SPPA-P3000
Process Optimization
Solution Compendium

Instrumentation & Controls
Siemens Power Plant Automation

Comprehensive solutions with outstanding benefit

Process Optimization

Our competence: power plant automation and IT know-how
Can I ... 

... optimize plant performance with software only?

Yes you can!
**The situation:** A power plant unit needs to be operated at all times at the most profitable operating point, which calls above all for greater **flexibility** and higher **efficiency**, better **availability** and lower **emissions**.

**Our solution**

Process Optimization Solutions SPPA-P3000
Increase performance!
Solutions for process optimization

Modern control principles are the basis for high profitability

Excellent control concepts are at the base of Process Optimization Solutions:

- model-based, predictive feedforward structures
- exploitation of inherently stable processes
- decoupling of highly intermeshed subprocesses

As a result, operating behavior is extremely stable, but still features flexible and fast response.
SPPA-P3000 Process Optimization for Steam Power Plants

Increased profitability by intelligent optimization solutions!

Runback Plus
Life Time Plus

High availability

Low Loss Start
Combustion Optimizer
Sootblower Optimizer

High efficiency

Temperature Optimizer
Low Throttling
Fuel Optimizer
Best Point

Low emissions

Emissions Control

High flexibility

Fast Start
Fast Ramp
Frequency Control

Dispatch Control
Minimum Load Reduction
Maximum Load Plus

No changes to mechanical equipment

Increased profitability by intelligent optimization solutions!
**Task:**
To get the unit back on the grid in the shortest possible time without thermal stresses for thick-walled components violating permissible limits.

**Features:**
- Model-based formation of setpoints for main steam pressure and temperature, and of firing rate
- Automatic startup of boiler and turbine
- Automatic differentiation between cold, warm and hot starts with bumpless transfer to coordinated power operation

**Benefit:**
- Reduction of forced trip duration
- Reduced fuel consumption
- Increased revenue through reproducible startup and shutdown to exploit market situation
SPPA-P3000 Process Optimization

**Fast Start**

*Increased revenues by getting back on the grid faster*

**References**

- **Parish, USA**
  - 565 MW, gas;
  - Startup time reduced by 50%

- **Simmering, Austria**
  - 380 MW, gas;
  - Startup time reduced by 25%

**Benefit for a standard unit**

- 300 MW lignite fired unit
- Startup time to full load reduced from 4 to 2 hrs
- 10 starts/year
- 50 EUR/MWh

**150,000 EUR/year**
Task:
Significant improvement of load gradients free from restrictions imposed by controls and from the need for manual actions.

Features:
- Automatic coordination of boiler and turbine
- Automatic derivation of dynamic setpoints from load setpoint and load gradient
- Optimization of control loops crucial to unit dynamics

Benefit:
Increased revenues thanks to
- Fast and repeatable response to changed load demands
- High ranking of the plant with grid dispatcher
SPPA-P3000 Process Optimization

Fast Ramp

Increased revenues by flexible response to market requirements

References

Vales Point, Australia
660 MW, coal
Load gradients doubled to 6%/min

Velsen 24, Holland
460 MW, Natural and industrial waste gas.
Load gradients tripled to 4%/min

Benefit for a standard unit

- 300 MW hard coal fired unit
- Load gradients increased from 2 to 2.5%/min, extending the load range from 30 MW to 37.5 MW after 5 min period
- Revenue (+)*: 90 EUR/kW/a
- Revenue (-)*: 35 EUR/kW/a

940,000 EUR/year for ± 7.5 MW

* Actual average values from EnBW, E.ON, RWE, Vattenfall

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Task:
Upgrade of the unit to provide primary frequency control and spinning reserve. Due to the fast load ramps that this service requires, it places very high demands on the dynamic control response of a power plant unit.

Features:
- Throttling of turbine valves
- Activation of condensate throttling to mobilize energy storage

Benefit:
- Increased revenues for primary frequency control and spinning reserve services
- Avoidance of fiscal penalties for non-provision of contractually agreed primary frequency control and spinning reserve services.
Lucrative services through frequency control

References

Völklingen, Germany
2 x 230 MW, hard coal
Frequency control range extended to 7.5%

Maor David, Israel
2 x 575 MW, hard coal
Frequency control range extended to 7.0%

Benefit for a standard unit

- 300 MW hard coal fired unit
- Frequency control using turbine valve throttling in the range of ± 7.5 MW
- Revenue (+)*: 115 EUR/kW/a

800,000 EUR/a for ± 7.5 MW

+ 3,700 t/a CO₂ (due to reduced efficiency)

* Actual average values from EnBW, E.ON, RWE, Vattenfall
**Task:**
Upgrade of the unit to provide increased secondary frequency control capability (AGC). Implementing faster load change rates will open up a larger window for high-return secondary frequency control services.

**Features:**
- Automatic coordination of boiler and turbine
- Automatic derivation of dynamic setpoints from load setpoint and load gradient
- Optimization of control loops crucial to unit dynamics

**Benefit:**
- Increased revenue through sale of secondary frequency control services
- Avoidance of fiscal penalties for non-provision of contractually agreed secondary frequency control services.
**SPPA-P3000 Process Optimization**

**Dispatch Control**

Lucrative services through dispatcher control

**References**

**Velsen 24, Holland**

460 MW, Natural and industrial waste gas. Load gradients tripled to 4%/min

**Vales Point, Australia**

660 MW, coal. Load gradients doubled to 6%/min

**Benefit for a standard unit**

- 300 MW hard coal fired unit
- Increased gradients rate from 2 to 2.5%/min, extending the load range from 30 MW to 37.5 MW after 5 min period
- Revenue (+)*: 90 EUR/kW/a
- Revenue (-)*: 35 EUR/kW/a

940,000 EUR/year for ± 7.5 MW

* Actual average values from EnBW, E.ON, RWE, Vattenfall
Task:
- Reduction of minimum load level imposed by process parameters
- Despite the reduction of minimum load level, fast and low-stress load increase capability on demand to meet market requirements.

Features:
- Adaptation, optimization and setting of lower-level controls for new minimum load level
- If necessary, supplementing of plant valves and sensors

Benefit:
- Reduced commercial losses during off-peak periods
- Faster response to increased load demands
- Avoidance of unnecessary start-ups and shut-downs

Potential for reducing the minimum load level through I&C optimization. Additional potential can be tapped by mechanical optimization.
Cost savings through reducing minimum load level

References

Parish, USA
565 MW, Benson gas;
Minimum load reduced from 22% to 9%

Manzanillo, Mexico
350 MW, drum boiler;
diesel, heavy fuel oil;
Minimum stable output reduced from 30% to 20%

Benefit for a standard unit

- 300 MW gas fired unit
- Reduction of minimum load from 90 MW to 60 MW (30% to 20%)
- Difference between production costs and electricity price during minimum load time: 10 EUR/MWh
- Duration of minimum load operation: 500 h/a

150,000 EUR/year
Task:
Fast and low-stress increase in output to above 100% on demand to meet market requirements

Features:
Upgrade of unit control to allow
- Valves wide open (VWO) operation of unit and/or
- Automatic coordination of shutdown of HP feedwater heaters and increase in firing rate

Benefit:
- Additional profits, particularly at times of high power prices without the need for upgrading of process equipment.

Graph:
- Throttling of HP heaters
- Electrical operation

- Time [min]
- 100 %
- 120 %
- 100 %
- 80 %

- HP heater 6
- HP heater 7

(1) Unit setpoint increased to 100 % (mod. variable pressure operation)
(2) HP feedwater heater 7 is shut off by this module
(3) Unit setpoint increased to 110 %, HP feedwater heater 6 shut off fully
(4) 110 % output achieved (spinning reserve is maintained)
Additional revenues by increased electrical output

References

**Callide, Australia**
420 MW, Benson
Max. load + 10%
1400 h/a max. load

**Enstedvaerket, Denmark**
650 MW, Benson
Max. load +7%
district heat extraction

Benefit for a standard unit

- 300 MW hard coal fired unit
- Maximum load + 7%, i.e. 320 MW
- Electricity price for max. load 60 EUR/MWh
- Duration of max. load operation 500 h/a

- 380,000 EUR/a
- + 13,200 t/a CO₂ (due to reduced efficiency)
Task:
Reduction of startup fuel consumption and ensuring reproducible startups.

Features:
- Automatic run-up of boiler to requisite parameters for turbine start
- Automatic differentiation between cold, warm and hot starts
- Automatic and bumpless transfer to coordinated power operation

Benefit:
- Savings through reduced fuel consumption
- Increased revenue through reproducible startup and shutdown
SPPA-P3000 Process Optimization
Low Loss Start

Lower costs for start-ups

References

Parish, USA
565 MW, Benson gas
Startup costs reduced by 66%

Mandalay, USA
215 MW, Drum gas
Startup costs reduced by 70%

Benefit for a standard unit

- 100 starts per year
- 4,000 EUR / start
- 50% reduction

200,000 EUR/year

Benefit for a standard unit

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Parish, USA
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215 MW, Drum gas
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- 4,000 EUR / start
- 50% reduction

200,000 EUR/year

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565 MW, Benson gas
Startup costs reduced by 66%

Mandalay, USA
215 MW, Drum gas
Startup costs reduced by 70%
Task:
Reducing unburned carbon in ash (‘LOI’ - loss on ignition), NOx, CO and achievement of optimum efficiency through improved combustion.

Features:
Optimized burner operating point with the aid of:
- On-line measurement of coal flow to individual burners using the ECT method
- Burner-specific matching of air and pulverized coal flow
- Burner-specific matching of air flow

Benefit:
- Higher efficiency
- Lower emissions (NOx / CO) and compliance with LOI limit for fly ash
Task:
Condition-based soot blowing integrated into unit DCS

Features:
- Use of existing temperature measurements to determine the degree of fouling
- Automatic cost-benefit analysis
- Activation of soot blowers, either automatically or by the operator

Benefit:
Lower fuel costs due to optimal operation of sootblowers
**Task:**
Stable control of steam temperature with setpoint close to material limits

**Features:**
- Use of dynamic models with prediction
- Identification of heat input variations using an observer structure
- Where needed, use of entire control range including injection into saturated steam
- Use on start-up and over the entire load range
- Use of flue gas recirculation, biflux, triflux or burner tilt to control reheat steam temperature to increase the efficiency

**Benefit:**
Increased efficiency thanks to
- Higher steam temperatures
- Reduced reheat injection flow
Increased revenues or lower costs by increasing efficiency

References

Simmering, Austria
360 MW, Gas
SH and RH-temp. increased by 5K

Velsen, Netherlands
360 MW, Natural and industrial waste gas. SH and RH-temp. increased by 5K

Benefit for a standard unit

- 300 MW hard coal fired unit
- SH and RH-temperature increased by 5K
- Coal price 50 EUR/t

60,000 EUR/a
-3,700 t/a CO₂
**Task:**
Minimization of throttling losses without any negative impact on load flexibility.

**Features:**
Setting of optimum degree of throttling for turbine valves, feedwater control valves and fan vanes for forced- and induced-draft fans on basis of a steady-state process model.

**Benefit:**
High efficiency thanks to minimum throttling losses
Increased revenues or lower costs by higher efficiency

Reference

**Karlsruhe, Germany**
550 MW, Benson hard coal, efficiency increased by 0.5%

**Wilhelmshaven, Germany**
820 MW, hard coal, provision of 20 MW for frequency control without reduced efficiency

Benefit for a standard unit

- 300 MW hard coal fired unit
- 5,000 h/a operation
- Coal price 50 EUR/t
- Efficiency increased by 0.33%

| 80,000 EUR/a | - 4,800 t/a CO₂ |
**Task:**
Ensuring safe and stable unit operation despite firing of low-cost supplementary fuels and fuels with widely fluctuating properties.

**Features:**
- Model-based determination of necessary fuel and air flows
- Modulating of flow for selected fuels for load control
- Automatic heating value correction
- Automatic correction of air flow
- Adjustment of control loops, e.g. flue gas recirculation

**Benefit:**
- Maximum use of low-cost fuels, i.e. reduced fuel costs
References

Völklingen MKV, Germany
230 MW, 210 MW heat extr., firing of hard coal for base load and load control, and methane / converter gas as supplementary fuel

Velsen 24, Netherlands
360 MW, firing of natural gas for load control and blast furnace gas as base fuel

Benefit for a standard unit

- 300 MW hard coal fired unit
- 5,000 h/a operation
- Coal price 50 EUR/t
- Costs of supplementary fuel 50% of coal costs per specific energy content
- Replacement of 1% hard coal by supplementary fuel

130,000 EUR/a
Task:
Automatic analysis of the overall process and of key components, fast provision of information about deviations from optimum operation, calculation of consequential costs for detection of improvement potentials.

Features:
- On-line calculation of key process data on the basis of a thermodynamic process model
- Data reconciliation / validation of measured actual process situation
- Interactive process analysis for “what if?” scenarios: Optimized operation and investment decisions
- Web-oriented visualization for office LANs

Benefit:
- Early detection of malfunctions and deviations from optimum operation
- Reduced maintenance costs through problem analysis
- Reduced generation costs
Reduced costs by operation at optimum operating point

Reference

Heilbronn, Germany
760 MW, heat extraction, hard coal; detailed boiler model, data reconciliation, what-if simulation

Taishan, People’s Republic of China
2 x 600 MW, hard coal, Data reconciliation, what-if simulation

Benefit for a standard unit

Improved operation and maintenance
• Early detection of malfunctions, deviations from optimum operation and slowly drifting values
• Determination of cleanliness of boiler heating surfaces

Support of operating staff for routine tasks and fast analysis of problems
• Easy analysis of actual and historic data
• Process analysis available at engineer’s office
• Cyclic report generation

50,000 - 150,000 EUR/year
Task:

Automatic runback of the unit on loss of major components and transition to the new safe operating mode.

Features:

- Assignment of dedicated load capability levels and runback rates for the different major components
- Consideration of fuel-related restrictions on the load
- Load reduction at the necessary rate with coincident changeover of turbine to stable initial pressure control mode.

Benefit:

- Reduced number of unit outages
- Extended service life
### References

- **Setubal, Portugal**
  - 250 MW, oil fired,
  - Reliable runback to 50% load

- **Nikola Tesla, Serbia & Montenegro**
  - 305 MW, lignite fired,
  - Reliable runback to 50% load

### Benefit for a standard unit

- **300 MW hard coal-fired unit,**
- Avoidance of 5 trips and 5 start-ups per year
- Instead:
  - operation at 50% load for 5 x 3 h/a
- **Startup costs 5,000 EUR**
- **Difference between electricity price and production costs:** 30 EUR/MWh

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93,000 EUR/a
**Task:**
Regardless of the demands for fast load changes and fast start-up, components must still be operated below specified stress limits so as to assure long-term availability.

**Features:**
- Model-based control process with prediction
- Automatic online adaptation of control parameters

**Benefit:**
- Extended service life thanks to avoidance of life-consuming plant trips and inadmissible operating conditions
- Reduced repair costs thanks to low-stress operation of final control elements
Task:
Compliance with requirements of environmental legislation at as low as possible cost.

Features:
- Continuous emissions monitoring for NO$_x$, CO, SO$_2$, O$_2$ and particulates
- Measurement of pulverized coal flow per burner to optimize fuel and air control for each separate burner
  - Reduction of NO$_x$ and CO at the origin
- Selected process optimization solutions to increase the plant efficiency
  - Reduction of emissions at the origin

Benefit:
- Compliance with air pollution control laws and regulations, avoidance of fines and even mandatory shutdown for non-compliance
- Increased revenue from emission credit trading
SPPA-P3000 Process Optimization for Steam Power Plants

Increased profitability by intelligent optimization solutions!

- Runback Plus
- Life Time Plus

High availability

- Low Loss Start
- Combustion Optimizer
- Sootblower Optimizer

High efficiency

- Temperature Optimizer
- Low Throttling
- Fuel Optimizer
- Best Point

High flexibility

- Fast Start
- Fast Ramp
- Frequency Control

- Dispatch Control
- Minimum Load Reduction
- Maximum Load Plus

Low emissions

- Emissions Control

No changes to mechanical equipment
Modernization with customized execution of SPAA-P3000 solutions

Concepts - from small to comprehensive - whatever fits your situation!

**Optimization add-on for third party I&C**
- Third party HMI
- Third party basic automation
- SPPA-P3000

**Partial modernization incl. optimization**
- Third party HMI
- Third party basic automation
- Siemens HMI
- SPPA-P3000
- Siemens automation

**Comprehensive modernization**
- Siemens HMI
- Siemens automation
- Plus Electrical, Field, Maintenance & Management solutions
One common platform: SPPA-P3000 fully embedded in SPPA-T3000

Consistent engineering and HMI for basic automation and optimization!

SPPA-T3000 architecture

User interfaces

Power services

Process interfaces

SPPA-P3000 Process Optimization
SPPA-P3000 Process Optimization

Five joint steps to success!

Discussion of situation

- Operating experience
- Targets
- Options for optimization
- Result: Which solutions are feasible for this unit?

On-site analysis

- Establish, localize and quantify existing potential
- Examine and evaluate archives and control schematics
- Plant tests and limits

Presentation and decision

- Result: Evaluation of examined solutions
- Proposal: Scope of modernization, different variants?
- Benefits?
- Profitability (return on investment)?

Implementation and fine-tuning

- Engineering based on comprehensive power plant know-how
- Start of installation while plant is still in operation
- Outage and connection to plant I&C
- Commissioning / fine-tuning
- Handover to customer

Optimized operation

Enhanced performance and higher profitability are guaranteed:
- Flexibility
- Efficiency
- Emissions
- Availability

Contract
A sound basis for your profitability

**Process engineering expertise**
- 600 GW installed fleet
- 10 GW O&M
- 100 years of power plant experience

**Automation expertise**
- 2000 systems installed throughout the world
- World market leader in automation systems

**Project management expertise**
- Shortest outage times
- Shortest execution times
- Benchmark in project management
Selected references with SPPA-P3000 solutions

Profitable, reliable and flexible process optimization - worldwide

Lippendorf, Germany
Fast Ramp
Temperature Optimizer
Frequency Control

Karlsruhe, Germany
Fast Ramp  
Fast Start
Frequency Control  
Dispatch Control

Simmering, Austria
Low Loss Start
Temperature Optimizer
Life Time Plus
Dispatch Control

Plomin, Croatia
Fast Start
Temperature Optimizer
Fast Ramp
Frequency Control
References
Powering the world

Profitable, reliable and flexible power generation - worldwide

More than 2000 power plants worldwide in operation with Siemens electrical systems, I&C and IT

Source: http://visibleearth.nasa.gov/