
KSU
KSU – Nuclear Training and Safety Centre
An international training service provider committed to developing nuclear competence for next generation.

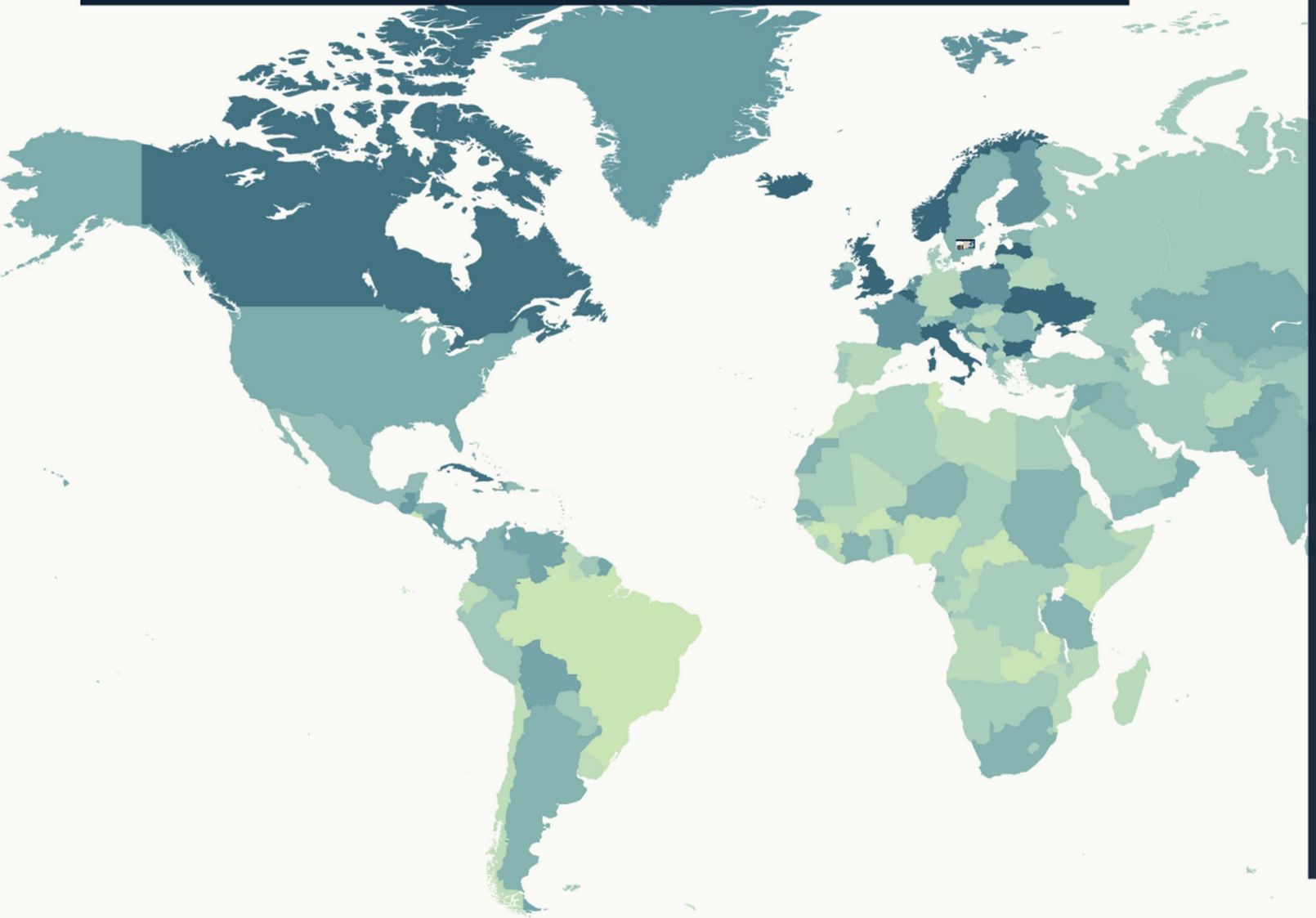
“Innovative approaches to train skills and competencies for next generation”.

Who is talking

Martin Mansfeld, Senior Project Manager

Antanas Romas, Senior Simulation and Nuclear Engineer

Role of KSU



- KSU as a Training Service Provider (TSP) offer our services globally.
- KSU is a decentralised training provider to all NPP units in Sweden and is jointly owned by the Swedish nuclear power plants and is a part of Vattenfall group.
- Focus on ensuring operational safety and regulatory compliance through training.
- KSU’s contributing to maintaining high standards of safety and operational excellence.

KSU Dashboard

Turnover **25 M€**	FTE **185**	Customer satisfaction **100%**
	Simulator investment **3 M€**	Profit margin **5%**
	Certification **ISO 9001, 14 001, OHSAS 18001, SS 624070**	

Training facilities

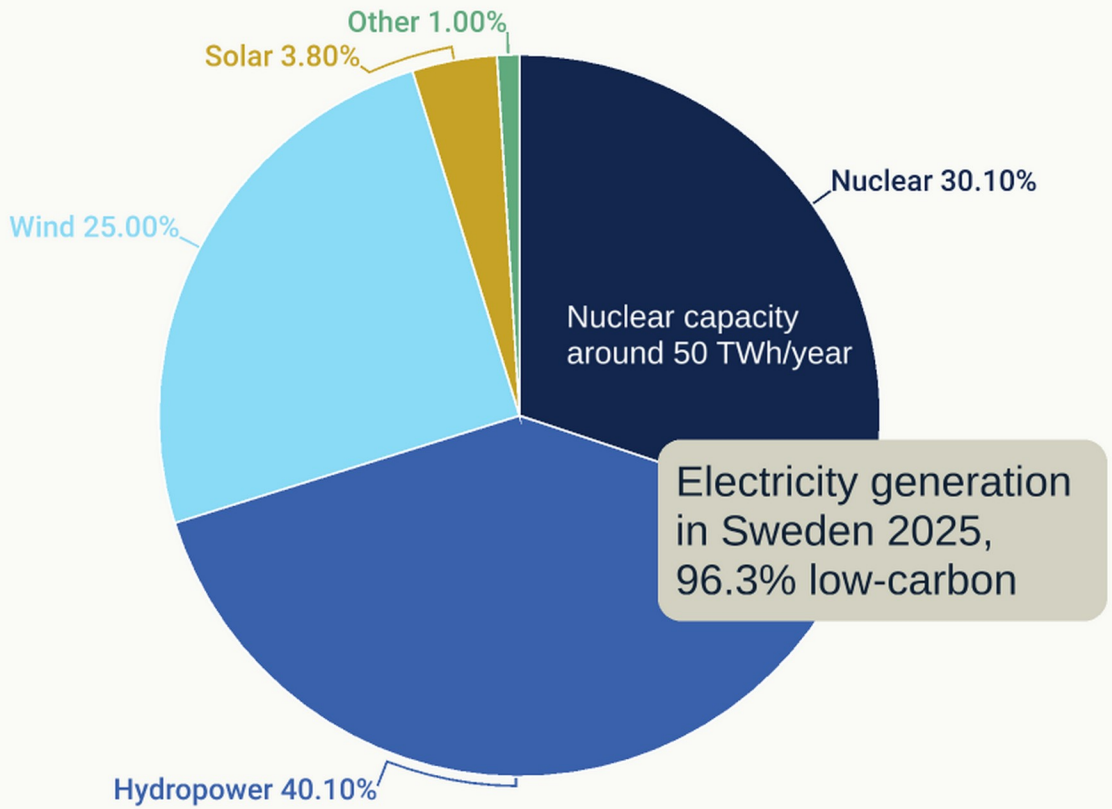
- **3 Training centres, 1 unit for Simulator development**
- **TTC – Technology & Training Centre (Hands-on Training)**
- **4 full scale simulators**
- **Graphic simulators, Part scale simulators, VR simulation**
- **Classroom training/Digital learning platform, KSU Online**

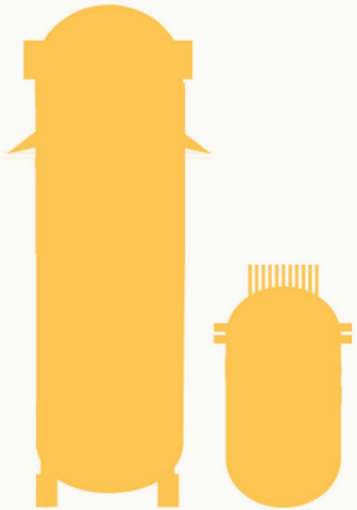
Our learner-centered approach is reinforced by skillfully integrating diverse tools and environment grounded in the SAT methodology.

Main domain for KSU is:

- Operator training, initial training and re-training.
- Maintenance training.
- Simulators and Simulations.
- Learning platform and IT Operations
- Courseware, e-Learning, Wikis etc.
- Immersive (XR) environments for training and other purposes.
- Management of training programs and training material.

KSUs focus is on competence building and all things that support efficient and governable training.





Operator	Reactortype	MW	Commissioning year
Ringhals 3	PWR	1.064	1981
Ringhals 4	PWR	1.130	1983
Forsmark 1	BWR	1.018	1980
Forsmark 2	BWR	1.028	1981
Forsmark 3	BWR	1.230	1985
Oskarshamn 3	BWR	1.450	1985
Oskarshamn 1, 2 Ringhals 1, 2 Barsebäck 1, 2	**Decommissioning phase**		

In 2045, Sweden´s electricity needs are estimated to be >320 TWh yearly.

Future perspectives for nuclear landscape:

- One or more new build projects.
- Life time extension of existing plants.
- Expanded nuclear waste repository capacity.

Electricity mix in and overview of nuclear power in Sweden

What are the needs for the future?

- The nuclear industry is facing a critical juncture where training needs to be modernised and adapted.
- The need for cost-effective approaches in training is paramount, especially with a projected increase in the number of nuclear plants and employees.
- This expansion necessitates scalable and efficient training methods that can accommodate a growing workforce while maintaining high standards of safety and competence.

Foundation pillars: **Safe, reliable, flexible, individual.**

Training philosophy

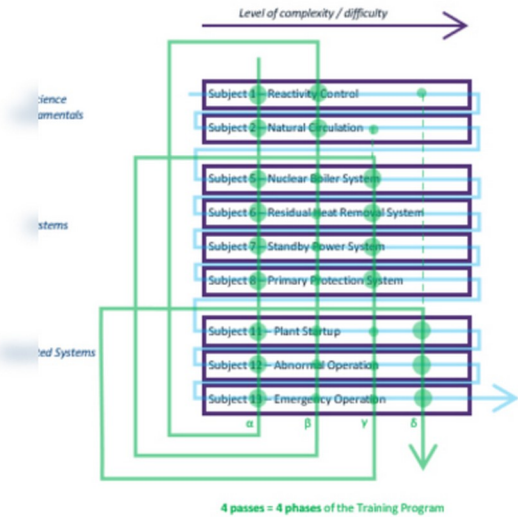
The training programme is based on a basic andragogical approach and permeate throughout all our training activities. To achieve its goal, the learning culture should focus on the individual learner, fostering support, development, and motivation. Applying the andragogical framework starts with establishing an understanding of the needs and reality of the customer and trainees.

Training philosophy

- Course participants should be motivated to take personal responsibility for their learning, to search for information and to reflect on connections to everyday working life and their learning.
- Course participants should develop the ability to analyze and evaluate information and apply it in a professional practice, with safety and quality in focus.
- Course participants should develop their ability to communicate and collaborate and contribute to a supportive group climate.
- The teaching situation should be based on the course participants' individual experiences and conditions for learning.
- Course participants should recognize a common thread throughout the training, with each part of the program contributing to the whole.
- The teaching methods used should support creativity, curiosity and commitment among the course participants.

Blended learning and learner-centered approach

Design thinking



4 passes = 4 phases of the Training Program

Virtual Classroom
(preferred/optional delivery)

What has been done:

- *Brainstorming individual ideas, experiences, lessons*
  - *Summarizing of what we want / don't want*
  - *Uncertainties*
- *Conceptualization of Training Program*
- *G22 distribution*

Next Steps:

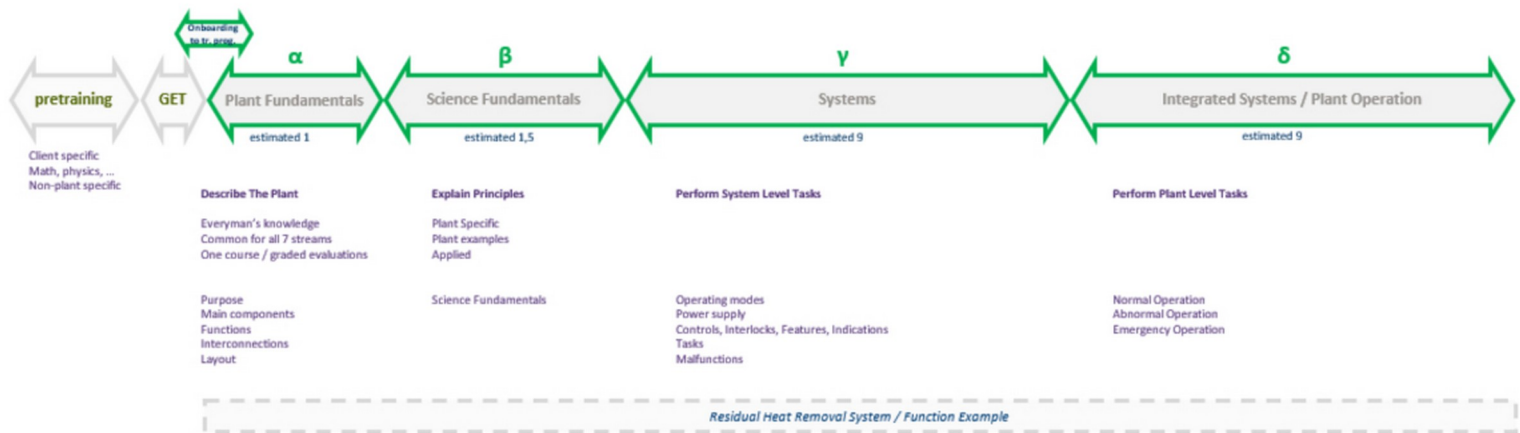
Review of resources - WANO, INPO, ...
Summary of Principles (Guide) and justifications
Descriptions, presentation materials
Presentation and discussion with stakeholders

Uncertainties

- availability of plant documentation, maximize use in training
- job descriptions & qualification paths, substitutability
- JITT, also in relation to fleet services
- Science Fundamentals in/out of licensed training program?
- Entry level requirements
- Trainee availability – no of training hours per day, number of training days per month

Definitions

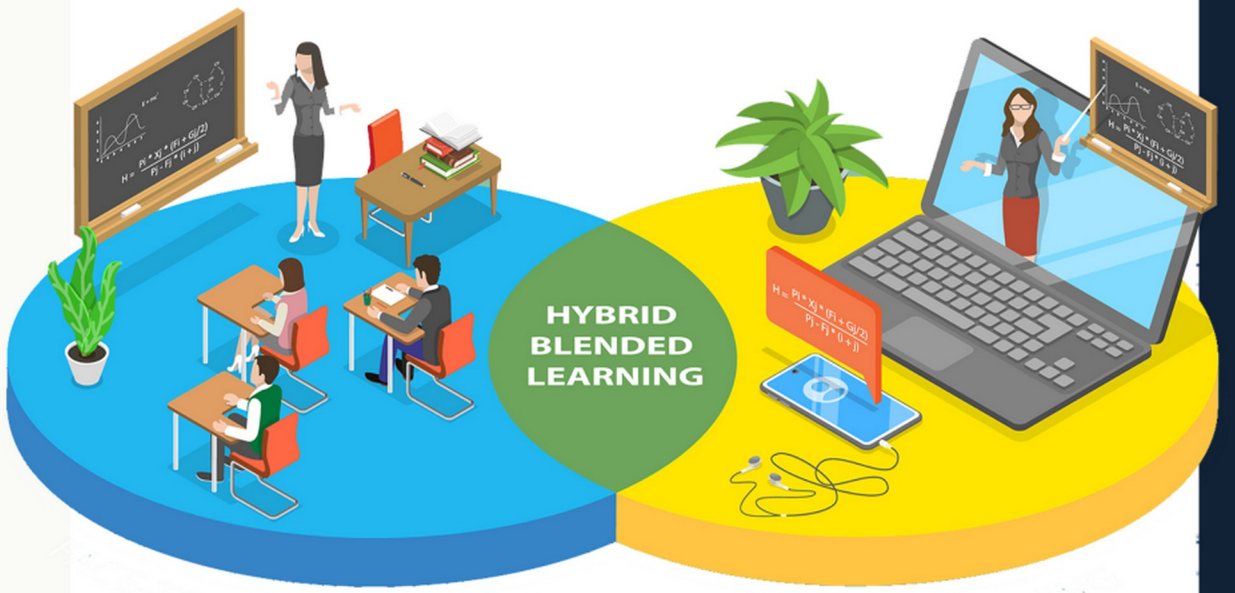
-

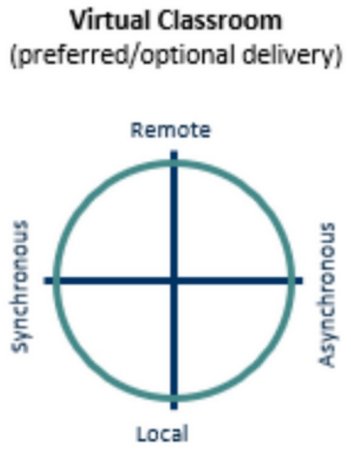


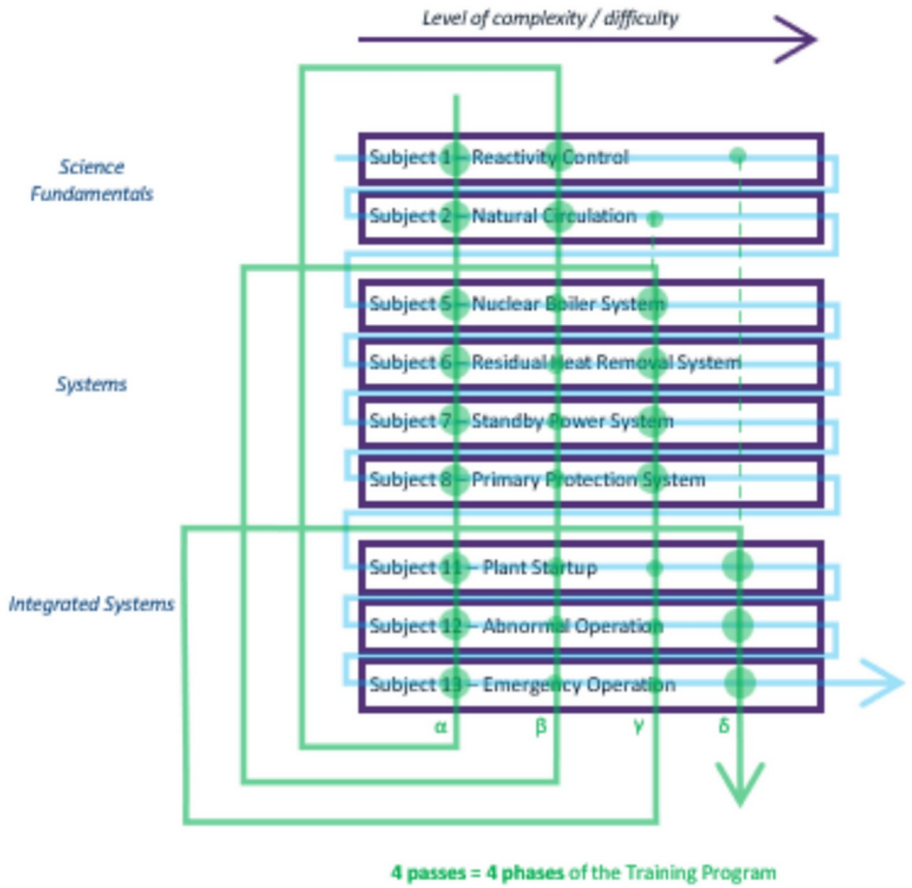
Blended learning:

Transitioning from on-site to asynchronous and back

Modern training approaches leverage a combination of synchronous and asynchronous methods to maximize engagement, flexibility, and learning outcomes. A phased transition model starts with structured on-site training, moves towards individualized, mobile, and asynchronous learning, and ultimately returns to team-based synchronous training for application and reinforcement.







Layered learning: A progressive approach to training design

Effective training should not only introduce new concepts but also reinforce and deepen understanding over time. A layered training design follows a structured approach where learners first grasp the fundamentals, then build upon that knowledge in cycles, revisiting key topics multiple times with increasing depth and complexity. This ensures better retention, application, and mastery of the subject matter.

Integrated Training Program – From Fundamentals to Performance

Theory in close connection with practice – building competence and teamwork step by step

PROGRAM PHASE	1. PLANT FUNDAMENTALS	2. SCIENCE FUNDAMENTALS	3. SYSTEM TRAINING – NORMAL OPERATION (EVENT CLASS 1–2)				4. SYSTEM TRAINING – DISTURBED OPERATION AND ACCIDENT CONDITIONS (EVENT CLASS 3–5)				5. INTEGRATION & PERFORMANCE
			3A System 1	3B System 2	3C System 3	3D System n	4A System 1	4B System 2	4C System 3	4D System n	
			Theory + Simulator Exercises	Theory + Simulator Exercises	Theory + Simulator Exercises	Theory + Simulator Exercises	Theory + Advanced Simulator Exercises	Theory + Advanced Simulator Exercises	Theory + Advanced Simulator Exercises	Theory + Advanced Simulator Exercises	
FOCUS	Plant overview, functions, main systems, operating principles	Scientific and technical principles governing plant behavior	System knowledge, normal operation, monitoring, control and optimization, handling of minor deviations				System behaviour under disturbances and accidents, diagnosis, decision-making, procedure application				Team performance, complex scenarios, continuous improvement
TRAINING METHODS	• Classroom lectures • Visualizations	• Classroom lectures • Partial simulator exercises	• Classroom + Simulator exercises • Step-by-step system training • Practice in control room interface				• Classroom + Advanced simulator exercises • Disturbances and accident scenarios • Use of procedures and tools under pressure				• Full plant simulator scenarios • Team performance and coordination
HUMAN PERFORMANCE & TEAM TRAINING	Introduction to Human Performance Tools (HPT) Communication, roles, verification, feedback		HPT and team training integrated in exercises in calm and controlled conditions				HPT and team training in more dynamic and time-pressured situations				Advanced teamwork, leadership and situation awareness
CONDITIONS	Stable and predictable conditions		Progressive increase in complexity and stress								High stress, time pressure, uncertainty
INTEGRATED SYSTEM TRAINING (FULL SCOPE SIMULATOR)			**INTEGRATED SYSTEM TRAINING – NORMAL OPERATION (EVENT CLASS 1–2)** **Using full scope simulator for training and evaluation** • Full plant scenarios in normal and mildly abhormal conditions • Builds interface familiarity and control room confidence • Enables team training and application of HPT • Evaluation of performance and achievement of objectives				**INTEGRATED SYSTEM TRAINING – DISTURBED OPERATION (EVENT CLASS 3–5)** **Using full scope simulator for training and evaluation** • Full plant scenarios with disturbances and accidents • Application of HPT under stress and time pressure • Evaluation of conduct of operation and decision-making • Feedback and lessons learned				Continued integration and performance evaluation in complex scenarios
EVALUATION (MAJOR GATE)	Formative evaluation of knowledge and skills		**EVALUATION 1** **After Normal Operation (Class 1–2)** • Achievement of learning objectives • Practical skills and HPT in calm conditions • Feedback for improvement				**EVALUATION 2** **After Disturbed Operation (Class 3–5)** • Scenario performance and decision-making • Use of procedures and HPT under pressure • Feedback for improvement				**FINAL EVALUATION** • Integrated scenario performance • Team performance • Readiness for plant operation

Theory in close connection with practice

Frequent simulator training builds familiarity with control room interface and systems

Teamwork and HPT trained continuously – from calm to high stress

Continuous evaluation of both participants and program drives improvement

KSU Technical Department

is developing, operating and maintaining multipurpose simulators.

KSU Technical Department

– Dedicated competence and professionals

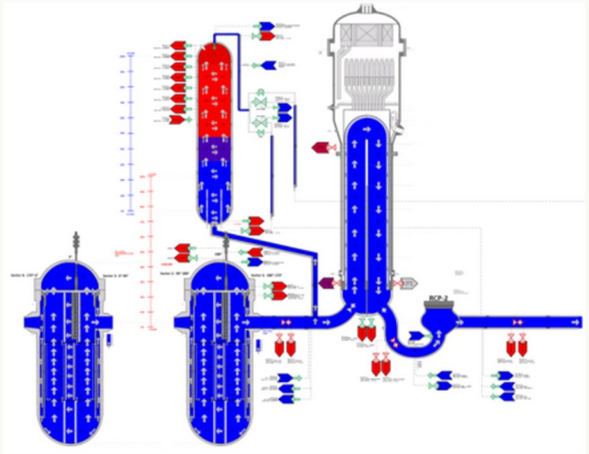
- Simulator development and maintenance.
- Simulation models, tools and infrastructure.
- Competence securing maintenance and development of simulators.
- Implementation new plant projects in simulators.
- Simulator availability.
- In house IT – department.

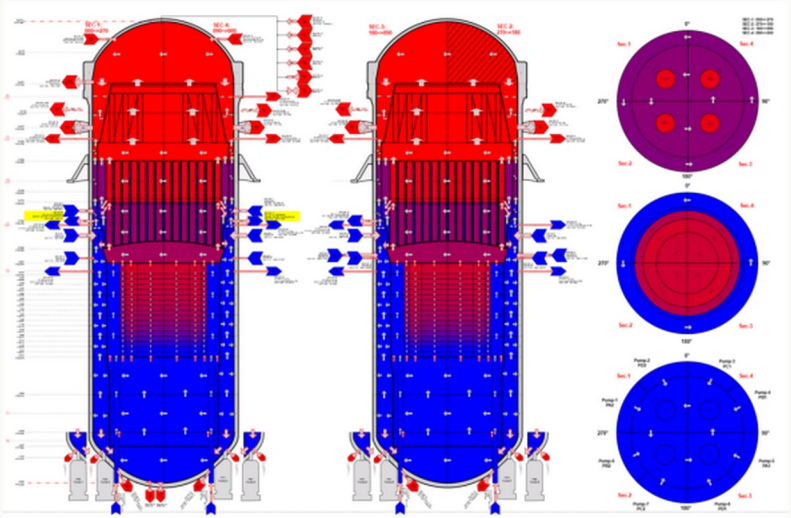
Full scope simulators operated by KSU

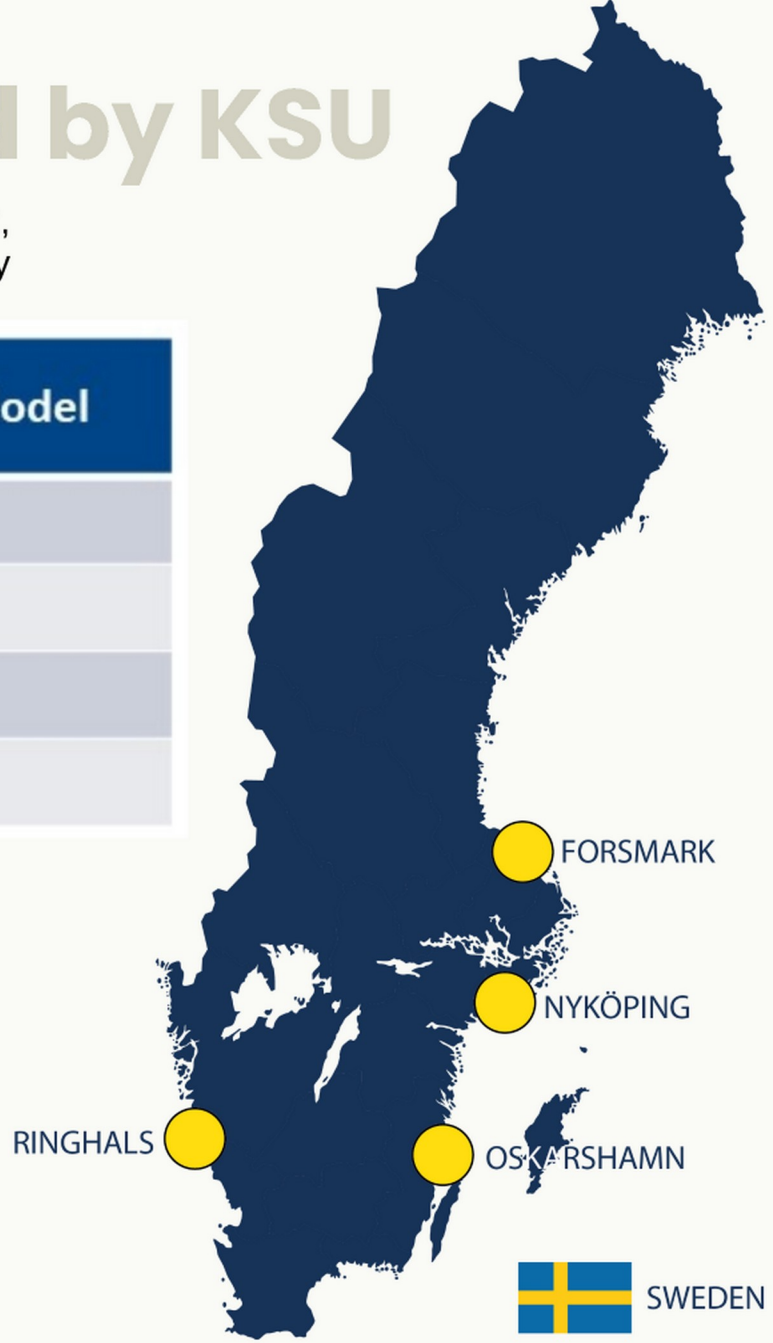
KSU has historically operated nine full-scope simulators — prior to shutdown of Barsebäck 1&2, Oskarshamn 1&2 and Ringhals 1&2. Four full-scope simulators remain in active operation today (3 BWR + 1 PWR).

Simulators	Reactor type	Used by	Type of Reactor Model
Forsmark-1	BWR	Forsmark 1 & 2	RELAP5-HD/S3R
Forsmark-3	BWR	Forsmark 3	RELAP5-RT/S3R
Ringhals-3	PWR	Ringhals 3 & 4	RELAP5-HD/S3R
Oskarshamn-3	BWR	Oskarshamn 3	RELAP5-HD/S3R

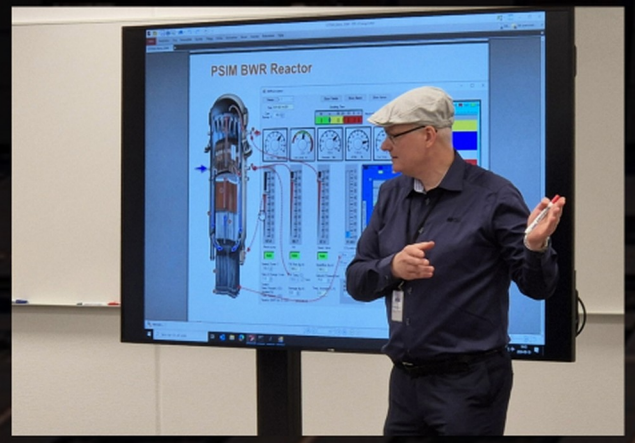
- RPV Thermohydraulics RELAP5-HD (INL/GSE)
- Core Neutron Dynamics S3R (SSP)







Simulators for specialised applications



Full Scope Simulators (FSIM)

Used for operational training of shift teams, V&V testing and verification of changes in NPPs. FSIM is a one-to-one replica of Plant's Control Room which is driven by the high fidelity mathematical simulation models of the actual systems operated at NPPs.

Graphical Full Scope Simulator (GSIM)

Used as a complement to the Full Scope Simulator by employing flexibly configurable graphical interface, visualisation of process and FSIM's simulation models facilitating the profound learning of plant behaviour.

Part Scope Simulator (DSIM)

Used for the deeper understanding of individual systems and physical phenomenon studied in the form of laboratory exercises. DSIMs are flexibly derived from FSIMs and specific training tasks can be performed as individual training exercises.

Principal Process Simulators (PSIM)

Uses for a general understanding of different types of NPPs. PSIMs are simulating a principal behaviour of NPPs in a simplified fashion but contributing to the early understanding of NPPs extremely efficiently.

Severe Accident Simulators (HSIM)

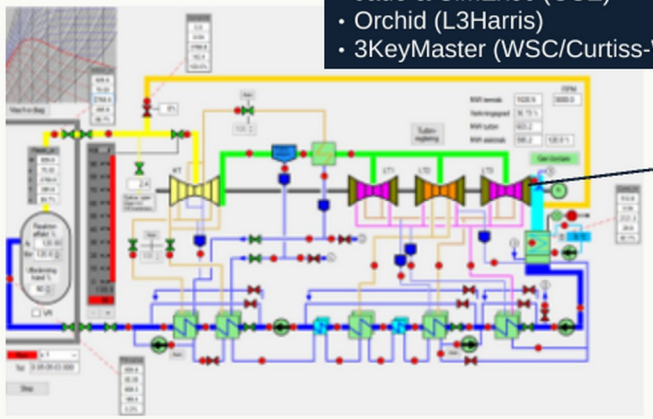
Used for the training of a severe accident's handling. The same simulators are shared with the Emergency Preparedness Teams at NPPs for the exercising and accident assessment in the case of a real severe accident.

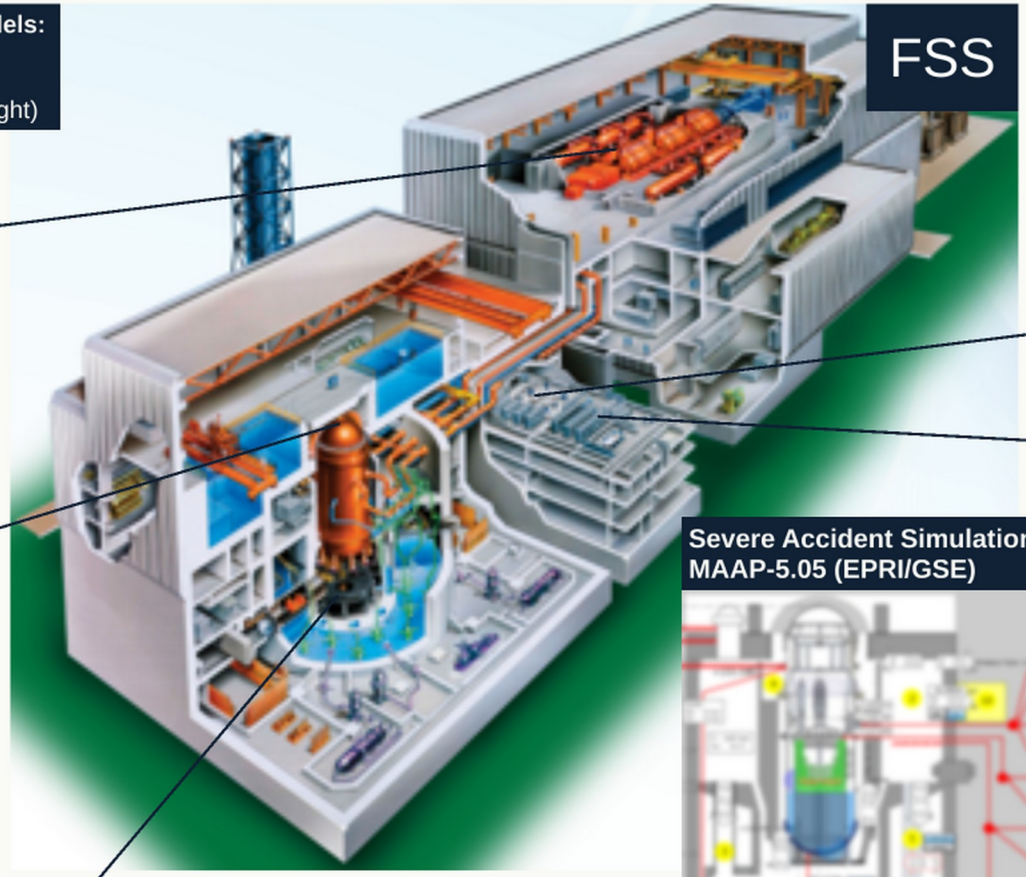
VR Simulation Environment

VR-based graphical environment coupled with the Full Scope Simulator. Using the VR environment training is possible in a copy of FSIM without using an expensive hardwired replica of an actual control rum.

Full Scope simulator design at KSU

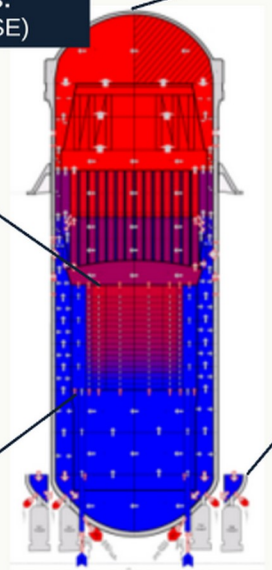
Full Scope Simulator BOP Models:
- Jade & SimExec (GSE)
- Orchid (L3Harris)
- 3KeyMaster (WSC/Curtiss-Wright)



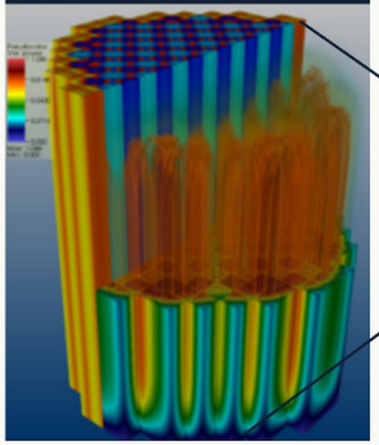


Control Panels HMI

RPV Thermohydraulics:
RELAP5-3D/HD (INL/GSE)



Core Neutron Dynamics S3R (SSP)



Severe Accident Simulation
MAAP-5.05 (EPRI/GSE)

Distributed Control System (DCS)
Controlling NPP/FSS, 800xA (ABB)

Full Scope Simulator design at KSU

- High simulation fidelity
- Realistic training in complex scenarios
- Increased safety and preparedness to handle emergency situations
- Ability to test and evaluate different operational procedures and responses
- Provides a controlled environment to ensure compliance with safety protocols and regulations
- Provides a controlled environment to test a new equipment before it is implemented in the actual NPPs

Simulator use beyond operator training

Simulation capability supports engineering, validation, and readiness

Procedure validation
Confirm practical usability before operation

HMI evaluation
Assess interaction and alarm response

Plant modification support
Test changes in controlled environments

Human factors assessment
Understand workload and teamwork

Scenario development
Build credible exercises

Emergency preparedness
Practice rare or severe events

The same technical asset can support training delivery, engineering decisions and organizational preparedness.

SMR / BWRX-300 readiness challenge

Training before the plant is complete

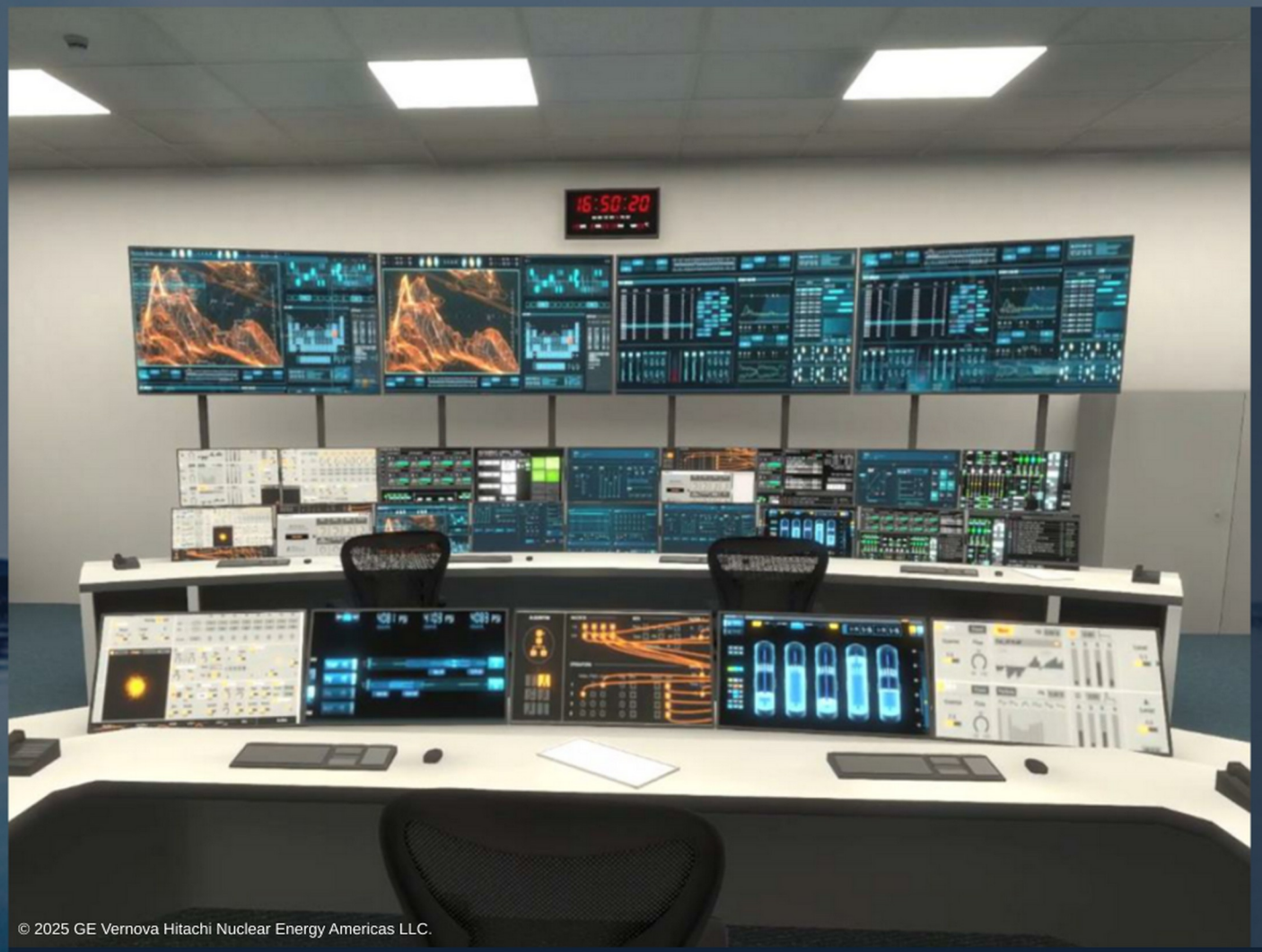
- Evolving design information
- Limited operational experience
- New control room concepts
- New automation and HMI solutions
- Need for early competence development

The challenge is readiness under design uncertainty.

Preparedness for the future challengers

- Need to support the new build – SMR
- Support of the Global Training Program for BWRX-300
- Planning for BWRX-300 Desktop Simulator in Nyköping, Sweden
- Development of the training on integrated systems and operational procedures

Program setup → Curriculum mapping → Desktop / prototype simulation → Integrated simulator & HMI → Scenario validation → Crew training ramp-up



BWRX-300 simulator platform: 3KeyMaster

- 3KeyMaster is presented by its vendor as an integrated simulation environment for development, execution, testing, integration, and deployment in real-time or non-real-time modes.
- For a training program, the value is architectural: the platform can host plant models, interface layers, instructor functions, and distributed clients within one controlled simulation environment.
- This supports progressive use: engineering integration, test activities, desktop training access, and later full training deployment.

DCS and HMI context: Mark VIe and CIMPLICITY

- GE Vernova describes Mark VIe as a flexible distributed control system with networked I/O and plant-wide control capability.
- The same source notes factory testing can include plant simulation, which aligns well with simulator-supported integration and control-room validation.
- CIMPLICITY is GE Vernova's HMI/SCADA software and provides the operator interface layer relevant for realistic control-room interaction.

Why this matters for training

A modern training program needs more than process values. It needs the operator to interact through realistic displays, alarms, controls, and procedures.

Practical implication

When process models, DCS behavior, and HMI are coherently integrated, simulator training can move from "watching variables" to "operating the plant."

KSU's Lessons Learned

Training Consequence

If the integrated simulator arrives later than planned:

- Curriculum validation compressed
- Instructor preparation delayed
- Early operator familiarization lost
- Scenario development stalled
- Programme schedule at risk

Without mitigation: training quality suffers or commissioning readiness is compromised.

Response Principle

Do not halt training development.

Use a staged architecture:

- Earlier, lighter models for physics & TH
- Principal simulators for conceptual training
- Preserve learning momentum
- Instructor preparation continues
- Scenarios pre-validated

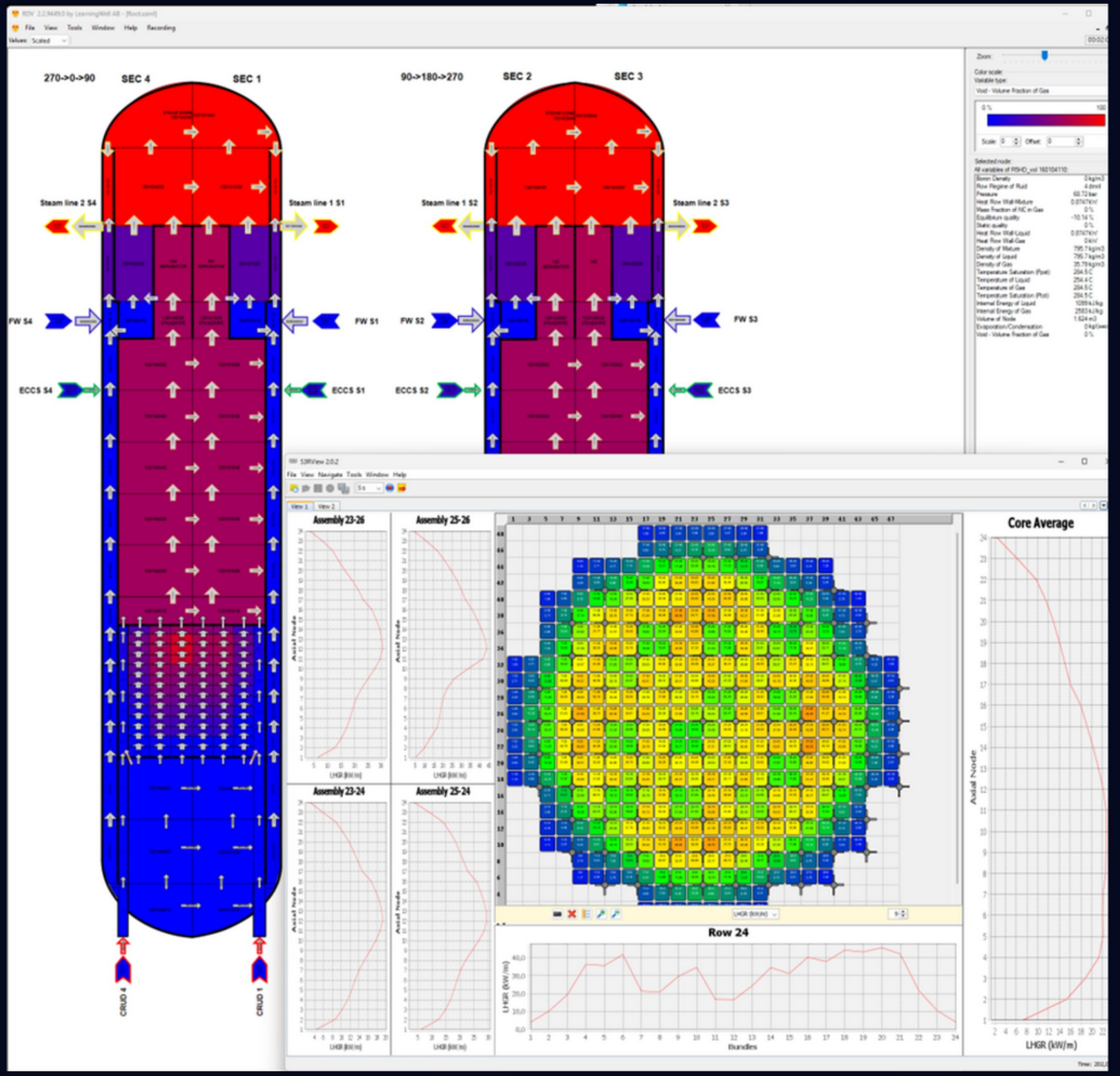
Final simulator arrives into a prepared team — not a blank slate.

Principal BWR-NC Reactor Model based on RELAP5-3D & S3R

- Principal reactor model of a natural-circulation BWR can be deployed on a lighter simulator environment using SimExec with RELAP5-3D and S3R.

- Preserves continuity by enabling reactor-physics and thermal-hydraulic familiarization, trend understanding, key normal and upset responses, and early instructor preparation.

- It is especially useful for explaining the operational meaning of natural circulation, passive safety behavior, startup / shutdown response, and cross-couplings that trainees must later recognize in the full simulator.



Proven Simulator Competence

KSU has historically developed, maintained and operated nine full-scope simulators.

SMR Programme Participation

KSU is a partner in the BWRX-300 global training programme.

FOAK Risk Management

KSU has proven experience in delivering technically challenging simulator projects.

Training Continuity

State of the Art =
Optimised Training Philosophy + Modern Simulation Technology

Dėkojame už dėmesį.

martin.mansfeld@ksu.se
antanas.romas@ksu.se

LinkedIn | @lifeatksu | @lifeatksu | info@ksu.se | www.ksu.se