# *Tritium Separation at Cernavoda Nuclear – Romania*

GENERATING SUCCESS --- FOR 100 YEARS

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life cycle management solutions

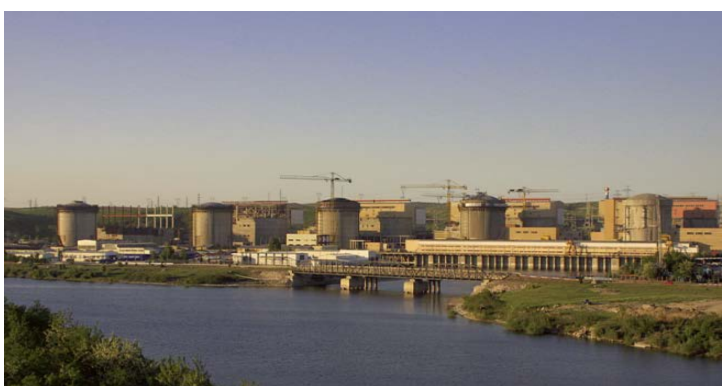
# Background – Cernavoda Nuclear

KINECTRICS

NUCLEARELECTRICA

SOCIETATEA NATIONALA NUCLEARELECTRICA
CNE Cernavoda

- SNN-CNE has 2 operating CANDU 6 Heavy Water reactors (706 MWe)
- U1 operational 1996, refurbishment – 2022
- U2 operational 2007, refurbishment planned
- Letter of intent to build U3, U4 with China General Nuclear – SNC Lavalin - Canada

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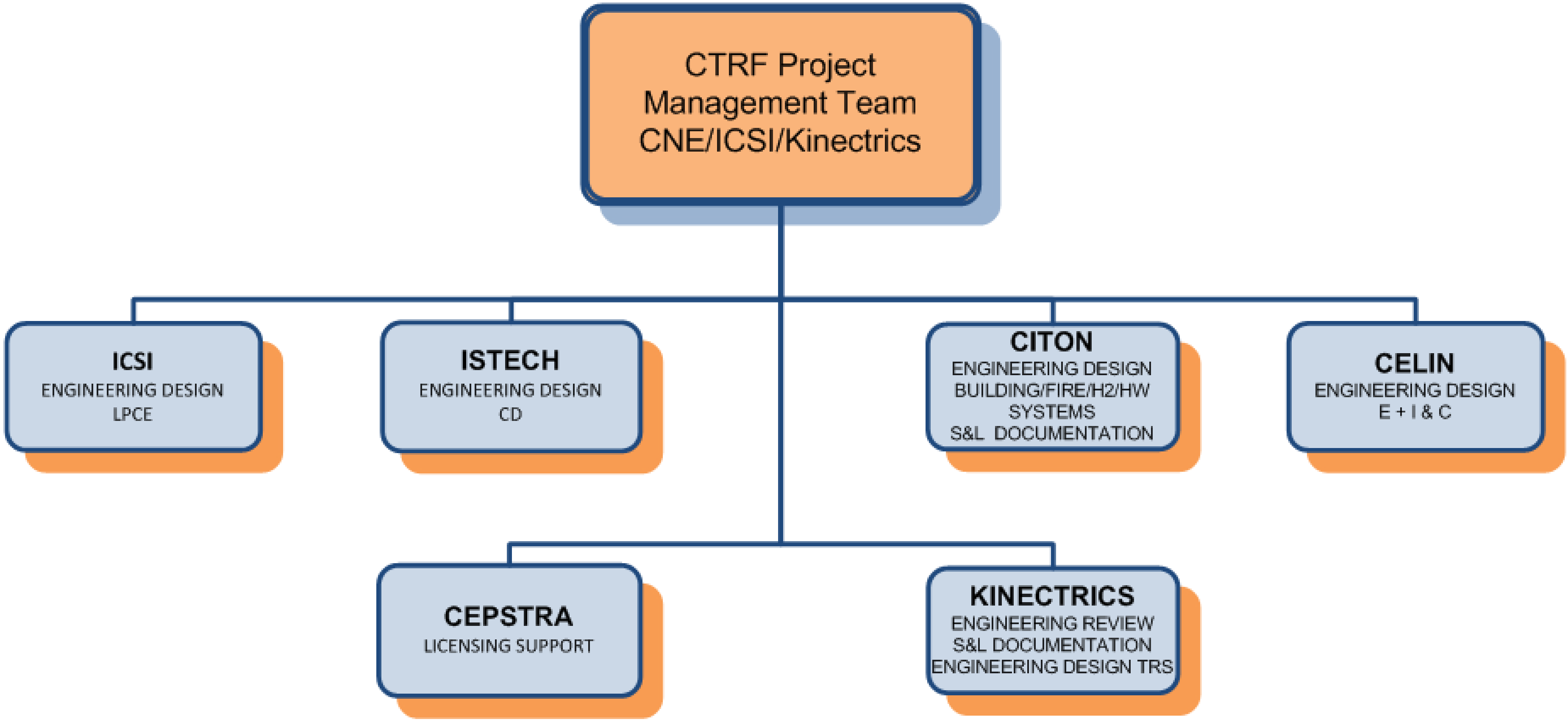
# Background – Need for Detritiation

- Reduction of tritium activity of moderator (U1~60 Ci/kg, U2 ~25 Ci/kg) and heat transport water for refurbishment activities
- General reduction in worker dose (~90% reduction at Wolsong U1)
- Reduction in environmental tritium emissions

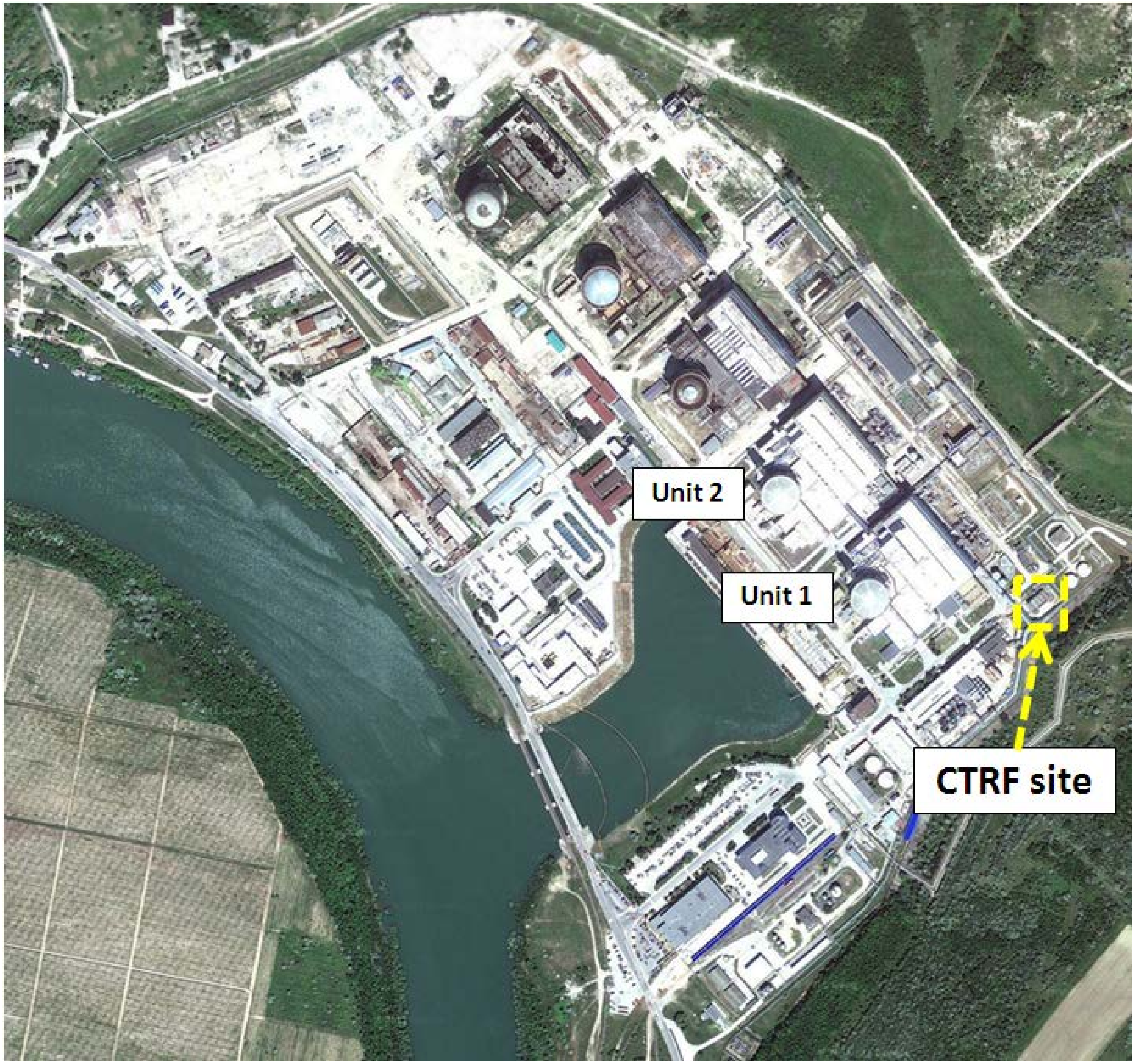
  (~ 75% reduction at Wolsong U1)

# CTRF Project Organization




**ICSI - NATIONAL RESEARCH AND DEVELOPMENT INSTITUTE FOR CRYOGENICS AND ISOTOPIC TECHNOLOGIES, RAMNICU VALCEA, ROMANIA**

# CTRF Location

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# CTRF History-Schedule

- 2005 – 2006: Early feasibility studies;
- 2008: Investment approved, starting design of CTRF;
- 2011: Major change into the project - location of CTRF changed, confirmed later by recommendations following Fukushima (due to risk of hydrogen explosion);
- 2015: End of conceptual design phase, including updates to feasibility study of the project.
- Issue Invitation for Tender for EPC tender: 2015;
- Construction license issued: 2017;
- Operational start: 2020;
- Unit 1 refurbishment starts: 2022.

# CTRF Safety and Licensing

To license a facility, the safety case must demonstrate that:

- the design complies with regulatory requirements, the mandatory codes and standards and quality assurance requirements and,
- the design, analysis and operation incorporate best practice and principles

Romanian nuclear regulator (CNCAN) unfamiliar with Tritium Removal Facility – education required

- Target to produce safety documentation for submission to CNCAN in order to receive Letter of Comfort that the CTRF is licensable

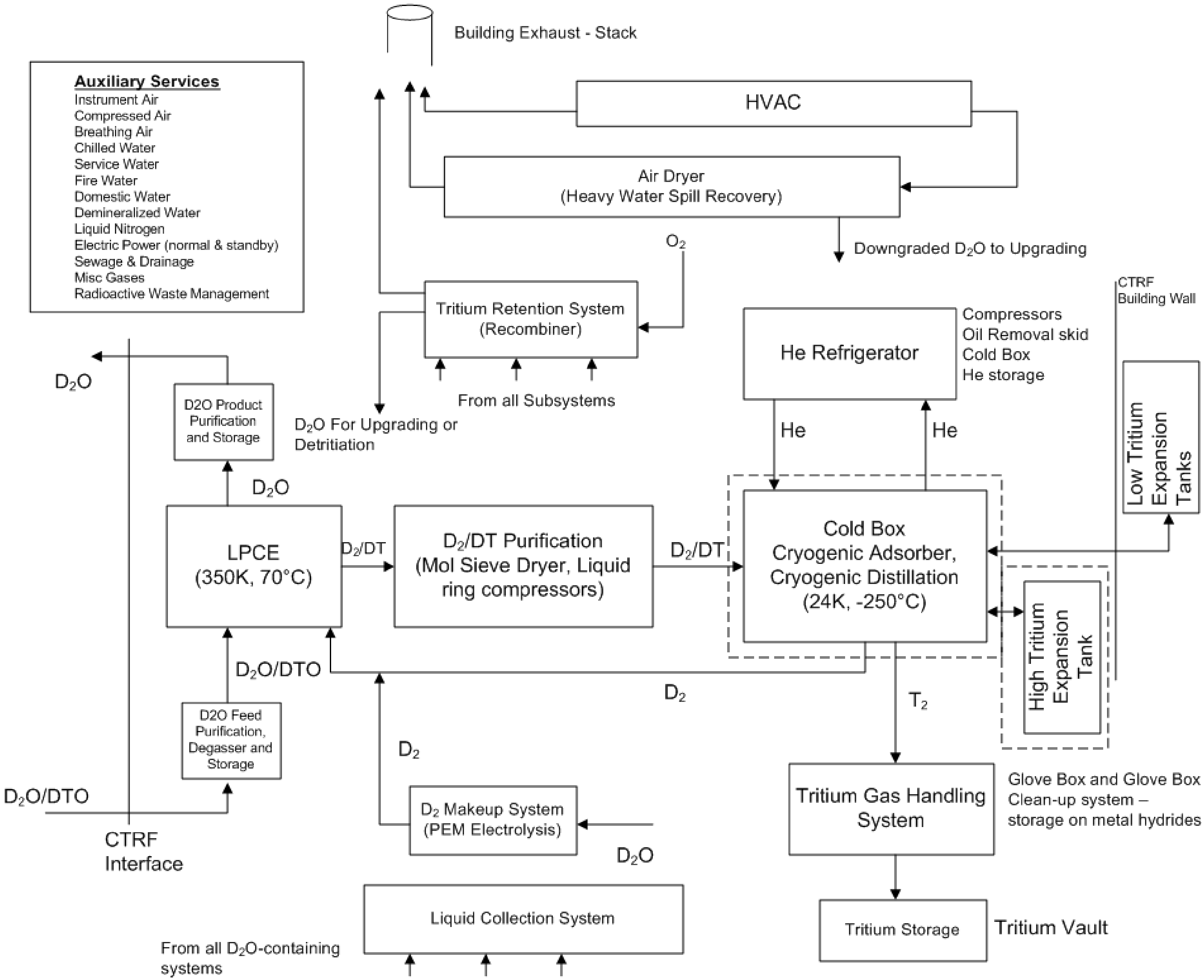
# CTRF Safety Philosophy

- CTRF will be a Radiological Facility with Reactor Grade Basis to the extent they are applicable;
- Follows IAEA safety approach and EU requirements;
- Always more than five barriers against public exposure;
- Incorporates operation experience from existing CANDU facilities;
- Considers good practices of US NRC and NASA for Hydrogen handling;
- Incorporates knowledge gained from the ICSI TR Pilot Facility;
- Harmonized design for the vicinity with reactors;
- Enhanced Safety Related Functions for facility systems;
- Iterative process design and safety analyses;

# Existing Commercial Tritium Removal Facilities

| | DTRF<br>OPG Canada | WTRF<br>KHNP Korea |
|---|---|---|
| Process | VPCE + CD | LPCE + CD |
| Feed rate (kg $D_2O$/hr) | 360 | 100 |
| Tritium extraction (design) | 97% | 97% |
| Tritiated product purity (isotopic) | ~99% $T_2$ | >99% $T_2$ |
| Tritium Storage | Ti-tritide | Ti-tritide |
| In-service | 1990 | 2007 |
| Service life | 30 years | 40 years |

# CTRF Process: LPCE-CD



# Tritium Removal Facilities Comparison

KINECTRICS

| | DTRF | WTRF | CTRF |
|---|---|---|---|
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→ Evolution in design

# CTRF differences vs WTRF

- Heavy Water Feed and Product Systems:
  - In the service building, no degasser (part of LPCE) – Reason: To reduce β/γ concerns in the CTRF Building
  - Batch transfer (slanted doubly contained pipes) of heavy water from station to CTRF (1 Mg/batch, off-shift hrs) – Reason: Reduce risk of spill
- DMS:
  - PEM electrolysis cell used – Reason: Now proven, believed to be better for intermittent use.
- LPCE:
  - Hydrophilic packing is inter-mixed with wet-proofed catalyst – Reason: better performance

# WTRF-CTRF Comparison

KINECTRICS

- Deuterium Purification System
  - Cryoadsorber uses charcoal – Reason: Designer experienced with charcoal
  - Cryoadsorber beds are directly cooled by the Helium Refrigeration System to 50K – Reason: Improved removal of contaminants

# WTRF-CTRF Comparison

KINECTRICS

- CDS
  - Same He flow to CD2, CD3, and CD4 condensers – Heaters used to regulate temperature vs flow – Reason:  Better control of heat input / output on CD columns
  - Pumps present on forward and reverse flows – Reason: Better control of column pressure and temperature
  - T2 bled off continuously vs batches – Reason: better control of column profile
  - New designs of collectors and distributors – Reason: lower hydrogen inventories

# WTRF-CTRF Comparison

- ITC
  - Doubly contained design – Reason: tritium/He-3 removal, tritium permeation containment
  - Heater integral part of the ITC design – Reason: Easier heat transfer for $T_2$ retrieval
- ADS:
  - Recombiner not included – Reason:  Hydrogen safety philosophy does not allow hydrogen leaks to be boxed up
- GCS
  - CuO bed for oxidation and subsequent trapping of water on molecular sieves – Reason: experience at TLK – Karlsruhe, no oxygen feed into GCS

# CTRF Building

- 6 floors plus basement
- Steel frame building with blowout panels over part of the structure
- Divided into hydrogen and non-hydrogen zones
- Hydrogen zones have grating floors to promote ventilation
- Hydrogen zone has 10 air changes per hour
- Divided into radiological zones
- Main expansion tanks, outside at back of building facing hillside away from reactors
- Tritium Vault in basement is designed to withstand explosion and flooding
- Feed & Product tanks are in the basement with sumps – within the heavy water area

# CTRF Safety

- A safe shutdown state to protect nuclear station against the effects of a hydrogen explosion;
- Hydrogen monitors prioritised over tritium monitors to trigger CTRF shutdown;
- Philosophy oriented to prevent hydrogen deflagration or explosion
- Consideration of airplane crash
- Whole nuclear site hazards integrated defence approach
- Seismic qualification to an annual frequency of occurrence of $10^{-4}$

# Present Status

KINECTRICS

- Conceptual/detail design developed for tendering process
- Completion of Safety Documentation to submit to Romanian nuclear regulator (CNCAN) with intent to receive Letter of Comfort concerning licensability of CTRF
- Completion environmental impact study for CTRF which will demonstrate expected receipt of environmental accord
- Awaiting approval for release of funds to build

# THANK-YOU