Advances in co-ordinated control

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10th HEEP May 23-25, 2011, Balatonfüred

Advances in co-ordinated control

Outline:

Foster Wheeler Energia Oy

Evolution of co-ordinated control - technology driven
Solid fuel fired steam generation plants

Examples: Metso DEB, Siemens, ABB, ÅF Consulting

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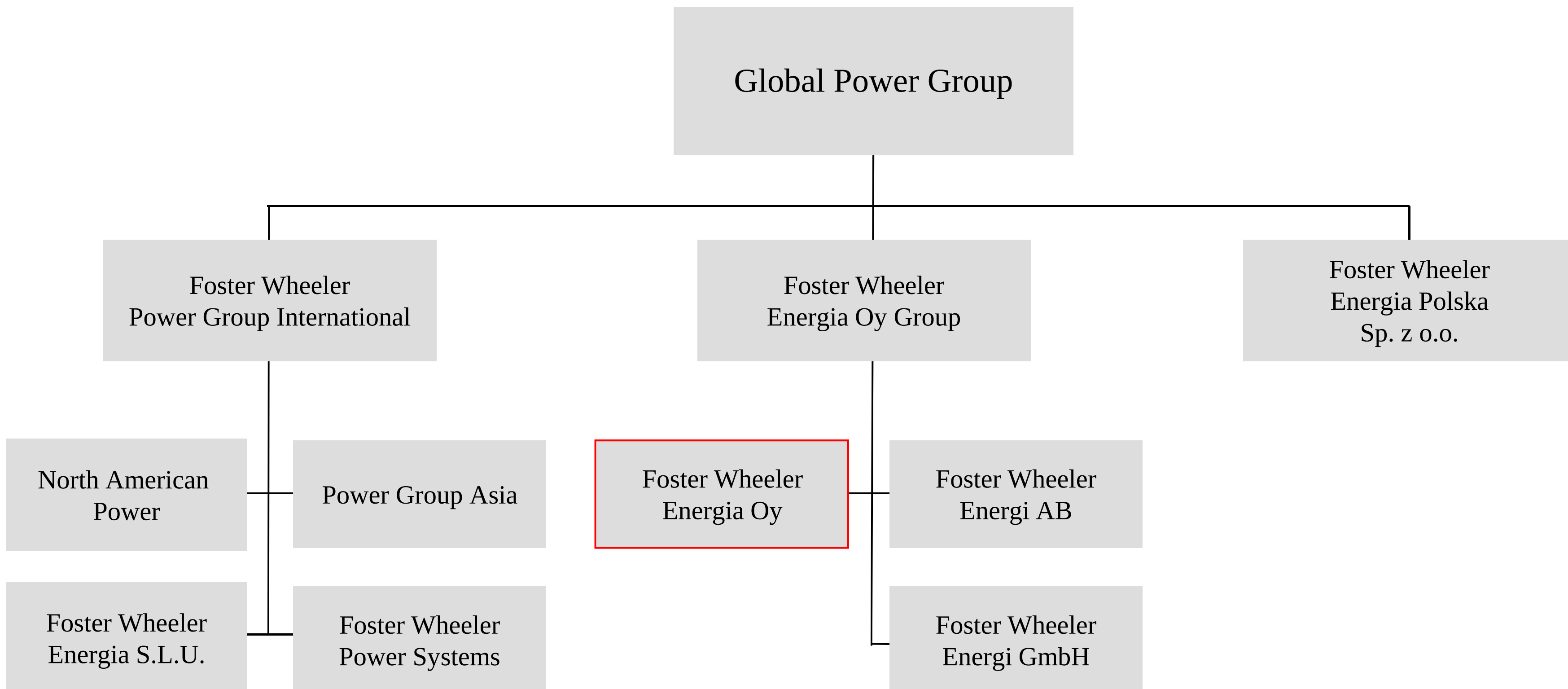
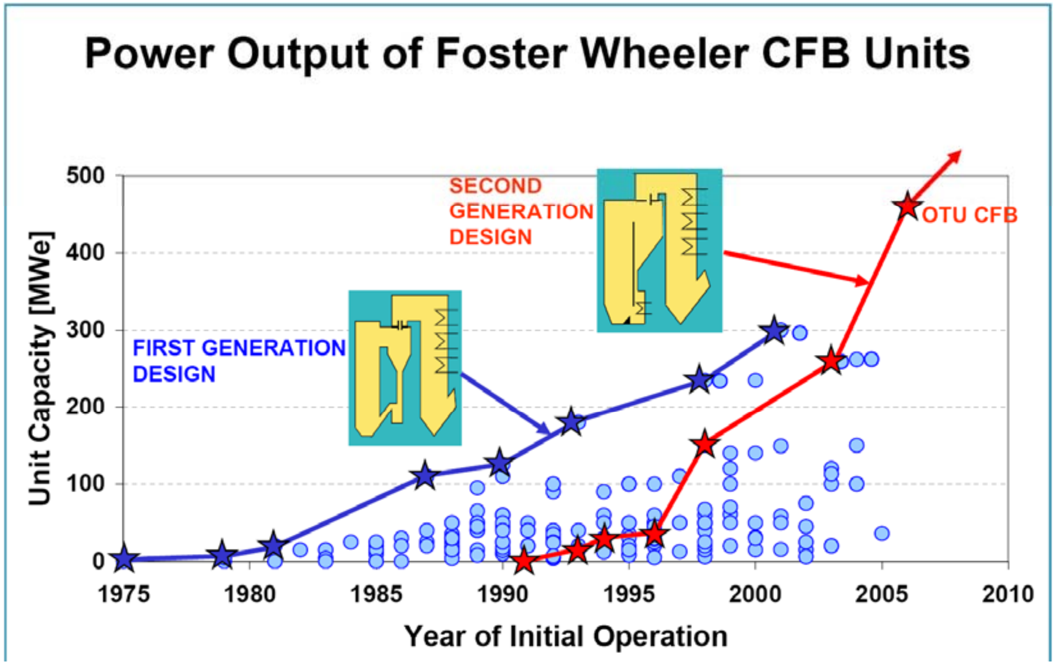
Foster Wheeler Global Power Group

- Established in 1884, known as Foster Wheeler since 1927.
- Foster Wheeler is a global engineering and construction contractor and power equipment supplier.



World Leader in Fluidized Bed Combustion Technology

- First BFB boilers delivered in the 1970s, and first CFB supplied in 1979.
- World's first once-through supercritical CFB (460MW$_e$) started operation in 2009 in Łagisza, Poland.
- 600 MW is commercially available; the 800 MW is under design.
- Flexi-Burn™ - air/oxy flexible CFB commercially available by the of end 2011/12.



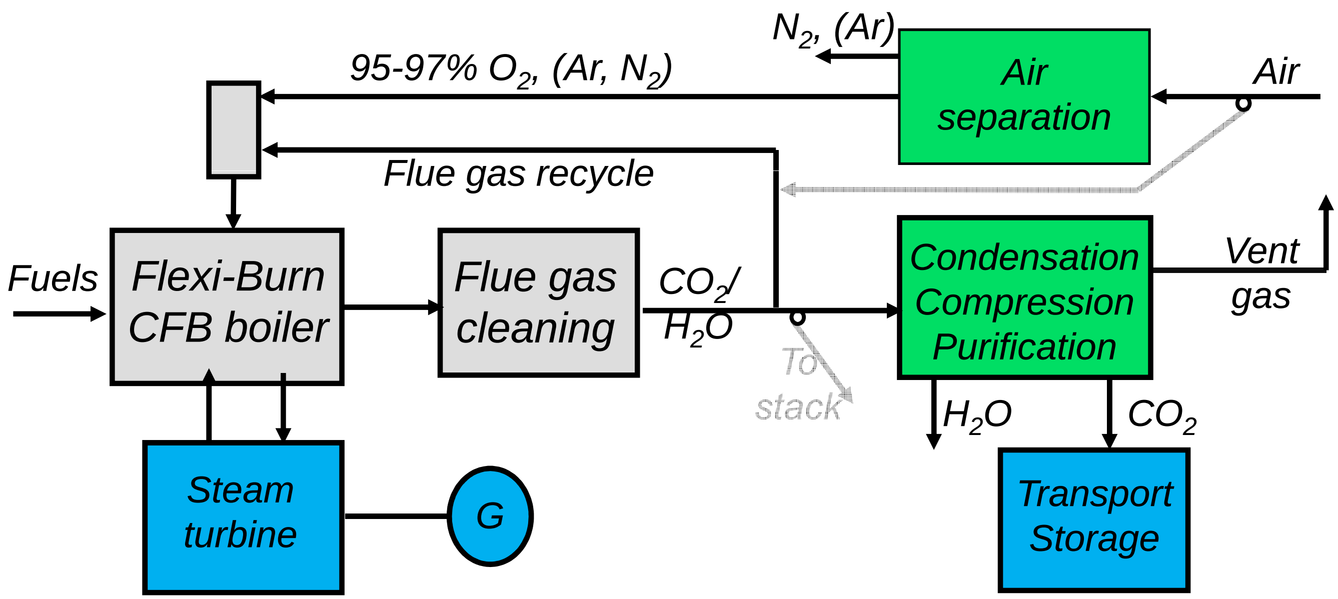
- CFB fuel flexibility and multifuel capability provide for efficient utilization of fossile and renewable fuels.
- Meets tough emission regulations without additional flue gas cleaning systems.
- 372 CFB, 136 BFB & 11 atmospheric gasifiers

The Compostilla Project OXYCFB300

Co-financed by the European Union
European Energy Programme for Recovery

- The OXYCFB300 Project within the EEPR Program is devoted to demonstrate the CCS value.
- Design phase 2009-2012 period, by mid-2012 the Investment Decision (FID) for the construction phase.
- A consortium between ENDESA GENERACIÓN, CIUDEN and FWEOy.

Flexi-Burn™ CFB power plant



Evolution of co-ordinated control

Evolution of co-ordinated control – technology driven

(Focusing on CFB and OTU)

- 1924 — Benson OTU techn.
- 1933 — Sliding pressure
- 1949 — 1st subcrit OTU (175 bar/610C, Siemens)
- 1954 — 1st supercrit OTU (300bar/600C, Siemens)
- 1979 — 1st CFB (FW)
- 2000's — PC OTU
- 2009 — 1st SC CFB OTU (FW)
- 2009-2012(5) — SC OXY CFB OTU (FW)

First concept of co-ordinated control: for once-through boilers in late 1950's

(Eddystone, 2x300MW by Leeds & Northtrup Company, USA, nowadays Metso)

Evolution of co-ordinated control – requirements

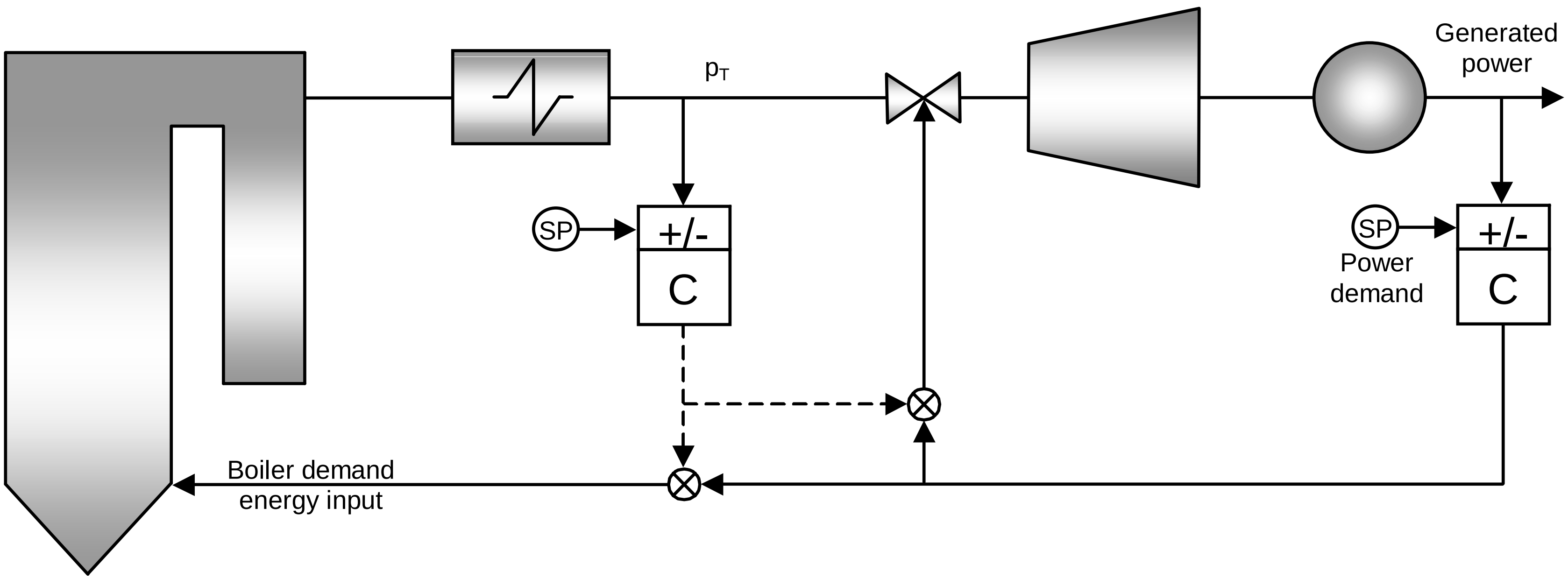
- Balance between the turbine power generation and the load demand.
- Balance between the boiler and turbine.
- Balance between heat release and feed water supply.
- Balance between fuel and air/oxygen feeding.

- Fast load change (4%MCR/min) and grid frequency support even in large OTU plants (460MW$_e$)

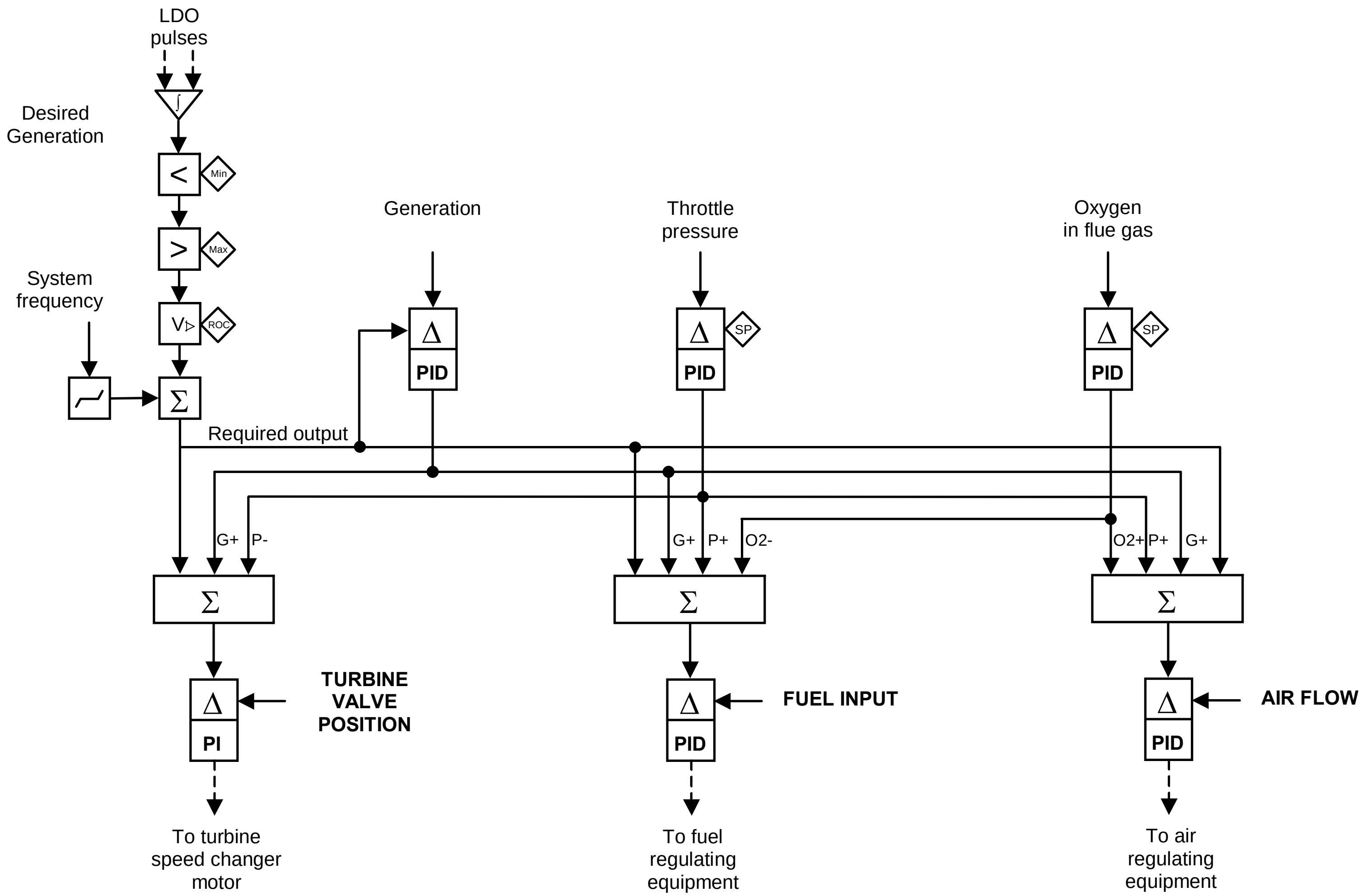
- Effect of parallel development (varying dominance) of drum and OTU boilers.
- Via the Metso's co-ordinated control development.

Evolution of co-ordinated control – 1st attempt

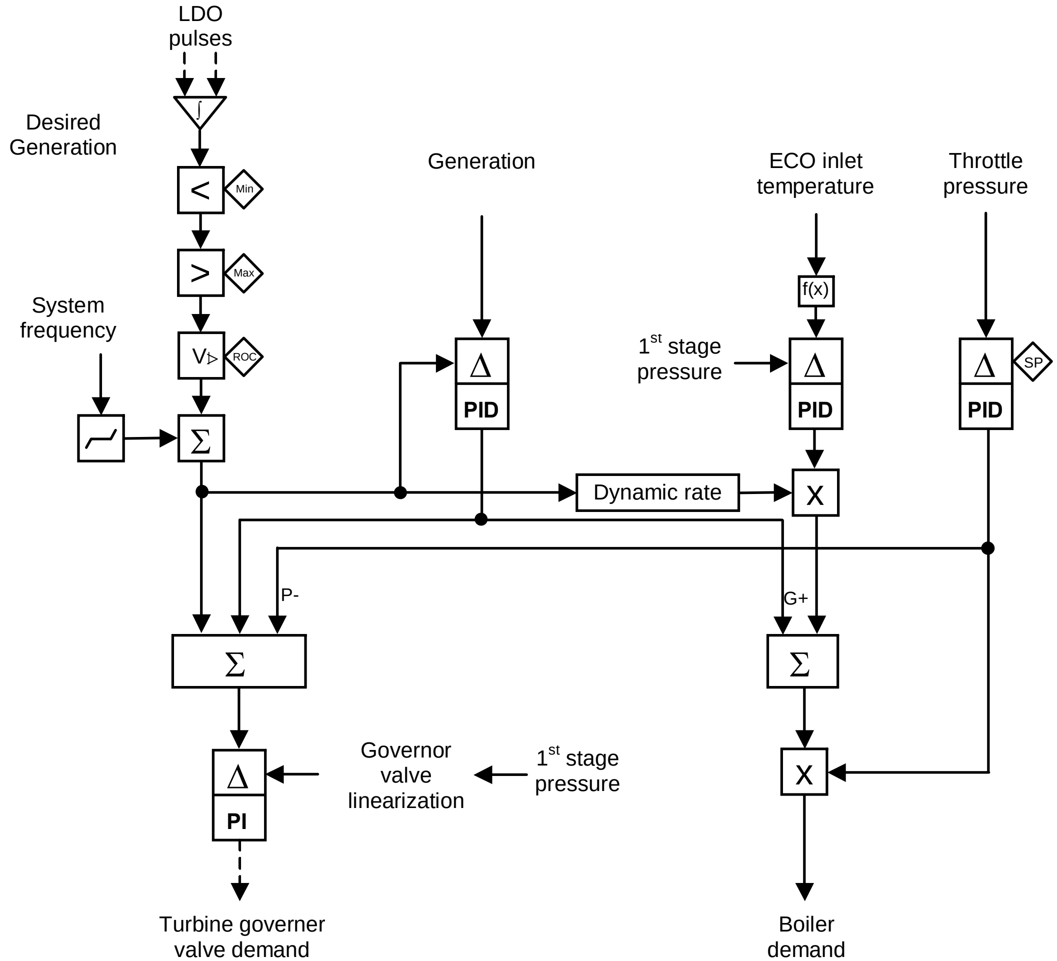
1st attempt (Eddystone, 2x300MW coal fired plant, grid frequency control):
common demand for boiler and turbine control calculated based on the generation error

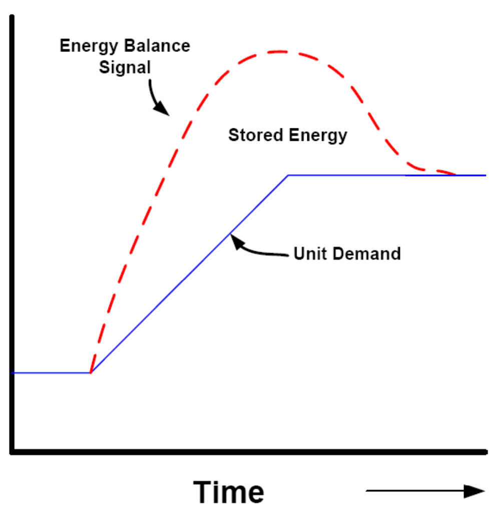


Evolution of co-ordinated control – 1st generation

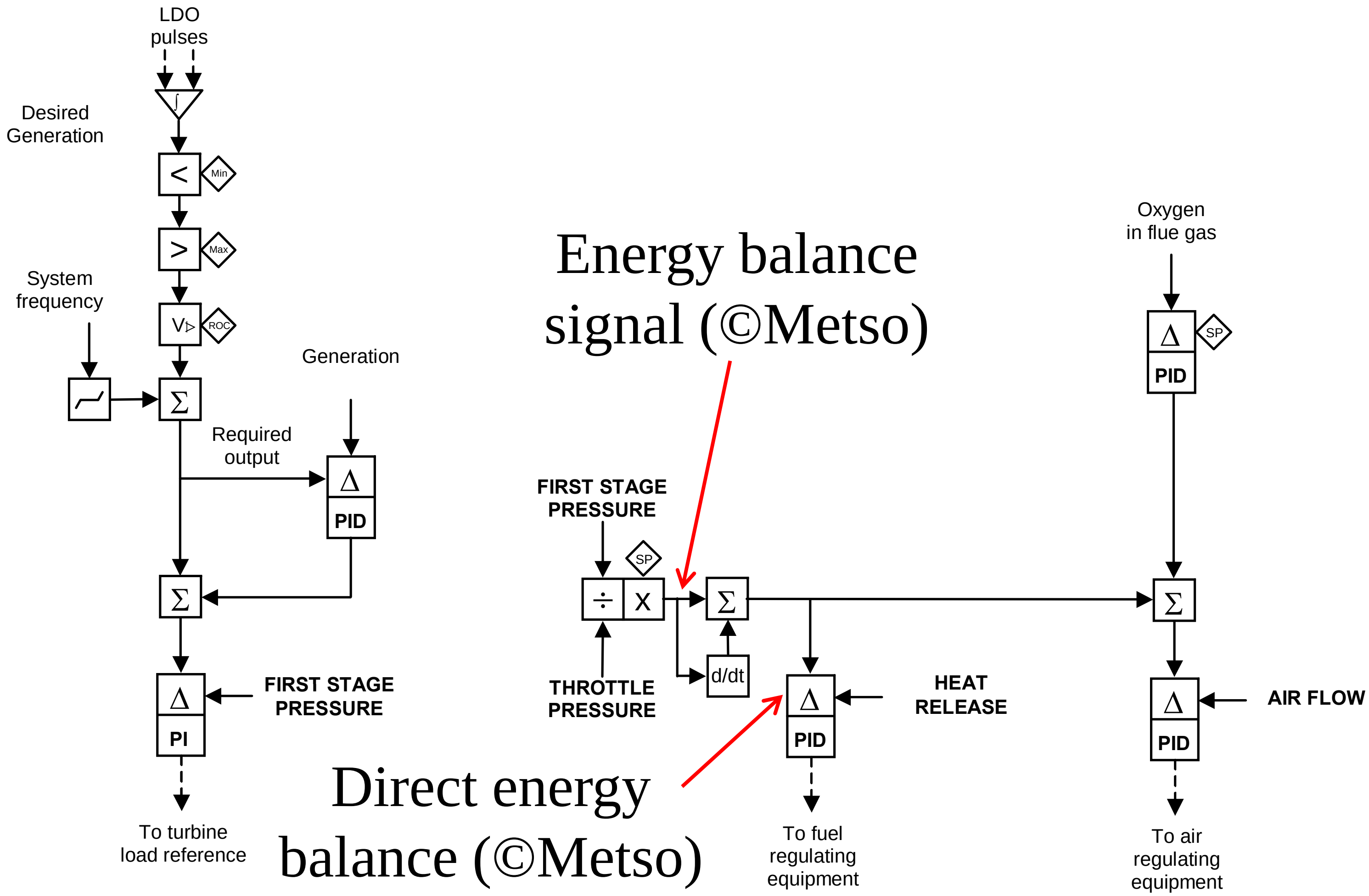


Evolution of co-ordinated control – 2nd-3rd generations





Evolution of co-ordinated control – 4th generation

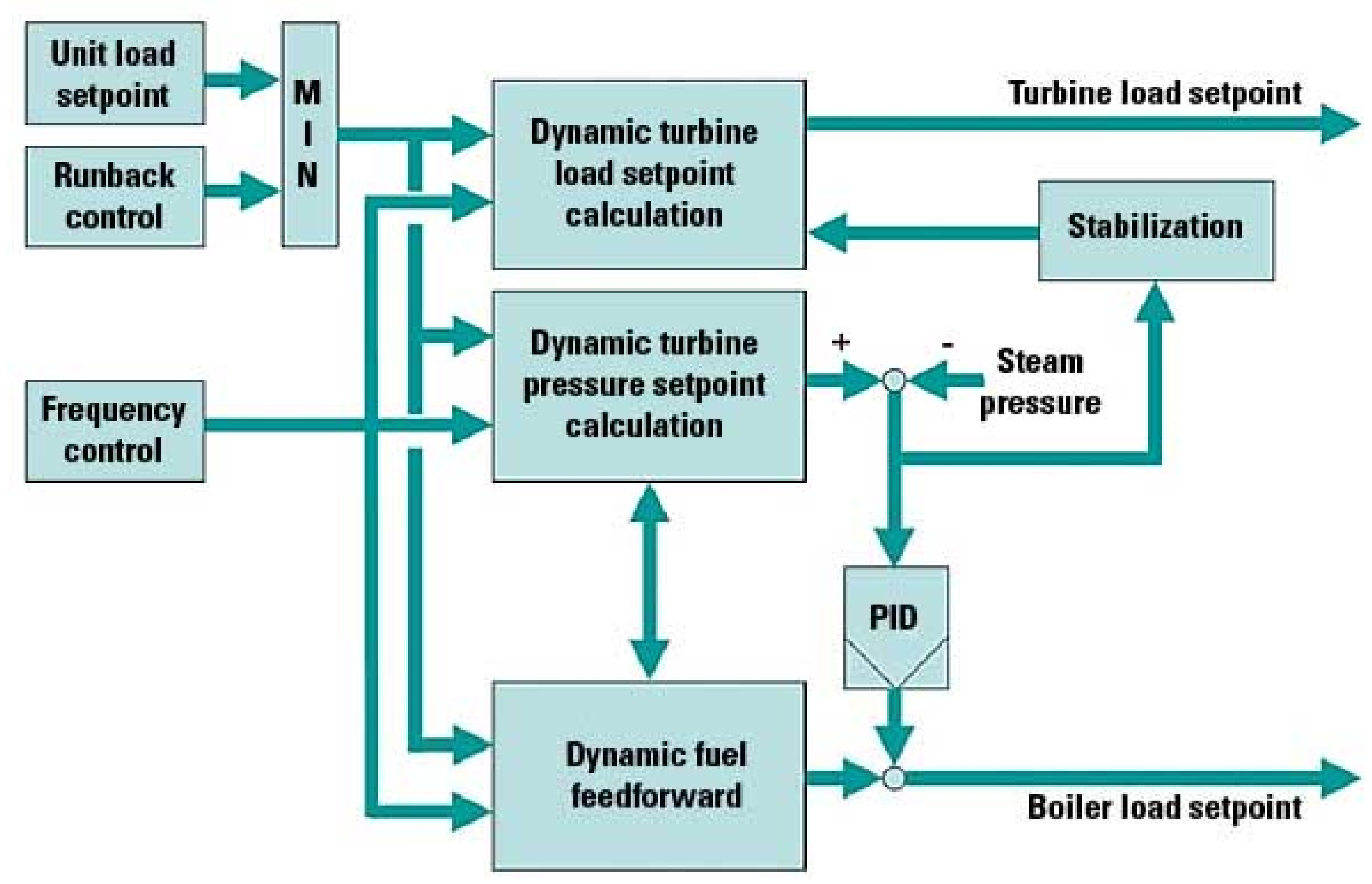


Co-ordinated control for OTU boilers

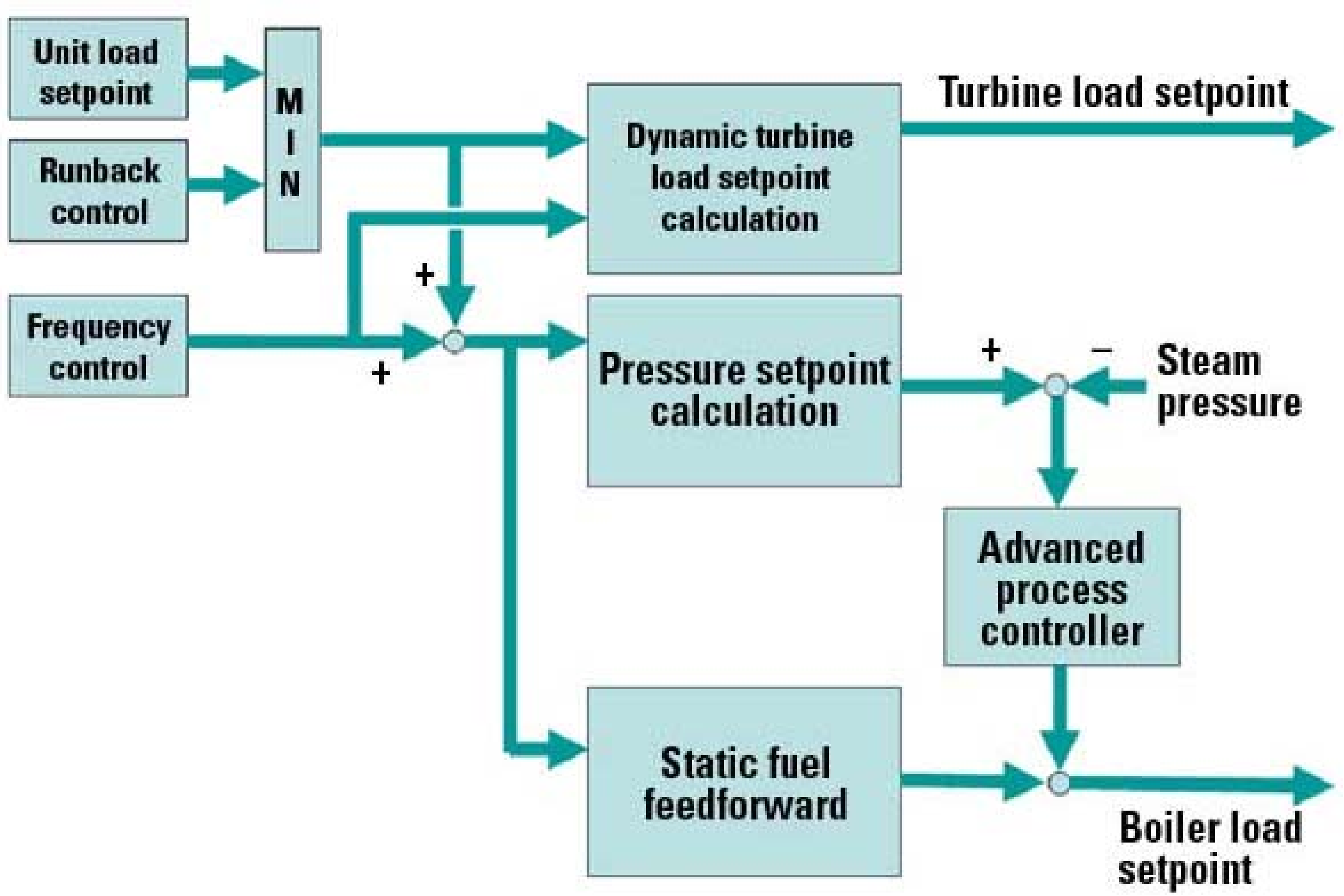
- Challenges in once-through boilers:
  - lack of drum and stored energy
  - sliding pressure operation (small throttling reserve)
  - fast load change requirement (4%MCR/min) and grid frequency support even for large plants
  - S-shape load curve versus close-to-MW requirement
- Feed forward control concept
- Overfiring the boiler
- Utilisation of BOP system: power forcing control concept
- Challenges in oxy-combustion: integration of ASU + CFB + CPU

- Examples:
  - Siemens, Metso DEB, ÅF consulting: Balance+, ABB MODACOND, MPC control

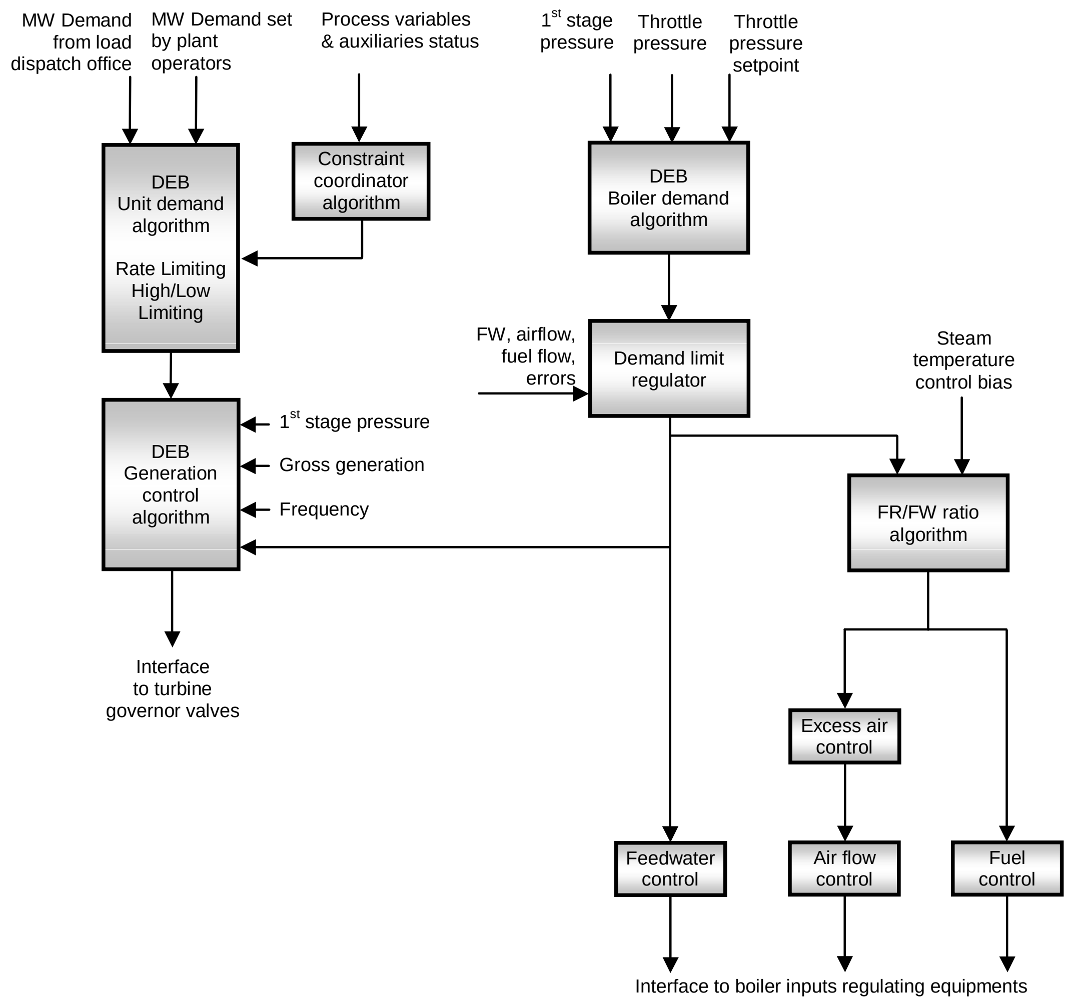
Conventional control



SIEMENS's Advanced Process Controller

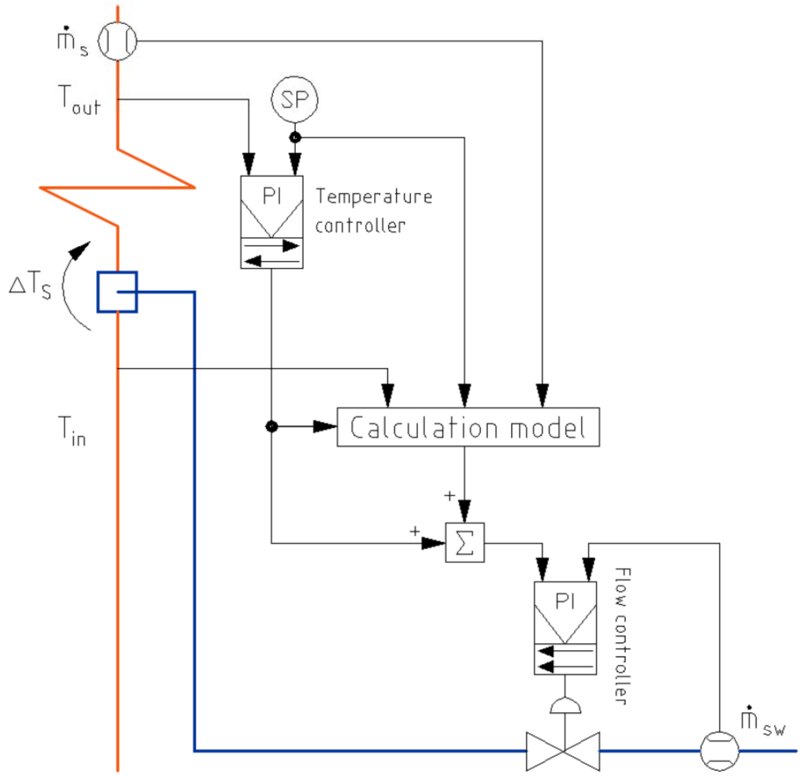


METSO's DEB control for once-through boilers



ÅF – Consulting: Balance+

The needed temperature drop ΔT_S can be calculated by using the incoming steam temperature T_{in}, the adaptive superheating grade and the target temperature $T_{out,SP}$. The calculation model calculates the corresponding amount of spray water to steam temperature drop.



The temperature controller is used for updating the model and for temperature fine tuning.

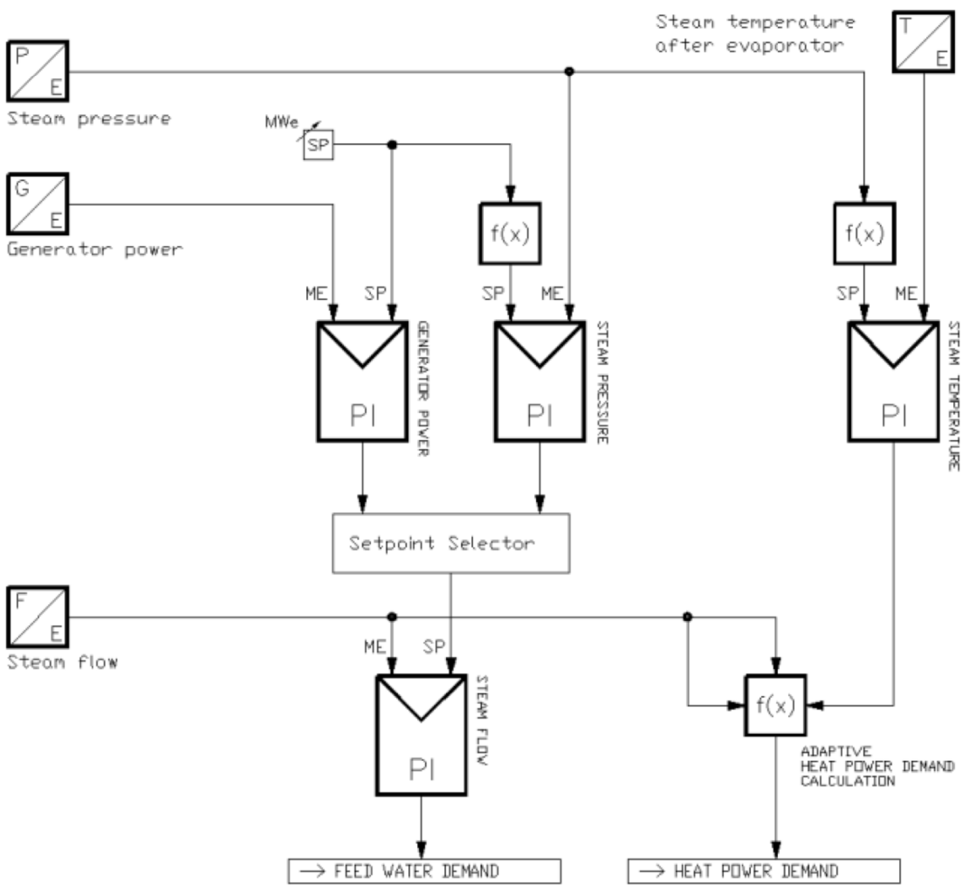
Real-time response to disturbances in incoming steam temperature and steam flow.

Ideal behavior in spite of decline in the heat transfer efficiency or change in the operation point.

Temperature stresses to superhea-ters and stresses to the actuators are minimized.

Steam production is stabilized.

ÅF – Consulting: Balance+ for OTU boiler



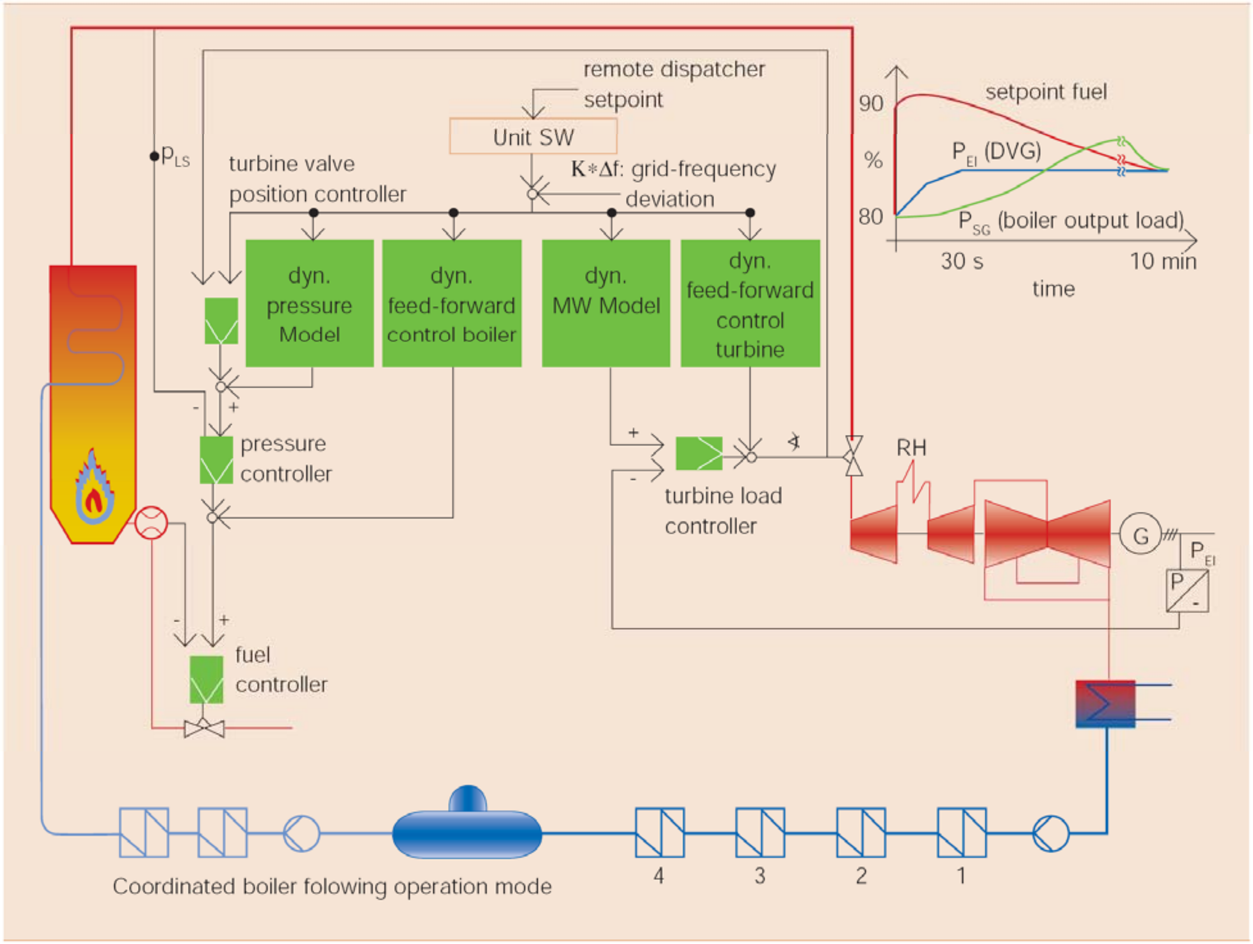
The ratio between the feed water and the combustion power is updated using the steam temperature after the evaporator. There are less stresses caused to boiler when the “water/fire” balance is correct during the load transients.

The following advantages can be gained:

Ideal real-time response of combustion power and feed water flow during and after the load changes.

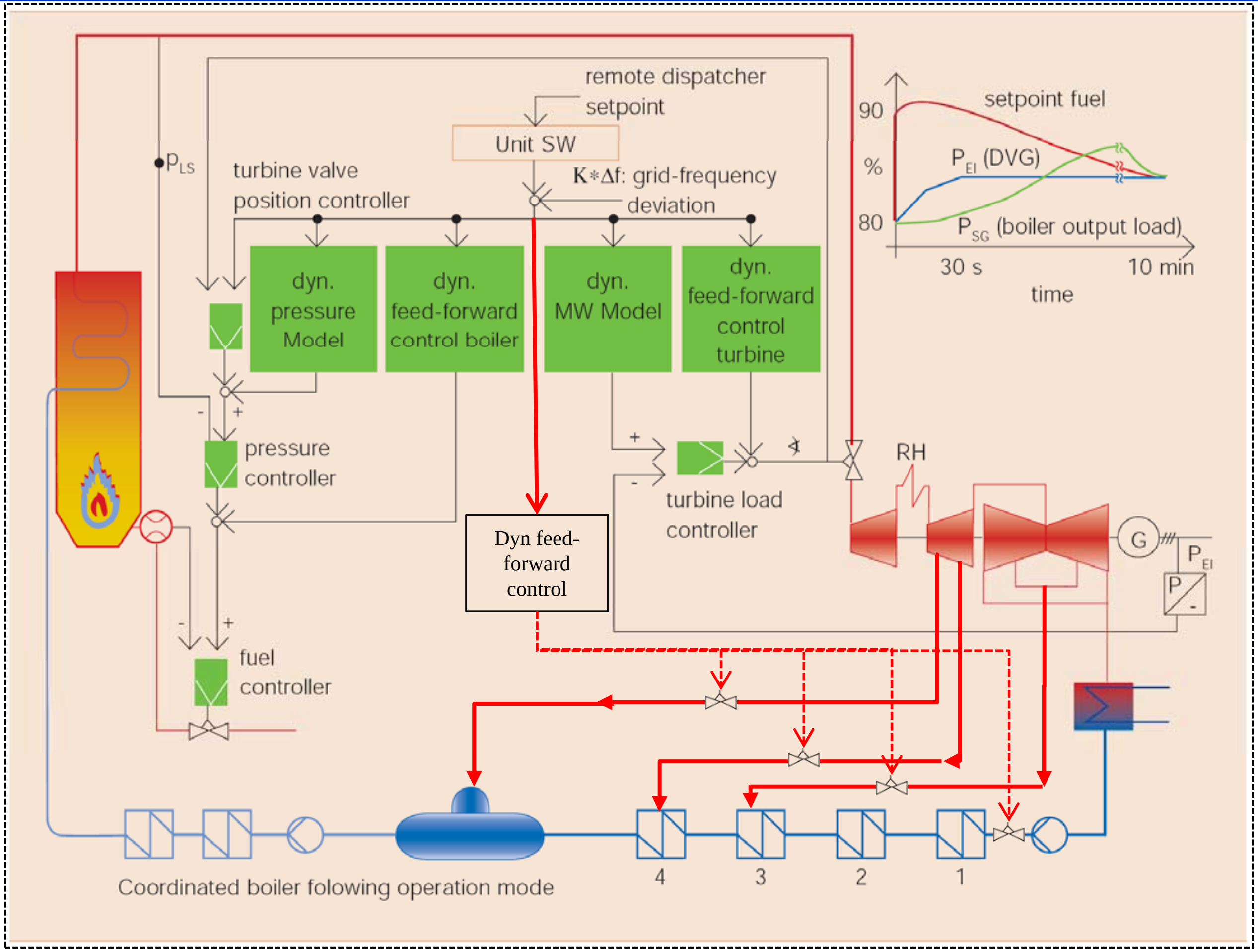
Due to adaptive control the ”water/fire” balance remains ideal despite changes in fuel or changes in heat transfer efficiency.

ABB's MODAN

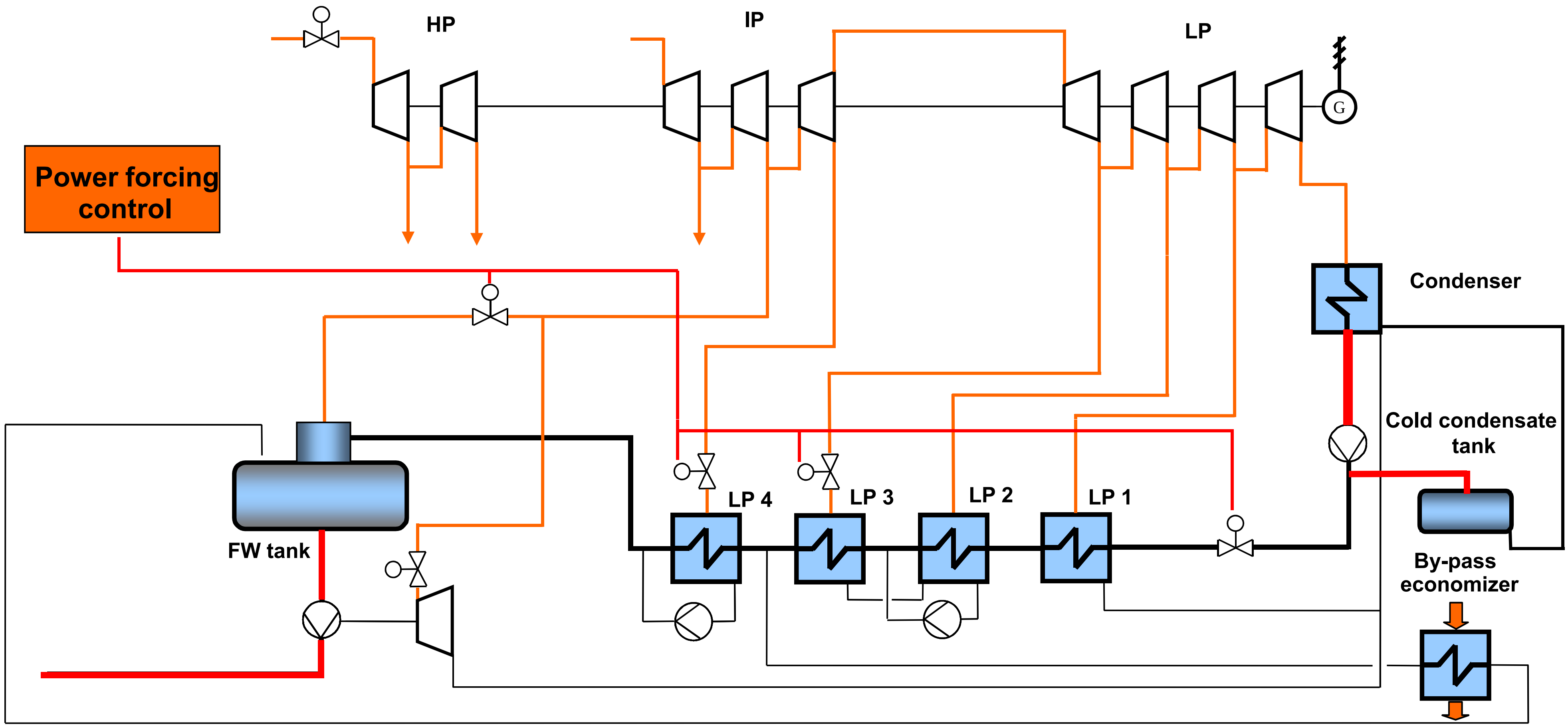


remote dispatcher
setpoint
Unit SW
P_{LS}
turbine valve
position controller
K∗Δf: grid-frequency
deviation
dyn.
pressure
Model
dyn.
feed-forward
control boiler
dyn.
MW Model
dyn.
feed-forward
control
turbine
pressure
controller
turbine load
controller
fuel
controller
RH
G
P_{El}
90
%
80
setpoint fuel
P_{El} (DVG)
P_{SG} (boiler output load)
30 s
10 min
time
4
3
2
1
Coordinated boiler folowing operation mode

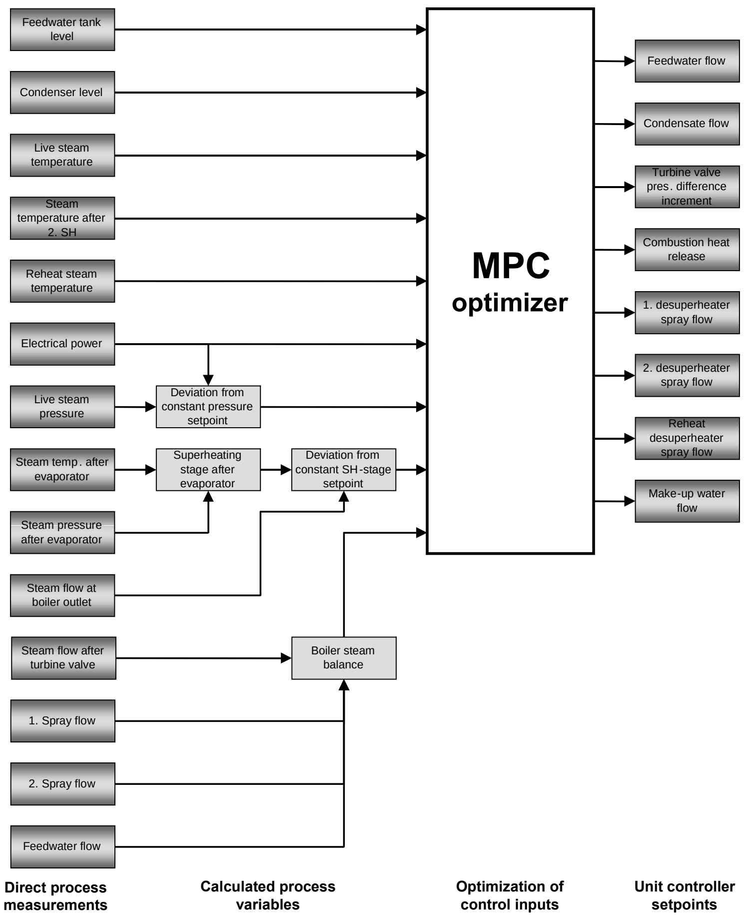
ABB's MODAKOND



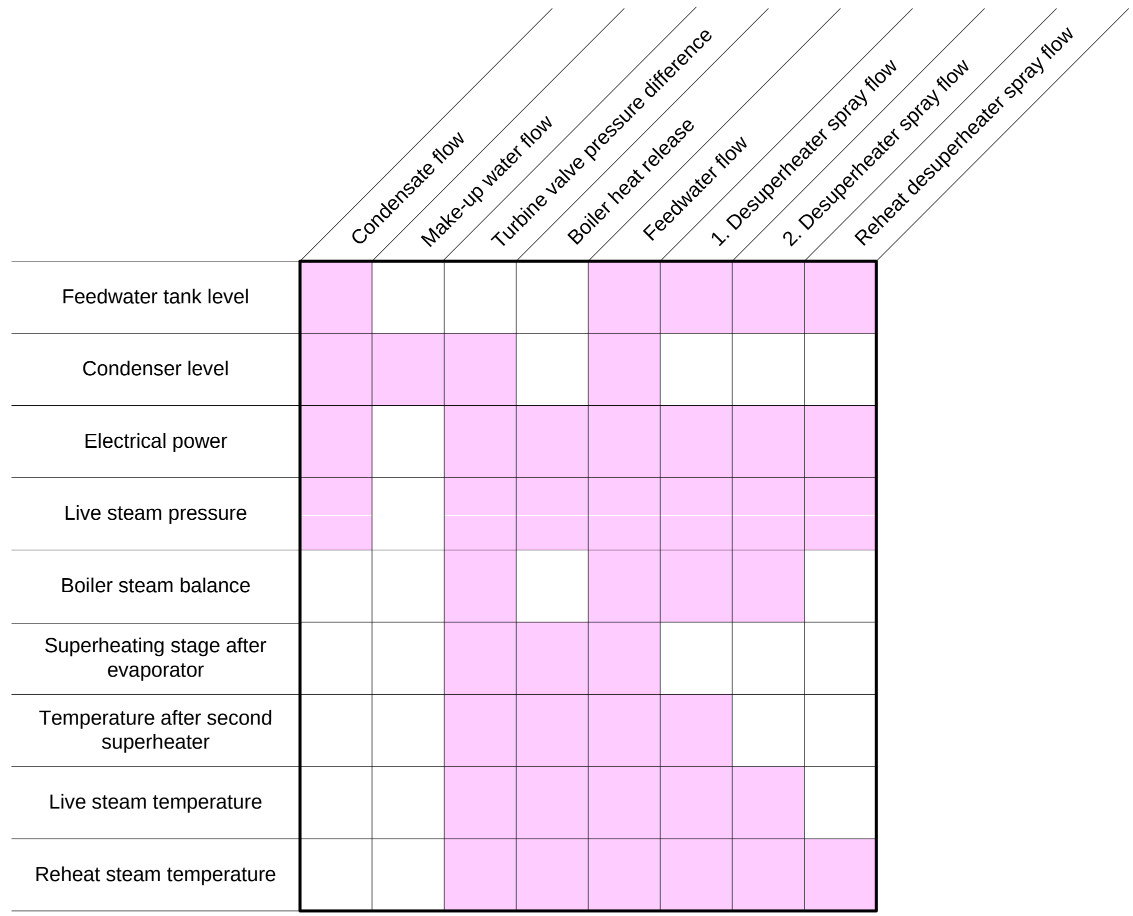
Fast power reserves – condensate throttling (power forcing)



METSO's MPC



Feedwater tank level
Condenser level
Live steam temperature
Steam temperature after 2. SH
Reheat steam temperature
Electrical power
Live steam pressure
Steam temp. after evaporator
Steam pressure after evaporator
Steam flow at boiler outlet
Steam flow after turbine valve
1. Spray flow
2. Spray flow
Feedwater flow
Deviation from constant pressure setpoint
Superheating stage after evaporator
Deviation from constant SH-stage setpoint
Boiler steam balance
MPC optimizer
Feedwater flow
Condensate flow
Turbine valve pres. difference increment
Combustion heat release
1. desuperheater spray flow
2. desuperheater spray flow
Reheat desuperheater spray flow
Make-up water flow
Direct process measurements
Calculated process variables
Optimization of control inputs
Unit controller setpoints



Condensate flow
Make-up water flow
Turbine valve pressure difference
Boiler heat release
Feedwater flow
1. Desuperheater spray flow
2. Desuperheater spray flow
Reheat desuperheater spray flow
Feedwater tank level
Condenser level
Electrical power
Live steam pressure
Boiler steam balance
Superheating stage after evaporator
Temperature after second superheater
Live steam temperature
Reheat steam temperature

SUMMARY

- Evolution of co-ordinated control
  - Technology and demand driven
  - Drum and once throug boilers
  - Priority between pressure and turbine power
  - Demanding operational requirements for large power plants
  - Feedforward control + local feedback control loops
  - Utilisation of boiler overfiring and power forcing

Thank you!

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