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Current Status of the Vietnam Nuclear Power Program and Future Vision of Nuclear Safety Research

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Outline

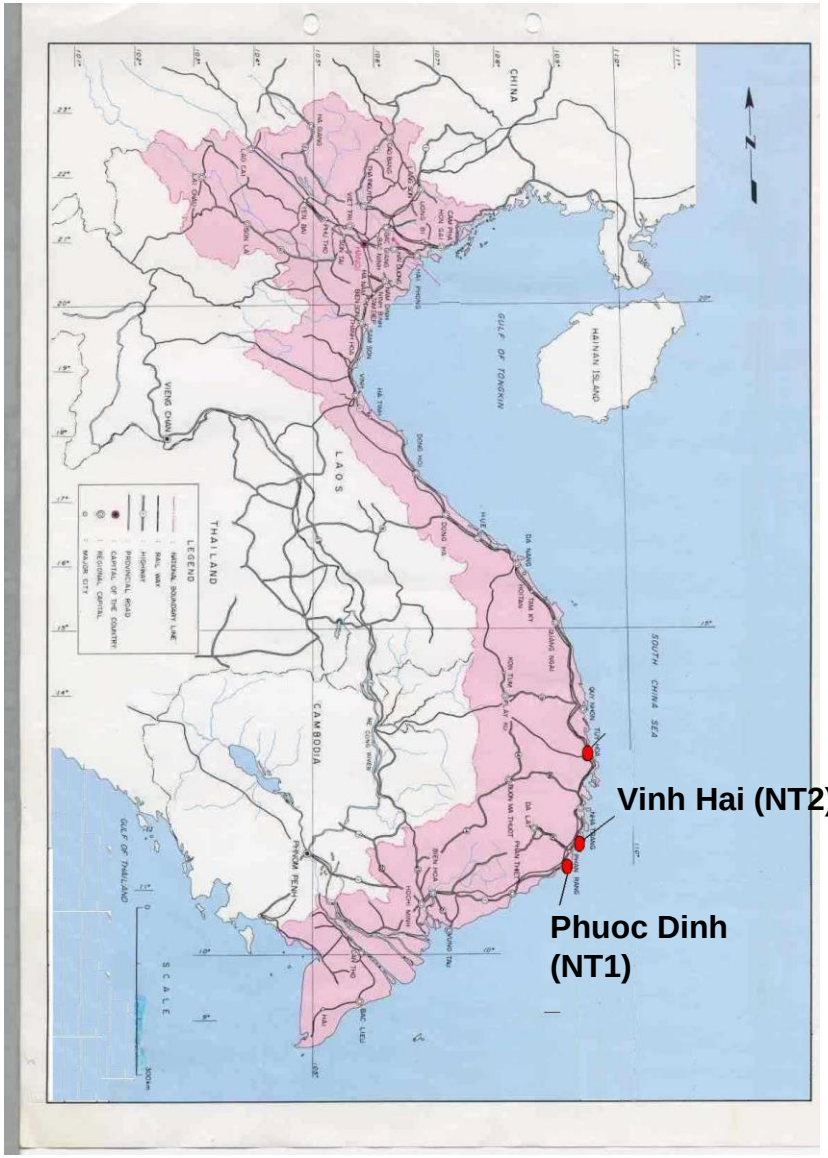
1) *Status of the National Nuclear Power Program*
2) *The New Research Reactor Project – The Center for Nuclear Energy Science and Technology (CNEST)*
3) *Adaption to the new situation in Vietnam*
4) *Nuclear Power Safety Research*
5) *Concluding Remarks*

1. Status of the Nuclear Power Program

History and Current Status

- Operation of Research Reactor (RR) in Dalat (1963)
- Atomic energy in Vietnam started since 1976
- 1979-1984: Reconstruction of Dalat RR
- 1996-2002: Study on NPP introduction into Vietnam
- 2002-2009: Pre-Feasibility Study (Pre-FS) on construction of the first NPPs in Vietnam
- 2008: Atomic Laws approved (need to improve)
- 2010: Contracts for the Ninh Thuan 1 (NT1) and Ninh Thuan 2 (NT2) NPPs Feasibility Studies (FS) and Dossiers for Site Approval (DSA) – *E4 and JAPC*

1. Status of the Nuclear Power Program



The First 2 NPP Projects

- ✓ Pre-FS: 2002-2009
- ✓ Ninh Thuan 1 – NT1:

2x1200 MWe + 2x1200 MWe

(Operation start: 2028/2029)

- ✓ Ninh Thuan 2 – NT2:

2x1000 MWe + 2x1000 MWe

(Operation start: 2029/2030)

- ✓ Location:

300 km from Ho Chi Minh City,
140 km from Dalat

1. Status of the Nuclear Power Program

Passive Safety is preferable!

- Ninh Thuan 1:
  - *AES-91 (Tianwan, China)*
  - *AES-92 (Kudan-Kulam, India; Belene, Bulgaria)*
  - ***AES2006/V491*** *(Leningrad, Belarus, Kaliningrad-, Czech, Finland?) – [Active + Passive]*
  - *AES2006/V392M (Novovoronhetz) – [Active + Passive]*
  - *VVER-TOI (Turkey?) – [Active + Passive]*
- Ninh Thuan 2:
  - *ABWR (Hitachi-GE, Toshiba)*
  - *MPWR+/Tomari PWR (Mitsubishi)*
  - ***AP1000*** *(Westinghouse + Toshiba) – Passive Plant*
  - *ATMEA1 (Mitsubishi + Areva)*

1. Status of the Nuclear Power Program

History and Curent Status (cont.)

- December 2013: Completion of FS (NT1 and NT2)
- October of 2014: Revision of FS Report (NT1) – **VVER1200**
- Ninh Thuan 2 NPP: Technology selection has not been completed; Additional survey of site has been carried out by Japan Atomic Power Co. (JAPC)
- 2015: Review tasks (Focus on Ninh Thuan 1) ➔ Formulation of tasks (Terms of Refereces – TOR); Documents/dossier of requirements for selection of a foreign Consultant to perform Review
- March 07, 2016: BID for selection of Consultant … cancelled
- **22/11/2016**: National Assembly cancelled the NPP projects

2. The New Research Reactor Project

Current research reactor (Dalat RR -- DRR)

- ✓ Pool type TRIGA reactor, built by US
- ✓ The reactor is old: First operation in 1963, reconstructed and restarted in March 1984
- ✓ Small capacity (500 kWt), low neutron flux (10^{13})
- ✓ The reactor was converted to LEU in 2011 (Russian fuel VVR, 19.75% of enrichment, enough for ~15 years)
- ✓ Dalat Nuclear Research Institute (DNRI): staff is about more than 200 people
- ✓ Dalat: Remote area, mostly focus on turism (lacking of other research institutes, universities, appl. centers)

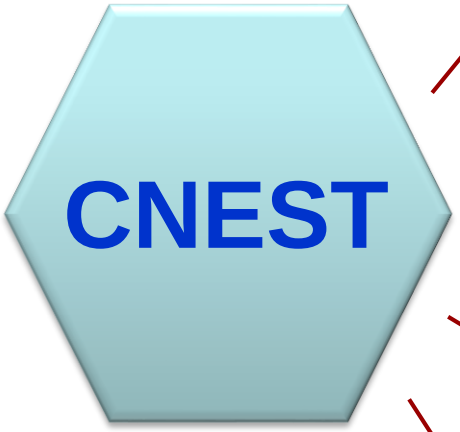
2. The New Research Reactor Project

The Center for Nuclear Energy Science and Technology (CNEST)

- ✓ Vietnam and Russia have signed an Inter-Governmental Agreement (21st November 2011) for building of a Center for Nuclear Energy Science and Technology (CNEST) -- < 500 millions USD (Credit from Russia)
- ✓ The main equipment of the CNEST is a new multipurpose Research Reactor (RR) of 15 MWt
- ✓ Other Labs of the CNEST are Non-Destructive Evaluation Techniques (NDET), NPP Systems Modeling and Simulation Center (NSMS), Material Sciences Center (MSC)

2. The New Research Reactor Project

The main purposes of the CNEST

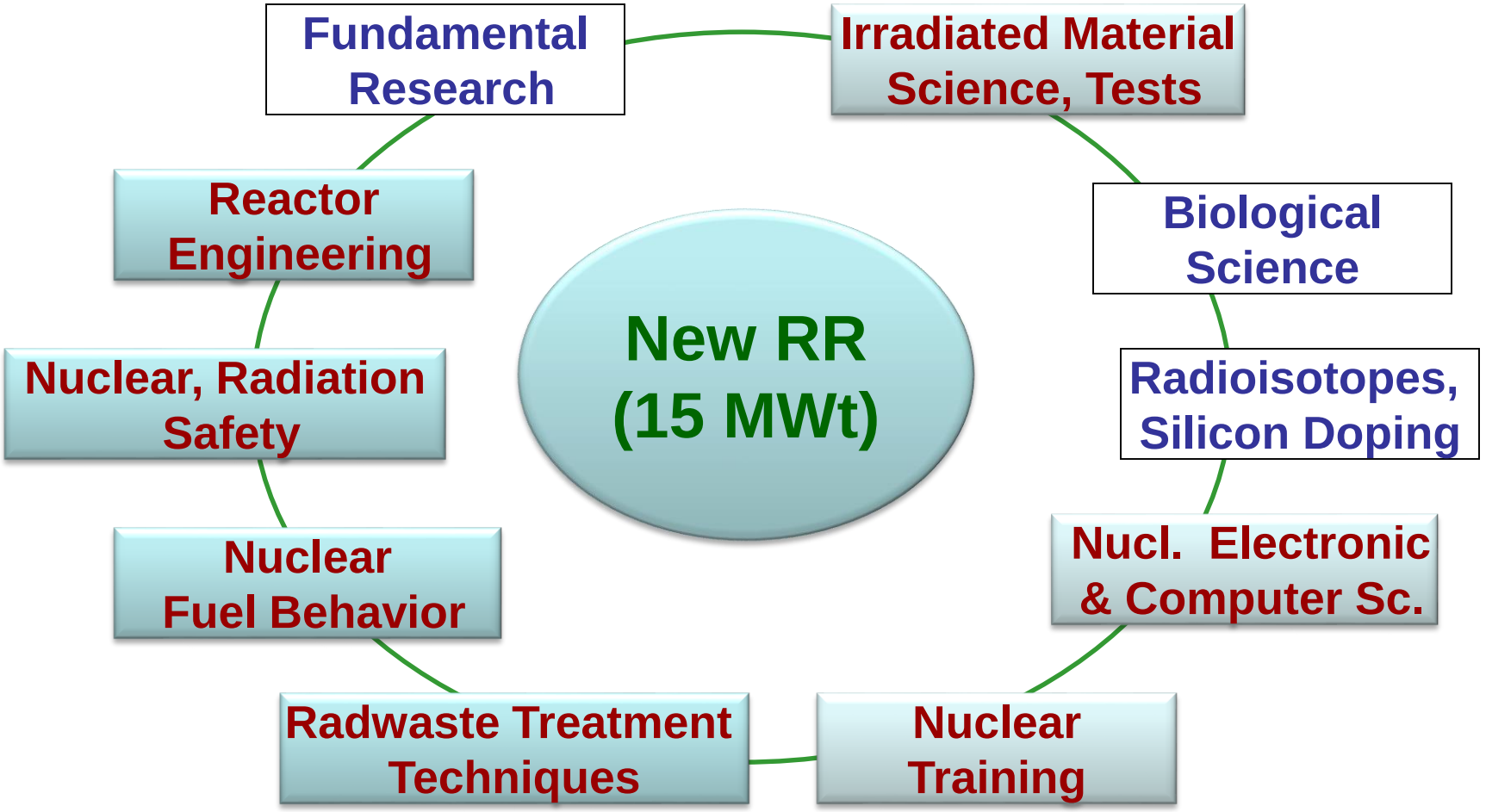


- Building capacity in nuclear power safety, emergency response (relevant to 8 operating units of Chinese NPPs)
- Advanced research in the area of atomic energy (nuclear physics etc.)
- Application of nuclear techniques, radiation technology; Production of isotopes, silicon (Si) doping
- Education and training (E&T) for atomic energy and nuclear power

2. The New Research Reactor Project

Research orientation with the new RR

Red – related to nuclear power



2. The New Research Reactor Project

North Vietnam Institutes, Universities

Hanoi

Risk and Safety Study Center

Material Science and Evaluation

Simulation/Training Center

Chinese NPPs close to Vietnam border

Dalat NRI

Dong Nai

Center for Nuclear Energy Science and Technology -- CNEST

New RR

Dong Nai Nuclear Research Center (DNRC)

South Vietnam Institutes, Universities, appl. centers

2. The New Research Reactor Project

Siting for the CNEST

Ninh Thuan

Dong Nai site

2. The New Research Reactor Project

Challenges for the RR project

- ✓ Commitment and support from the Government
- ✓ Selection of a site for the new RR (5 years, not decided)
- ✓ Budget and financial resources (FS, site investigation…)
- ✓ Future vision and establishment of a long term research plan for RR utilization, involvement of stakeholders
- ✓ Regulatory framework to support the RR project (priority of legislative documents – experience from the NPP projects – not to repeat mistakes in the past)
- ✓ Public acceptance (for the new site – not in Dalat)

2. The New Research Reactor Project

Current Status of the CNEST

1) MOU with Russian Government – 2010
2) InterGovernmental Agreement 21/11/2011
3) August 2015: Submitted the Pre-FS for the Vietnamese Government – further submitted to the InterMinistrial Committee for review
4) ***September 2017 – The revised Pre-FS of the new RR project submitted to Vietnam Government***

3. Adaptation to the New Situation in Vietnam

1) The NPP projects (Ninh Thuan 1 and Ninh Thuan 2 NPP projects) have been cancelled (November 2016)
2) New Chinese NPP units (8 units) operate close to Vietnamese border (about 300 km to Hanoi)
3) China has launched a new program related to Floating NPPs (FNPPs) which can be used for disputing islands
4) Renewable energy becomes a focus of Vietnamese Government (however, many difficulties have been arisen)
5) Thermal Power Plants (TPPs) are facing with big difficulties related to public acceptance

3. Adaptation to the New Situation in Vietnam

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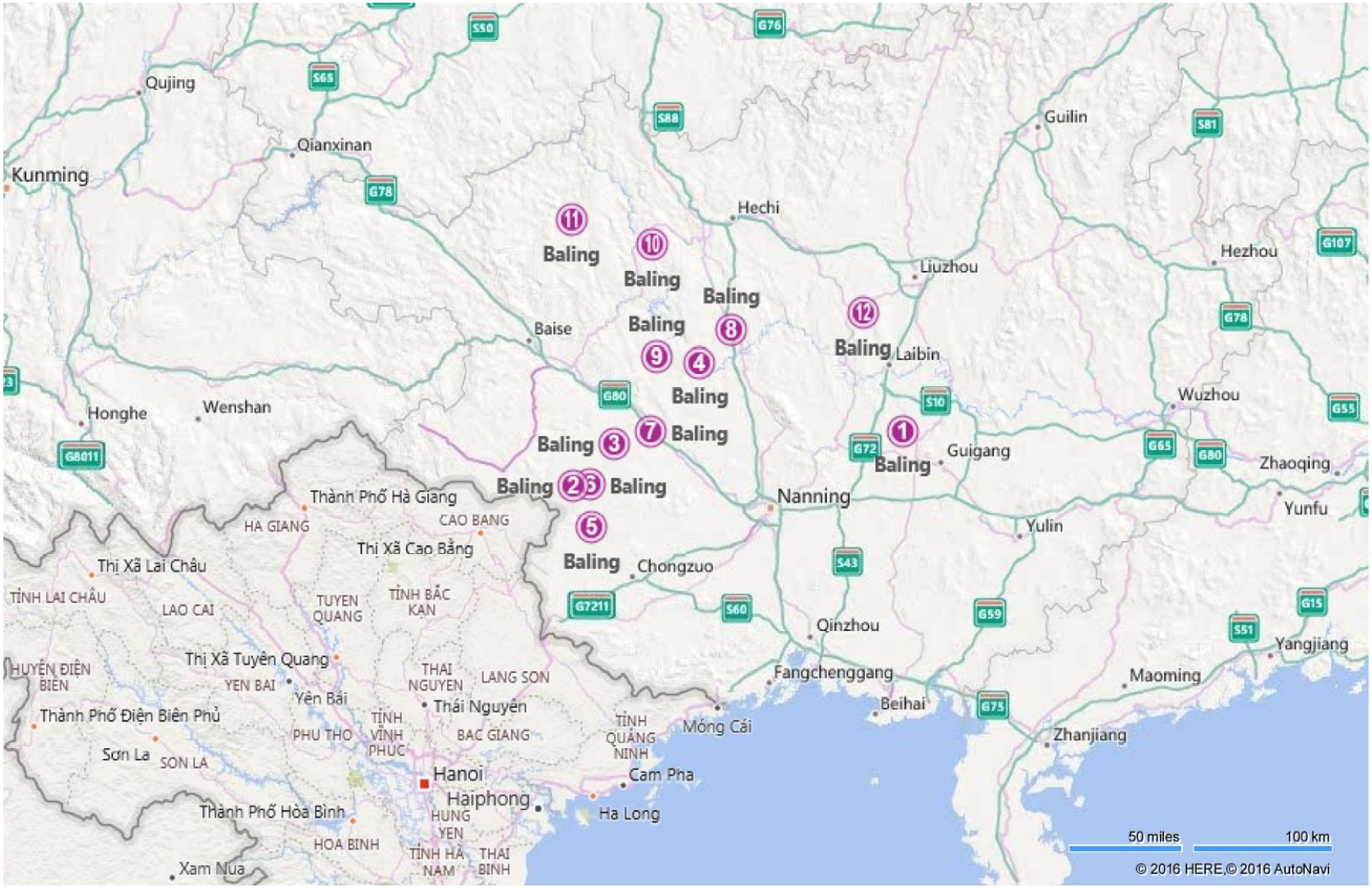


3. Adaptation to the New Situation in Vietnam

The Main Focus for Vietnam Currently:

1) Reactor physics (Neutron Kinetics – N/K), nuclear physics (relevant to the new Research Reactor – RR project) – the Center for Nuclear Energy Science and Technology – CNEST; **Relevant research around the new RR**
2) Thermal Hydraulics (T/H), safety analysis/ assessment
3) Radiation dispersion calculation and simulation (the Radiation Monitoring and Emergency Warning System – **RMEWS** project)
4) Non-Destructive Evaluation techniques; Seismic designs
5) Risk and Safety Study Center (RSSC/CNEST) etc.

Radiation Monitoring and Emergency Response

1) Pre-Feasibility has been carried out by VINATOM
2) Total cost of the project is about 30-35 millions USD
3) Vietnam Government supports the idea to get ODA funding from Hungary
4) First phase (2018-2020): Start to build National Station in VINATOM/ Hanoi and few stations; Next phase: To build other regional stations and local stations by ODA and Vietnam budget
5) ***Today this project becomes more urgent due to operation of Chinese NPPs close to Vietnam***

3. Adaptation to the New Situation in Vietnam

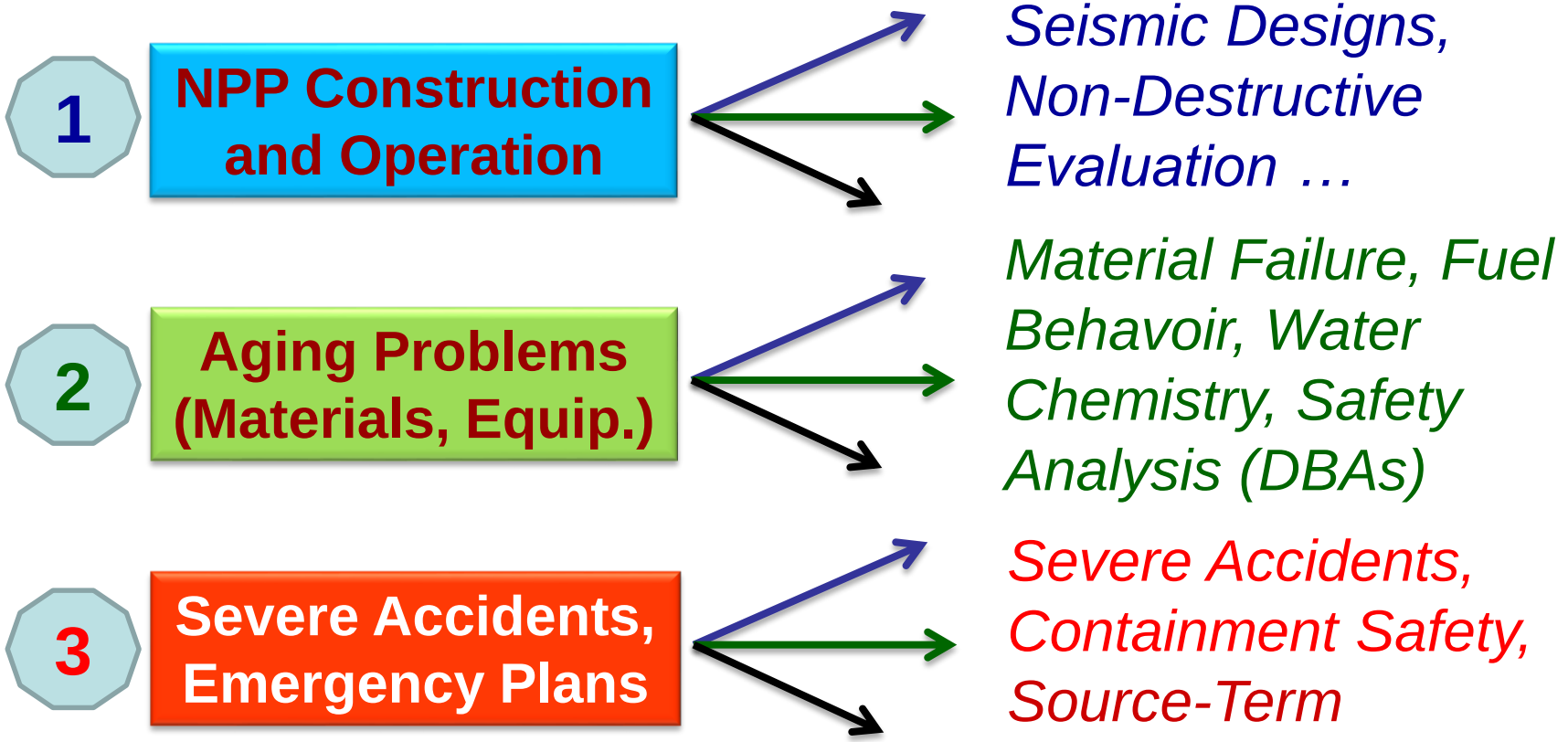
VINATOM is building a new unit at Danang.

A Marine Environmental Studies Laboratory will be established next year.

Regional and International cooperation is very important.

4. Nuclear Power Safety Research

Nuclear Power: 3 Research Orientations (2015-2020)



Capacity Building for Nuclear Safety Research

1) Nuclear designs assessment: with focus on VVER1200 (AES2006) and AP1000 – Detailed analysis of designs and evaluation of safety analysis report (SAR) – 2014-2015; A group of > 30 researchers is ready to perform Review of Ninh Thuan 1 SAR of VARANS with **VUJE**
2) Few research projects on burnup calculation (Nuclear Energy Center/Institute of Nuclear Science and Technology – INST/VINATOM – 2015-2016
3) Designs of the new research reactor (a national project from 2015)
4) Seismic design calculation (AP1000 etc.) – 2016
5) Radiation dispersion simulation (Chinese NPPs) - 2017

Capacity Building for Nuclear Safety Research

6) Severe accident analysis (VVER1000): Possibility of the In-Vessel Retention (IVR) for VVER-1000

7) Nuclear physics: Study on nuclear level scheme, level density and radiative gamma strength function (Duy Tan University + Dalat Nuclear Research Institute – DNRI) using gamma-gamma coincidence spectrometer

8) Study on subcooled boiling (thermal hydraulics) – experimental facility and simulation (OpenFOAM, RELAP, COBRA-TF, MELCOR, CFD) + Artificial Intelligence -- AI)

9) Radiation dispersion through the ocean flows (2018)

10) NDE nuclear technique – the new technique to be implemented in Vietnam

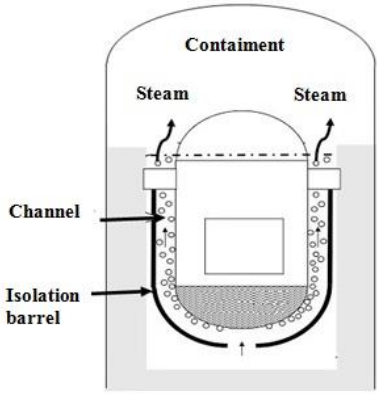
Computer code

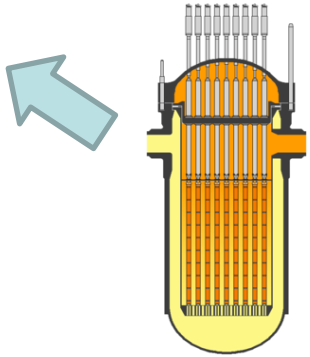
- **Fuel:** FRAPTRAN, FRAPCON
- **Reactor physics:** MCNP5, PARCS,
- **Thermal-hydraulic :** CATHARE , RELAP5, COBRA-TF, MARS, OpenFOAM, MELCOR, CFD, AI
- **Severe accident:** MELCOR, MAAP4, RELAP5

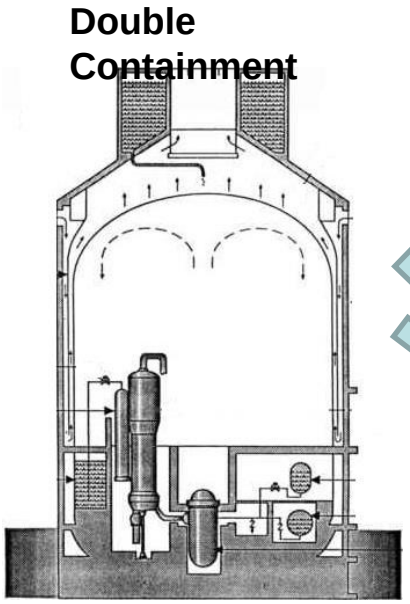
4. Nuclear Power Safety Research

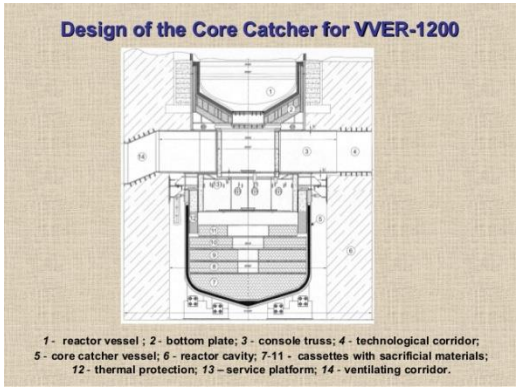
Possibility of the In-Vessel Retention (IVR) for VVER

In-**V**essel **M**elt **R**etention through **E**xternal **R**eactor **V**essel **C**ooling (**IVMR/ERVC** or **IVR**)

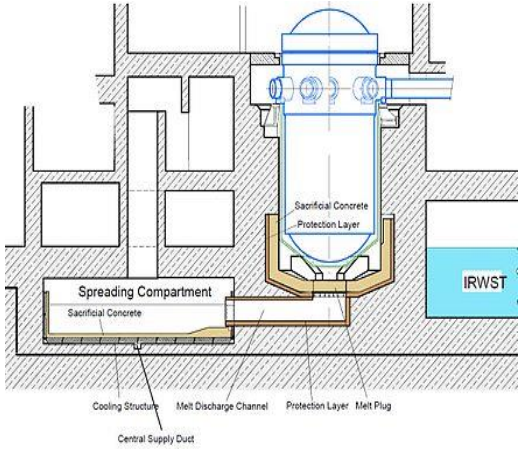








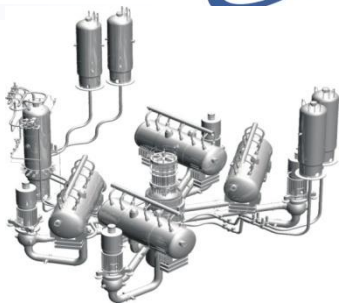
Core catcher

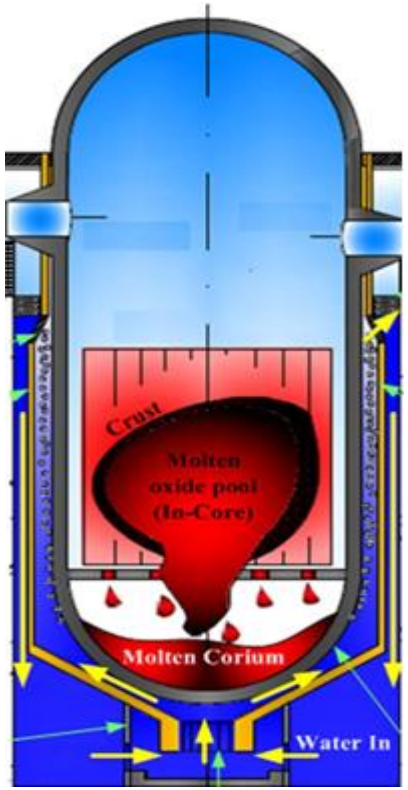


4. Nuclear Power Safety Research

Possibility of the In-Vessel Retention (IVR) for VVER

Our project → **study** / **Apply IVR** → **VVER100/V320**





Phase 1

MELCOR, RELAP5/SCDAP → **Outcomes**

- The time of establishment of molten pool in LP
- The decay heat in molten pool
- The mass of materials in molten pool
- The temperature of external cooling environment

Establish a molten pool in lower plenum

Phase 2

CFD, PECM

Input

Estimate the thermal load and evaluate

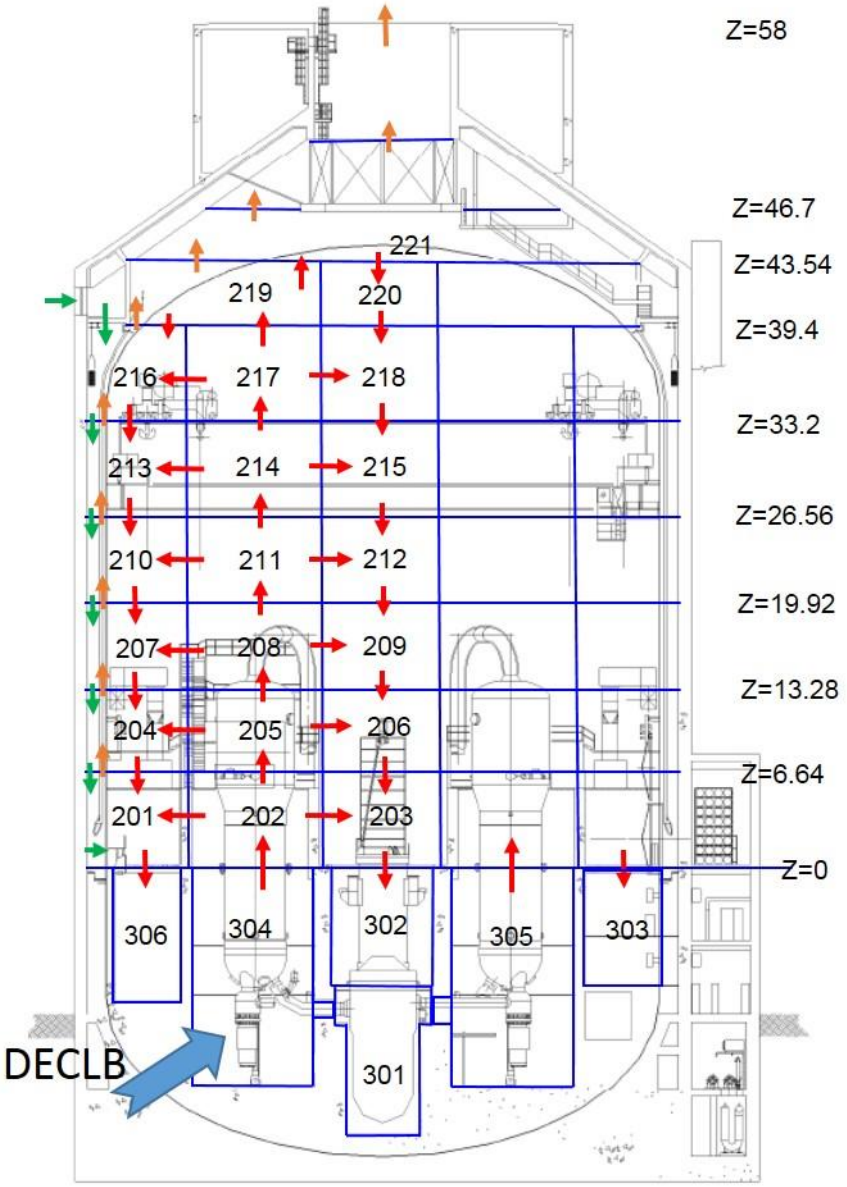
The integrity of RPV

4. Nuclear Power Safety Research

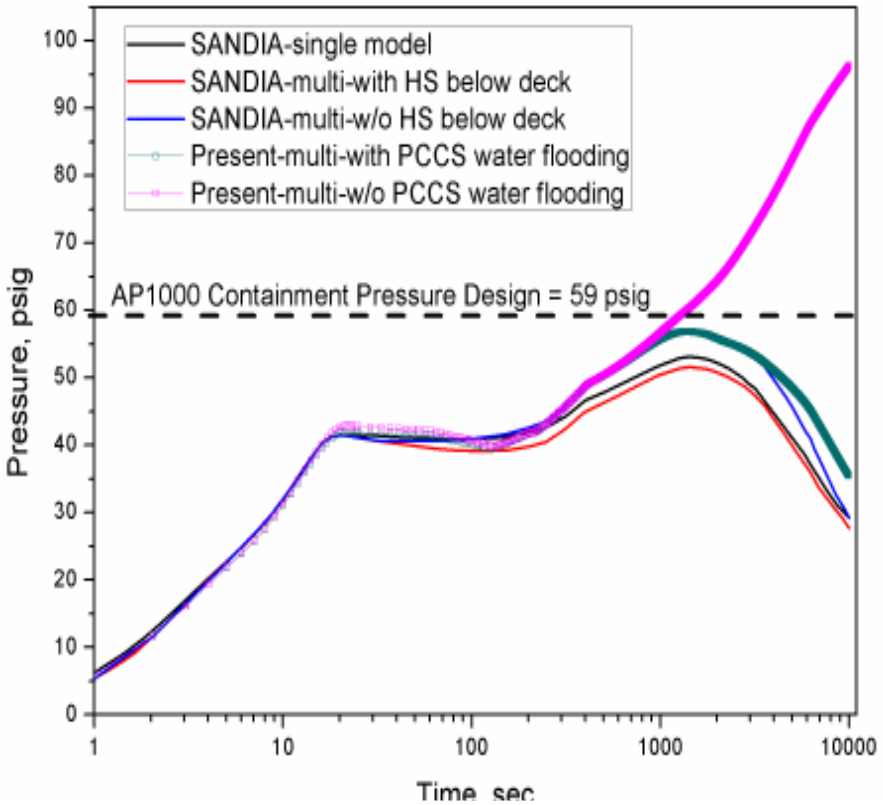
Severe accident analysis

Analysis of containment pressure and temperature changes following LOCA

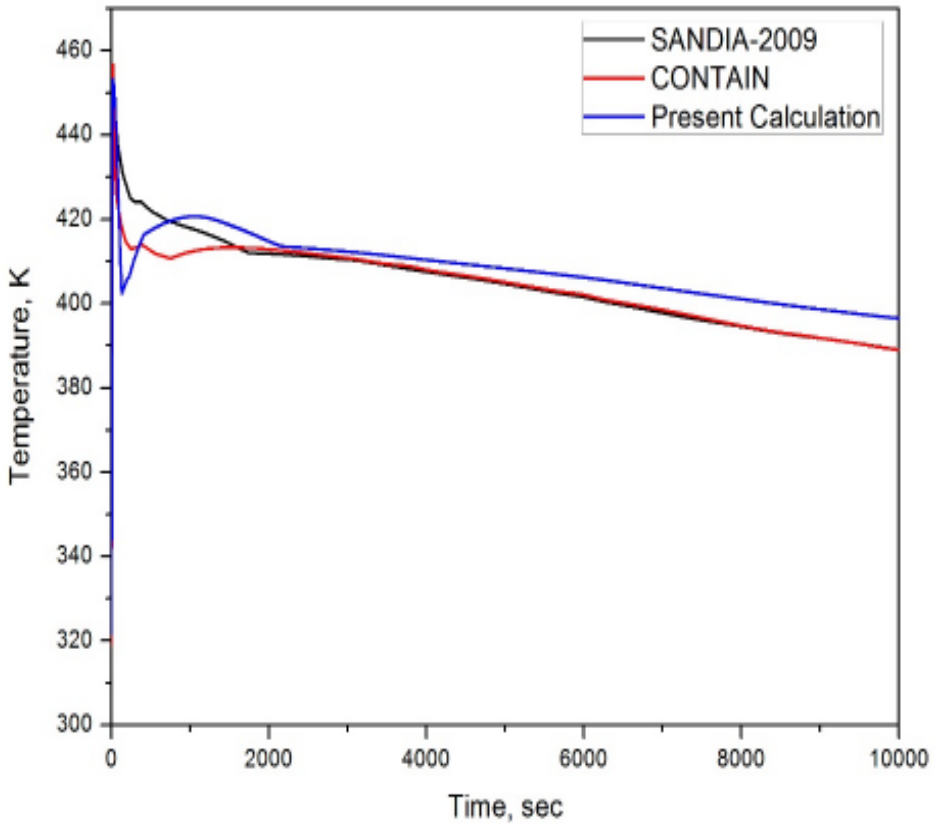
Nodalization scheme of AP1000



4. Nuclear Power Safety Research



Comparison of MELCOR-calculated long-term pressure profiles during AP1000 LOCA event



Comparison of MELCOR-calculated long-term gas temperature in the region above the deck

4. Nuclear Power Safety Research

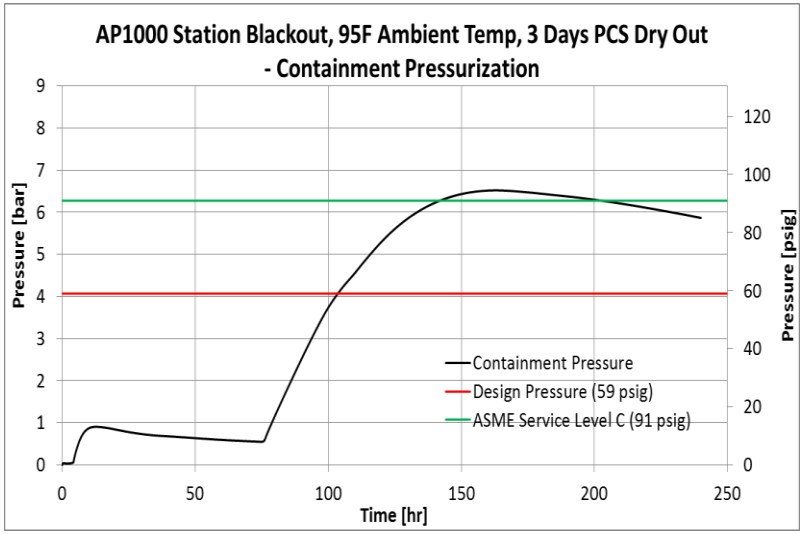
Study of AP1000 Containment Pressurization Transients following PCS Cooling Water Depletion using MAAP4 Code (in cooperation with Westinghouse)

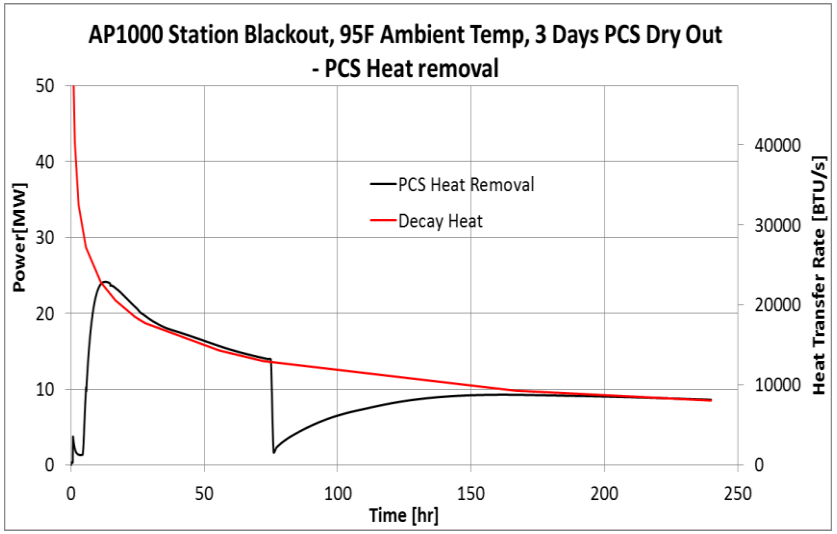
The purpose of this analysis is to assess the peak equilibrium containment pressure after the PCS shell dries out.

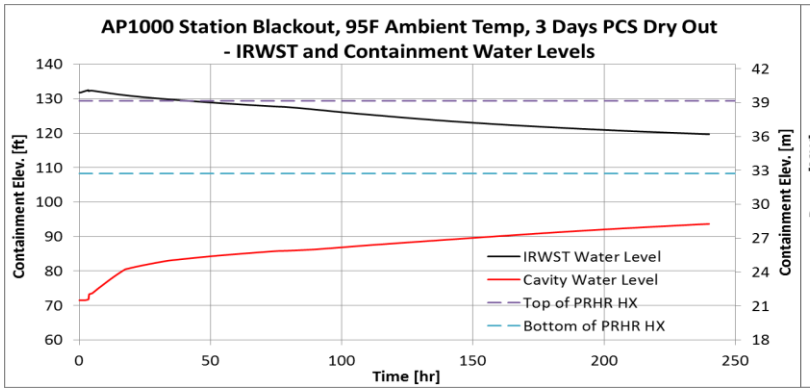
The analysis is comprised of the following SBO scenarios:

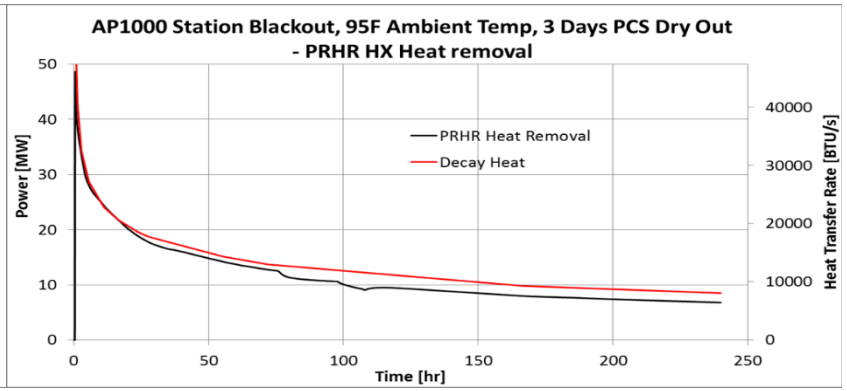
1. PCS Water Storage Tank depleted with no makeup from the Anciliary Water Tank (dry out after 3 days)
2. PCS Water Storage Tank and Anciliary Water Tank depleted with no makeup (dry out after 7 days)
3. PCS cooling water failure to actuate
4. PCS air inlet turning vane flow area blocked with flood water, with PCS water cooling with no makeup from the Anciliary Water Tank

AP1000 Containment Pressurization Transients following PCS Cooling Water Depletion



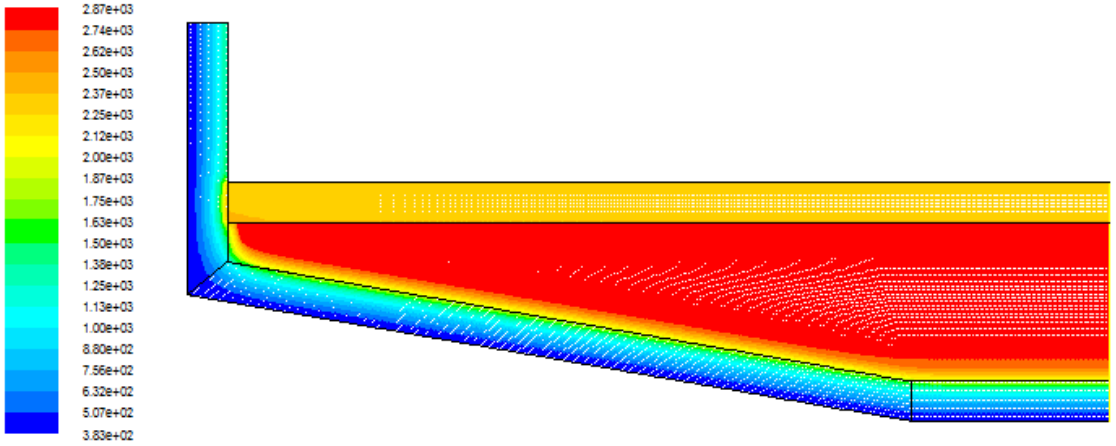






4. Nuclear Power Safety Research

A Study on Transient Heat Transfer of The EU-ABWR External Core Catcher using The Phase-Change Effective Convectivity Model
(*Chi-Thanh Tran, Viet-Hung Nguyen, M. Tahara, Y. Kojima, R. Hamazaki and P. Kudinov, NURETH16, August 30 September , 2015, Chicago, USA*)

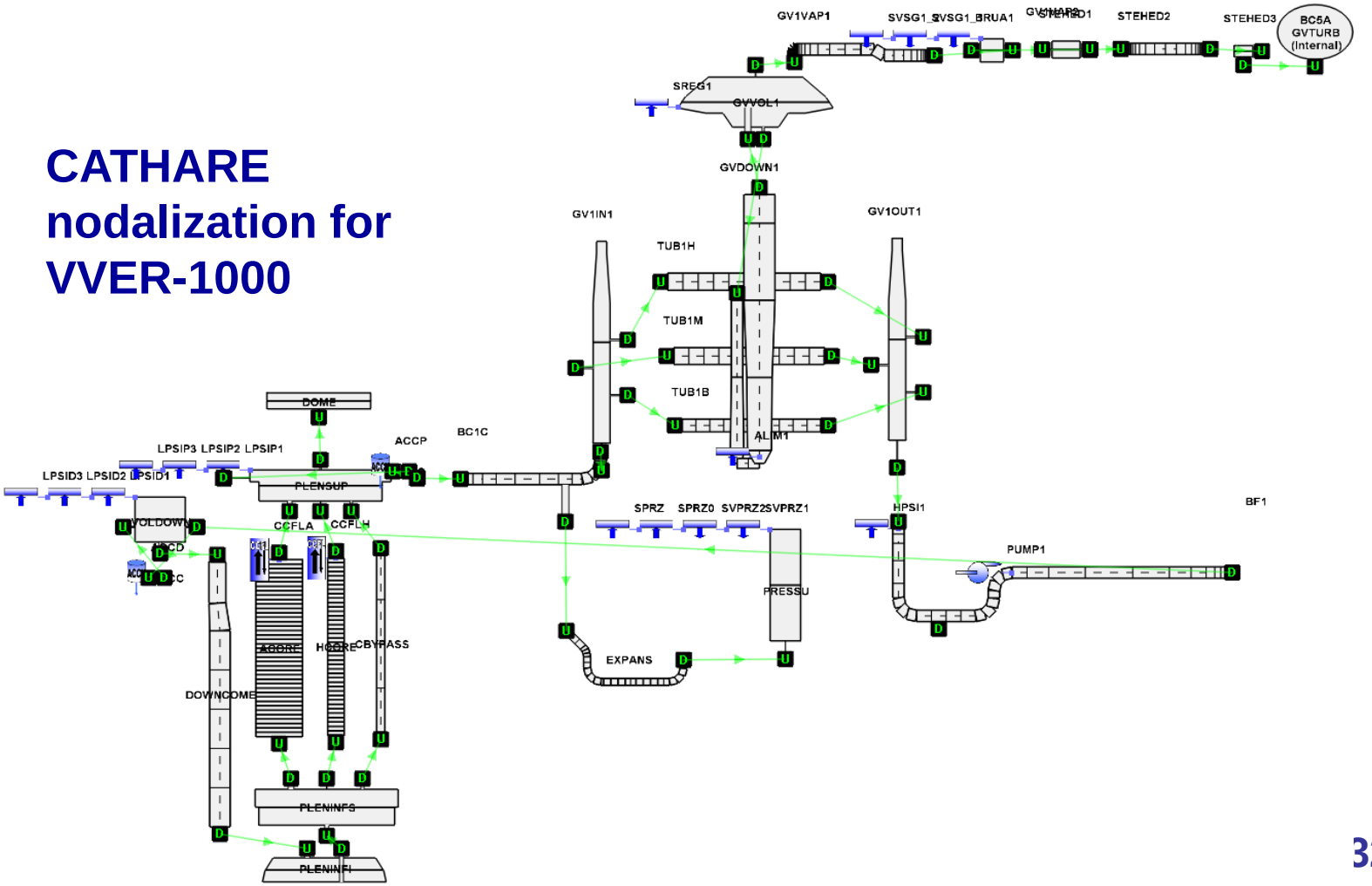


Temperature contour of the melt pool and core catcher in 9000 sec in case of accident scenario without water cooing from the top surface of melt pool (only water cooling from the outside walls of the core catcher, case 1B)

4. Nuclear Power Safety Research

- Analytical study of Surge Line Break LOCA in VVER-1000 with CATHARE and RELAP

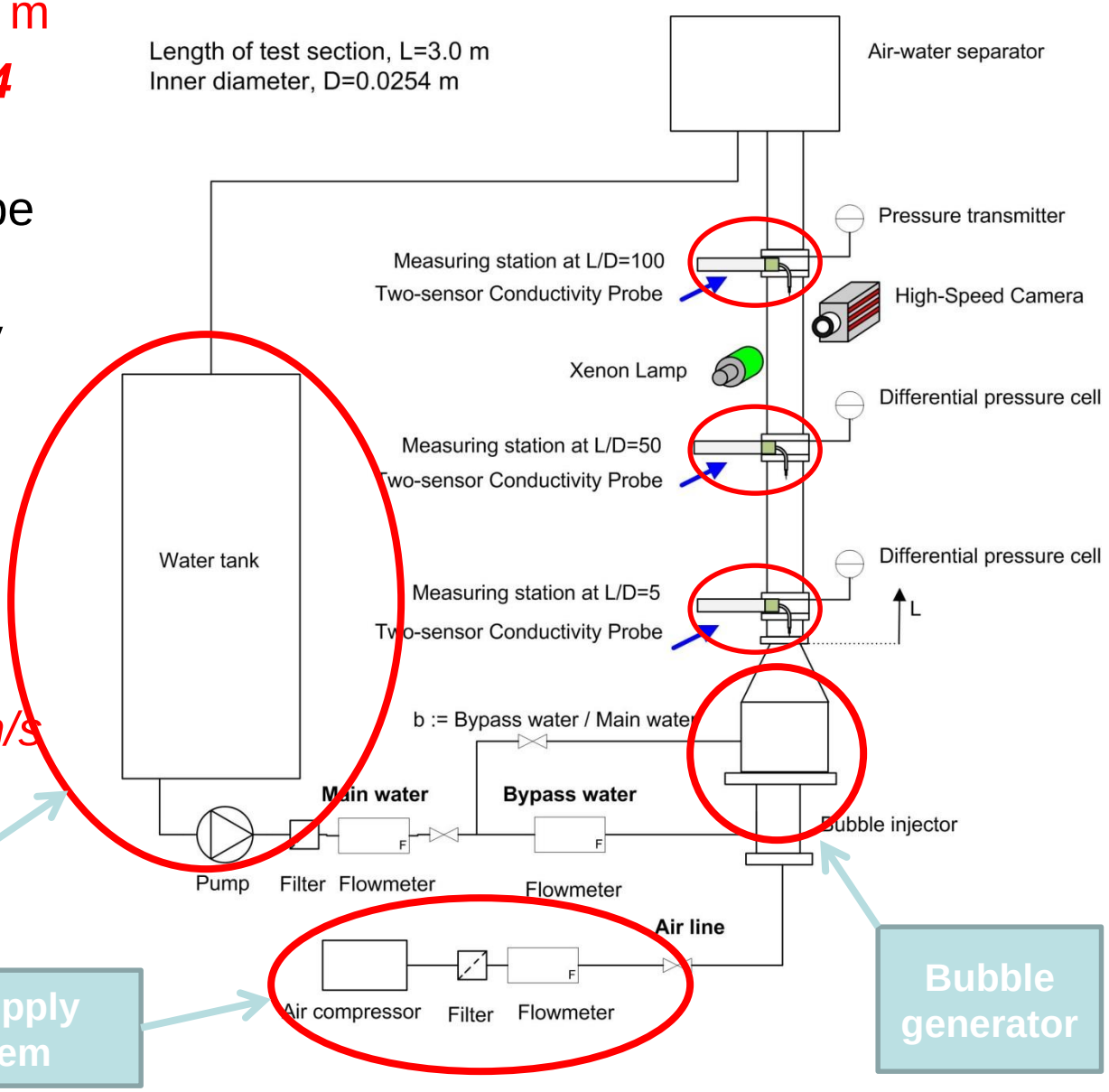
CATHARE nodalization for VVER-1000



4. Nuclear Power Safety Research

Principle scheme of two phase flow experiment

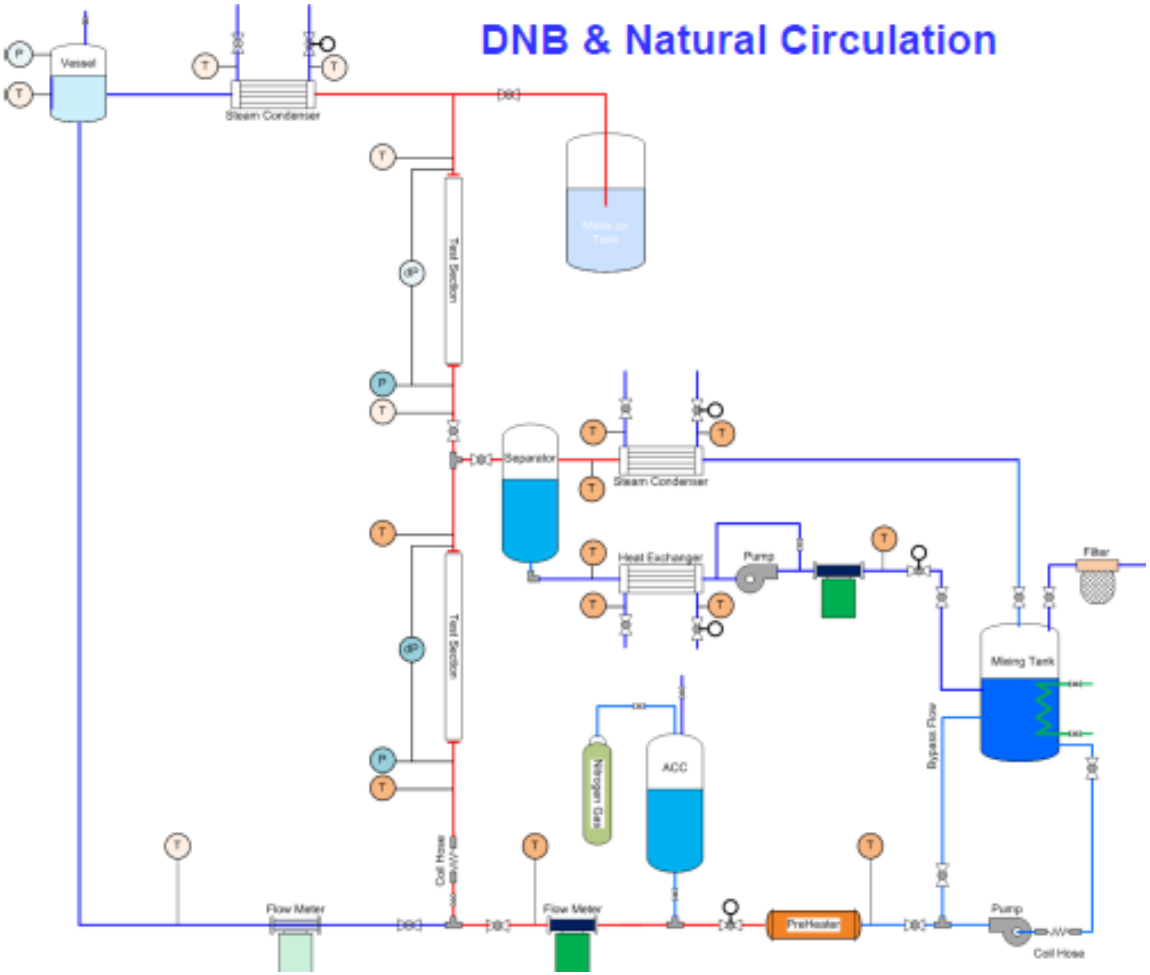
- Length of test section: 2 m
- *Tube diameter:* ***Φ = 25.4 mm***
- Material: transparent tube made of Acrylic
- Temperature: laboratory temperature (10-40^{o}C)
- Measurement method: Conductivity probe
- *Pressure: 1 atm*
- *Bubble size: 2mm-4mm*
- *Bubble Velocity: 0 ÷ 2 m/s*
- *Void fraction: 0 ÷ 100%*



4. Nuclear Power Safety Research

➢ Hybrid Test

National Project on Two phase flow experiment



Future Vision of Nuclear Safety Research

1) Next 5-10 years: New research reactor project ➔ To support the new RR project; To identify relevant researches around the **new RR** (configuration of the new RR plays an important role); The RSSC
2) Nuclear technologies: Advanced designs, FNPPs; safety analysis and assessments; To build the capacity in experiments (**thermal hydraulics**)
3) **Radiation dispersion calculation and simulation**; Measurement techniques and detectors; To build the RMEWS
4) Nuclear techniques applied into industry (safety related)

5. Concluding Remarks

- ✓ Vietnam has had an ambitious nuclear power program in the last 8 years. However, it has been postponed due to economical reason, etc.
- ✓ The postponement of the NPP program in Vietnam raised several difficulties for the atomic energy sector: How to maintain capability and keep good people in the field; How to use NPP students in Russia; How to continue research in the field of nuclear power etc.
- ✓ Due to Chinese operating NPPs close to Vietnamese border, the main research directions in VINATOM are kept, VINATOM is trying to keep people and to attract new engineers from Russia

5. Concluding Remarks

- ✓ Vietnam should be prepared to the emergency situation
- ✓ Vietnam is building a national project of Radiation Monitoring and Emergency Warning System (RMEWS)
- ✓ Nuclear technologies and designs, safety assessment are still important for research in Vietnam: Chinese NPPs, Floating NPPs, Gen IV and advanced designs; Calculation of source terms etc.

5. Concluding Remarks

- We can have a proposal on Assessment of Consequences of NPP Accidents: focus on Chinese design – HPR1000 (Hualong-1)
- Because of the real design data of HPR1000 we need the support from IAEA.

Thank you!


Thank you!