

STEAG's Experience in Energy Transition – Flexible Operation of Thermal Power Plants



A Joint Initiative with IGEF-GIZ, VGBE and EEC

Energy Transition – Indian Power Sector Perspective



India targeting large-scale renewable integration



Renewable energy is variable and intermittent



Grid stability and reliability remain critical



Coal-based thermal plants continue to play balancing role

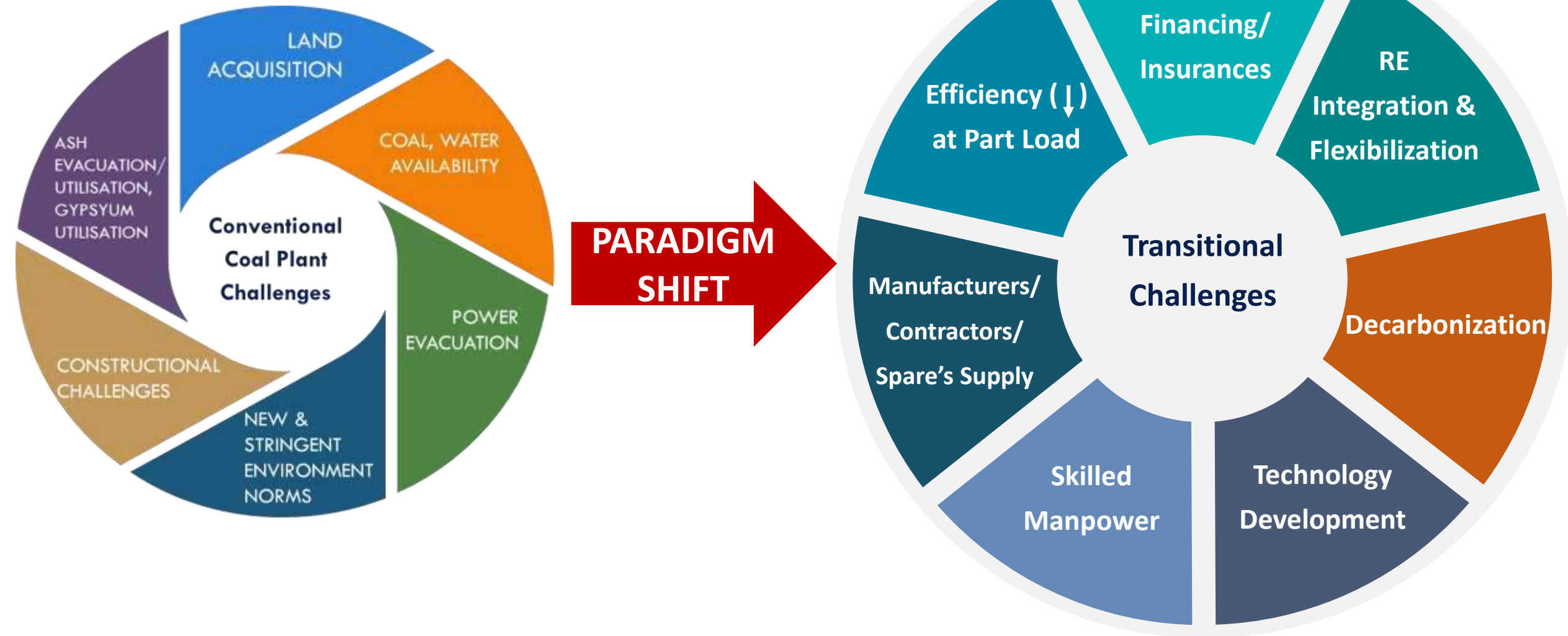


Flexibility is becoming operational necessity

ENERGY TRANSITION IS NOT REPLACEMENT OF THERMAL POWER –
IT IS TRANSFORMATION OF THERMAL POWER.

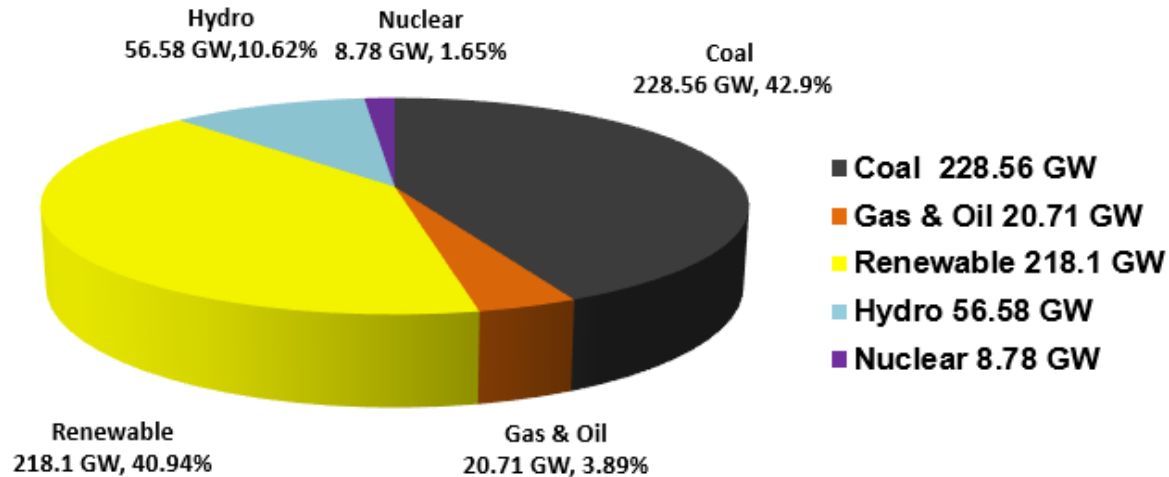


Challenges with Energy Transition



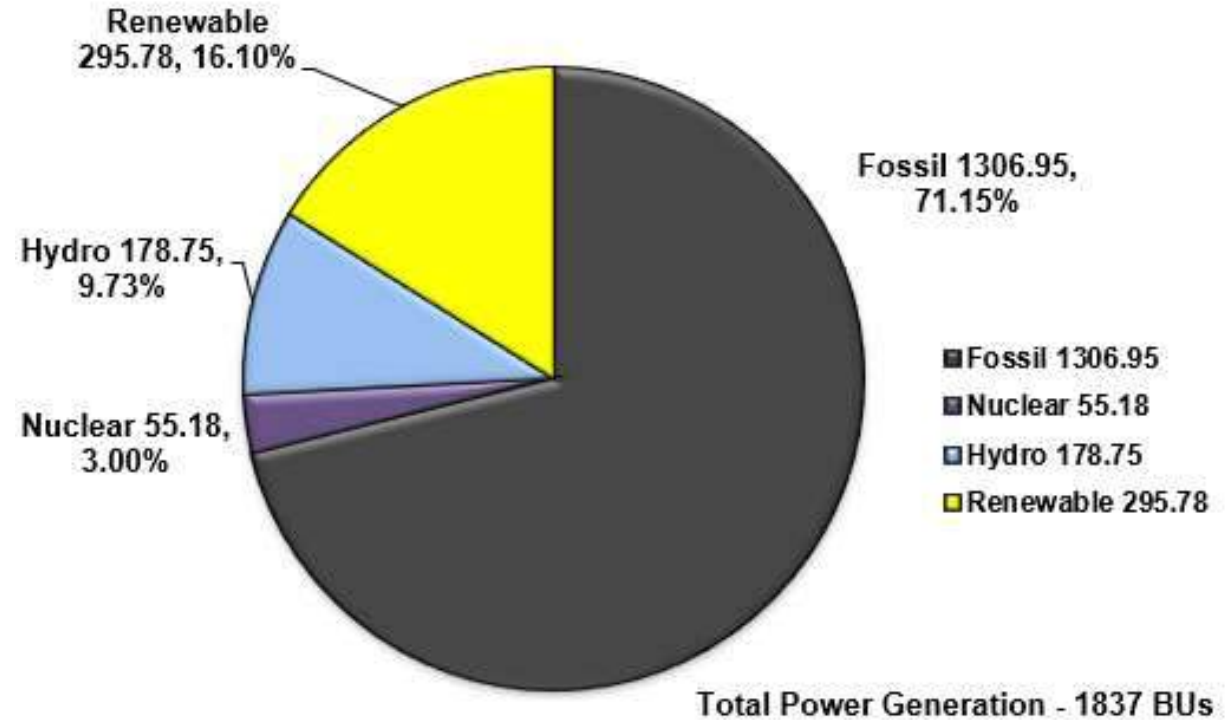
Thermal Power: Reality of the Indian Grid

Total Installed Capacity (GW)



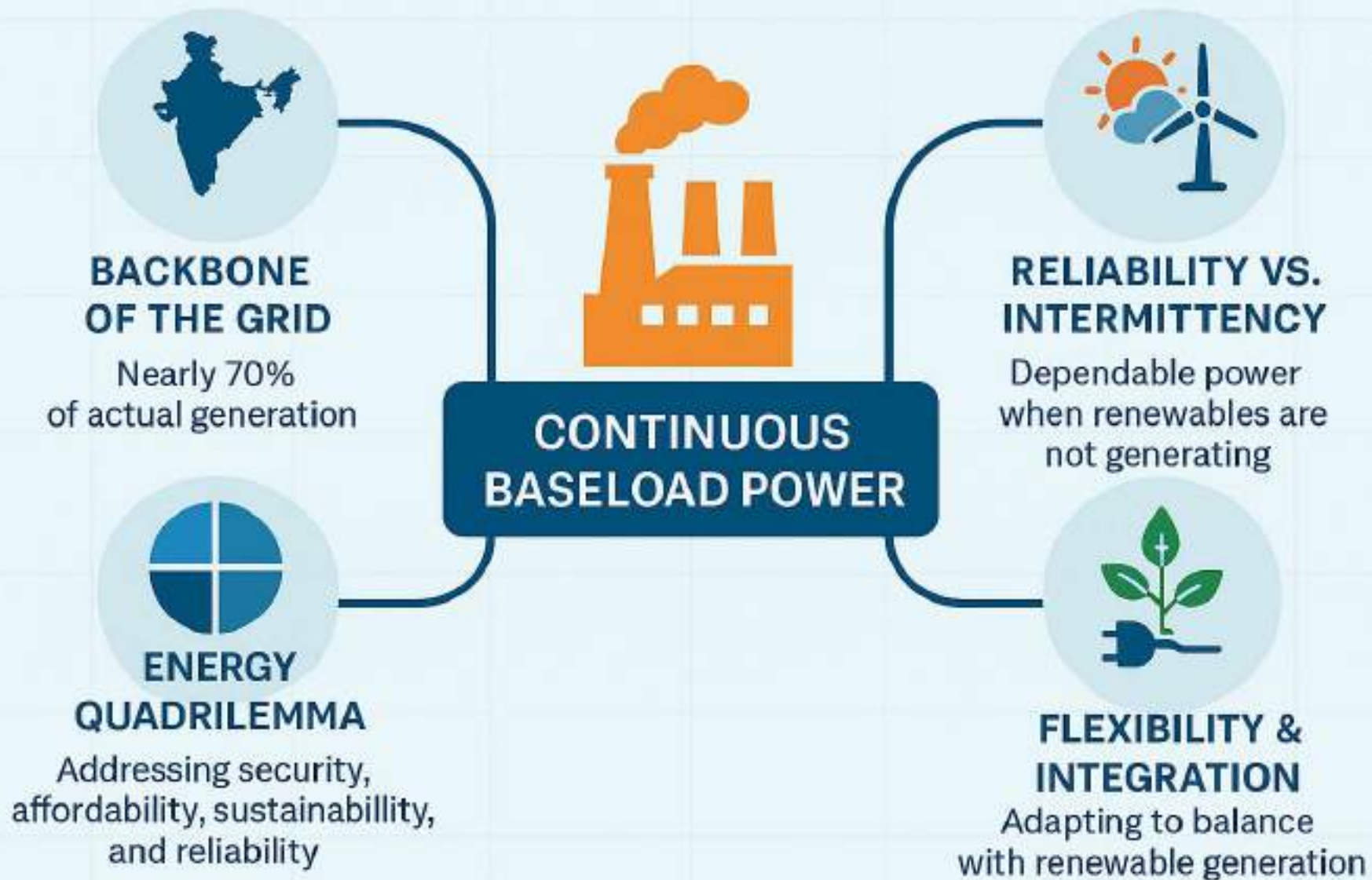
Total Capacity 532.73 GW

Fossil Fuels	249.27 GW
Non Fossil Fuels	283.46 GW



Efficient coal-based thermal power with flexible operation capability will continue to play a critical balancing role in the Indian power system

The Importance of Thermal Power Generation as Baseload Power for Grid Stability



Coal plants must now operate flexibly:

- Ramp down to level well below 55% and possibly up to 40% load
- Ramp up rapidly during peaks in the morning and evening
- Operate in cyclic and two-shift modes as required
- Operate with least oil support while ensuring boiler safety

Flexible operation is no longer an exception, it is the new normal.

Flexible Operation – Key Challenges

Earlier Operation

Present Requirement

New Challenges

Base load operation

Frequent ramping

Thermal stress

Stable operation

Low load operation

Flame instability

Predictable dispatch

Faster start/stop

Equipment fatigue

Limited cycling

Renewable balancing

Operator preparedness

Human capability and operational confidence are critical for successful flexibilization.

The Challenge and Opportunity of Flexible Thermal Plant Operation

Requirement



Coal plants made to operate flexibly to accommodate renewables



Operation ramped down to 40% load



Technical Challenges



Operation ramped down to 40% load



Operational Excellence



R&M and modernization



15-20% OF FLEET OVER 25 YEARS



Improving plant efficiency and maintaining grid reliability



Adopting high efficiency, low emission technologies



CEA Notifications on Flexible Operation and Phasing Plan

- CEA has already come out with a time bound mandate to achieve Flexibilization by coal-based power plants.
- Coal fired generating units shall achieve 40% technical minimum load
- The preliminary phasing has been worked out in the CEA report “Flexibilization of coal fired power plant – **A road map for achieving 40% technical minimum load published in Feb 2023**”
- Subsequently a draft phasing plan has been prepared for coal based generating units.

People Capability: The Defining Challenge of the Transition



**Aging Workforce,
Shrinking Experience Base**

**Equipment Can Be
Procured – Experience
Cannot**



**Capability Building Is
Now Mission-Critical**

STEAG's Experience in Energy Transition



Flexible Operation Expertise



- Decades of experience in operating & maintaining thermal power plants
- Proven methodologies for flexibilization
- Supporting plants to achieve low load & high ramp capability



Operator Training & Flexibilization Programs



- Structured training to build operator competency
- "Flexpert" development through simulator-based learning
- Practical programs aligned with CEA roadmap



High Fidelity Simulator Solutions



- High fidelity, plant-specific simulators
- Realistic replication of plant dynamics & controls
- Safe environment to practice ramping, low load & transients



Digital & Performance Optimization



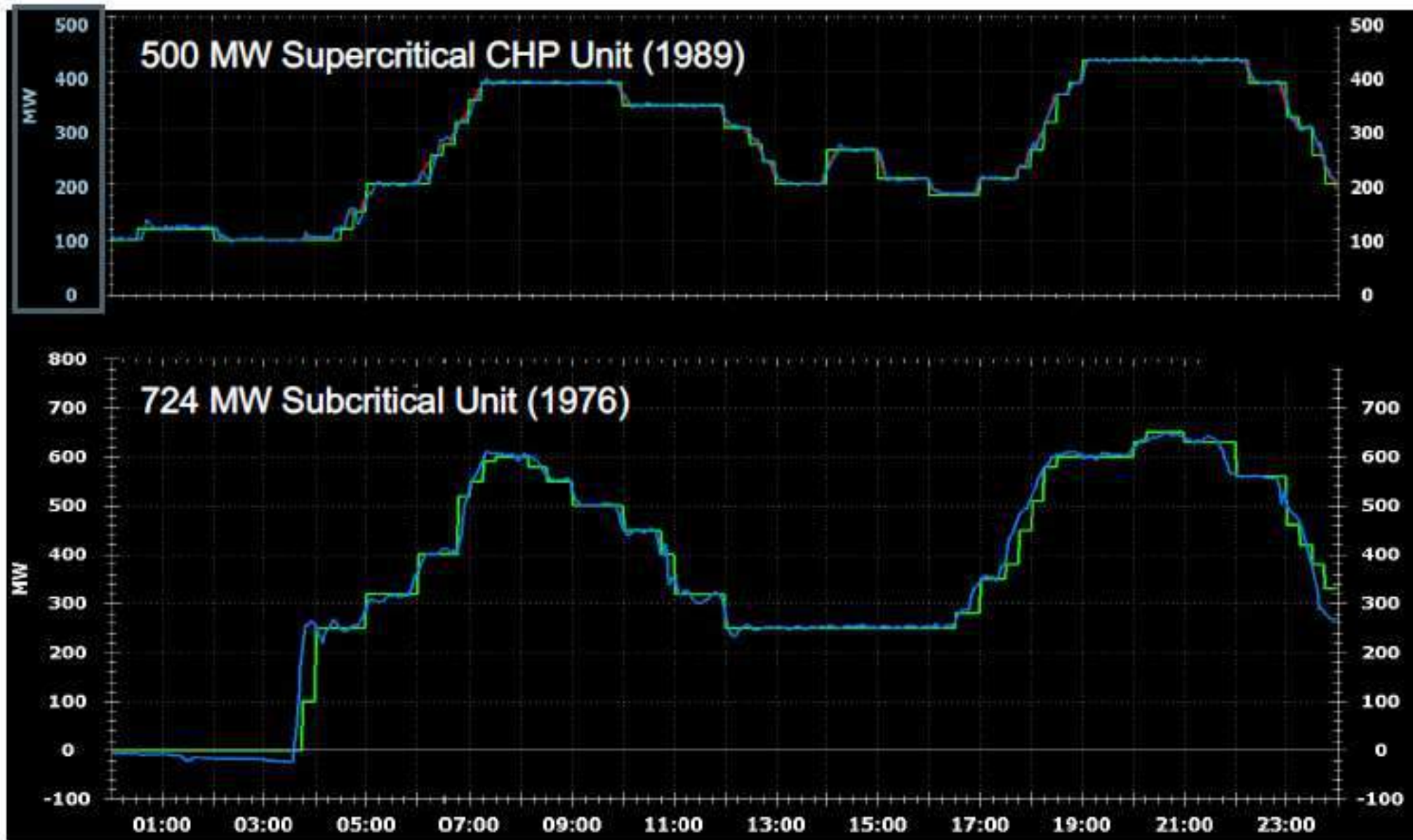
- Data-driven insights for better decision making
- Performance improvement & reliability enhancement
- Enabling smarter & sustainable plant operation



STEAG supports the energy transition through practical implementation, operator competency development, and flexible operation readiness.



Optimization of low load operations

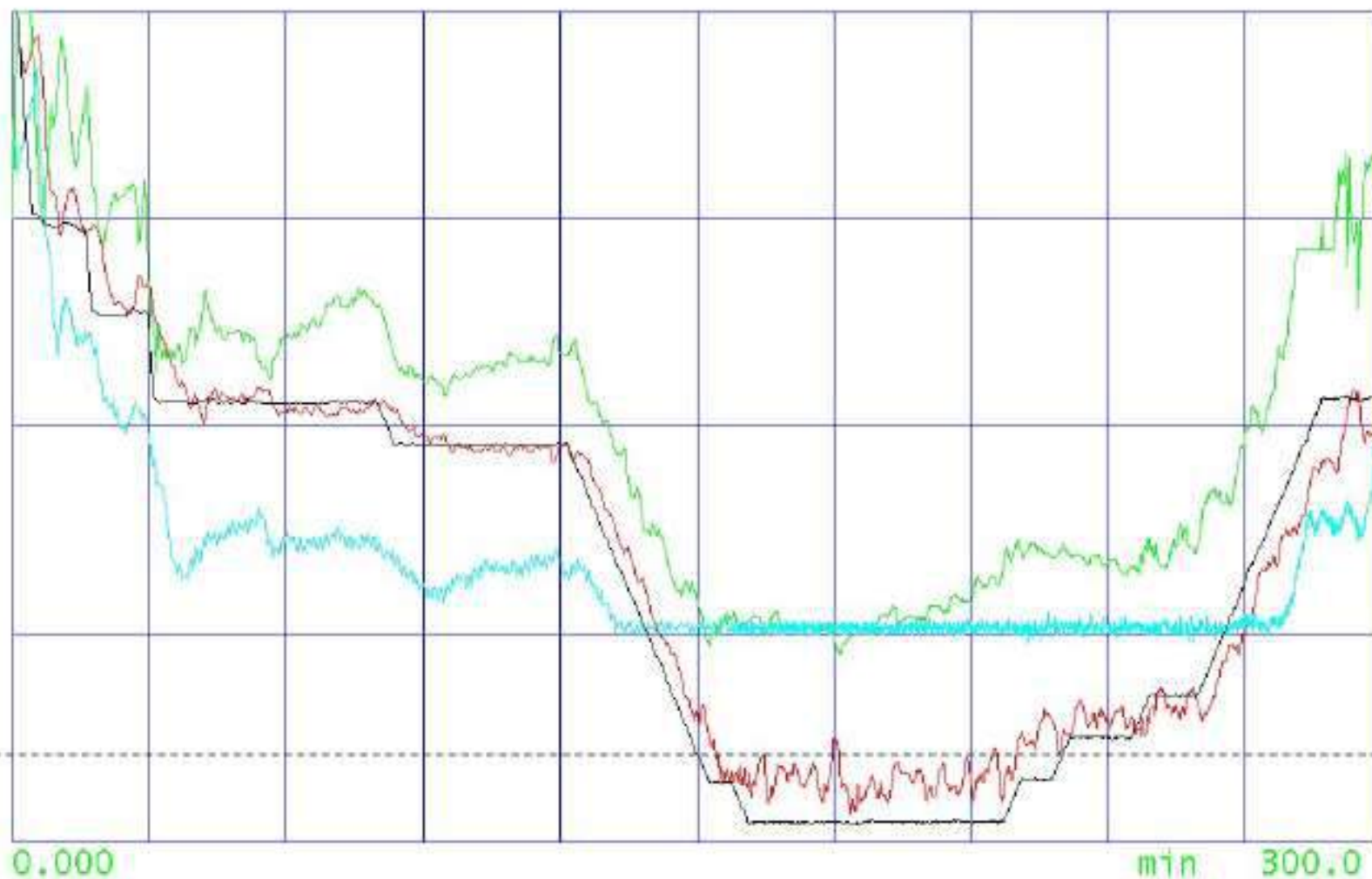


Results in a STEAG power plant

$\Delta = 50 \text{ MW}$
 $\Delta = 10\%$
 $\Delta = 10\%$
 $\Delta = 50 \text{ MW}$

P_{el}
 m_{fuel}
 m_{Evap}
 $SP_{P_{el}}$

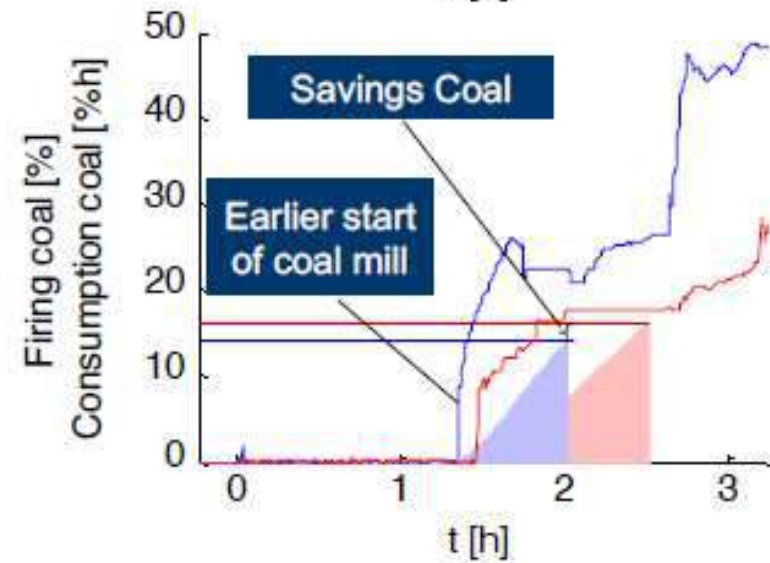
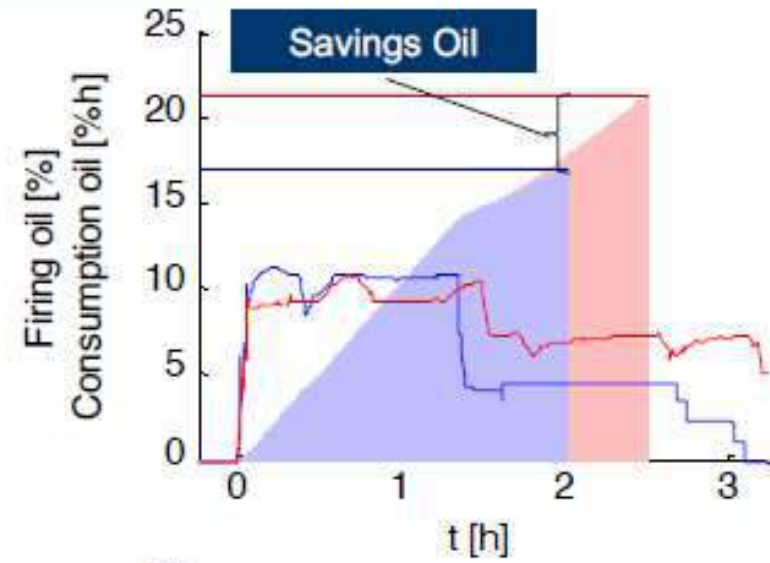
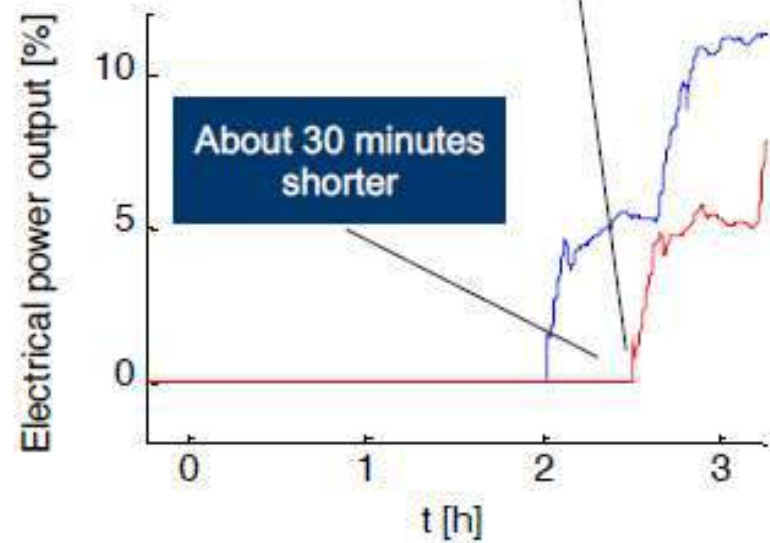
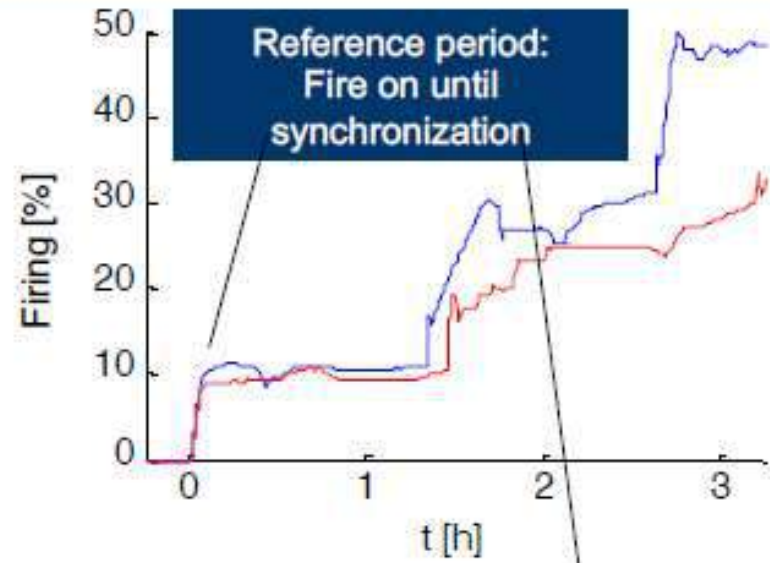
$P_{el} \approx 20\%$



APC based optimization without any process modifications required

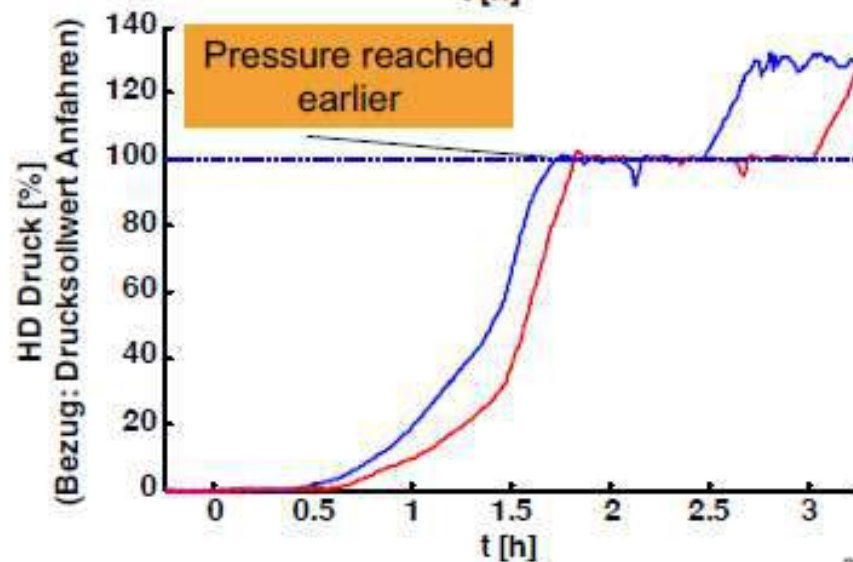
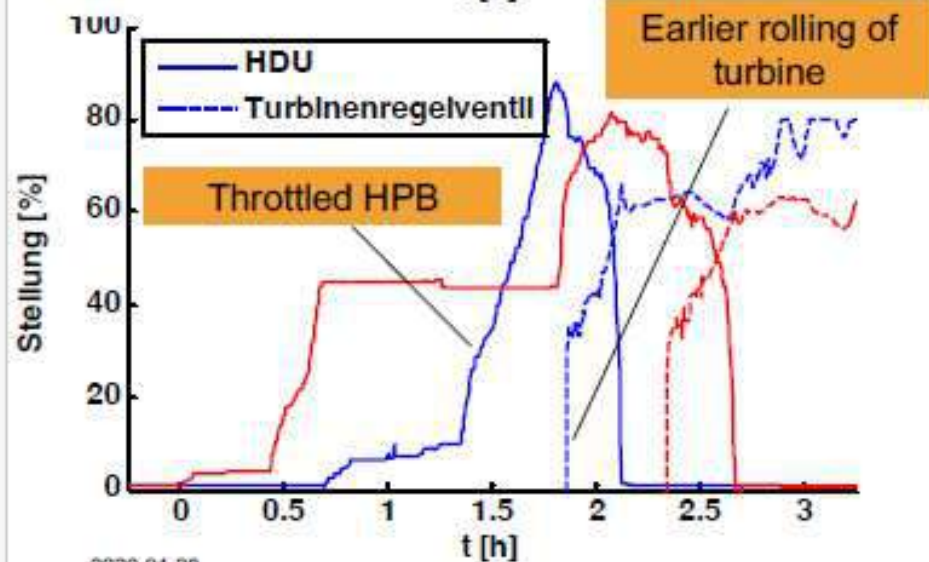
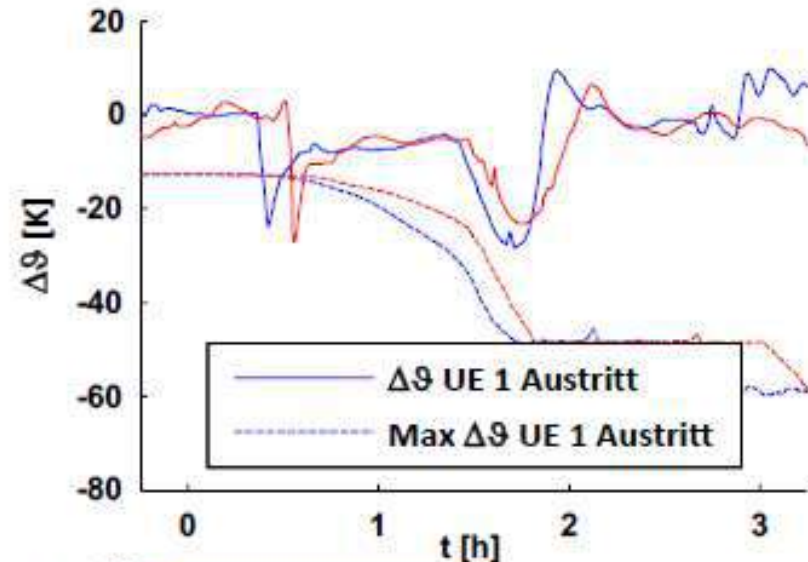
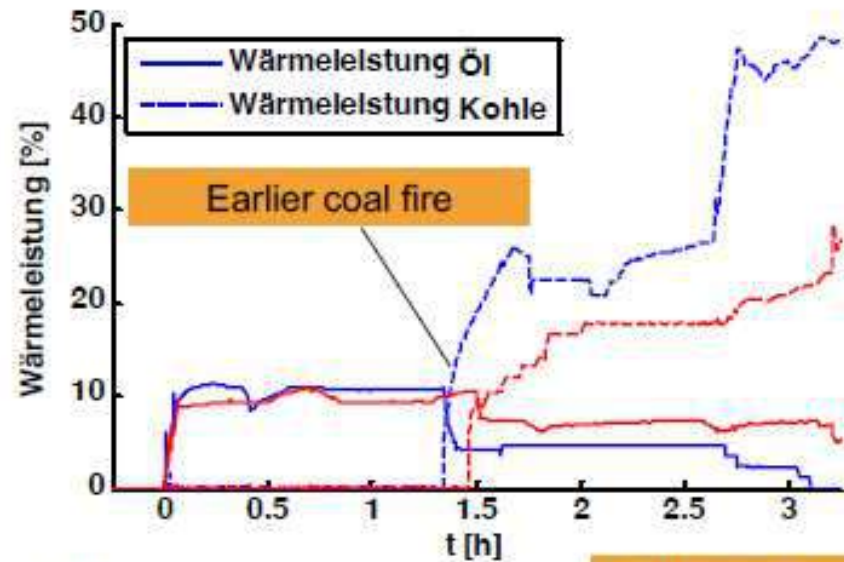
Results in a STEAG power plant

Automated start-up vs. Good manual start-up



Results in a STEAG power plant

Automated start-up vs. Good manual start-up



Training Objective



Importance for any Power Plant

- **Safe, reliable and efficient O&M**
- Require **competent O&M staff.**



Concerns

- A single mistake on the part of an operator can result in **huge production loss**
- Practical experience can only be achieved through hands-on working experience and long years of service



Training is whole gamut of plant operation

- Companies can increase profitability through increase in efficiency and minimum failures
- Simulator is an advanced hands-on-training tool, used mainly for training in areas such as unit start-up, shut-down, load ramping, emergency handling etc.
- Simulator gives the feeling of operating a real power plant without incurring any generation loss or damaging any plant equipment's.
- It raises the level of proficiency and builds up confidence required to handle emergencies in an actual plant operation.

Simulator is the best tool for an operator to build, practice, keep up to date and develop confidence on their skill

Simulator Training Benefits



Special skills and confidence are required for coal-fired power plant operators to adapt fluctuation due to renewables.



Flexibilization operation is new for the operators.



A training simulator is required for the operator to practice and build up confidence.



Operator will learn fast ramp up and ramp down as well as minimum stable load operation – with necessary monitoring of the parameters.



Learning flexibilization operation effects on critical parameters; MST, Spray, A/F ratio, FW flow, Turbine operation

“Simulator-based learning enables operators to practice flexibility safely without risk to actual plant equipment.”

A Systematic Training Approach

Becoming a Flexpert!

FLEXIBLE OPERATION TRAINING FOR COAL-BASED POWER PLANTS



Study

- E-learning, awareness workshops and professional seminars
- Target: acknowledge the need for flexibility, understand principles of operation of flexible power plant



Try

- Using Simulator: Try out flexible operation on Power plant operator training Simulator
- Test runs at own plant as per CEA guidelines



Apply

- Implement new procedures in the operational scheme (e.g. mill scheduler, switch over of pumps and fans)
- Increase level of automation for routine sequences and optimize control system
- Implement advanced control solutions.

LEARNING



SIMULATOR TRAINING



PRACTICAL APPLICATION



To upskill Operation engineers as “**Flexperts**” for smooth operation of coal based generating units

STEAG's Unique capabilities on Simulator



STEAG's experience as power plant owner, operator and training provider adds significant value in developing realistic simulator solutions including flexibilization scenarios.



STEAG's exclusive collaboration with TRAX , USA, TRAX is world's famous Simulator tool developer and supplier of more than 300 simulators globally

STEAG's Training Centre is recognized by CEA, Ministry of Power, Government of India

STEAG Training Centre has various simulators with knowledge of knowhow to set up training centre with various simulators.



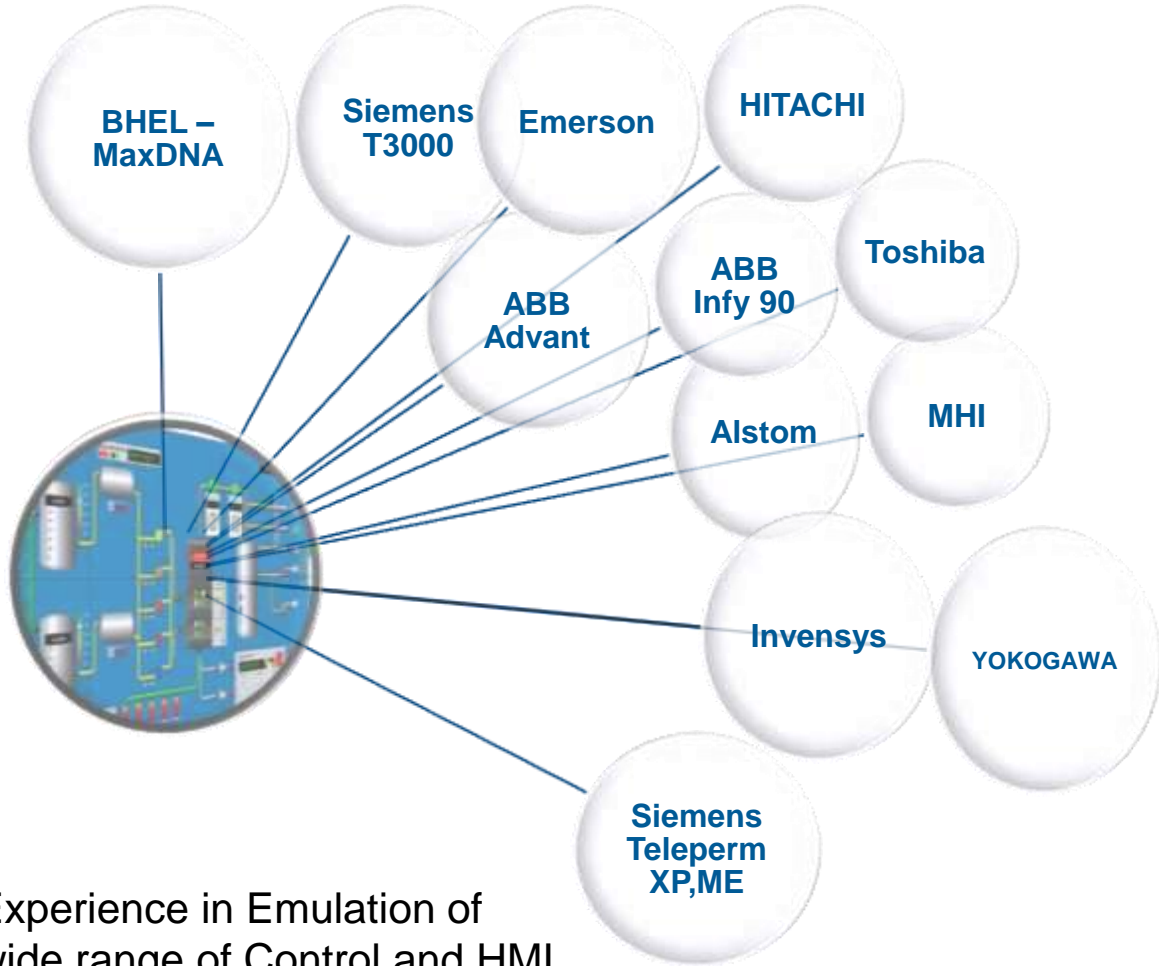
STEAG has successfully executed a turnkey project for setting up training centre with 11 high fidelity Simulators for NTPC Ltd.

Apart from NTPC, STEAG helped to set up training centre for RAWEC-KSA,HIWPT-KSA, NAPTIN- Nigeria, ZPC – Zimbabwe, BPC- Botswana, various Indian state utilities



STEAG's experience in Simulators covers most of the fuel technologies (coal, gas, hydro, oil, solar, Biomass) and key global OEMs of equipment and DCS.

Simulator Credentials

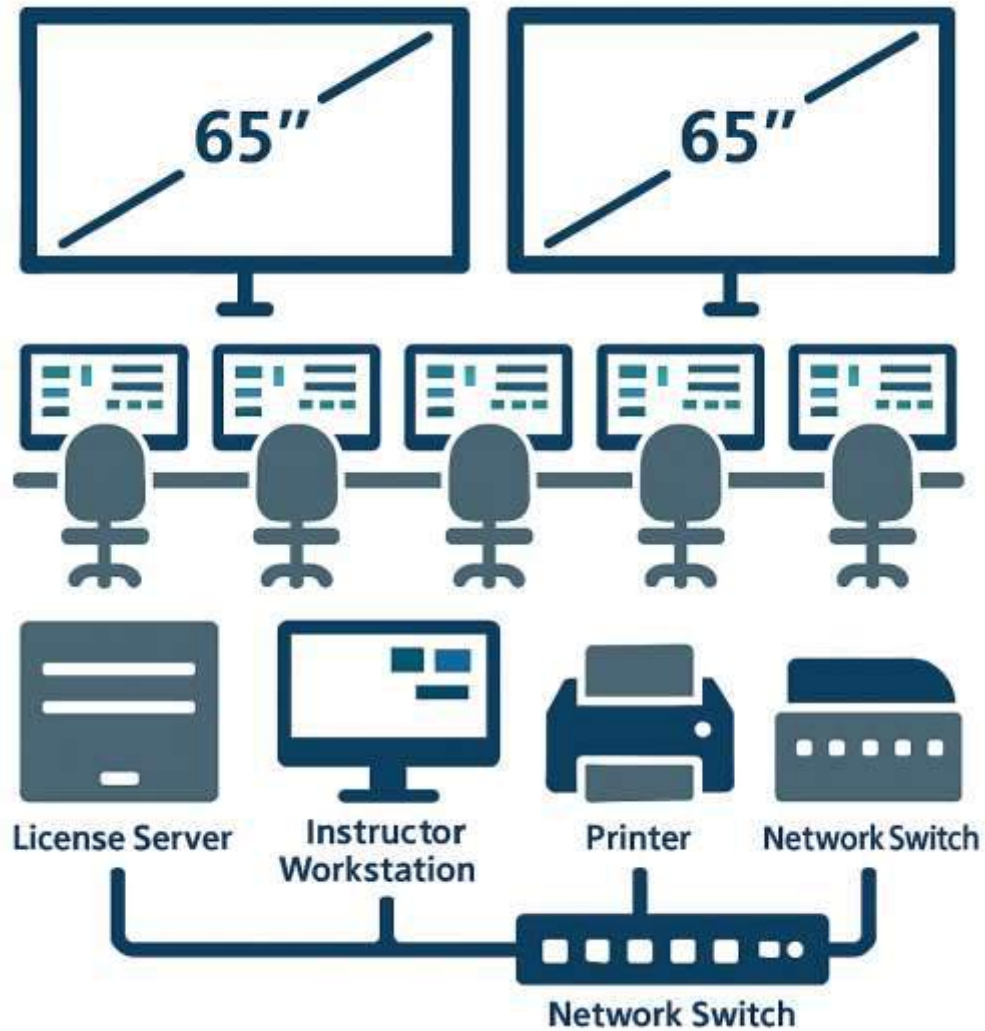


Experience in Emulation of wide range of Control and HMI

Sr. no.	Type of Simulators	Credential Nos.
1	Coal Fired	25
2	CCGT	6
3	Solar Thermal	1
4	Oil fired	1
5	Hydro	1
6	Biomass	1
7	RO & FGD	1

Simulation of Different Fuel Technology

General Network Architecture of a Simulator

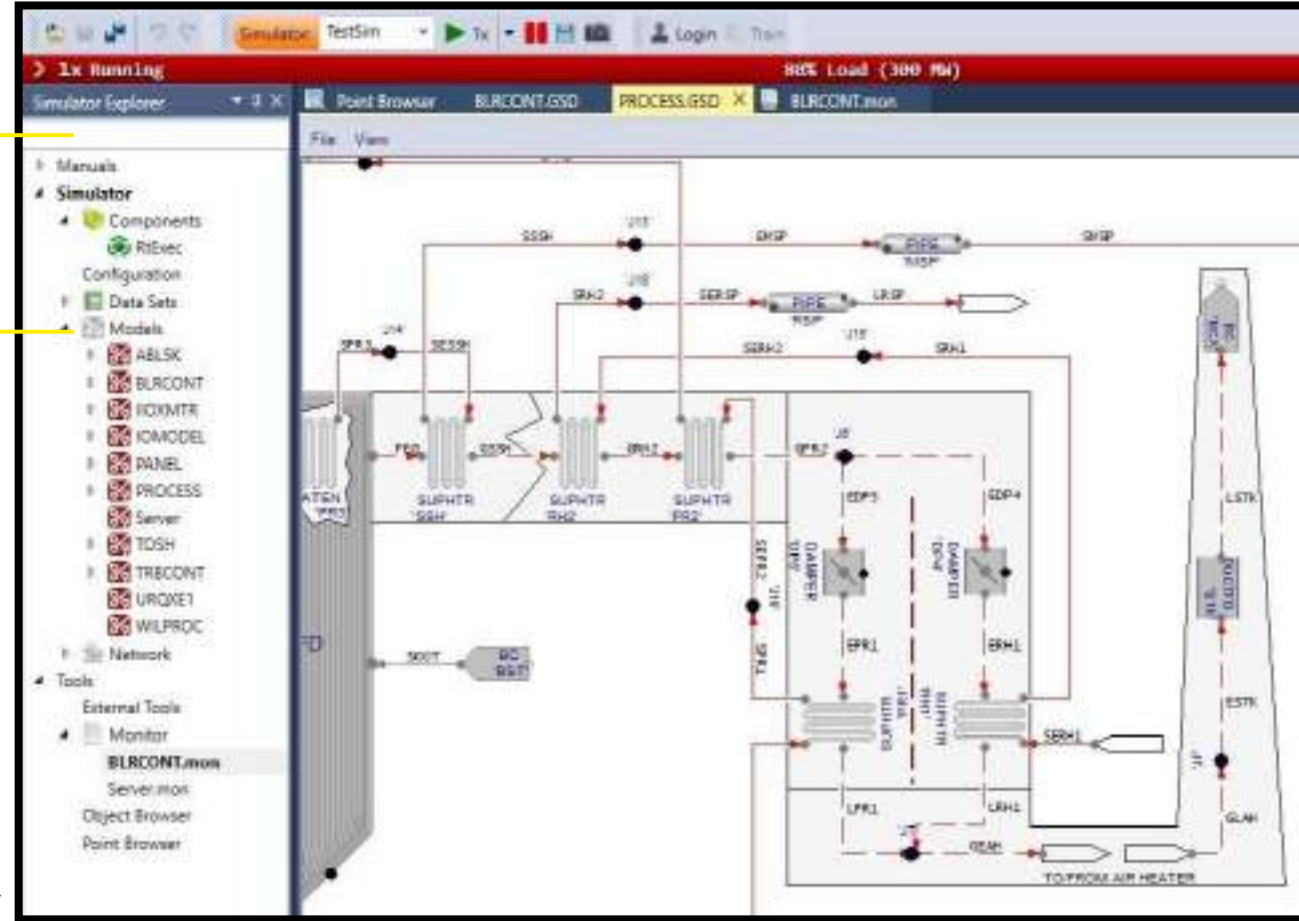


General Network Architecture of a Simulator

ProTRAX- Simulation Tool

ProTRAX instructor function, Training proficiency, Malfunctions, etc.

Modeling of the Plant process model and Controls



INSTRUCTOR
STATION



Matured



Precise



All International
standards for Accuracy

Simulation Tool: ProTRAX

STEAG is exclusive partner of TRAX in India .



For over 30 years, TRAX has been the world's leading supplier of high-fidelity power plant operator training simulators.



Extraordinary experience: over 300 simulators delivered



ProTRAX, is a modular, dynamic simulation tool*



Software is mature, precise, and comply to all international standards for accuracy.*

ProTRAX Features

Ease of Model Development –
Drag and drop of components...

Object oriented
GUI based model
building and
runtime software
since 1989

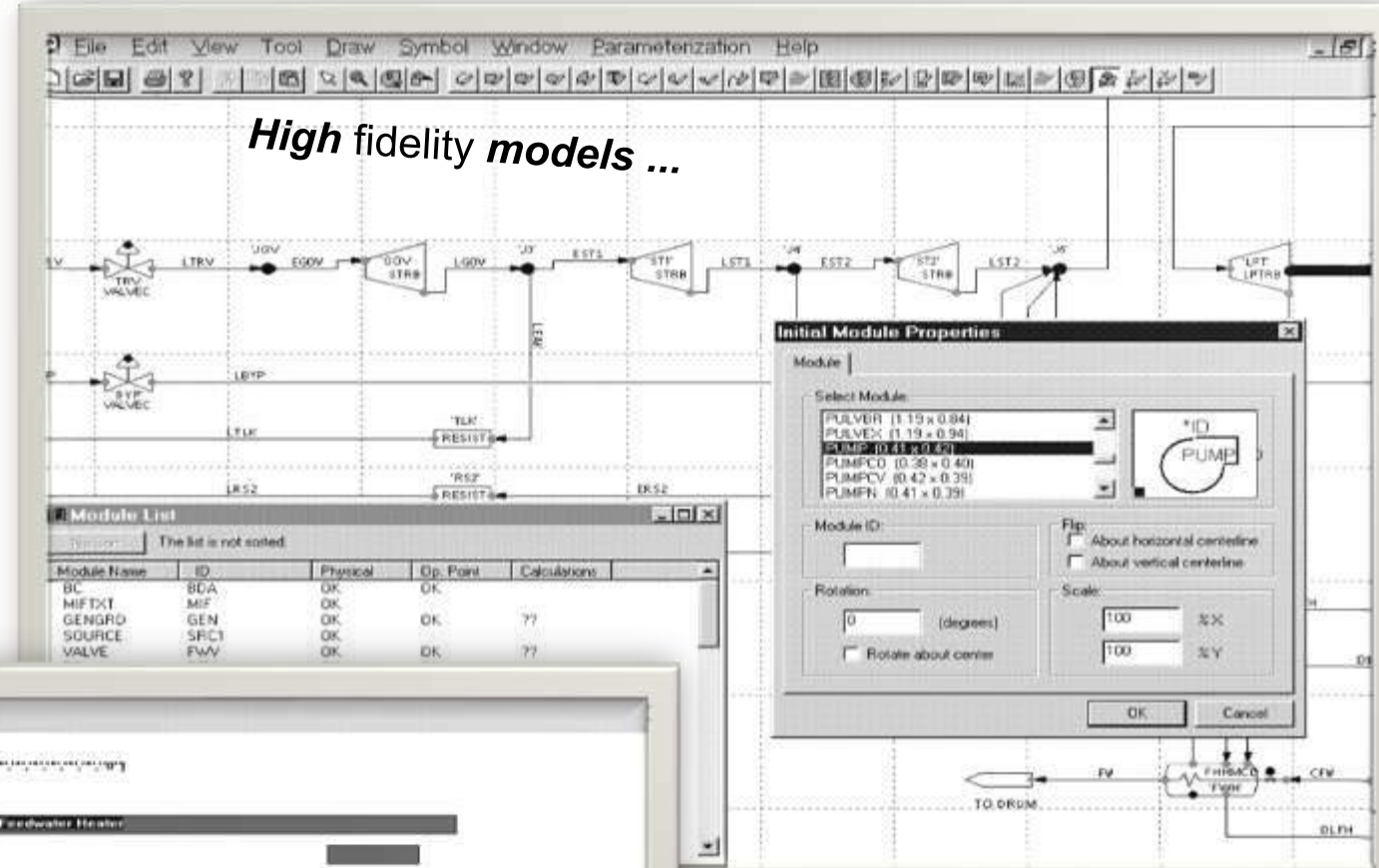
Windows operating
system

Large library of
component models
(Plant Equipment)

Structured data
entry

First principles
modeling

Training features



Parameterization

Parameter	Value
Tube Inner Diameter [m]	0.565
Tube Outer Diameter [m]	0.750
Straight Effective Tube Length [m]	30.900
Inside Diameter of Heater [m]	56.000
Length of Heater Shell [m]	37.000
Number of Tubes	1100
Number of Tube-side passes (Ntube = 2)	2
Thermal Cond. of Tube Wall [W/m²K]	25.000
Height of Lowest Tube [m]	4.000
Height of Highest Tube [m]	52.000
Fouling (m F 1/2) [m]	0.000

ProTRAX – Instructor Functions

Training Scenarios

Trends

Plot

Logs

Initial Condition

Run/Freeze

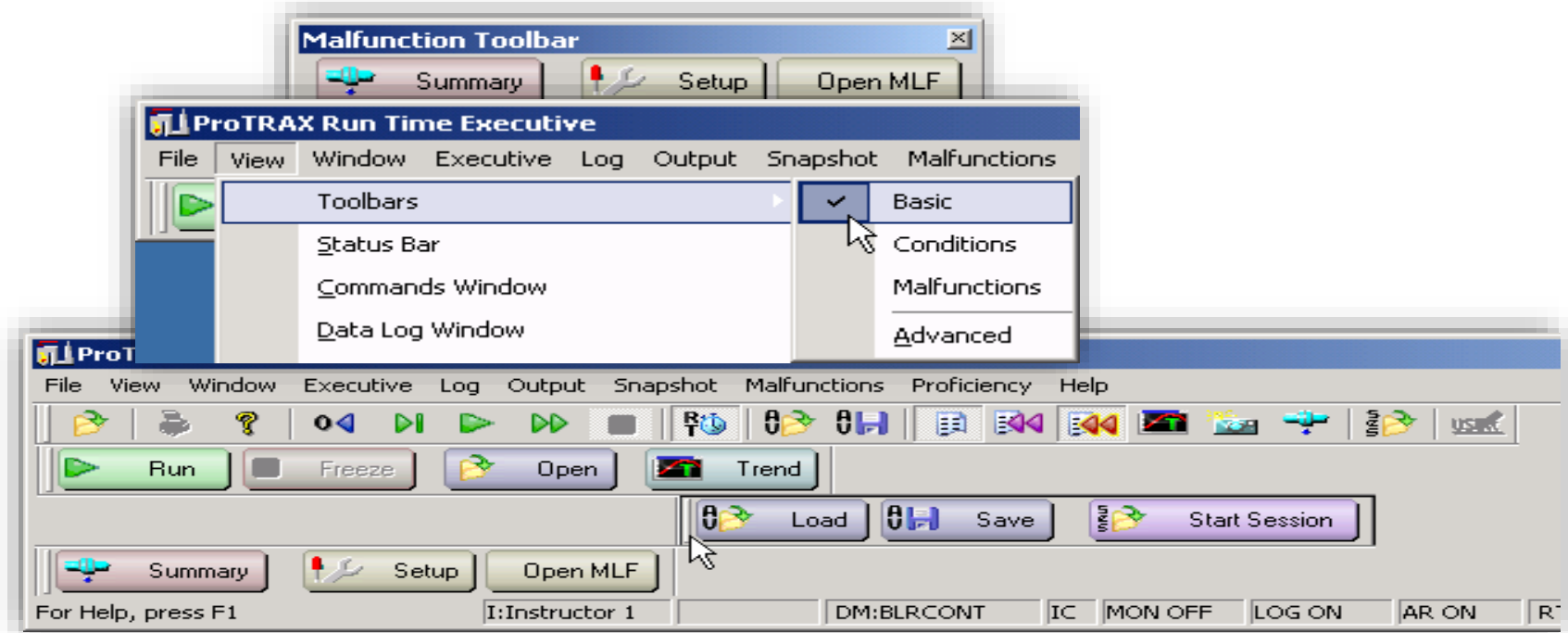
Fast/Slow Time

Dynamic Schematic

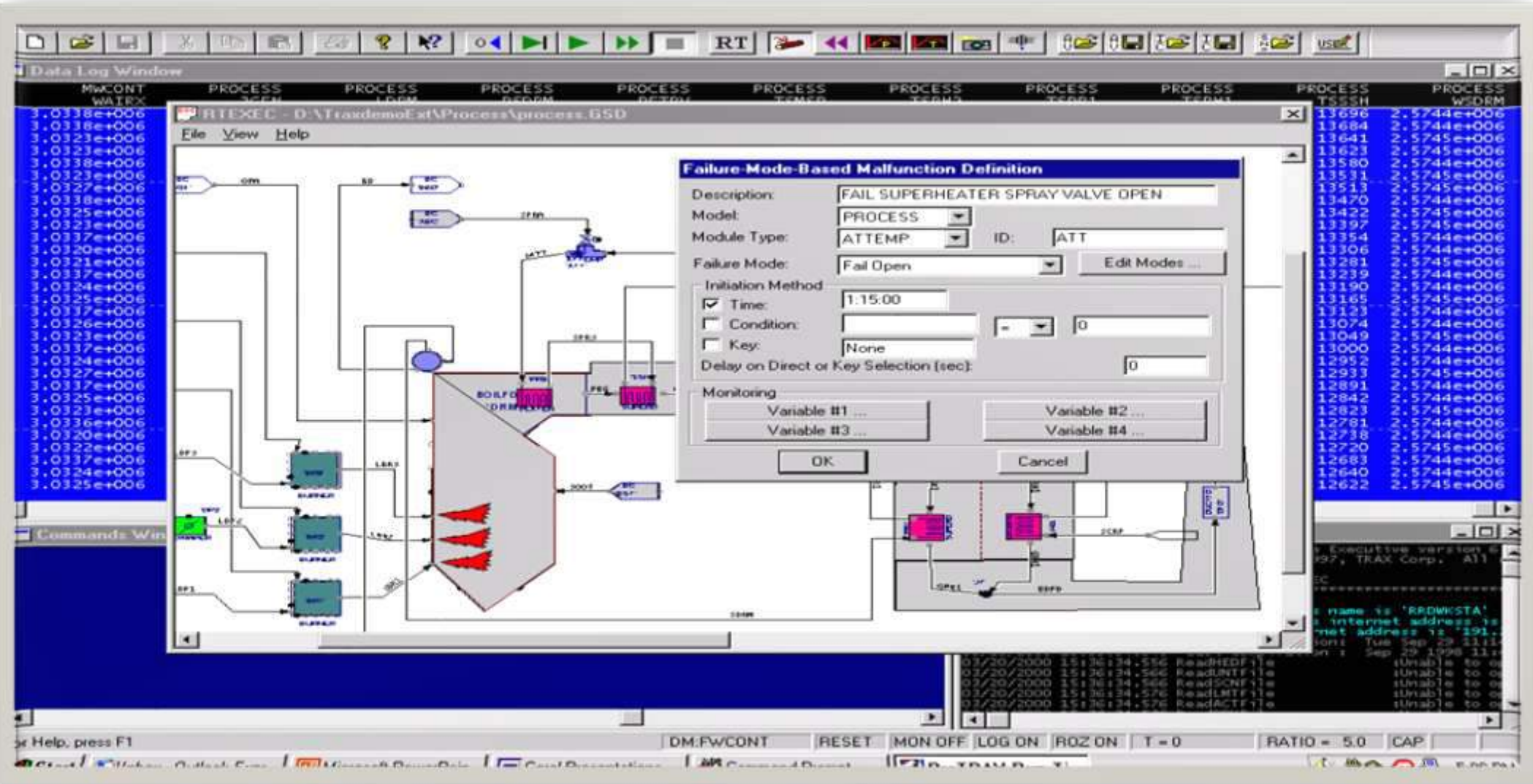
Malfunctions

Parameter Changes

Snapshots



ProTRAX - Malfunctions

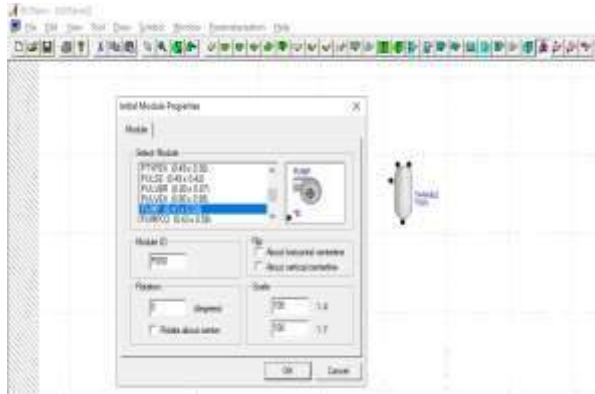


The screenshot displays the ProTRAX software interface. The main window shows a process diagram with various components like pumps, valves, and tanks. A dialog box titled "Failure-Mode-Based Malfunction Definition" is open, showing the following configuration:

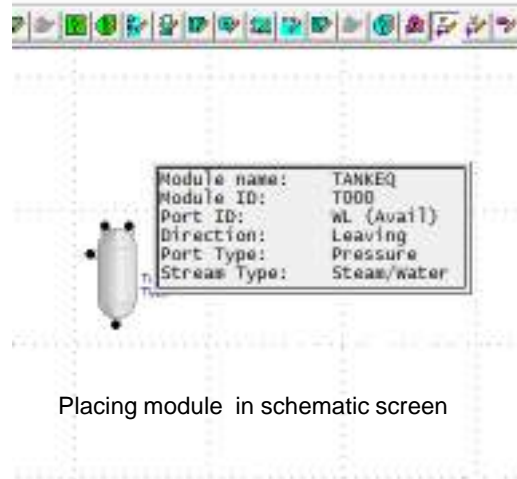
- Description: FAIL SUPERHEATER SPRAY VALVE OPEN
- Model: PROCESS
- Module Type: ATTEMP
- ID: ATT
- Failure Mode: Fail Open
- Initiation Method:
 - Time: 1:15:00
 - Condition: [] = [] 0
 - Key: None
- Delay on Direct or Key Selection (sec): 0
- Monitoring: Variable #1, Variable #2, Variable #3, Variable #4

The background shows a data log window with a list of process variables and their values, and a command window with system logs.

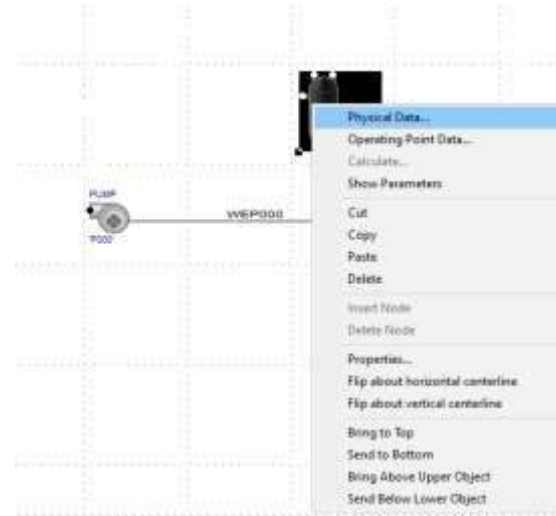
Basic Model Development steps



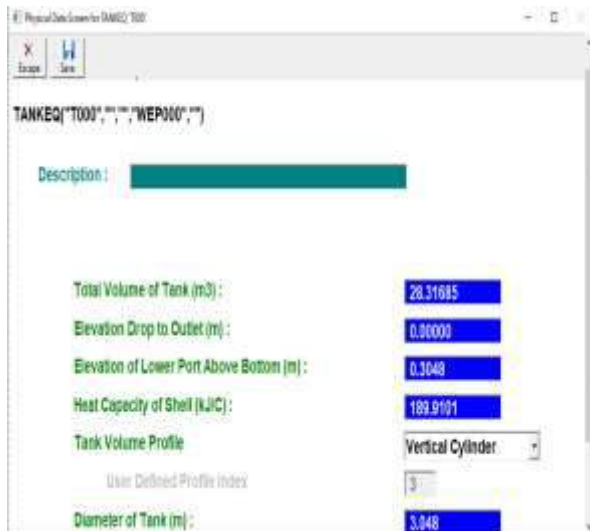
Selection of suitable component



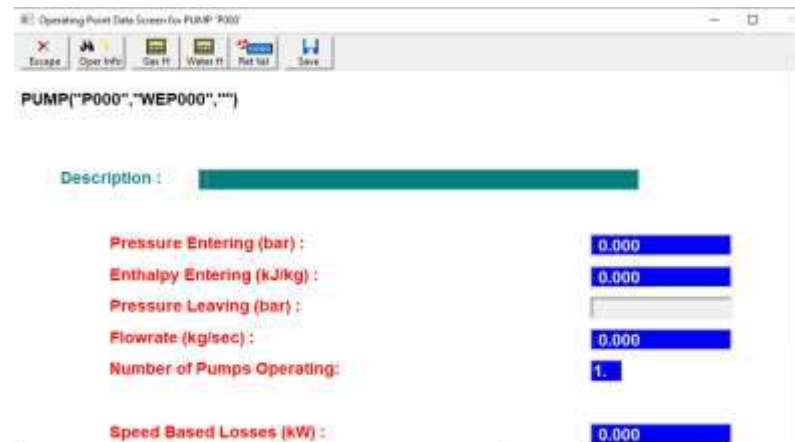
Placing module in schematic screen



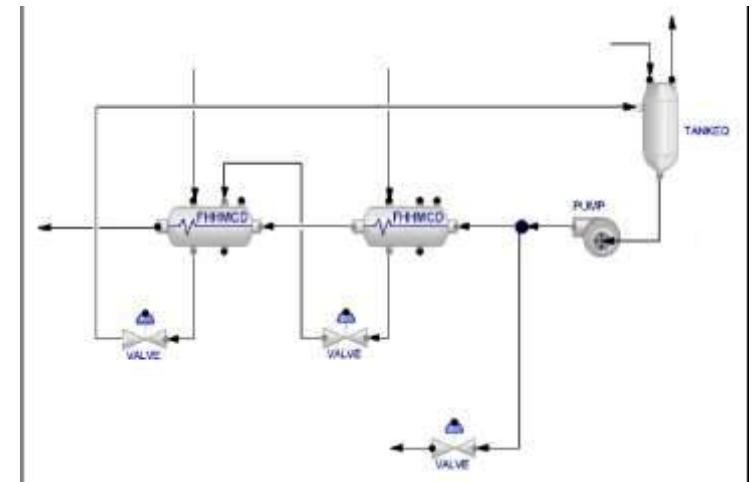
Component property window for parameterization



Physical data of the module



Operating data of the module



Sample model

Customization of Generic to plant Specific Module

Physical Data Screen for SUPHTR 'LTSHL'

Escape Save

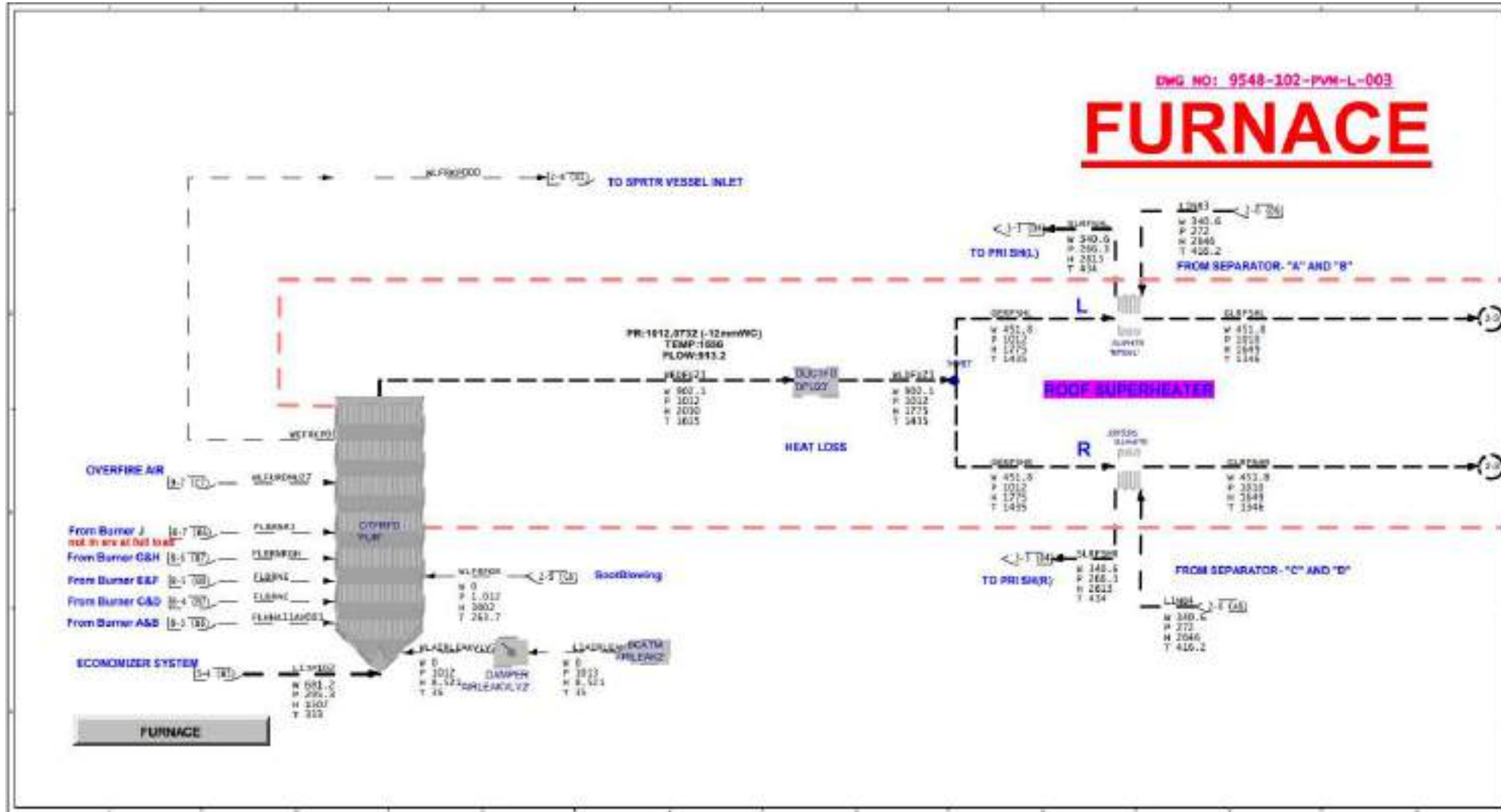
Tube Inner Diameter (cm) :	0.470
Tube Outer Diameter (cm) :	3.800
Center to Center Spacing Parallel to Gas Flow (cm) :	12.000
Number of Tubes Parallel to Gas Flow :	656
Center to Center Spacing Perpend. to Gas Flow (cm) :	12.000
Number of Tubes Perpend. to Gas Flow :	656
Number of Parallel Tubes in the Same Flow Path :	656
Average Length of Tube Passes (m) :	8.000
(See AIM for Detailed Information)	
Fin Spacing (cm) :	0.000
Fin Width (cm) :	0.00000

Operating Point Data Screen for SUPHTR 'LTSHL'

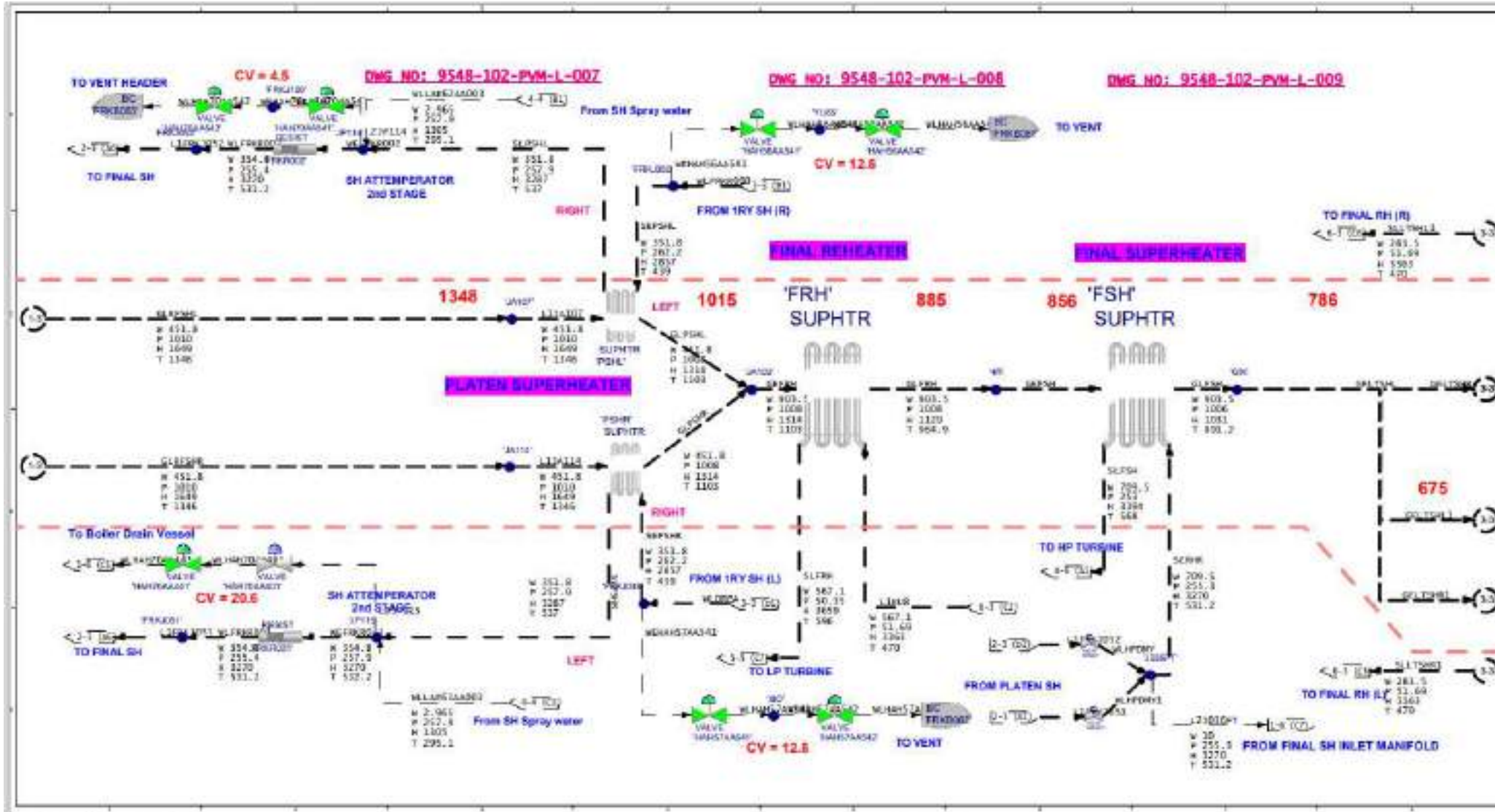
Escape Oper Info Gas H Water H Ret Val Save

Pressure of Steam/Water Entering (bar) :	259.000
Enthalpy of Steam/Water Entering (kJ/kg) :	3016.395
Flowrate of Steam/Water Entering (kg/sec) :	258.3465
Pressure of Steam/Water Leaving (bar) :	255.000
Enthalpy of Steam/Water Leaving (kJ/kg) :	3226.000
Pressure of Gas Entering (mbar) :	956.740
Flowrate of Gas Entering (kg/sec) :	380.000
Enthalpy of Gas Entering (kJ/kg) :	974.6013
Pressure of Gas Leaving (mbar) :	955.590
Composition of Gas (mass fraction):	
Water Vapor (H ₂ O):	0.00000765

Plant model schematic (Furnace screenshot)



Plant model schematic (Superheater screenshot)



OTS Supplied by STEAG





- RAWEC SAUDI ARABIA** Captive Power plant
Simulation for 815 MW, Oil Fired
- (1) 13 Boilers,
 - (2) 7 Turbine
 - (3) 5 Limestone FGDs
 - (4) 24 Sea water reverse osmosis Desalination plant

NTPC SOLAPUR

Eleven simulator in two set of hardware.

(1) 800 MW simulators

- KUDGI 800
- DARLIPALLI 800
- LARA 800 MW
- GADARWARA 800 MW
- TELENGANA 800 MW

(2) 660 MW simulators

- SOLAPUR 660 MW
- MEJA 660 MW
- BARH-II 660 MW
- TANDA STAGE-II 660MW
- KHARGONE 660 MW
- BARH-I 660 MW



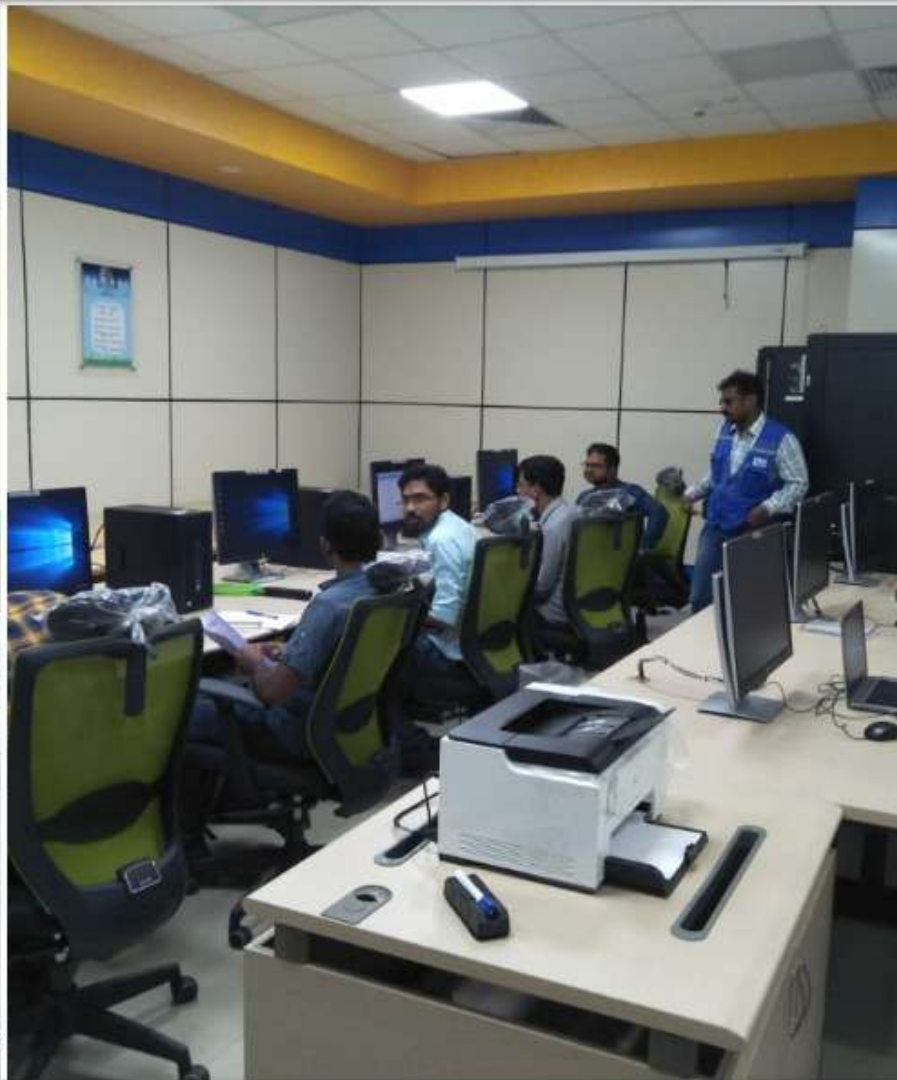
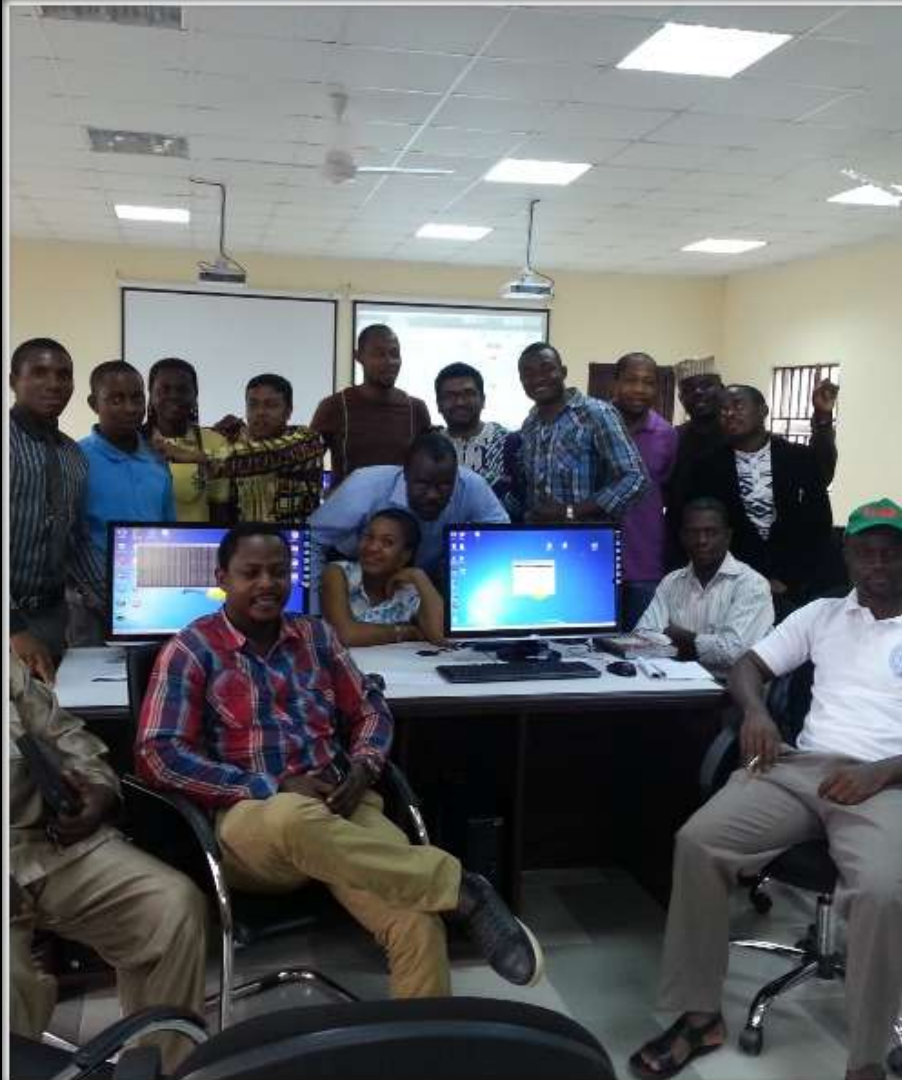
NPTI Nangal Hydro Simulator



**Hydro Simulator ,
NPTI Nangal, 250
MW**

**Control System-ABB
Advant**

Turbine -Francis



LEFT PICTURE:

NAPTIN NIGERIA 440 MW CCGT SIMULATOR

HRS-G-Siemens

ST-BHEL

GT-Siemens AG

V94.2 Combined Cycle

Fuel: HSD, Naphtha, Natural
Gas

RIGHT PICTURE:

NTPC KUDGI 800 MW

SG-Siemens

TG-Toshiba,

BOP-Yokogawa



NAPTIN NIGERIA 440 MW CCGT SIMULATOR

HRS-G-Siemens

ST-BHEL

GT-Siemens AG

V94.2 Combined Cycle

Fuel: HSD, Naphtha, Natural
Gas





RRVUNAL KOTA THERMAL POWER PLANT 195/210 MW COAL FIRED

SG- MAXDNA
TG- MAXDNA
BOP-ABB

Flexibilization programs with GIZ, VGBE & EEC



Flexibilization programs with GIZ, VGBE & EEC



Flexibilization Training – 500 MW Simulator



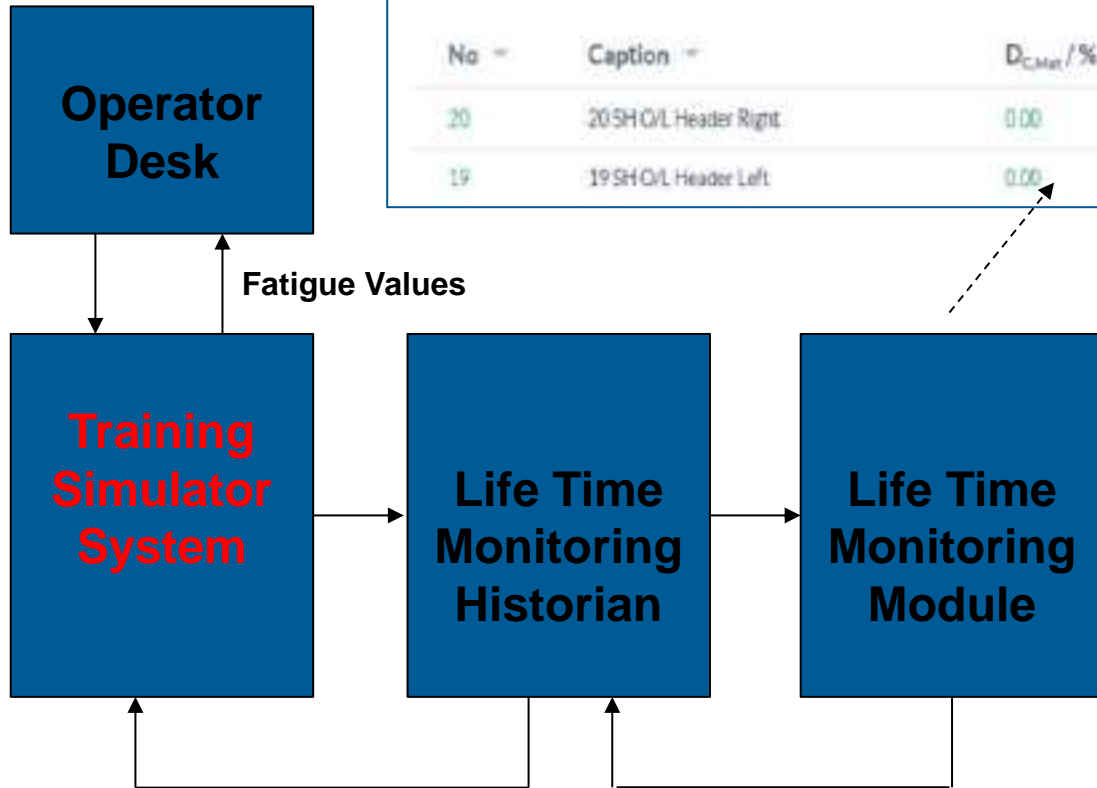
FLEXIBILIZATION – 1st Successful Completion of Pilot Training & Demo
40% Technical Min Load in Auto Mode on Simulator



Flexibilization Training – 660 MW Simulator



Integration of Flexible Simulator with Life Time Monitoring SR1



steag SR1 Cockpit

08/28/2017 20:10

UNIT SUMMARY
MOUD44

No	Caption	D _{Crit} / %	D _{Fat} / %	D _{total} / %	D _{300,000h} / %	D _{First} / %
20	20SH O/L Header Right	0.00	0.07	0.07	<div style="width: 100%;"></div>	0.27
19	19SH O/L Header Left	0.00	0.07	0.07	<div style="width: 100%;"></div>	0.27

1. Starting simulator with specific ramping and / or disturbances.
2. Data like temperatures, pressures, main steam mass flow goes to SRx Server
3. SR1 calculations start and transfer fatigue results to simulator historian

Advantage:

1. Increasing trainee's awareness of the impact of the boiler startup / shut down ramping on the wear of its thick-walled elements
2. Possibility of examining how different ramping values affect fatigue of thick-walled boiler elements and piping

Key Takeaways



Flexible thermal operation is essential for renewable integration



Flexibilization requires both technology and operator competency



Simulator-based learning enables safe operational preparedness



STEAG supports utilities through practical implementation experience



Building Flexperts for a Reliable Energy Transition



Thank You

STEAG Energy Services (India) Pvt. Ltd.

A-29, Sector 16,

NOIDA 201 301

Phone +91 120 4625-320

Telefax +91 120 4625-000

www.steag.in

steag