Innovative Simulation Solutions

TRTR
National Organization of Test, Research and Training Reactors

IGORR
International Group on Research Reactors

KEYSOFTWARE® Unlock The Power of Simulation

UNLOCK THE POWER OF SIMULATION

Simulation Assisted Engineering SAE Applied to New Builds

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KEYSOFTWARE® Unlock The Power of Simulation

Topics

- Introduction to WSC
- What is SAE?
- SAE Phases with Sample Projects and Benefits
- Summary
- Questions

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Unlock The Power of Simulation
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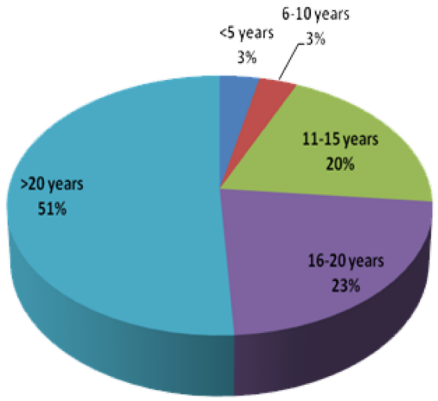
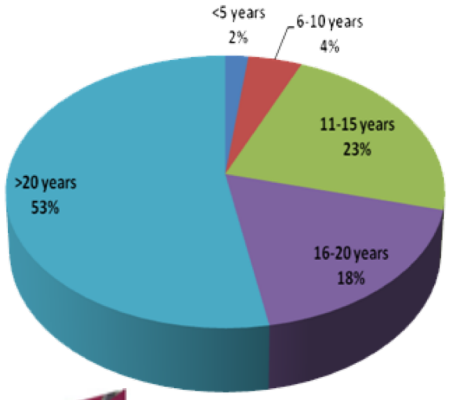
WSC Company Overview

- Founded in 1995 with over 250 simulators delivered successfully
- Employees: ≈ 85; Multidisciplinary team of nuclear, mechanical, electrical, chemical engineers, physicists and computer scientists, 30% with advances degrees.
- Research Oriented – over 20% of gross profit goes into R&D
- Headquarters in Frederick, Maryland, USA
- Main Business - Power Plant Simulation
  - Nuclear Power Plant Simulators 40%
  - Conventional Power Plant Simulators 30%
  - Simulation Assisted Engineering 20%
  - Navy and Marine Simulation 5%
  - Process and Pipelines 5%
- ISO 9001:2015 & ISO 27001:2013 Certified

More than 700 Man Years Simulation Experience



More than 730 Man Years Nuclear Experience



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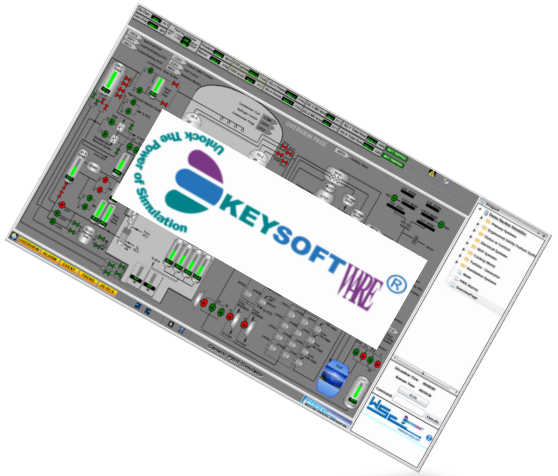
Diverse Applications for Power & Process Industries

Fossil

Simple / Combined Cycle

Nuclear

Process Oil and Gas, Desalination, Gasification and other



Renewable Energy & Grid

Pipeline

Hydro-Power

Marine

WSC Simulation Technology

High Fidelity Simulators for use in the:

- **Development of Replica Training Simulators**
  - Nuclear, Coal, Combined Cycle Gas Plants, …
  - Part-Task and Full-Scope Simulators
  - Classroom Simulators
  - Web based simulators
- **Simulation Assisted Engineering (SAE)**
  - System Analysis and Design
  - Human Factors
  - Logic and Control Testing & V&V
  - Plant Optimization
  - Plant Test and Operating procedures – e.g. commissioning procedures

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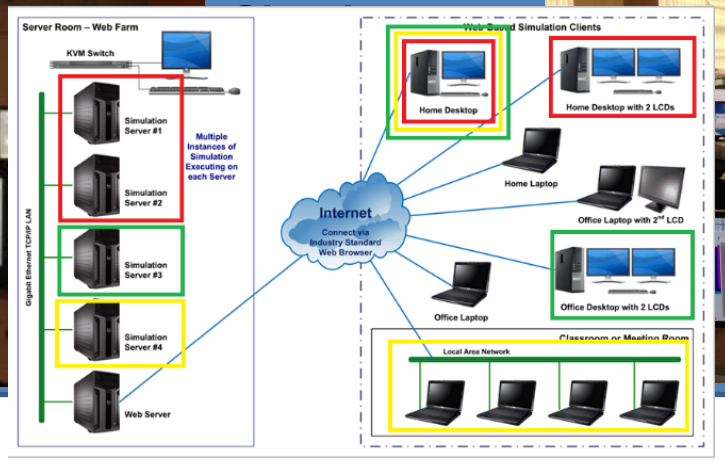
Classroom & Web based



KEYTOUCH™

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KEYSTUDENT™

Touch Screen Virtual Panels

Family of Simulation Products

3KEYMASTER™ Simulation Platform and Modeling Tools - Flagship for this Suite

- Graphical Engineering Station for Simulation Development and Control / Instructor Station
- 2-Phase Flow network Tool
- Electrical Network Tool
- Logic & Control and Relay Tools
- Component Tool and Library

3KEYRELAP5-RT™ – Adaptation of INEEL's RELAP-3D©, including NESTLE, to run in real-time with visualization, provides best-estimate engineering grade modeling for Thermal-hydraulics and Neutron Kinetics

3KEYSAA™ – Severe Accident Analysis Models MELCOR / MAAP

3KEYTOUCH™ – Alternative Training Delivery Platform / Control Room Glasstop Simulators

3KEYSTUDENT™ – Web and Classroom based Simulator Lesson delivery

3KEYITS™ – Intelligent Tutoring System

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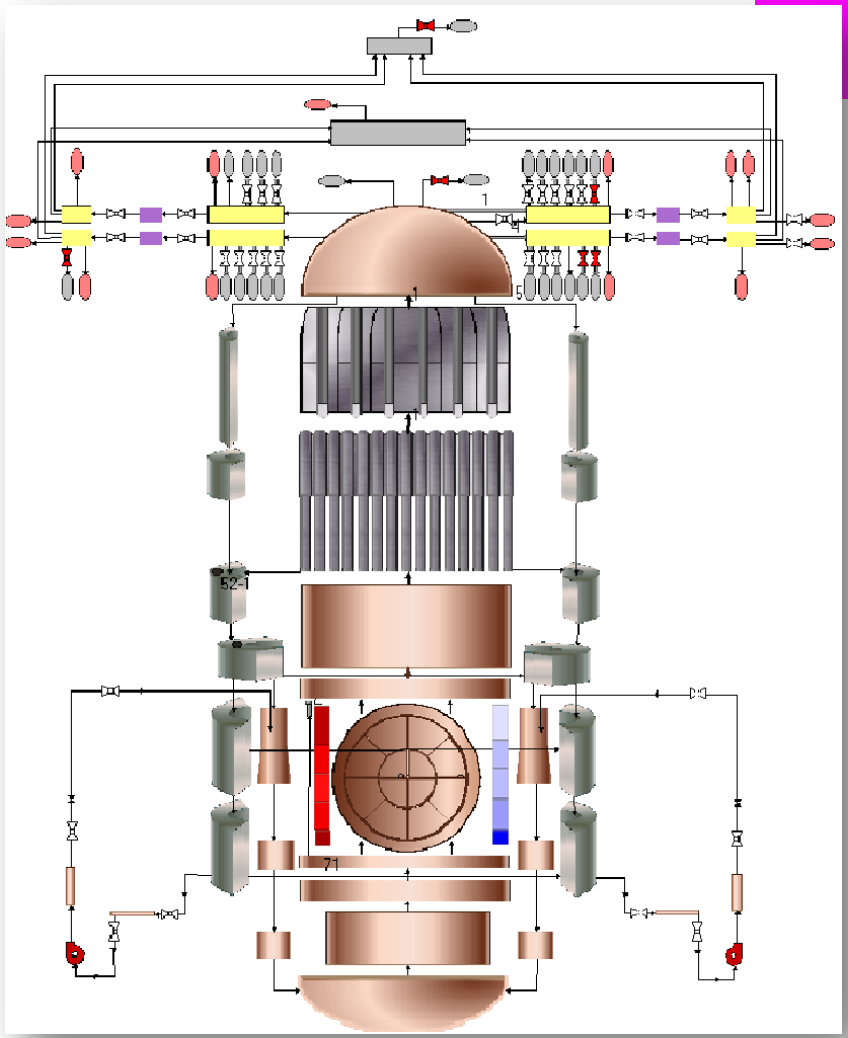
Embedding Complex Predictive Models

- WSC has the experience of embedding complex models into the simulator
- RELAP5 / TRACG / MARS Thermal-Hydraulic Codes
- NESTLE / S3R Neutronic Models
- MELCOR / MAAP Severe accident models.



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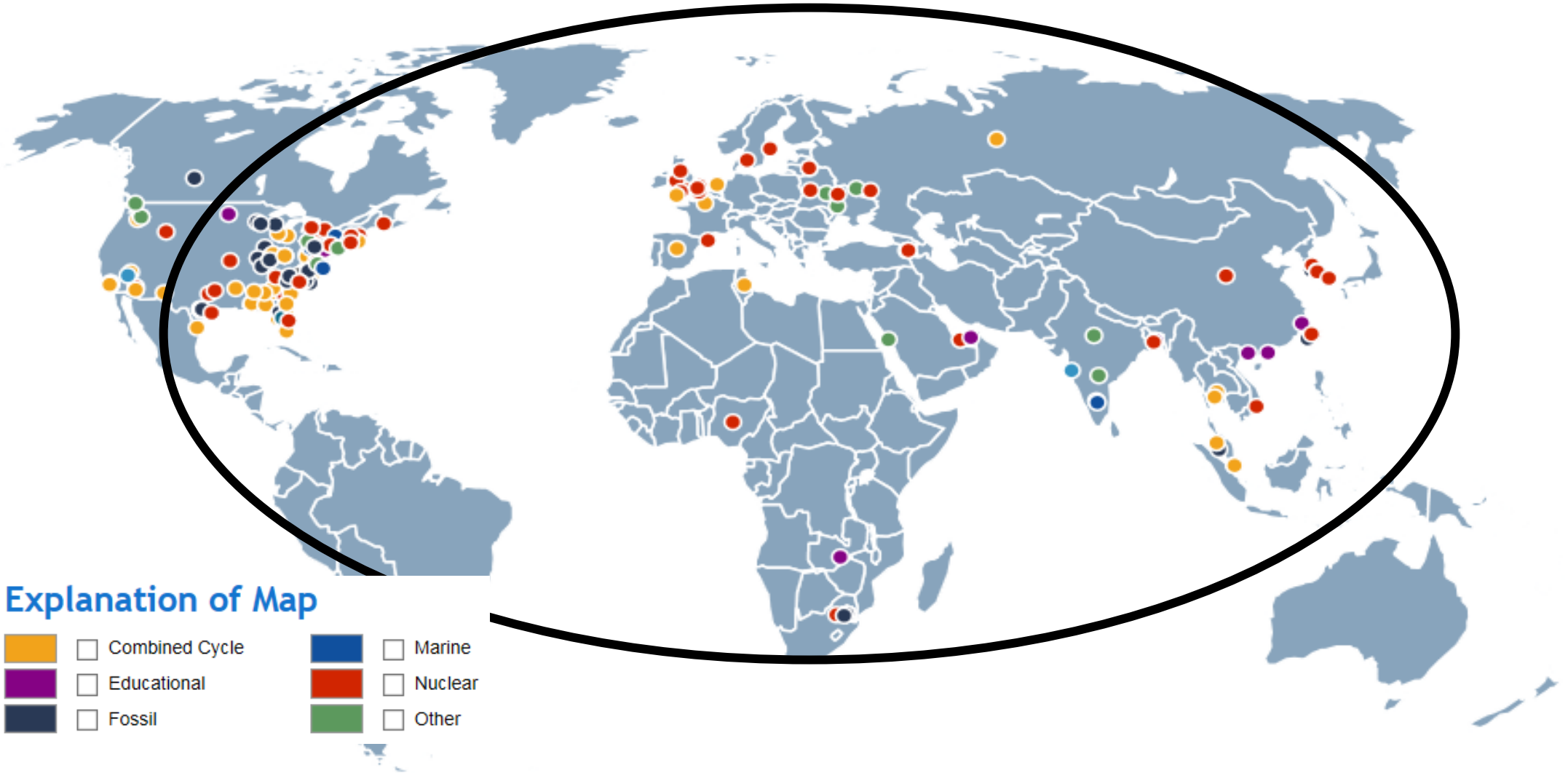
WSC Simulator Installations



Explanation of Map

- Combined Cycle
- Educational
- Fossil
- Marine
- Nuclear
- Other

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Premier Customer Base

WSC provides simulation software solutions to power and process clients and education institutions worldwide, and teams with various strategic partners, in efforts to deliver innovative, collaborative solutions

Power Companies

AEP American Electric Power, aps, Ameren Illinois Utilities, ALSTOM, ATCO Electric, CPS Energy, Allegheny Power, B&W, invensys, Dominion, Gulf Power, GE, HITACHI, Bechtel, Holtec International, Bruce Power, GenOn, Malakoff, BAeHAL, FPL, Lockheed Martin, Northrop Grumman, EEI, Southern Company, Ehepro Energo Atom, Honeywell, KHNP, Los Angeles Department of Water & Power, Eskom, KAPL, Burbank Water and Power, Xcel Energy, KEPCO Korea Electric Power Corporation, Magnox, Emirates Nuclear Energy Corporation, Duke Energy, General Dynamics Electric Boat, Entergy Vermont Yankee, Westinghouse, Toshiba

Universities & Research Institutes

Massachusetts Institute of Technology, Khalifa University, College of the Siskiyous, Three Rivers Community College, EPRI Electric Power Research Institute, Bismarck State College, KAERI Korea Atomic Energy Research Institute, Nigeria Atomic Energy Commission (NAEC), University of Sharjah, UNIST, IAEA International Atomic Energy Agency, The University of Idaho

Partners

ABB, INL Idaho National Laboratory, ADTECH, CNPSC, SOS Reliability Matters, GP Strategies, GE, mauell

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New Nuclear Plants & Engineering Simulators

Recent nuclear new builds and next generation reactors selecting WSC technology:

- Korea Hydro Nuclear Power, Barakah Plants, all Korean APR 1400 PWR units,
- China Guangdong Nuclear Power Company, Ningde, Yang Jiang & Fangchengang CPR 1000, CNRSC Generic CPR 1000 with Severe Accident Modelling
- Emirates Nuclear Energy Corporation (ENEC) in UAE for Barakah NPP GPWR Classroom Simulator and Full Scope Simulators
- Toshiba ABWR, South Texas
- Taiwan Power Company TPC, Lungmen ABWR
- Chinergy China HTR PBMR
- KAERI Maritime and SMART SMR
- GE-Hitachi, ESBWR/BWRX300 SMR SAE
- TerraPower Traveling Wave Reactor & Natrium SMR
- Holtec SMR 160
- BWXT MMR Pele Project

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SAE provides an effective test bed through all phases of project execution commencing at conceptual design through the building and commissioning of a complex asset such as a nuclear power plant.

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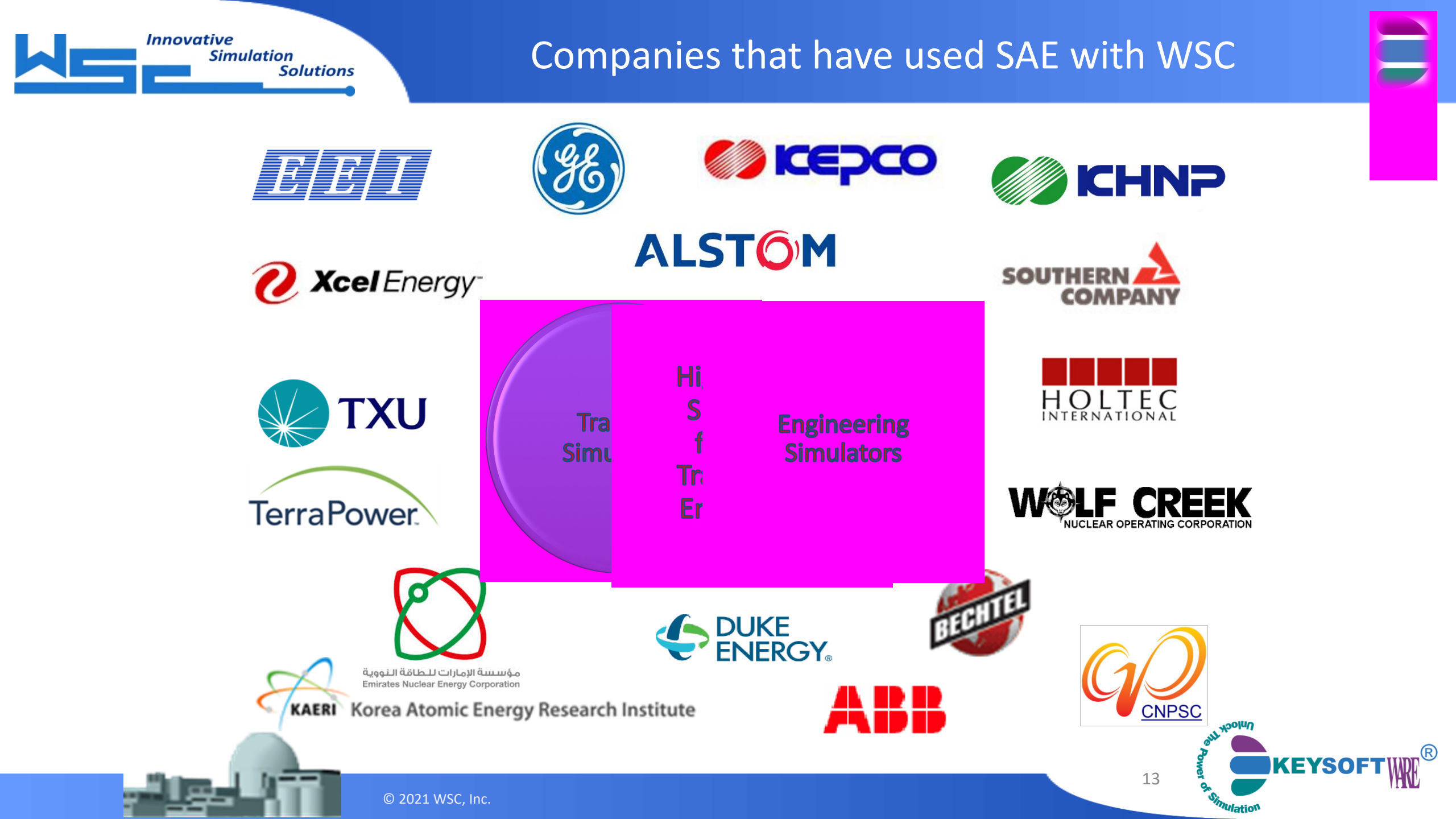
Companies that have used SAE with WSC



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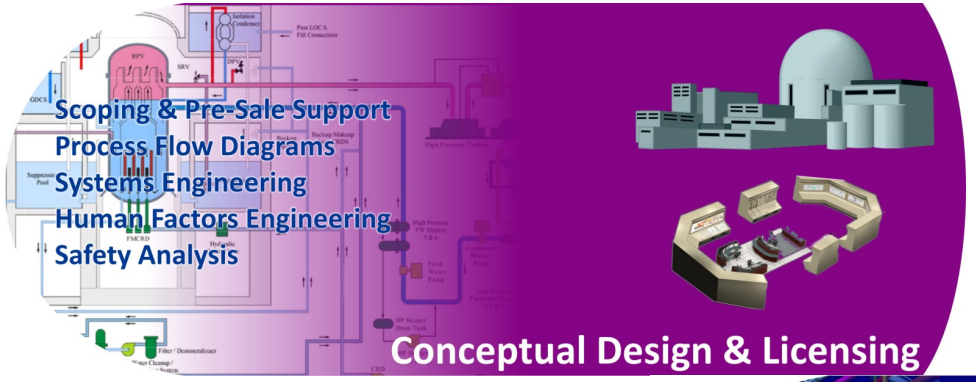
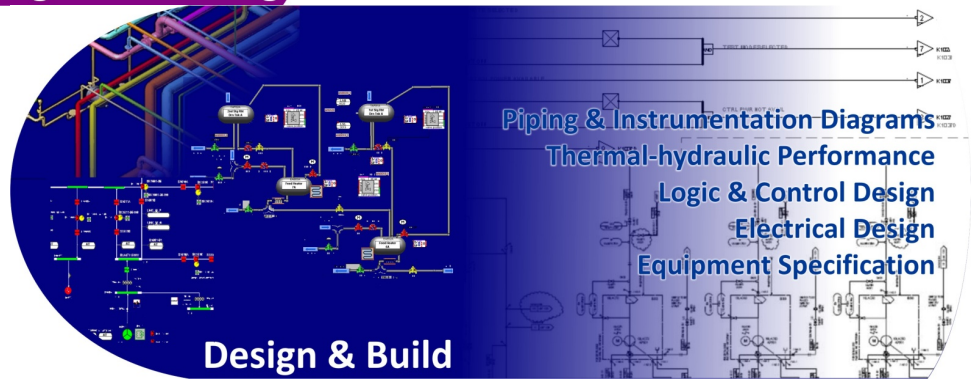
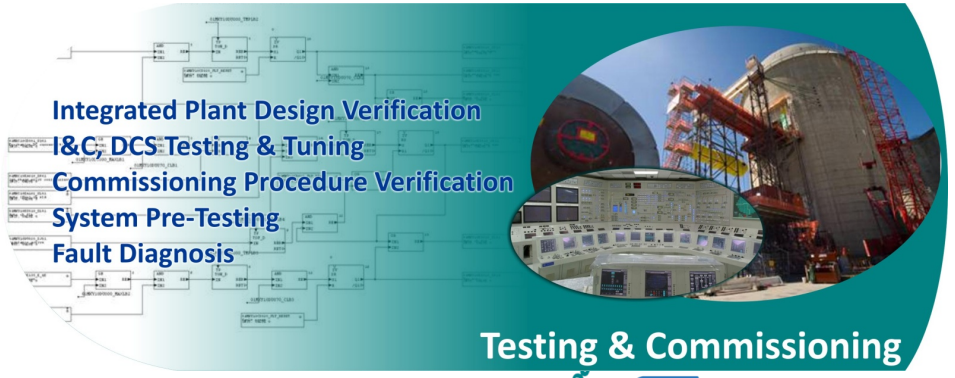
SAE STAGES







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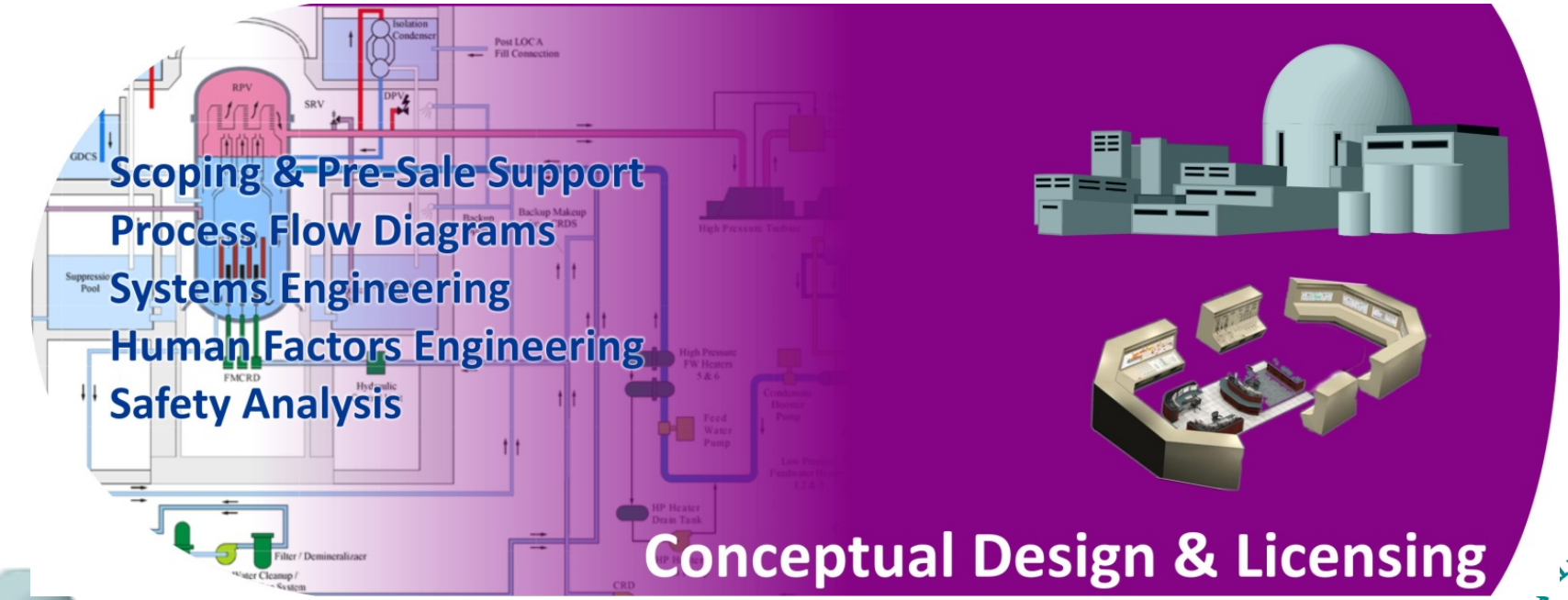
SAE – In Conceptual Design and Licensing

- Developing process flow sheets and nominal operating parameters for equipment
- Specifying system boundaries and integration parameters at key operating conditions
- Conducting human-factors engineering studies and developing HMI design
- Conducting preliminary failures and safety analysis studies for single or complex failures



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APR1400 HFE Control Room Simulator

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The APR1400

The APR-1400 (Advanced Power Reactor 1400 MW electricity) is an advanced pressurized water nuclear reactor designed by the Korea Electric Power Corporation (KEPCO). The Generation III reactor was developed from the earlier OPR-1000 design and also incorporates features from the US Combustion Engineering (C-E) System 80+ design.

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Planned APR-1400

Site	Unit	Status	Construction Start	Construction Complete	Operation
Shin-Kori S. Korea	3	Operational	Oct 2008	Late 2015	2016
	4	Operational	Aug 2009	Late 2018	2019
	5	under construction	Sept 2016	–	Mar 2021
	6	under construction	Sept 2017	–	Mar 2022
Shin-Hanul S. Korea	1	under construction	July 2012	–	2022
	2	under construction	June 2013	–	2023
Barakah Abu Dhabi UAE	1	Operational	July 2012	2018	2020
	2	Operational	May 2013	2020	2022
	3	Operational	Sept 2014	2021	2023
	4	under construction	Sept 2015	2022	2024

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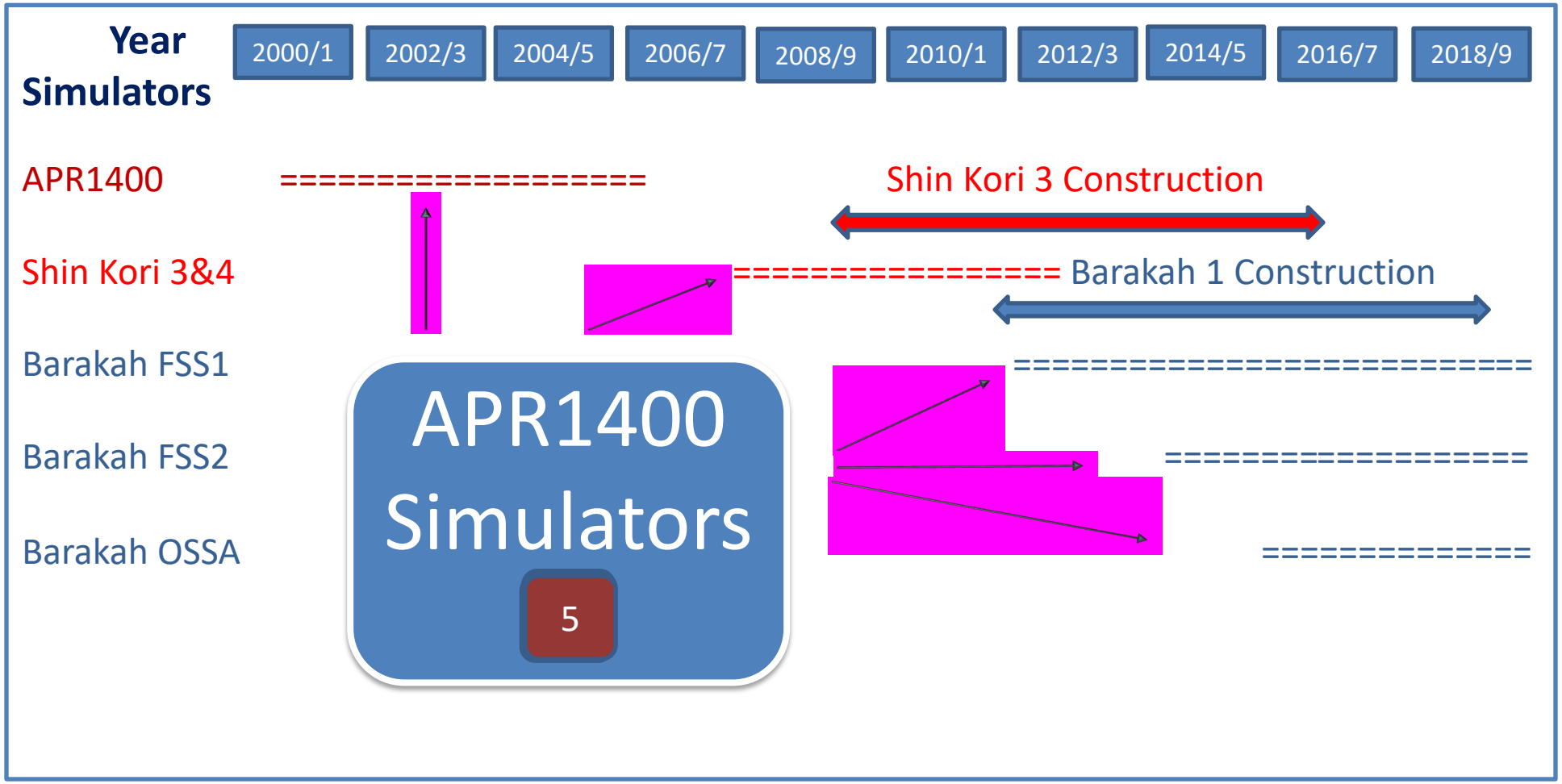
APR1400 Simulators



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APR1400 Control Room Design

- Full Replica Simulator for the Purpose
  - Control Room Ergonomics
  - Plant Control Room and Control Room Operator Behavior
  - Test Design Basis
  - Certification of Design
  - Support Tool for Licensing Agency

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APR1400 HFE Control Room

APR1400 Operator Action

Cameras and Operator Action sensing equipment. Eye movement, heartbeat, head and hand movement

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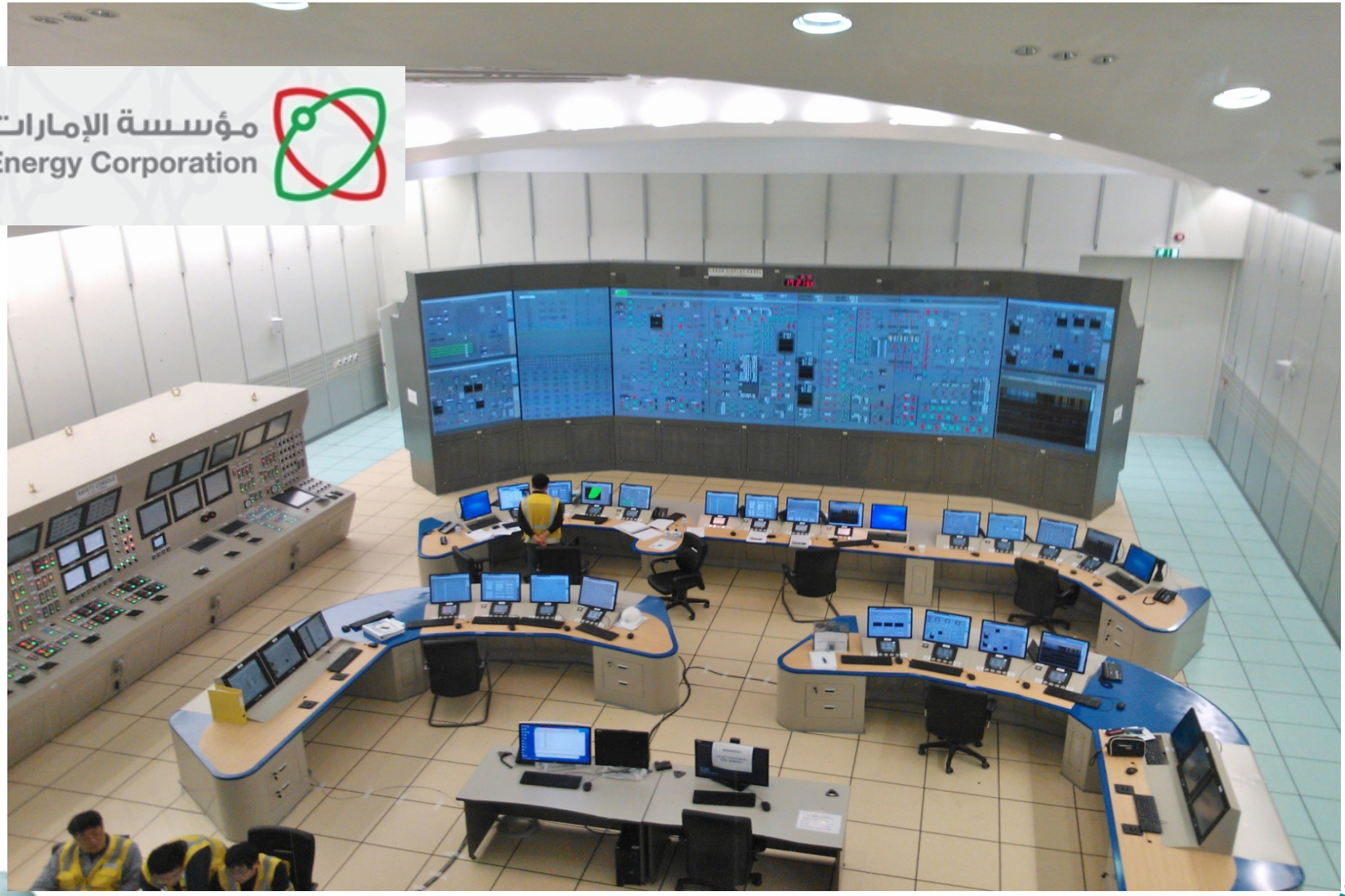
Barakah Replica Control Room Simulators

مؤسسة الإمارات للطاقة النووية
Emirates Nuclear Energy Corporation



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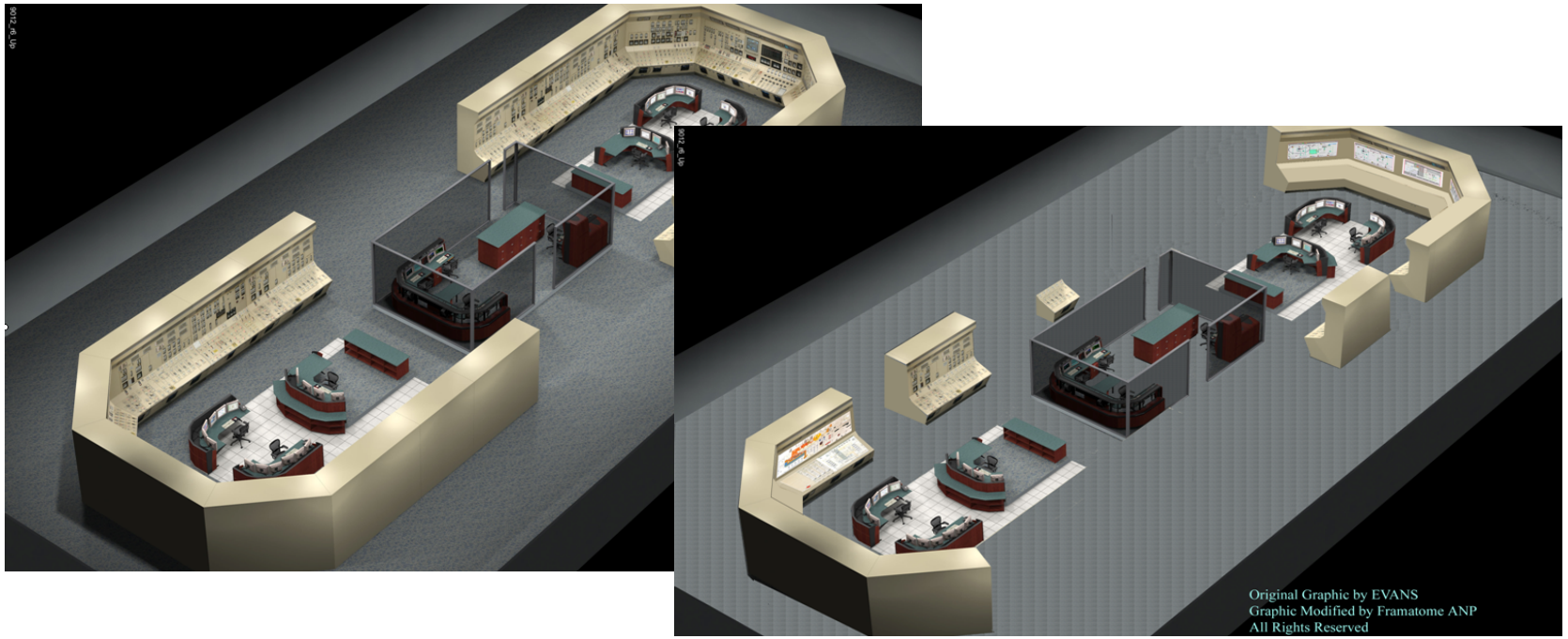
Control Room Modernization

- Needed a Human Factors tool to evaluate incremental changes over several years
- Operating crews can validate the proposed placement of controls before the design is finalized



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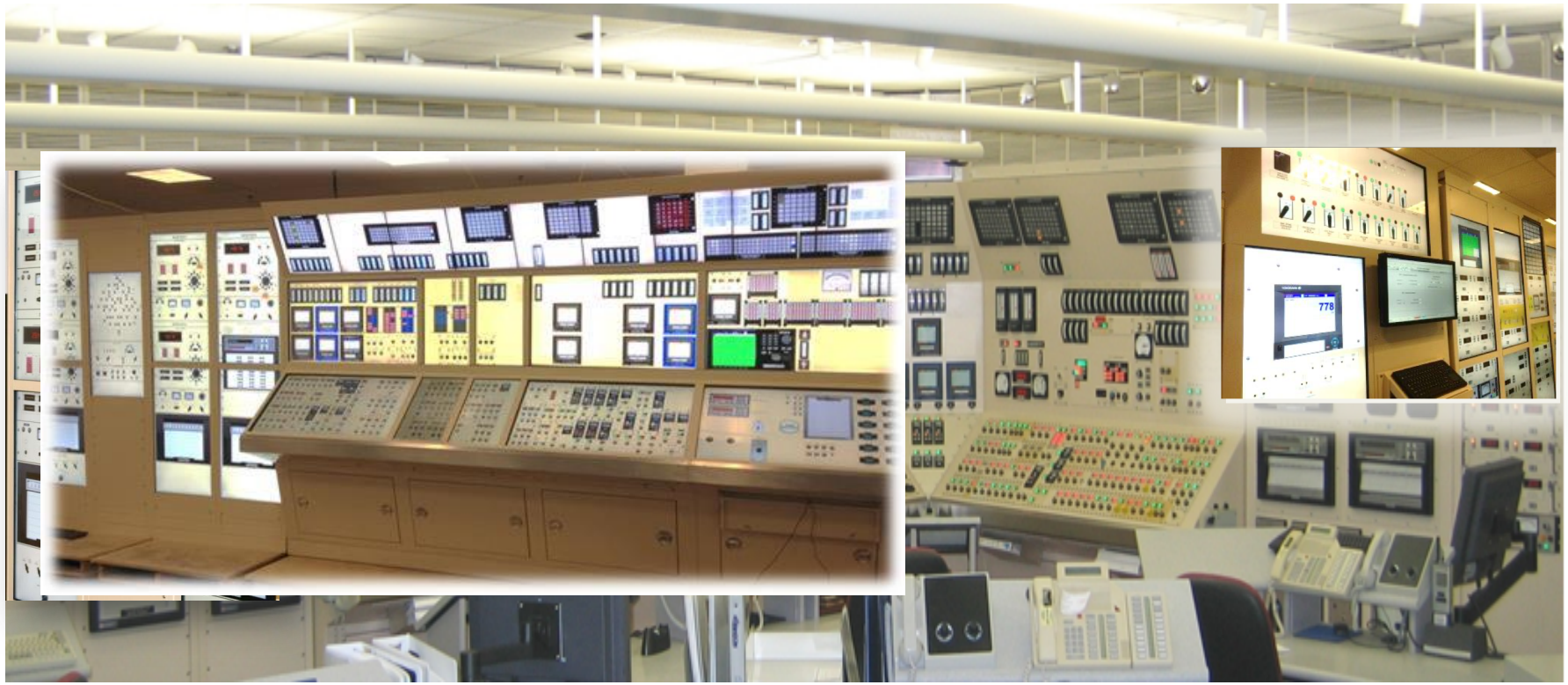
Duke Robinson Traditional Control Room

- Replicate Hard Panel Control Room with Touch Screen Replica Control Room
- Used for integration of New DCS Systems and modernization of the plant
- HFE Evaluations and Training on Updated Systems



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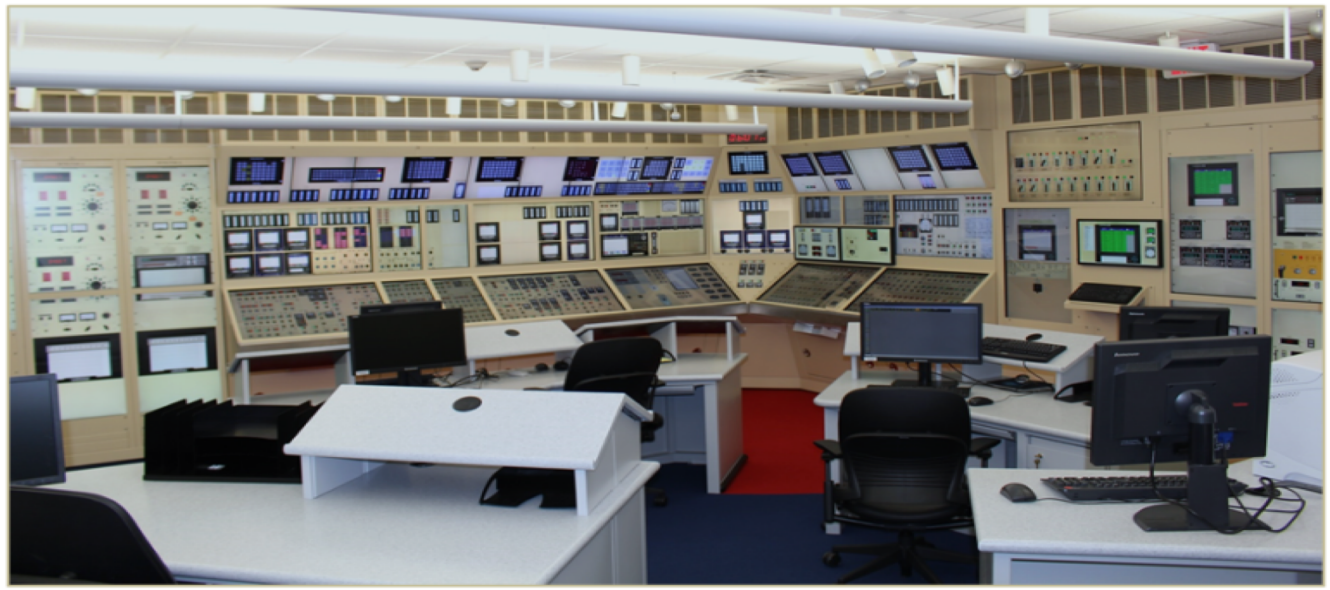
Actual vs. Touch Screen Panels

Actual Control Room Panel

Touch Screens Control Room Panel



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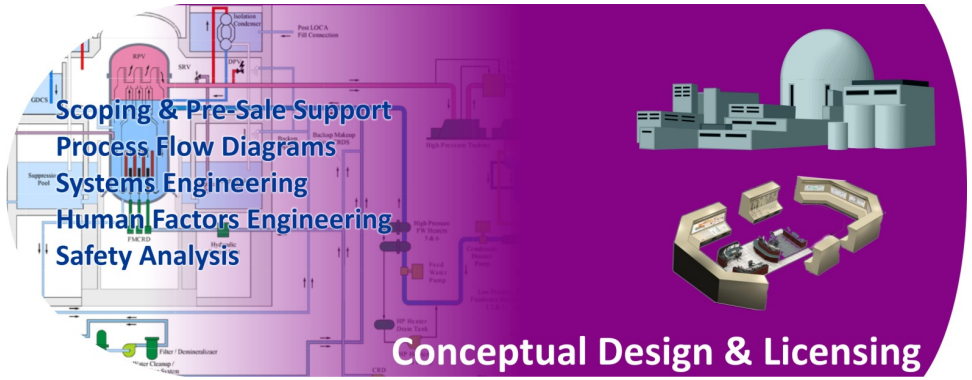
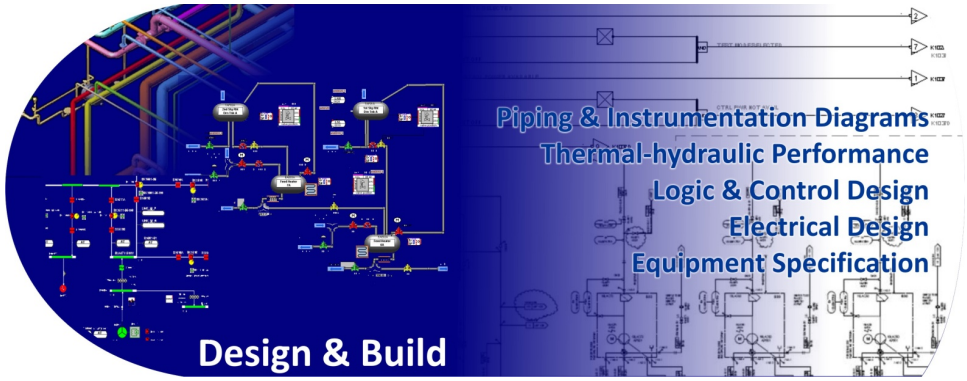
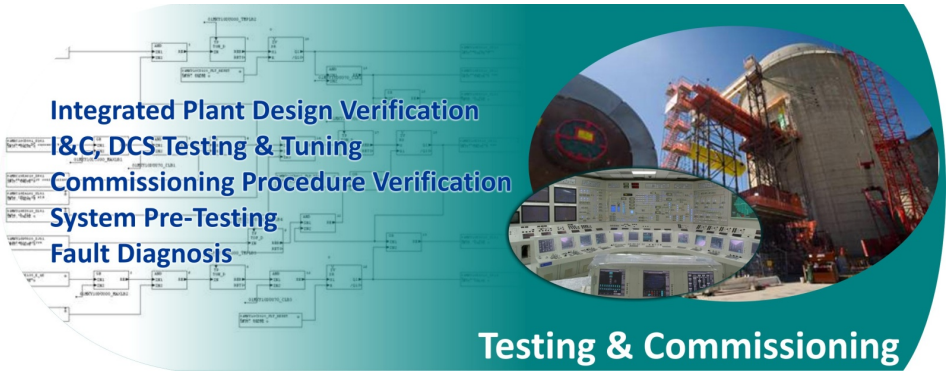
SAE STAGES







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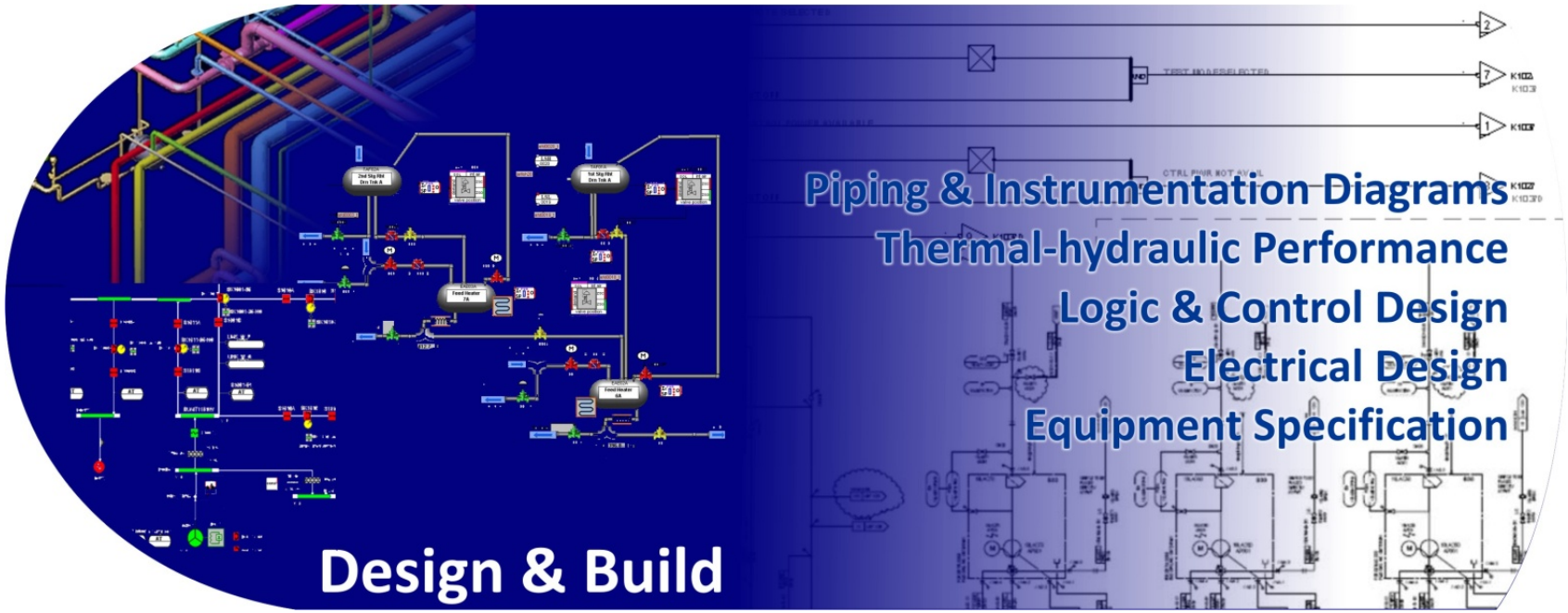
SAE – In Design and Build

- Developing systems engineering artifacts — P&IDs, Logic & Control and Electrical Diagrams
- Developing equipment sizing and capacity specifications
- Engineered safety features and redundancy design



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Plant Databases

- Piping and Instrumentation Diagrams
- Isometrics and 3D models
- Electrical Diagrams
- Equipment Data
- Functional Logic and Control
- Initial HMI design

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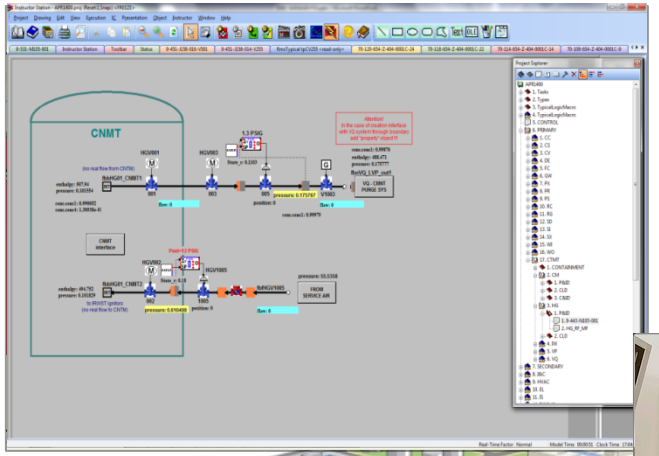
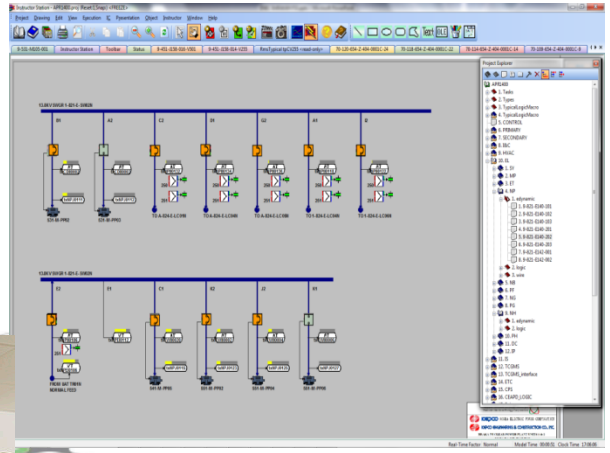
The Virtual SAE Plant



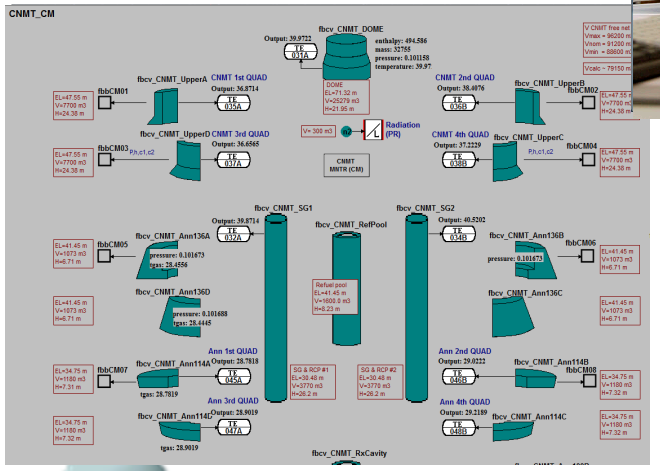
Piping and Instrumentation

Electrical



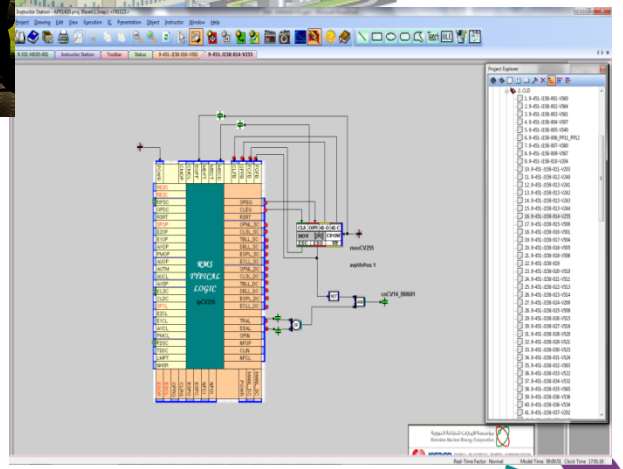
Control

HMI



Isometrics

Instrumentation



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The Virtual SAE Plant

- Verification of Piping and Instrumentation
- Equipment Sizing
- System to system interfaces “the glue”
- Verification of Isometric Data
- Instrumentation effectiveness and location
- Evaluation of electrical systems loading and distribution
- Regulatory Compliance
- Plant Data Handover and configuration

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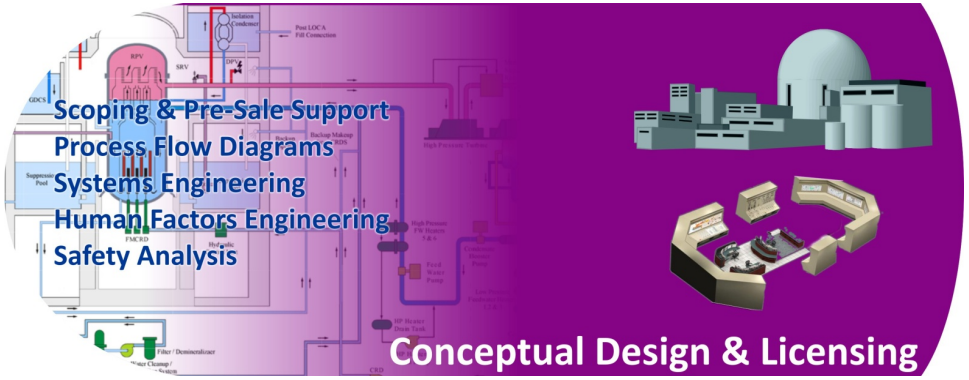
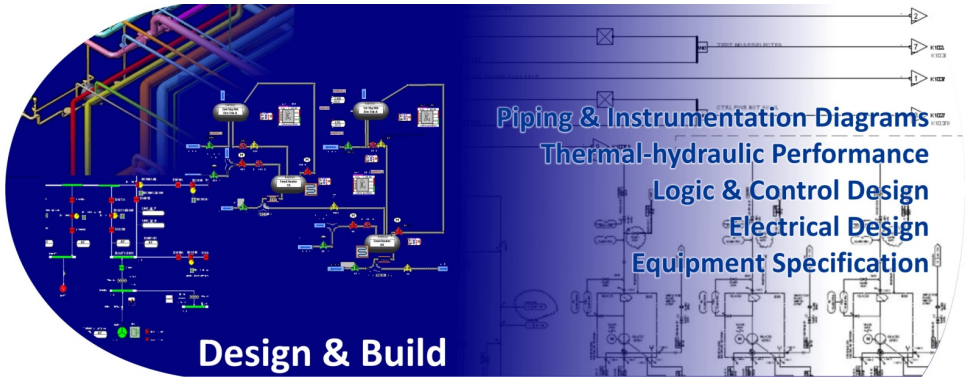
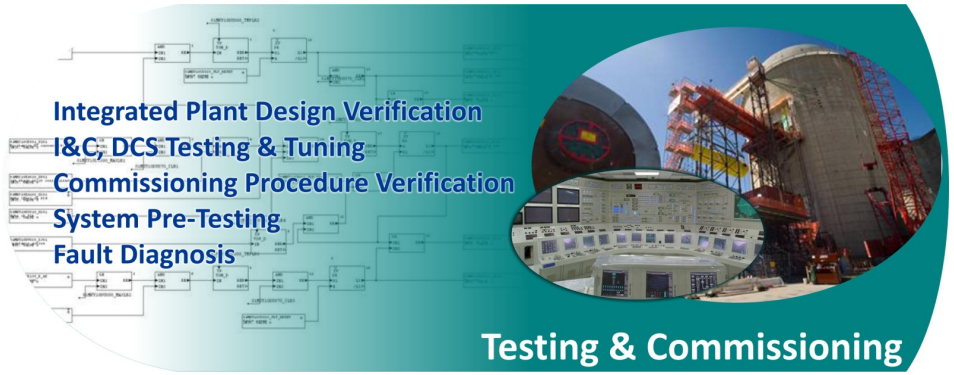
SAE STAGES







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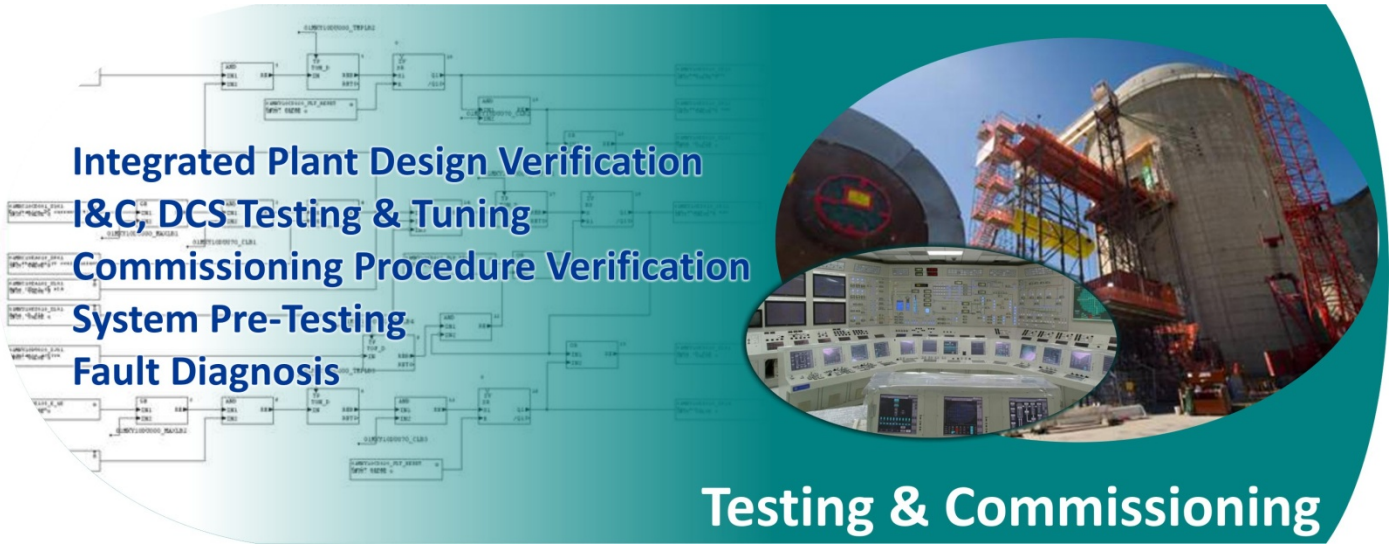
SAE – In Testing and Commissioning

- Virtual commissioning and verification of the entire integrated plant
- Performing DCS systems functional and sensitivity tests, and tuning
- Verifying test and operating procedures
- Verifying response to failures and faults
- Identifying and diagnosing problems, and exploring solutions to these



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The Development Process

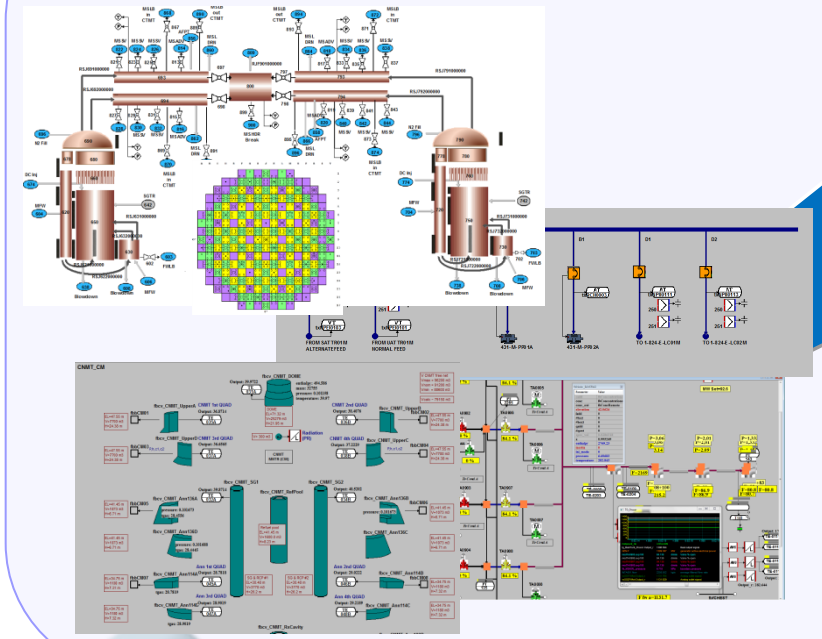
Approach:

- Integrate simulation into design process
- Identify defects and performance gaps
- Iterate to optimize & validate

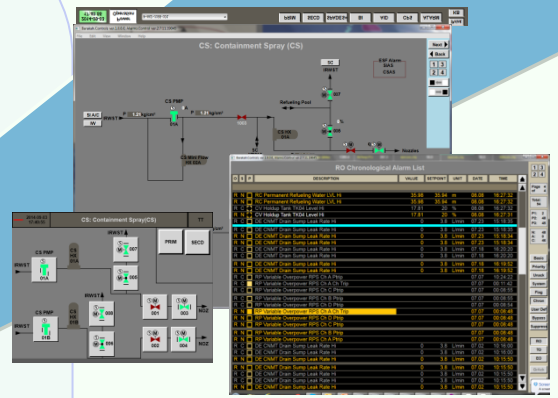
Virtual Plant

Soft Controls
or Hard Panels

Physical Models



Control Models



Benefits:

- Simplify design process
- Minimize overall defects and reduce rework for plant

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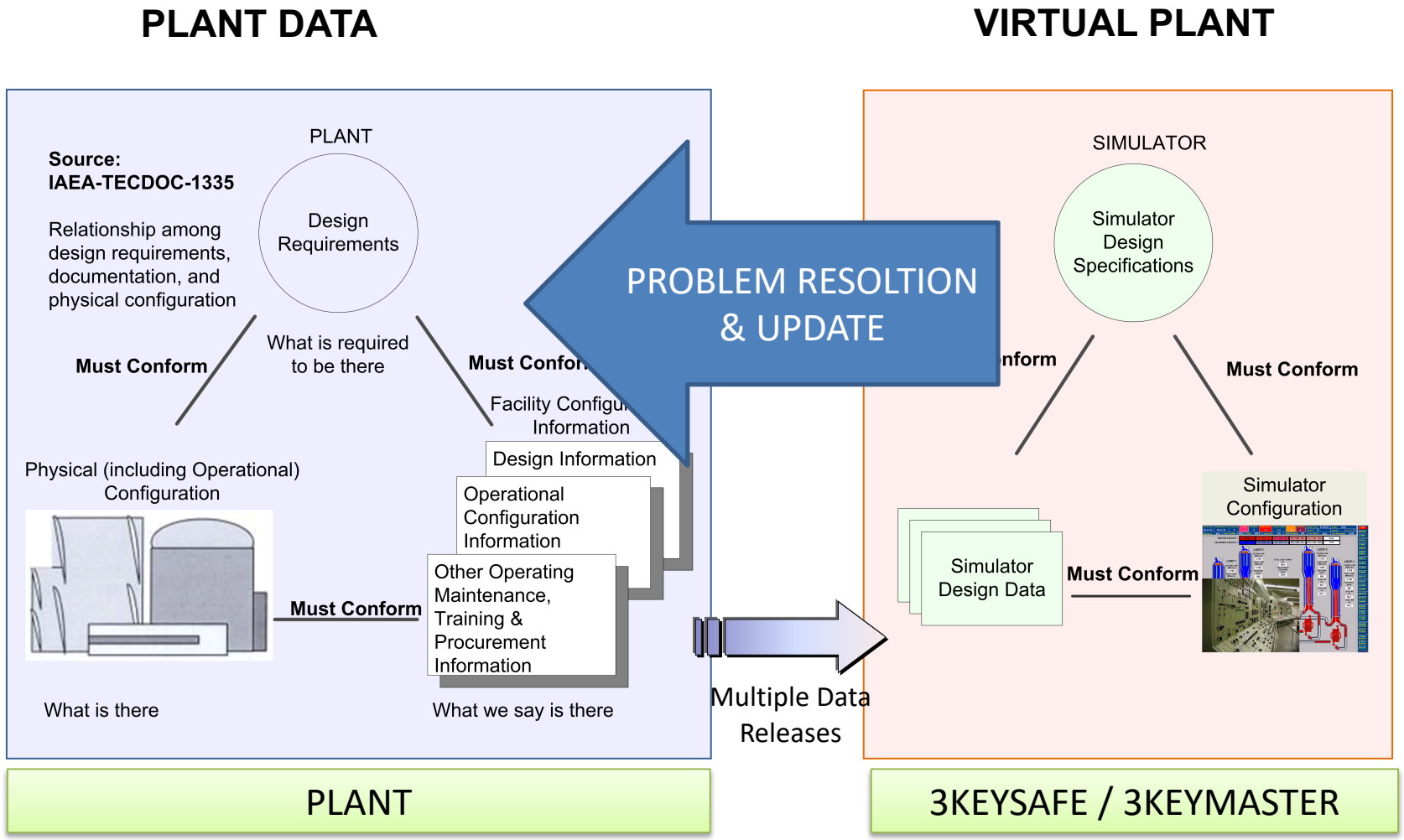
SAE Feedback to Plant Design



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Barakah DCS Systems Safety/Non Safety and Turbine Generator Control

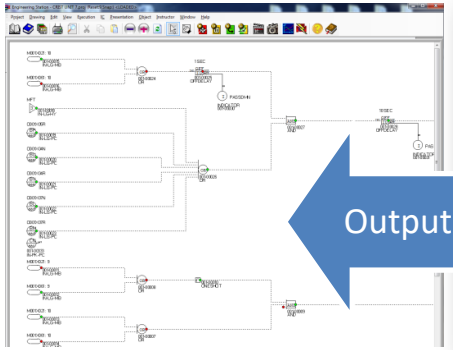
DCS 1

DCS 2

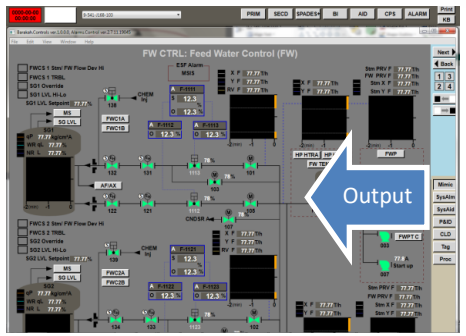
DCS/PLC Interface

DCS 3

Process Models



Output



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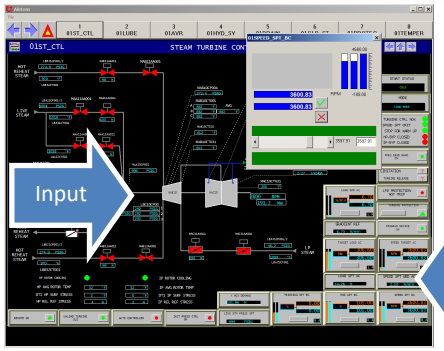

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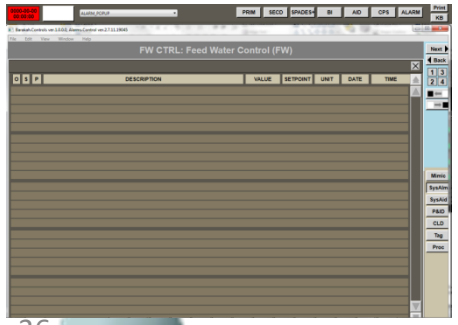
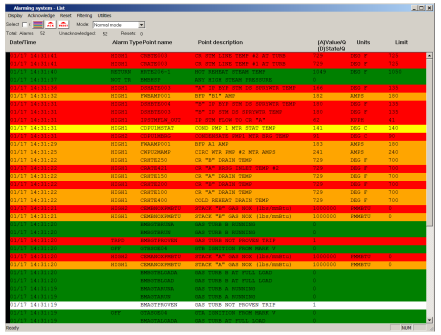
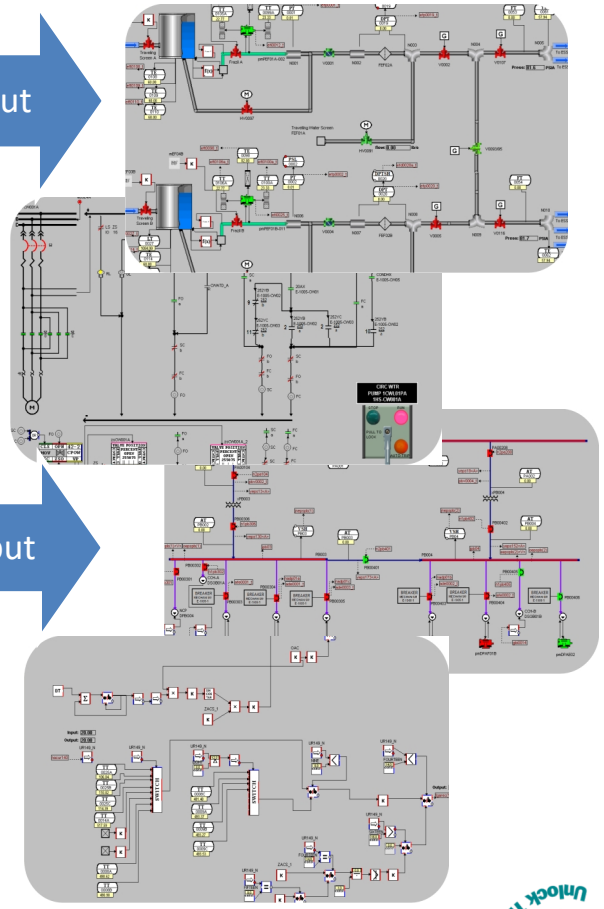




Input



Input

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❑ SAE - In New DCS Installations

- ✓ Commissioning time is reduced due the full testing of the Human Machine Interface and Logic & Control on the Simulator
- ✓ Plant procedures are developed and verified on the simulator pre start-up of the unit
- ✓ Reduction of dead or waiting time for commissioning engineers to resolve specific I&C problems
- ✓ Incremental resolution of problems results in reduced commissioning time

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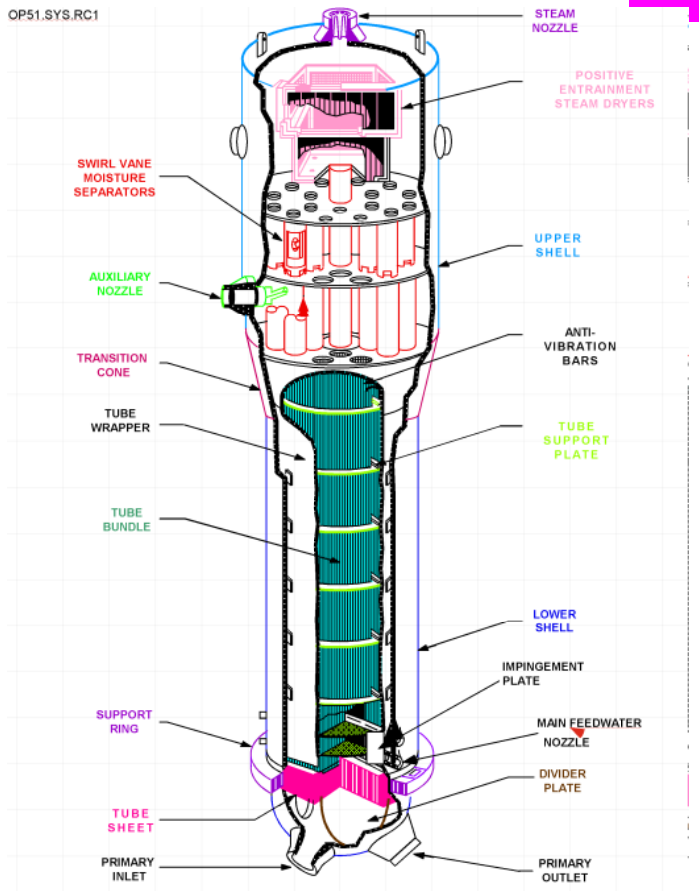
SAE Experiences

- **Major Companies are using simulation in DCS testing**
  - ✓ Experience from commissioning of DCS systems is that over 50 % of DCS I&C diagrams are changed during commissioning
  - ✓ Over 70 % of the DCS graphic pages are updated due to mapping, color, & ergonomics errors or improvements
  - ✓ 5-10 % Interface and I/O Errors
- **Simulation can provide a test bed to resolve these errors before commissioning**
- **Having an engineering grade full scope simulator allows operation and engineering to use the simulator beyond its primary charter for training**



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Results – L&C Issues

- Typical applications of SAE V&V for logic and controls:
  - Verify logic and controller functional diagrams
  - Address operating in multiple modes simultaneously
  - Ability to change setpoints, bias, or control mode
  - Impact of transmitter failures
  - Ensuring proper IO connections
  - Impact of loss of power supplies on system performance
  - Testing alarm system issues (false actuation or alarms not actuating)
  - Failure Modes and Effects Analysis can be evaluated using malfunction capabilities
  - Resolve inability to reset certain alarms or trips
  - Evaluate automatic actions not operating per design

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Results – HMI Issues

- Typical applications of SAE V&V for HMI:
  - Identify control buttons not functional, not configured properly, or providing incorrect inputs to logic
  - Verify Input, control, and output interfaces for multiple trains
  - Verify operator selection of manual or automatic controls, trip resets, etc.
  - Evaluate engineering unit conversions or display issues
  - Resolve ergonomics issues requiring renaming of controls or relocation to other screens
  - Optimize popup control priority and precedence
  - Resolve incorrect or false indication of equipment e.g. valve status:
    - scaling issues, such as false contradictory or deceiving indications or bar graphs
    - text flashing or “dynamics” display issues
    - colors or shading
    - other minor issues, e.g. labels, typos, layout, formatting, trend colors

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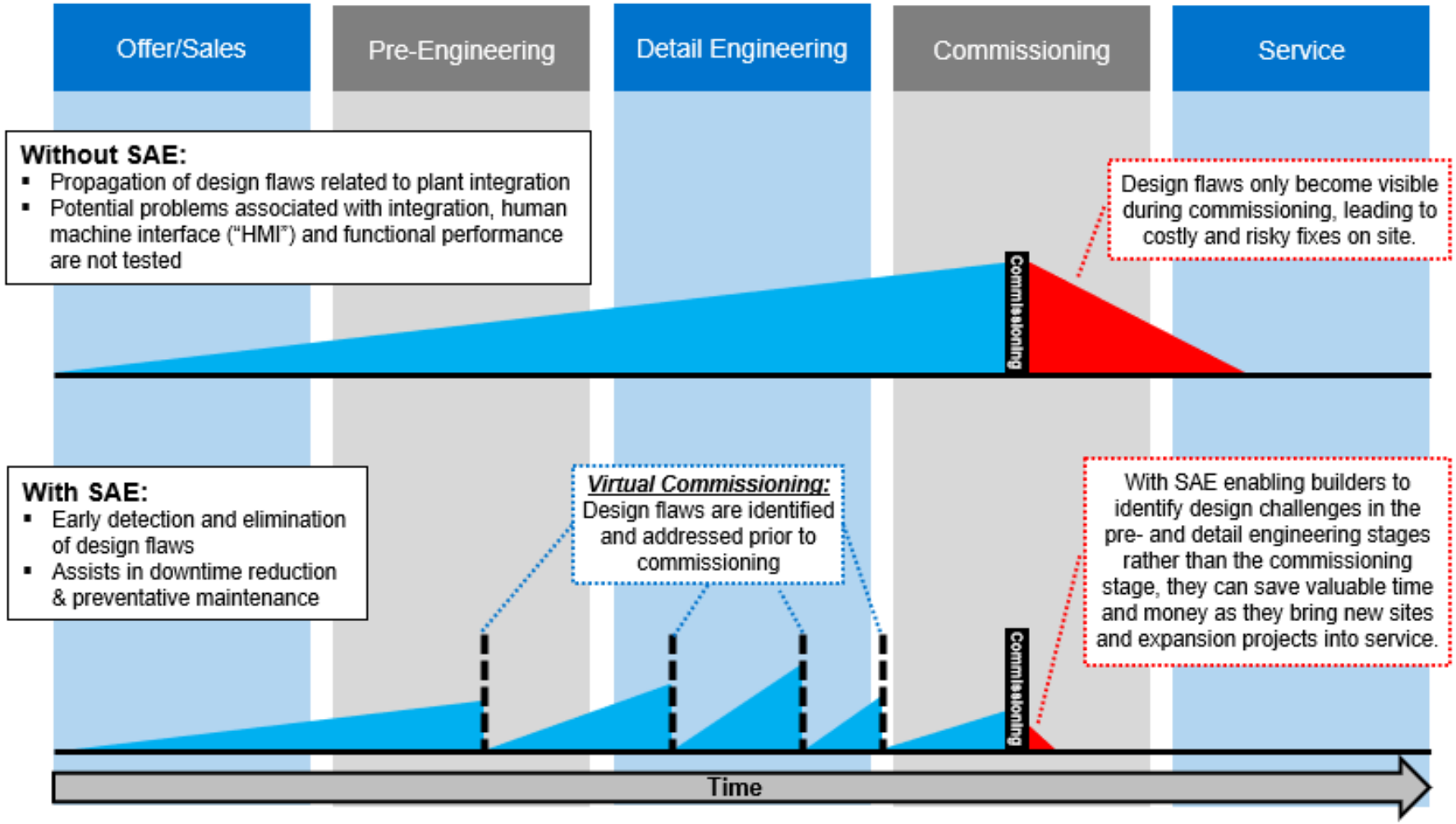
SAE Integrated Engineering Process Vision

The SAE approach provides an efficient and cost-effective means of detecting and correcting issues prior of a power plant design prior to the actual plant commissioning. The chart below graphically depicts the SAE process and benefits that can be achieved.



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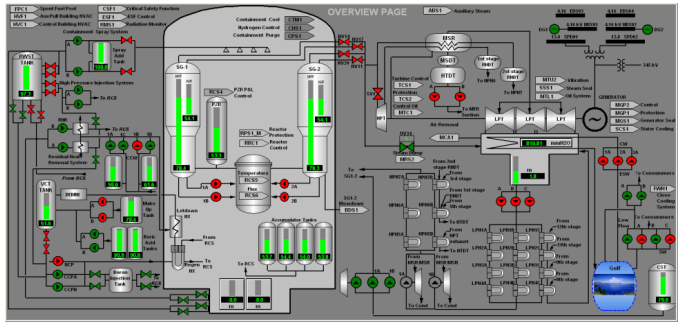
Benefits and Application of New Design Simulators

Training

- MCR Operator Training
- Field Operator Training
- Engineers Training
- Plant Management Training



Engineering Support

- Operating Procedures
- Modifications
- R&D

PR

- Public Visits
- Demonstrations

Education

- Universities
- TSO
- Regulatory Body

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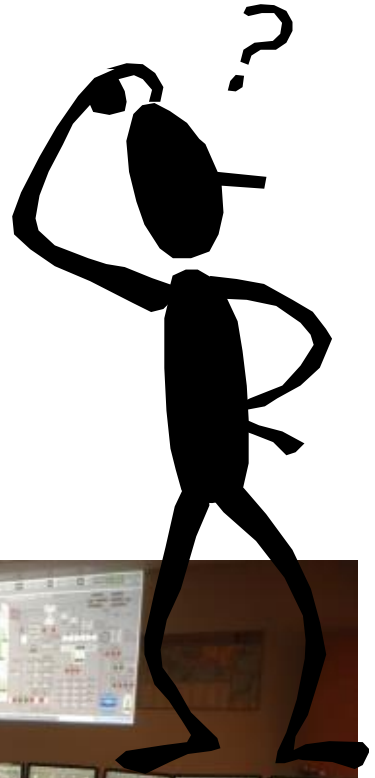

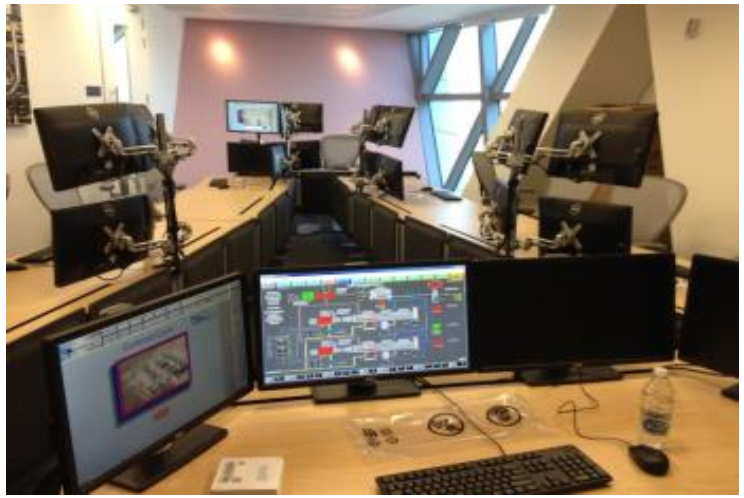

Thank You!

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