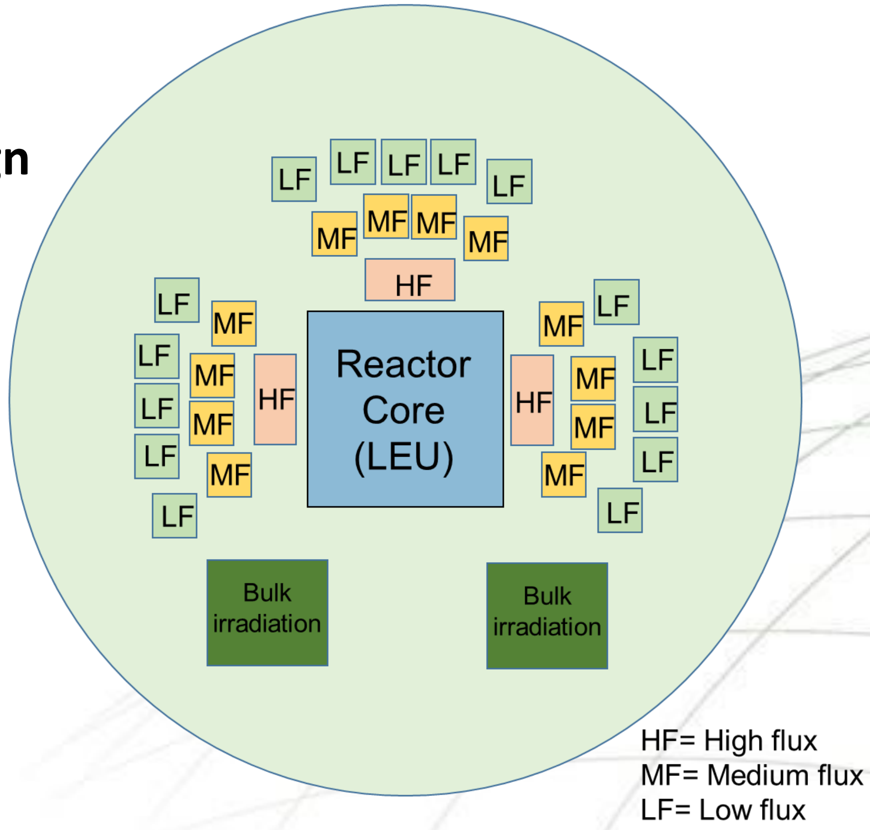
2.1 Main grounds of INVAP's reactor designs:
The philosophy behind our reactor designs

- Within INVAP's approach **the designs are tailored** depending on the main application both for the core and out-of-core devices (defined by client).

Multipurpose reactor design



Dedicated reactor design



- **Use of LEU is the standard approach → optimization is mandatory!**

2.1 Main grounds of INVAP's reactor designs:
The philosophy behind our reactor designs

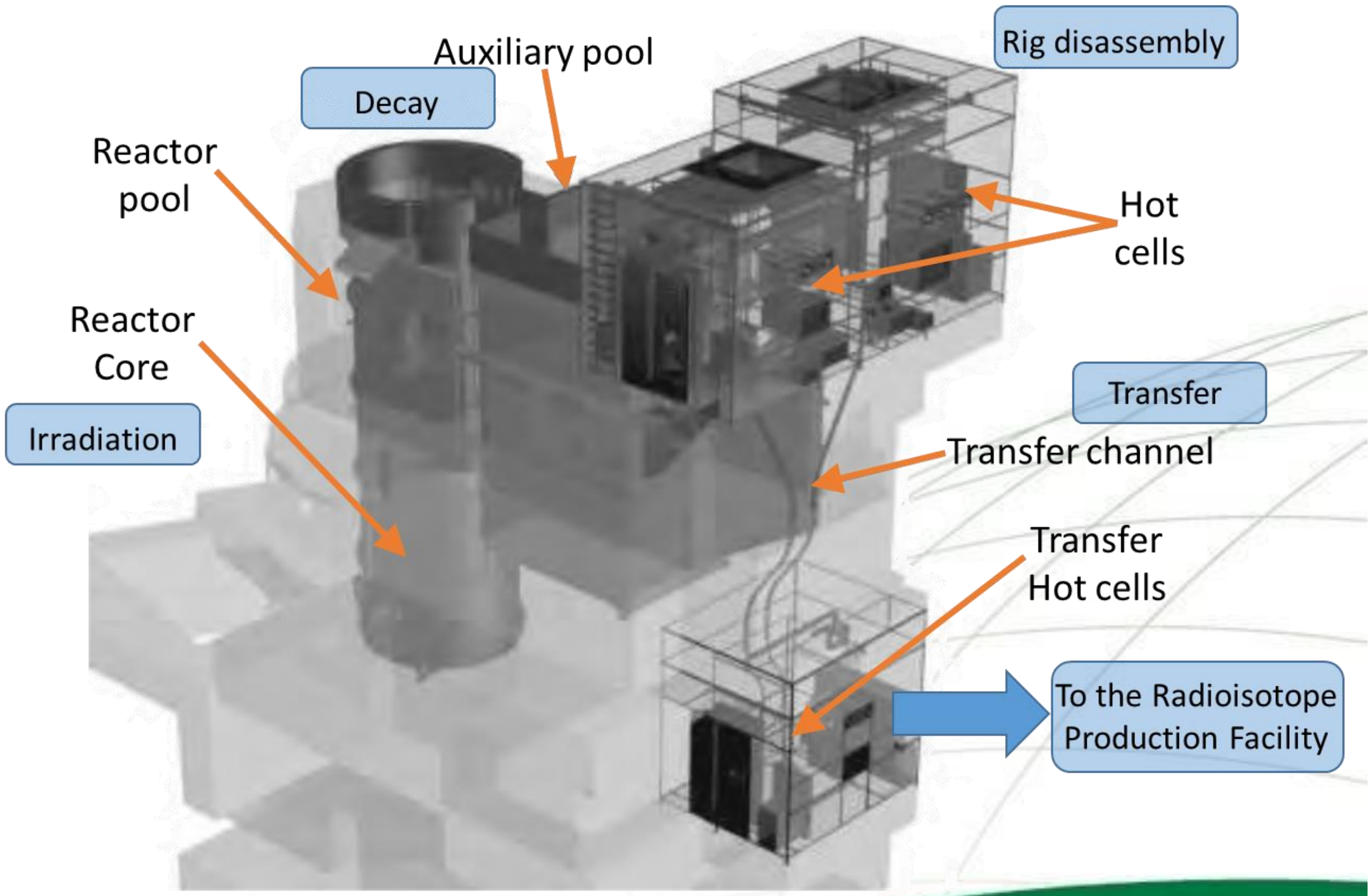
INVAP's designs characteristics:

i. Safety-oriented designs: High safety-margins, FSS + SSS (if applicable).
ii. Utilization of (LEU) fuels: MTR-type U_3Si_2 (dispersed) or rodded-type (UO_2). LEU (< 20%wgt for all cases)
i. Optimization of core performance and safety margins: Tailored refueling strategy, optimized burnup (isotopical barrier) + burnable poisons (if applicable).
ii. Consideration of LEU targets: LEU targets (U-Al_x) for ^{99}Mo production approach.
iii. High availability designs: > 300 FPD per year.
iv. Provide versatile design solutions: Core and out-of-core devices are customized + room to optimization/upgrade/reformulation.
v. Continuous improvement of computational tools and processes: State-of-the-art approach to improve margins.

2.2 - Main grounds of INVAP's reactor designs:
The full scope use of LEU

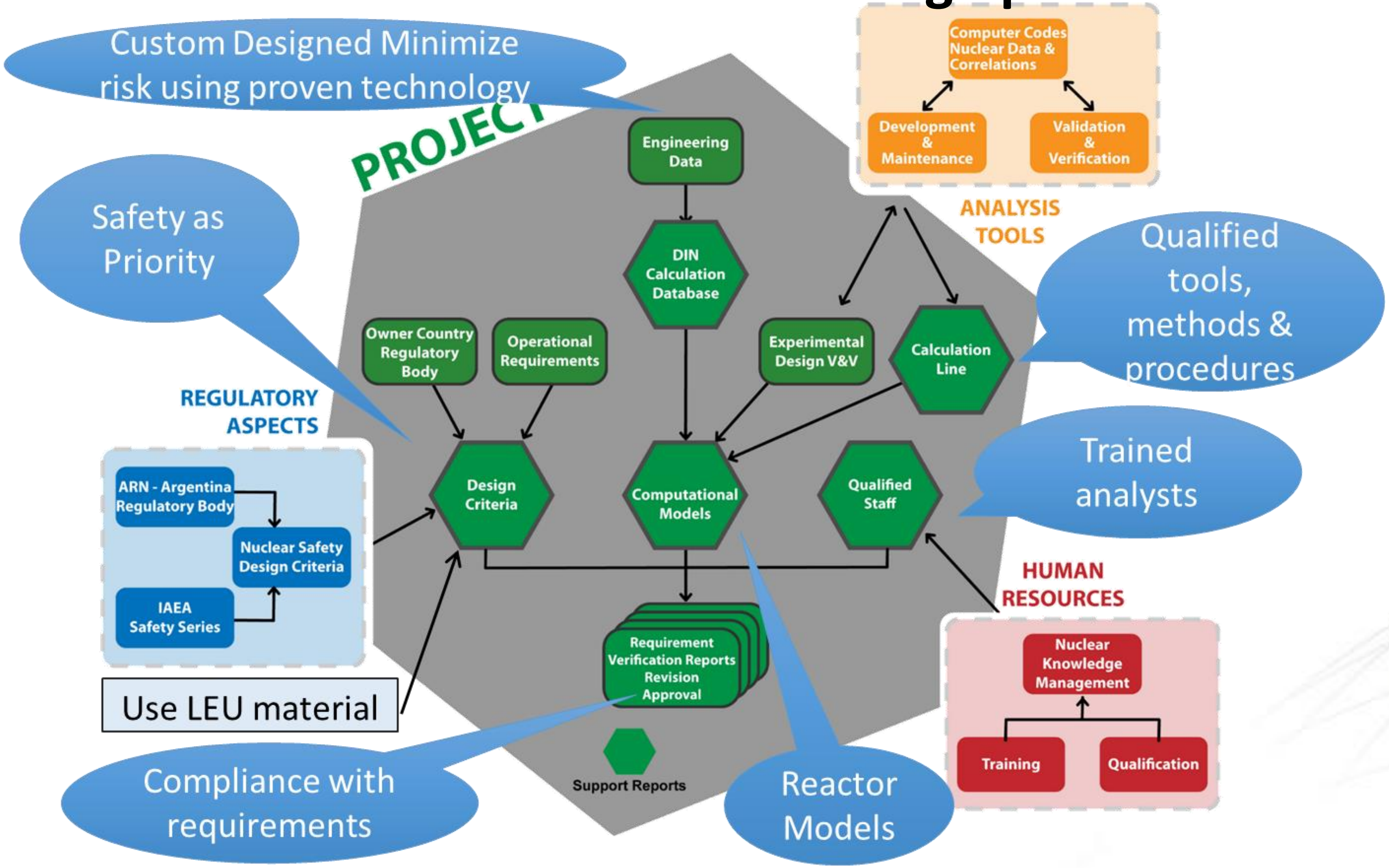
- ✓INVAP's **preferred technology** choice for the massive production of ^{99}**Mo: UAl$_x$ mini-plate fission** (developed by Argentine Atomic Energy Commission – CNEA, 2002).
- ✓Proven scalability and high performance, **full LEU**.
- ✓Ad-hoc processing facility.
- ✓On-going designs: easy-to-follow and transparent path for LEU.

Scheme of the transfer of LEU targets from core for RA-10 reactor



2.3 - Main grounds of INVAP's reactor designs:
Involved aspects during our reactor design process

- **How to handle this within the design process?**



Some aspects to regard:

- High workload in early stages of Engineering for Nuclear D&A groups.
- Preserved considering project execution times.
- Changes in DD or Construction are very hard to implement / times for provision of components (export-control) .
- Conservativeness is mandatory.
- Full-scope use of LEU.

2.4 - Main grounds of INVAP's reactor designs:
Tailored training and knowledge transfer

- **INVAP's approach regarding training and knowledge transfer:**
  - ✓ Tailored to customer's background and oriented to **enhance the safe and peaceful use of the nuclear energy.**
  - ✓ Aimed to gain a deep understanding of the underlying technology, features, characteristics and limitations of the nuclear facility provided.

Training course for operators of the ETRR-2 (Egypt) – 1996

On-the-job training during commissioning (OPAL, Australia) – 2006

Training course for the LPRR operators (Saudi Arabia) – 2017

3.1 - Examples of INVAP's designs:

Successfully completed research reactors projects

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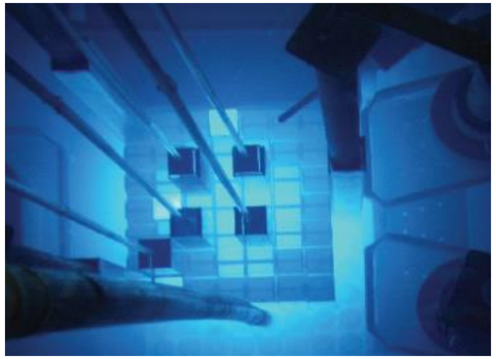
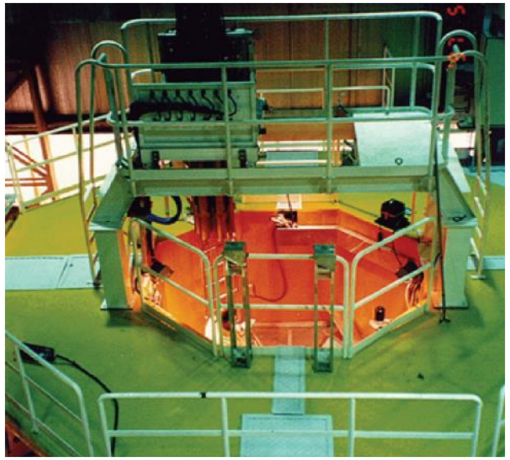
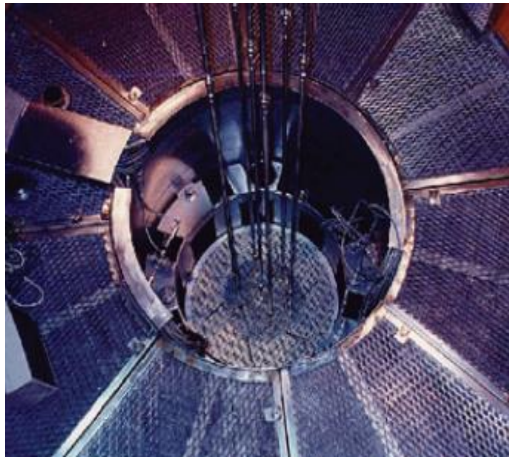
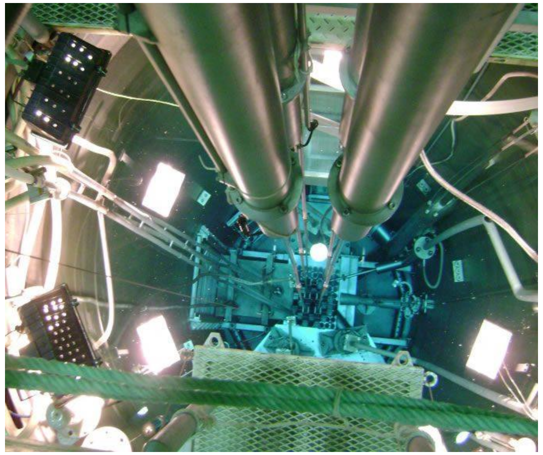


RA-6 (1982, Argentina – upgraded by owner up to 1MWth in 2009)





RA-8 (1997, Argentina – critical facility)



NUR (1989, Algeria)

↓

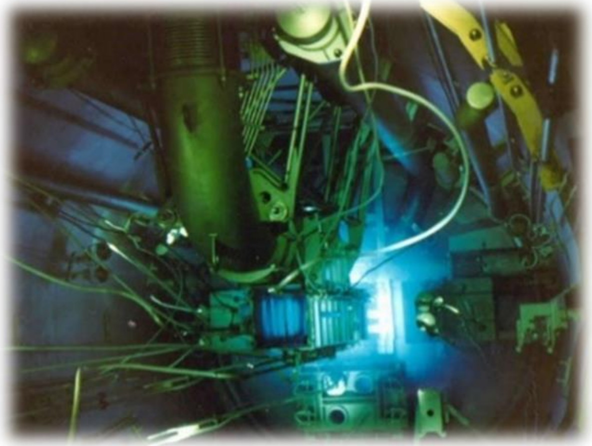
To be upgraded up to 3.5MWth + LEU ^{99}Mo production

3.1 - Examples of INVAP's designs:

Successfully completed research reactors projects

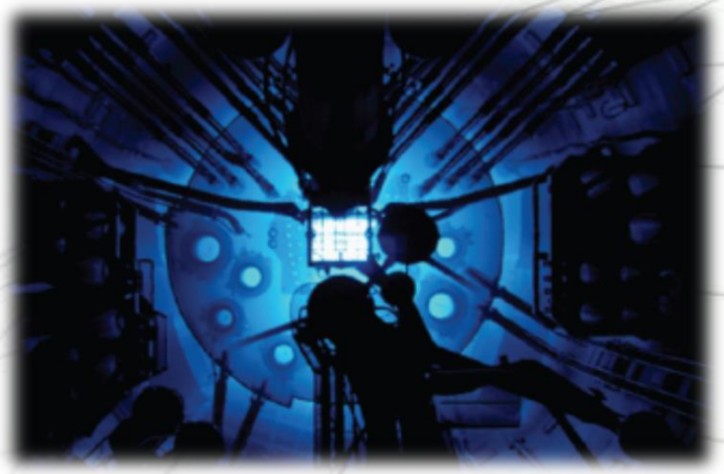
ETRR-2 reactor (1997, Egypt)

- ✓ 22 MWth
- ✓ Multipurpose.
- ✓ ^{99}Mo production with LEU (2012).



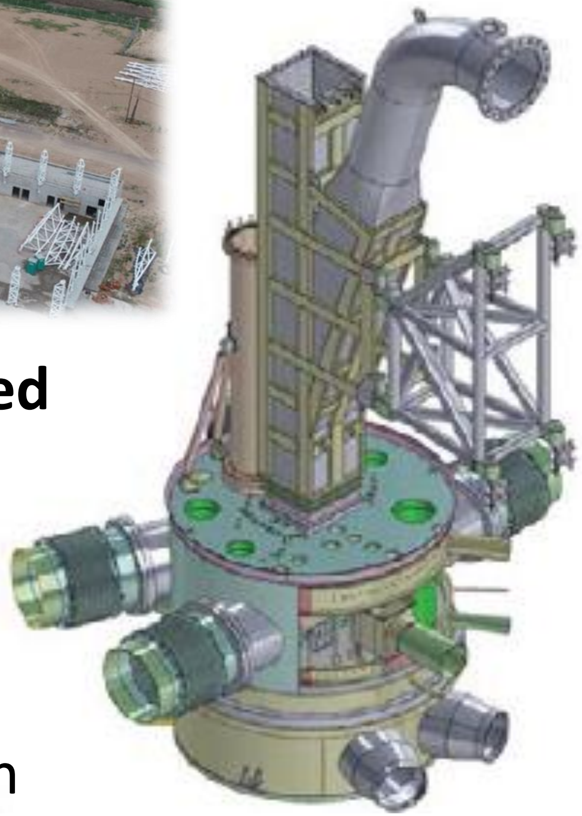
OPAL reactor (2006, Australia)

- ✓ 20 MWth
- ✓ Multipurpose.
- ✓ Materials science.
- ✓ ^{99}Mo production with LEU (2008).



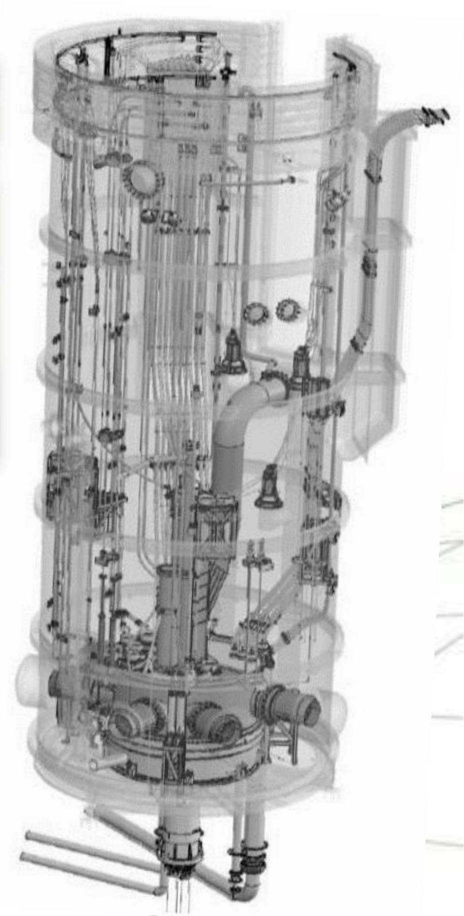
3.2 - Examples of INVAP's designs:

On-going research reactors projects



RA-10 reactor (estimated 2024, Argentina):

- ✓ 30 MWth
- ✓ Multipurpose.
- ✓ Materials science.
- ✓ ^{99}Mo production with LEU.



RA-10 reactor (DD completed, Brazil):

- ✓ 30 MWth
- ✓ Multipurpose.
- ✓ Materials science.
- ✓ ^{99}Mo production with LEU.

3.2 - Examples of INVAP's designs:
On-going research reactors projects

LPRR reactor (estimated 2024, Saudi Arabia):
- ✓ 30 kWth
- ✓ LEU, rodded-type.
- ✓ Multipurpose.

PALLAS (estimated 2030, The Netherlands):
- ✓ 25 MWth
- ✓ Oriented to medical RI.
- ✓ Massive ^{99}Mo production with LEU.
- ✓ Several bulk-irradiation positions.

3.3 - Examples of INVAP's designs:
Successfully completed associated facilities

LEU radioisotope production facility – Egypt (commissioned 2012)

LEU FA production facility – Egypt

4- Conclusions

- INVAP's projects portfolio covers **research reactors and the associated facilities**.
- Wide range of technological solutions developed during last four decades, **adapted to customers' capabilities and backgroun**d.
- Tailored and custom-oriented solutions successfully applied worldwide, where diverse regulatory frameworks apply.
- Approach → optimization, preserving safety as a priority and following all international good practices.
- **Ad-hoc training and knowledge** transfer schemes according to customers' background and capabilities to be developed → oriented to safe and peaceful use of nuclear technology.
- **Full-scope use of LEU, high burnup of cores, high-visibility projects, integration in the world research reactor community**.
- **Philosophy is applied from early design stages**.

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Questions?
Thanks for your attention!