PowerOPTI

NPP Thermal Performance Monitoring & Optimization System

NPP continuously generates a huge amount of process data. The important objective is their validation, correct interpretation and utilization for control, diagnostics and optimization purposes.

OBJECTIVE

Enhancement of power output, performance supervision and equipment health diagnostics.

FUNCTIONS

- **Early warning of hidden faults and performance degradation**, long trend evaluation of critical equipment performance – turbine, condenser, heat exchanger, cooling tower
- **Unit power output uprate** by cooling water flow rate optimization
- **Lost megawatt hunting**
- **Accurate on-line reactor thermal output calculation**, uncertainty reduction of calculate value compared to actual one

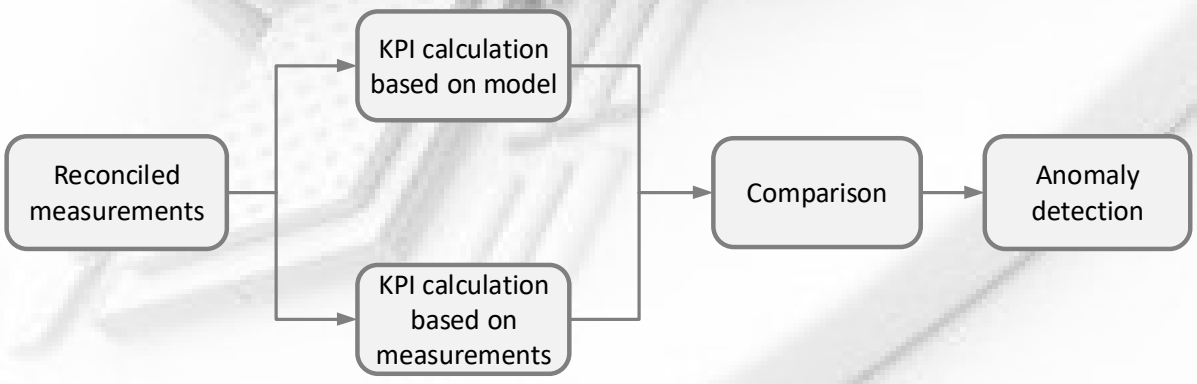
KEY COMPONENTS

(1) On-line robust measured data validation and reconciliation by mathematical model based on mass and energy balances:

- Detection, identification and elimination of gross errors in measurements
- Accuracy of measurement improvement
- Reliable calculation of unmeasured variables and **KPI** (**key performance parameter of equipment / process**); reactor thermal output, cooling water flow rate, turbine efficiency, etc.

(2) **On-line equipment health diagnostics and thermal cycle optimization** by high accurate empirical models (digital twins). Comparison between actual and expected states in given operating conditions:

- Turbine
- Condenser, heat exchanger
- Cooling tower, cooling circuit



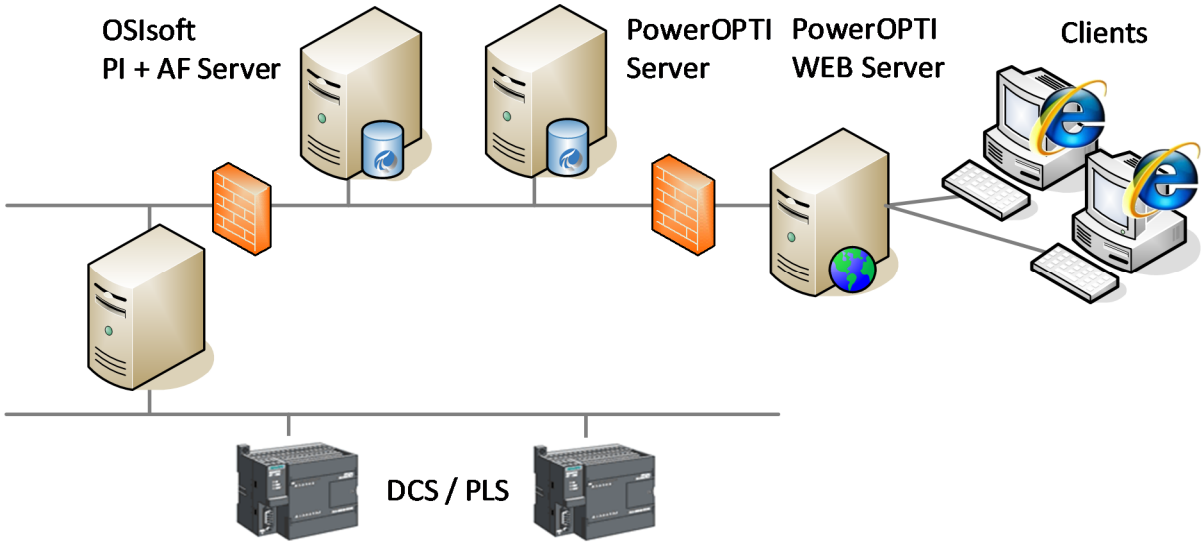
Empirical model accuracy vs. output power loss; fault detection ability = power loss prevention

Equipment	Fault detection starting	Reliable fault detection	Output power loss
Condenser	↑ 0,1 kPa	↑ 0,2 kPa	↑0,5 kPa → 5 MW loss / 1000 MW turbine
Turbine	↑ 1,0 MW	↑ 2,0 MW	= loss detection
Cooling tower	↑ 0,2 °C	↑ 0, 4 °C	↑1, 0 °C → 3 MW loss / 1000 MW turbine

BENEFITS

(1) Better accuracy, better confidence in data
• Detection, identification and elimination of measurement errors • Measurement accuracy improvements, reconciled values satisfy mass and energy balances
(2) Deep view inside the processes and equipment health
• Unmeasured quantities and KPI calculation • Unusual states detection and to this time unused information exploitation
(3) Equipment supervision & diagnostics
• On-line equipment health evaluation, early fault detection • Process performance supervision, lost MW hunting, predictive maintenance support
(4) Process optimization & prediction
• 1 to 2 MW power output uprate for 1000 MW unit / twin unit • Accurate power output planning

M&O structure example using OSIsoft components



DEPLOYMENT ACTIVITIES

- Data validation and reconciliation; gross errors detection, identification and elimination
- Diagnostics model building; equipment fault detection, evaluation of degradation trends
- Trail operation; loss MW hunting
- Cold end turbine optimization; power output uprate

BUSINESS CASE EXAMPLE: VVER NUCLEAR POWER PLANT (2 000 MWe) 2015 – 2017

Cooling water flow rate optimization; turbine power output – CW pump power input	2,0 MW power uprate 350 000 EUR/1 year income increasing
Early condenser fault detection	1,5 MW output power decreasing elimination 120 000 EUR/3 month loss elimination
Fouling evaluation of cooling tower fills	3,5 MW output power decreasing elimination 550 000 EUR /1 year loss elimination

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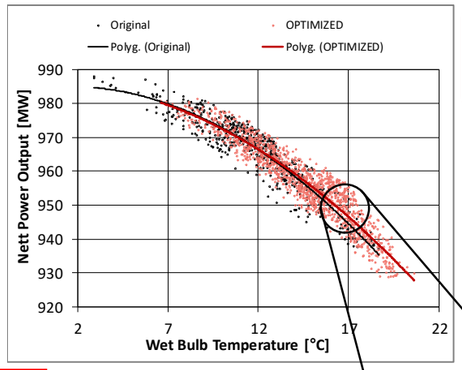
Reactor heat output accurate calculation
- Based on FW flow rate and temperature measurements
- Validation of primary circuit temperature sensors
- Elimination of hot loop temperature stratification

Accuracy 0.5 %

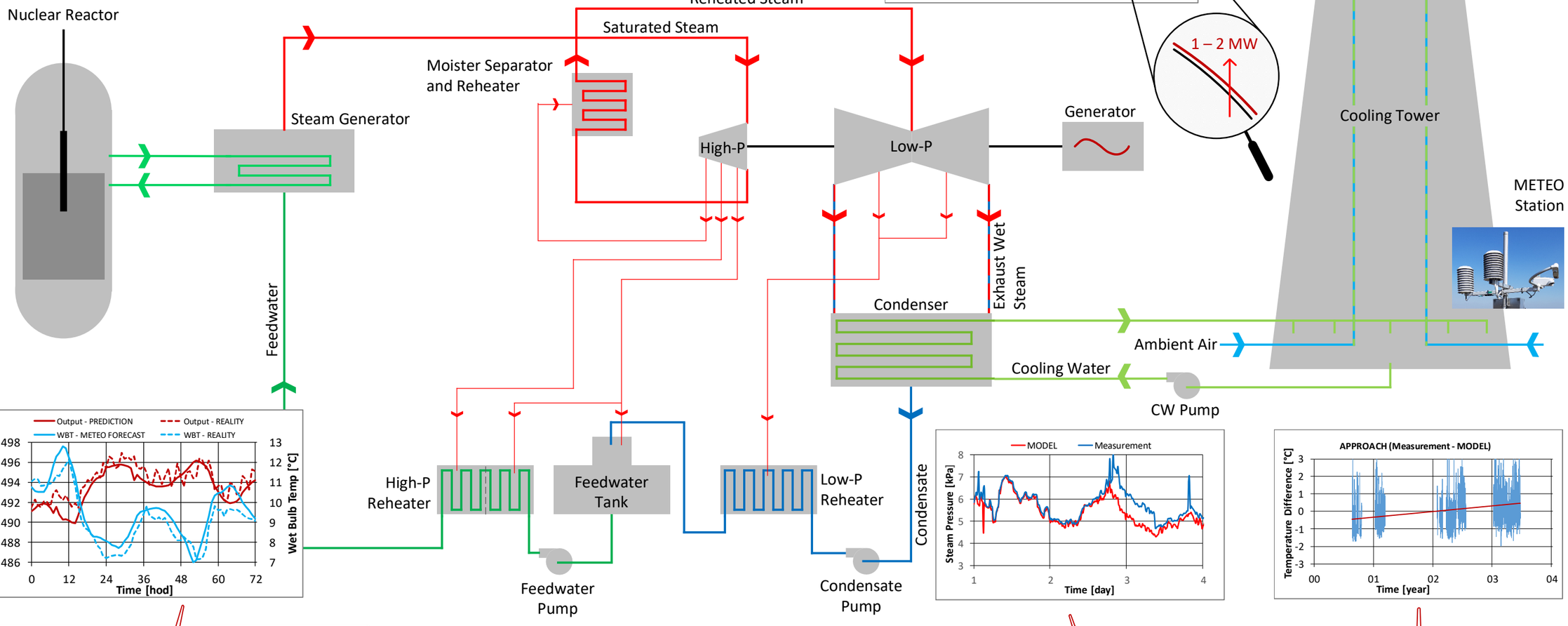
On-line Turbine Diagnostics
- Early alarms, after service testing
- Air in-leakage, exchanger fouling, ...
- Unmeasured quantities and KPIs calculation

Accuracy 2,0 MW (1,0 MW)



Turbine cold end Optimization / Cooling water flow rate optimization

1000 MW unit power uprate ↑ 1 MW (2 MW)



On-line Unit Supervizion & Diagnostics
- Power output accurate prediction
- Loss MW hunting
- Thermal efficiency enhancement

Accuracy for 1000 MW unit 2,0 (1,0) MW

On-line Condenser Diagnostics
- Early alarms
- Air in-leakage, fouling

Accuracy 0,2 kPa (0,1 kPa)

Off-line Cooling Tower Diagnostics
- Fill fouling and damaging
- Maintenance planning

Accuracy 0,4 °C (0,2 °C)