Modern CHP solutions on the example of Nowa EC Czechnica

Dr. eng. Isidor Giglmayr, mgr inż. Wladyslaw Jaroszuk,
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Agenda

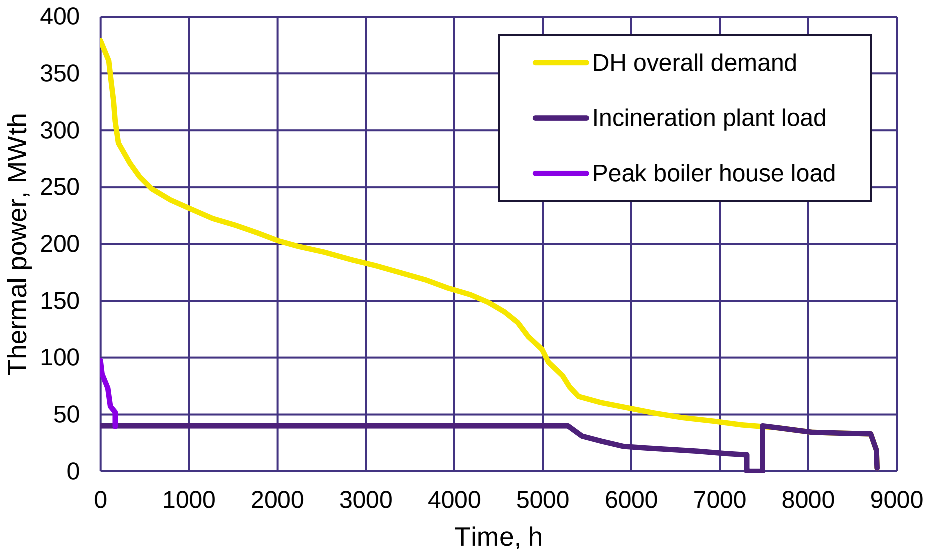
- Requirements set forth for modern CHPs
- Nowa EC Czechnica implementation example
- Other ways to improve plants flexibility

Requirements set forth for modern CHPs

Requirements put forth by district heating (DH) networks

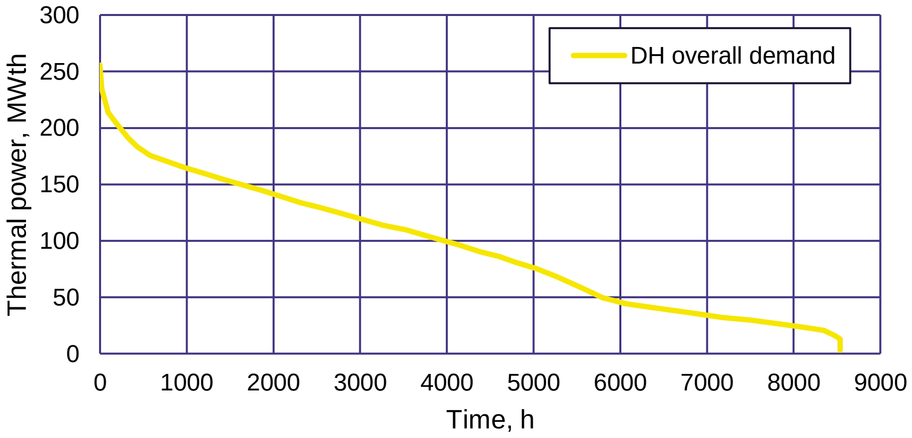
Key features of the DH networks:

- 130°C/70°C design temperature
- 70°C/40°C in the summer
- Low DH requirements in the summer
- Decreasing peak DH demand due to warm winters
- Renewable energy sources appear in the base of the heating curve
- Industrial scale heat pumps are seen as competition in short to mid term

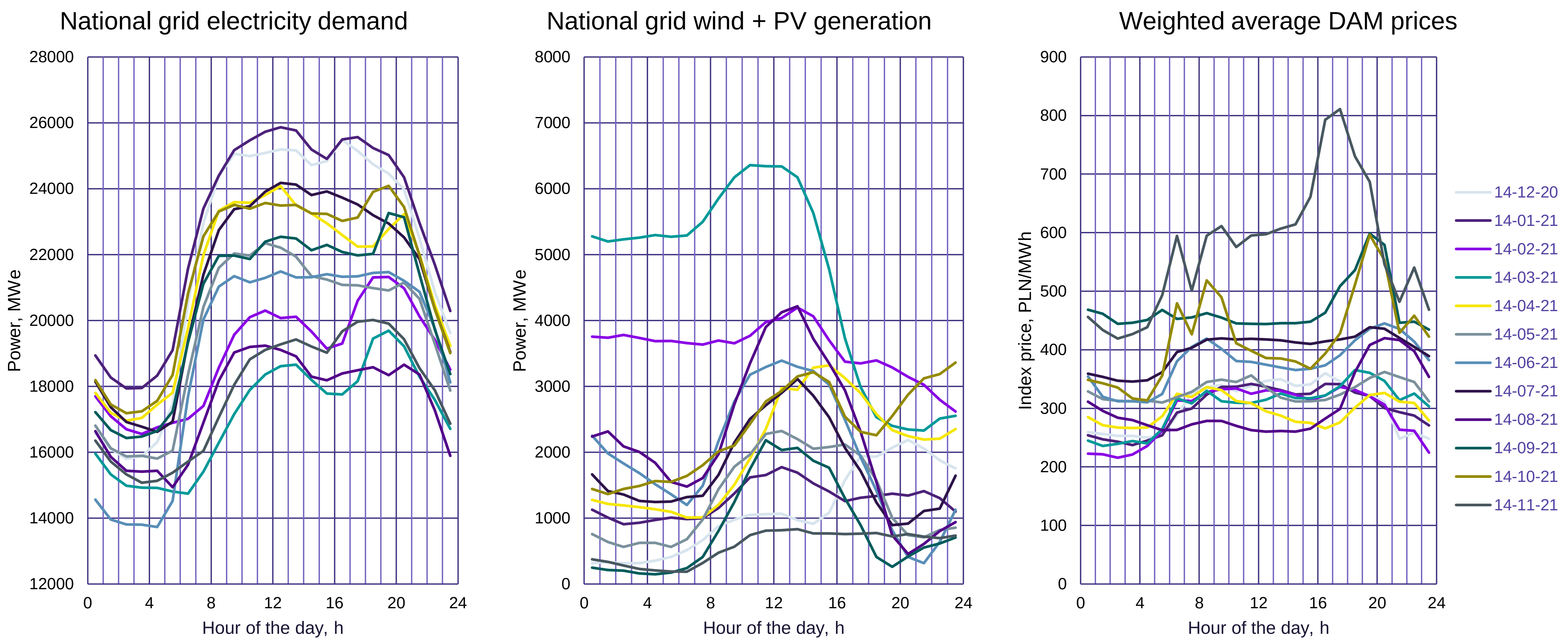


Bydgoszcz DH curve including incineration plant in the base load and gas fired water boilers as the peak loads

Siechnice DH curve with no heat sources available



Requirements put forth by electrical network 14th day of each month for last 12 months

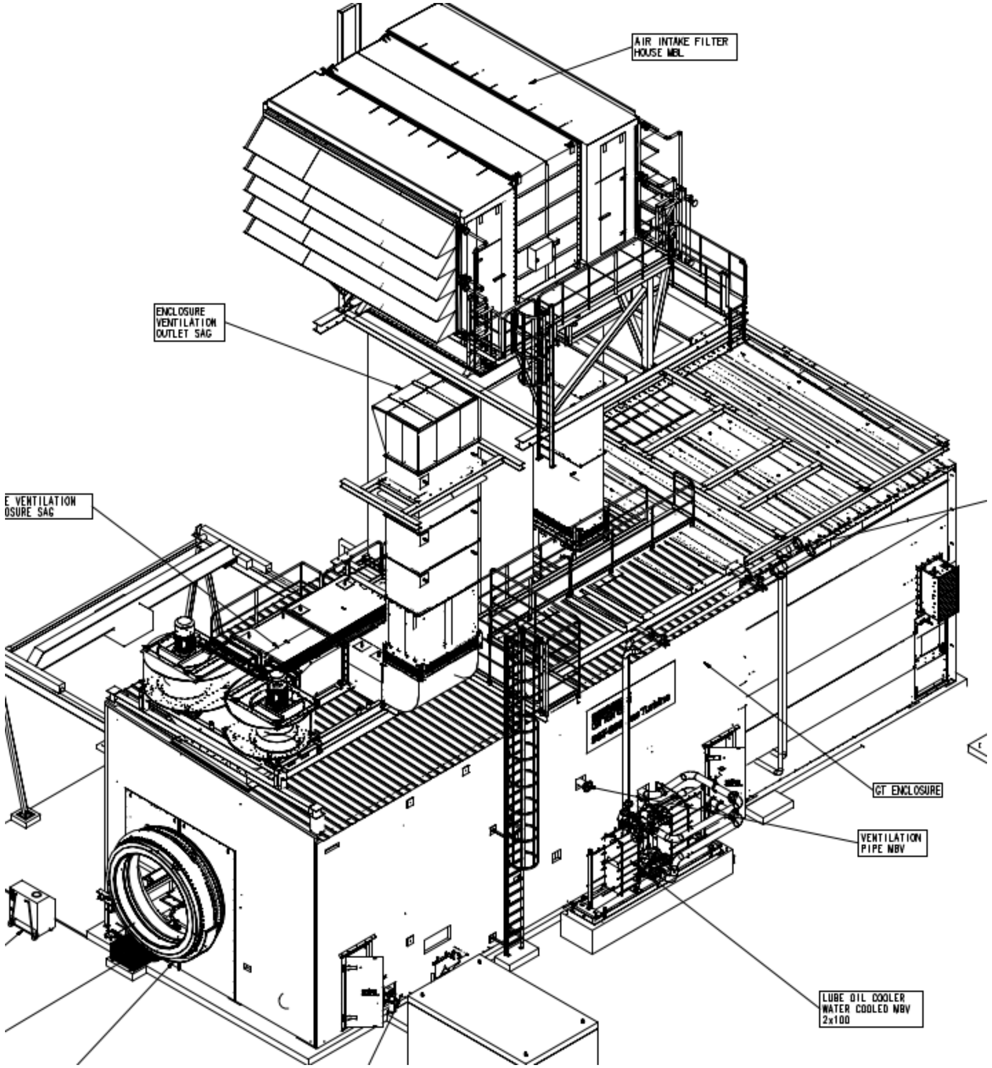


Source: PSE, TGE

DAM – Day Ahead Market

Nowa EC Czechnica
Flexible Plant Implementation

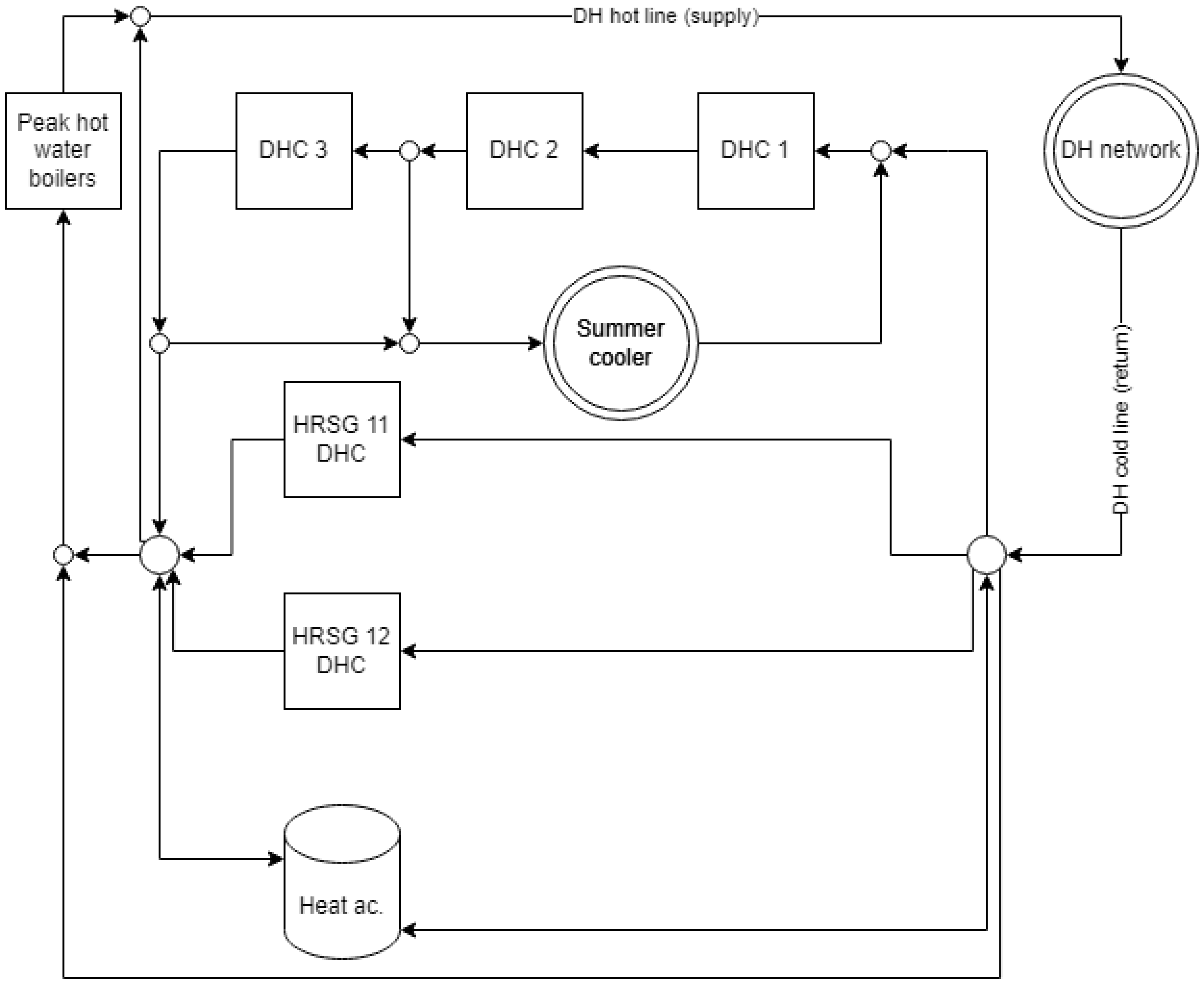
SGT-800 Gas Turbine



- 57MWe Gas Turbine
- Efficiency of up to 40.2%
- Works on both cold and hot natural gas fuel
- Each GT outputs approx. 70MWth of usable exhaust heat
- MEL of the GT at 50% of rated load*
- Exhaust gas temperature semi-independent on load and environmental conditions
- Three stage static air filter with HEPA final stage filters extending time between compressor washing cycles
- TEWAC generator cooled with air internally
- CO2 fire-fighting within GT enclosure

*) measured at ISO conditions, gaseous fuel operation

District Heating loop with summer cooler and heat accumulator



- 3 DH heat exchangers fed with steam:
  - 2 sub turbine exchangers – approx. 140MWth
  - 1 by-pass and peak heat exchanger – approx. 140MWth
- 2 HRSG DH heat exchangers connected in parallel to ST heat exchangers – approx. 5.5MWth each
- One summer cooler with capacity of 50MWth DH cooling connected in parallel to ST heat exchangers
- Heat accumulator with approx. 13000m3 capacity and charging/discharging of approx. 2000t/h
- 4 peak hot water boilers 38MWth each for a total of 152MWth

Heat accumulator

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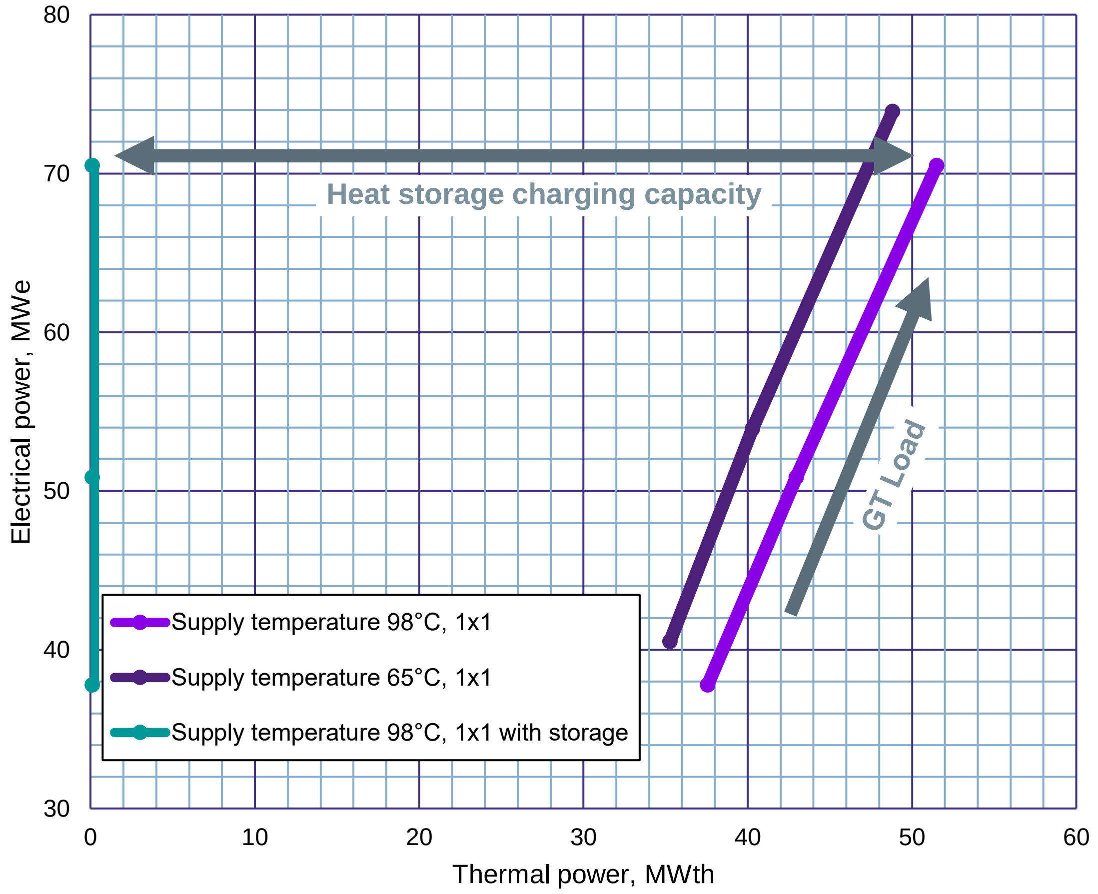
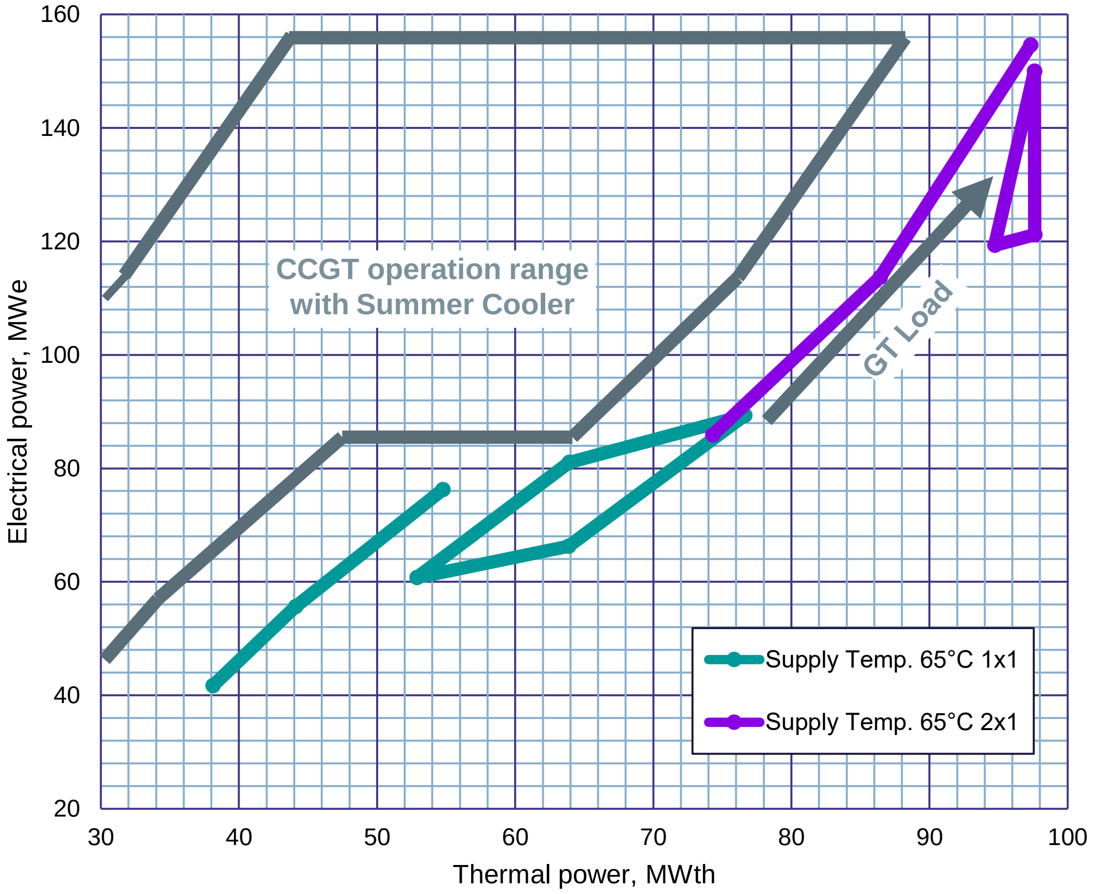
CCGT operation range with heat accumulator



Aim of the heat accumulator:

- Provide heat sink during time of low heat demand and high electricity price
- Provide heat source during low electricity price and allow the CCGT to either lower load or shut down the plant completely
- Allow unit to operate with no external heat demand at 50MWth output for approx. 14h

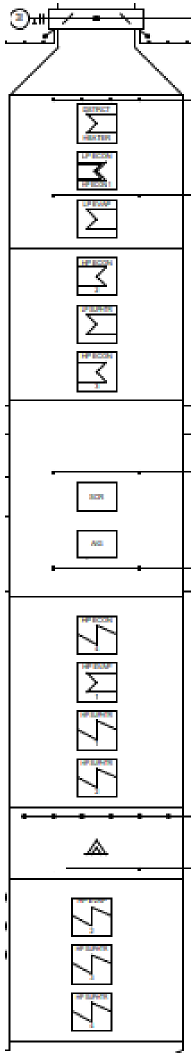
Summer cooler

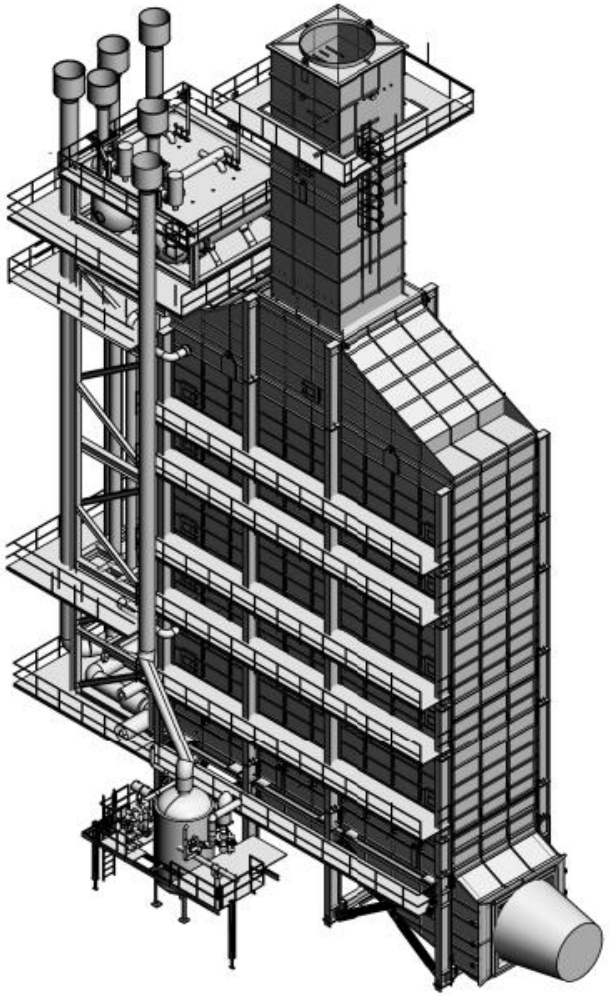


Aim of the summer cooler:

- Allow the unit operate during summer period when there is no heat demand and electricity prices are high
- Make plant possible to operate in semi-condensate mode increasing ST power

Modular 2p HRSG with SF and SCR modules





Siemens Heat Transfer Technologies HRSG:

- Fully modular construction with erection time of approx. 2 months
- HP section split in two with SF burner grid in between
- SF capable of up to 34MWth input per HRSG
- Ammonia injection grid and SCR module located downstream of HP section
- Space in the SCR module left for future upgrade of the catalyst
- LP section combined with internal HRSG deaeration heater
- Additional DH module located in the tail of each HRSG with thermal power of up to 5.5MWth
- GPH fed from the HP ECO extraction

HRSG supplementary firing

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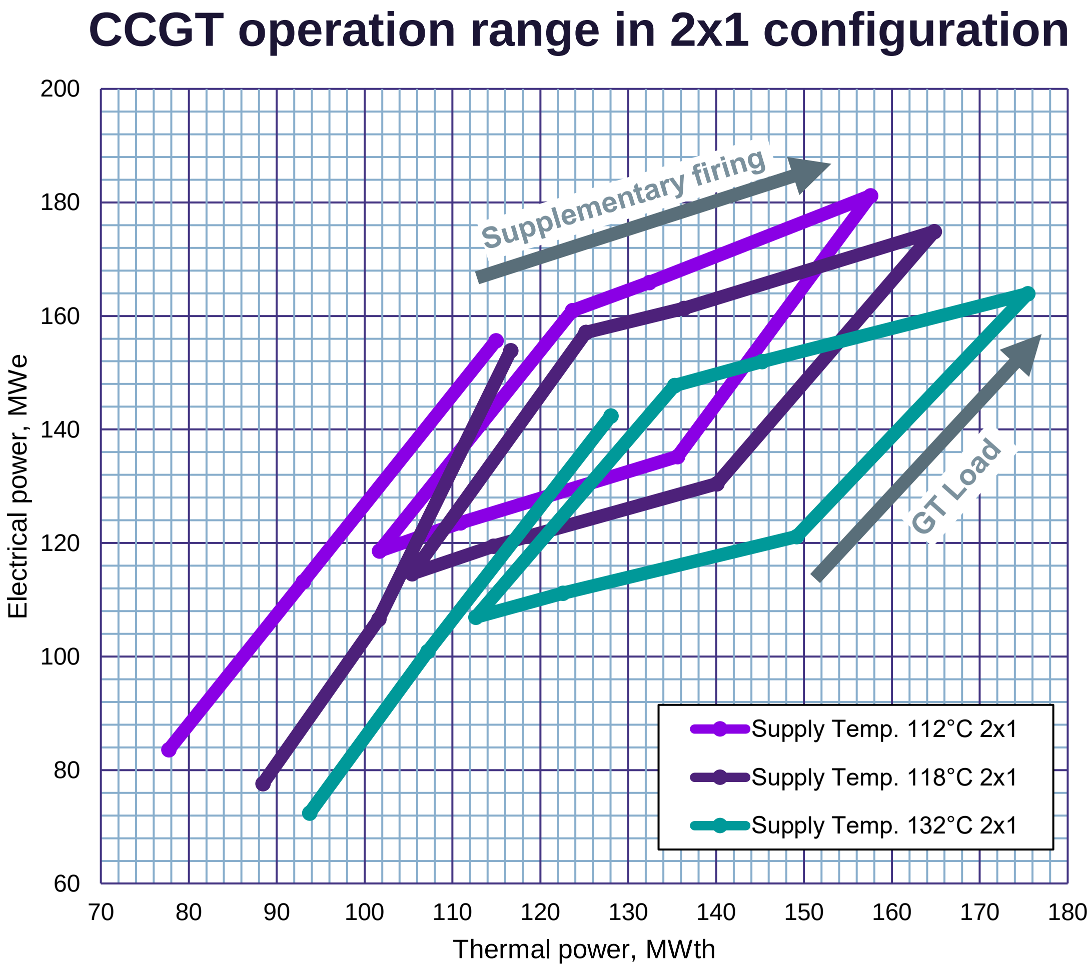
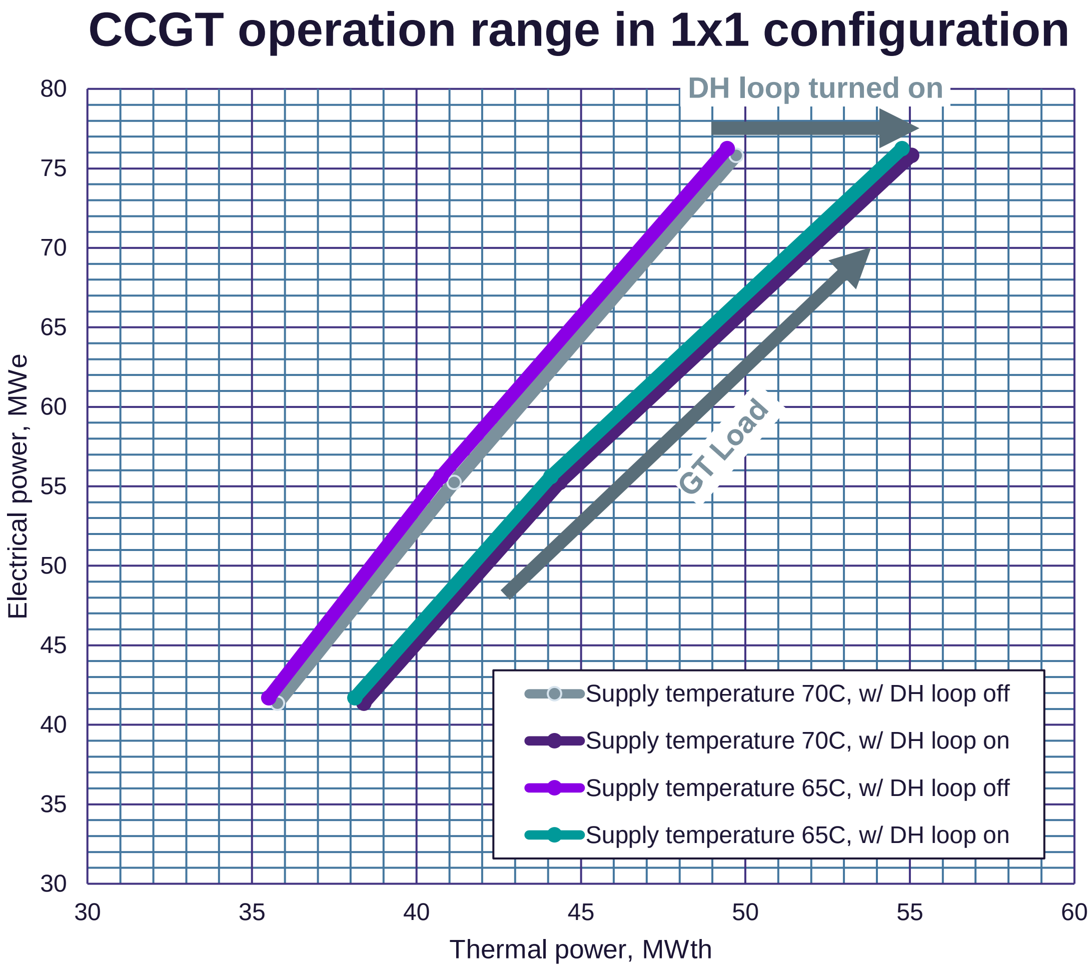


Aim of the supplementary firing:

- Increase exhaust gas temperature with utilization of remaining O2 in the exhaust gas
- Increase steam output and thus performance of the water-steam cycle
- Improve total efficiency of the CCGT at a cost of electrical efficiency
- Add ability to boost DH output without need to fire-up peak boilers

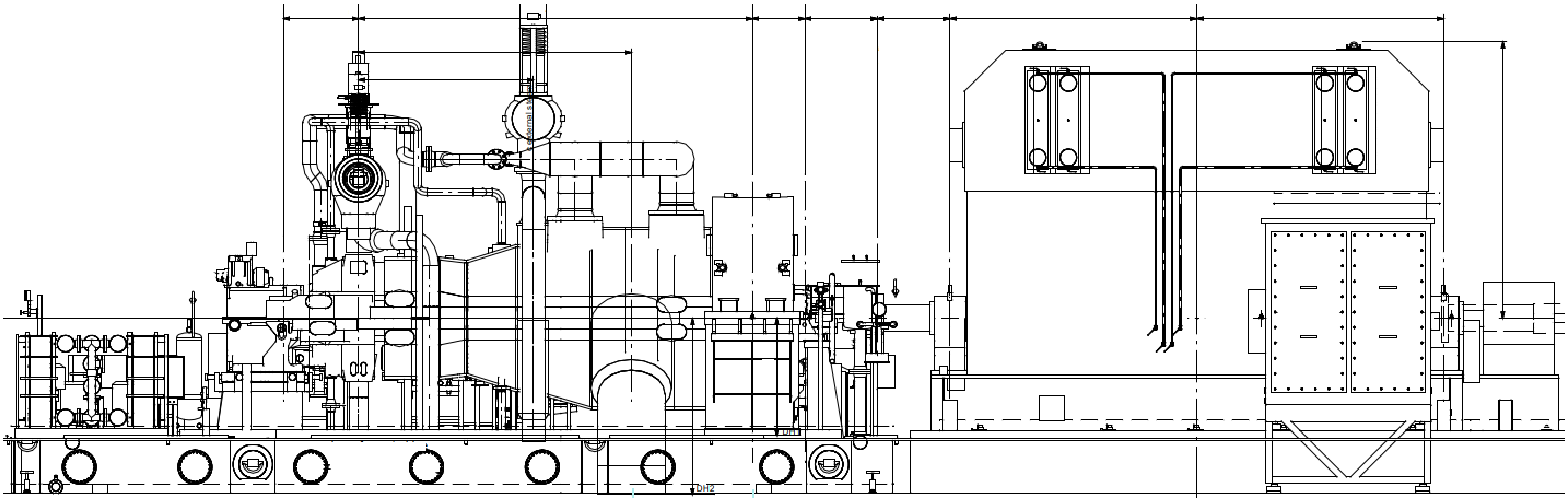
HRSG tail DH module



Aim of the HRSG DH module:

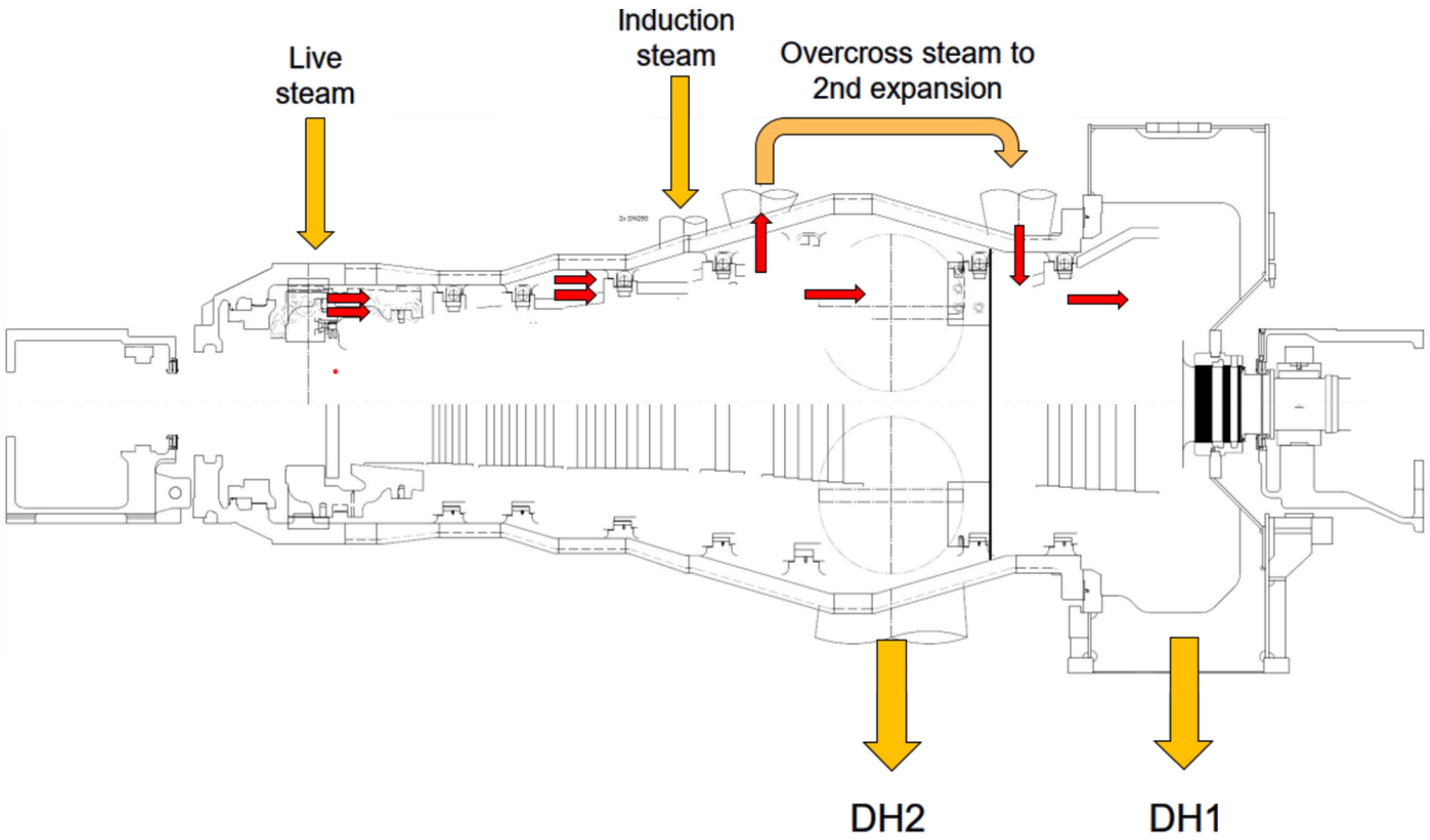
- Improve HRSG heat recovery by lowering exhaust temperature from appox. 120°C to under 75°C
- Increase DH output
- Loop can be shut down to allow more flexibility

SST-600 Tandem Steam Turbine



- Single casing 60MWe steam turbine
- Two steam exhausts operating at different pressures
- Two DH heat exchangers operating at variable pressures with approx. 140MWth output
- Two steam admission levels:
  - HP at 8MPa
  - LP at 0.6MPa
- Sliding pressure operation
- Generator of the same type as in case of GT

SST-600 Tandem Steam Turbine



Natural gas performance heater

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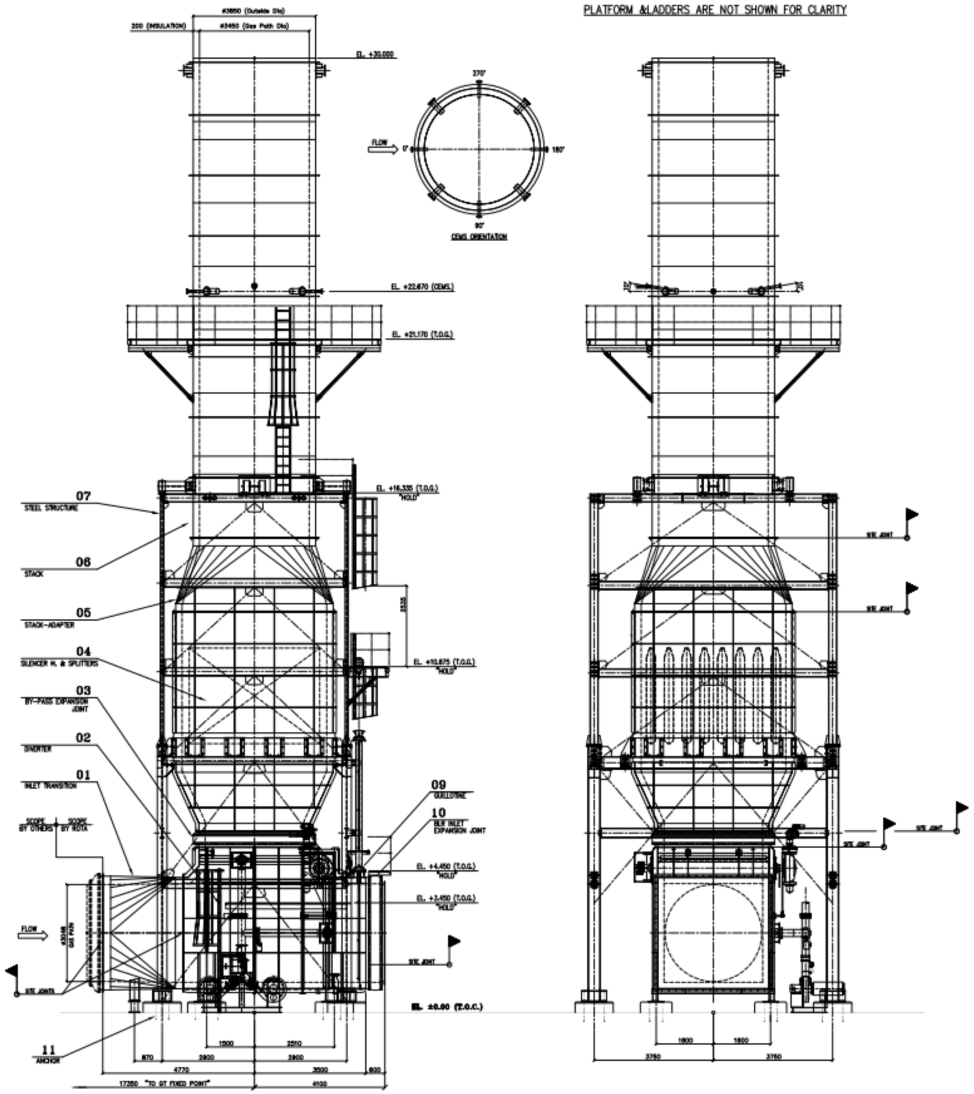
Case	dP_{el}, MWe	dQ_{DH}, MWth	dQ_{FUEL}, MWth	$d\eta_{el}$, p.p.
no GPH	0.0	0.0	0.0	0.0
GPH	-1.4	-1.8	-3.4	+0.1

Aim of the natural gas performance heater:

- Improve GT electrical efficiency and CCGT efficiency
- Decrease DH output by heat needed to heat up the gaseous fuel
- Lower CO2 emissions of the power plant

Other ways to improve plants flexibility

Hot stack



Aim of the hot stack:

- Allow for the GTs to operate during the HRSG downtime or lack of heat demand
- Increase flexibility of the CCGT by adding additional degree of freedom
- Allows to maintain HRSG without shutting down the GT
- Cheap alternative to water-steam cycle modifications

Condensing-extraction ST

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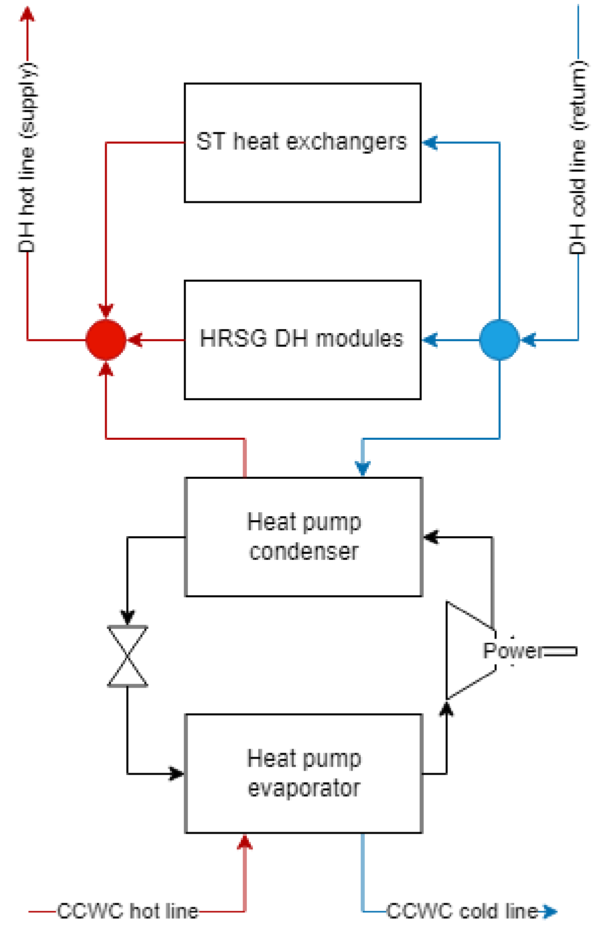
Condensing tail operation	P_{el}, MWe	Q_{DH}, MWth	Q_{FUEL}, MWth	η_{tot}, %
0°C	136	0	256	53.1%
8°C	136	0	256	53.2%

DH operation	dP_{el}, MWe	dQ_{DH}, MWth	dQ_{FUEL}, MWth	$d\eta_{tot}$, p.p.
0°C	-16	+92	±0	+29.9%
8°C	-15	+93	±0	+30.4%

Aim of the condensing extraction ST:

- Increase flexibility of operation of the plant by allowing it to work in both DH and condensing modes
- Solution reduces maximum DH output of the plant with respect to fully back-pressure ST
- Configuration allows for the highest flexibility of the plant considering no heat accumulator nor summer cooler are available



Heat pump

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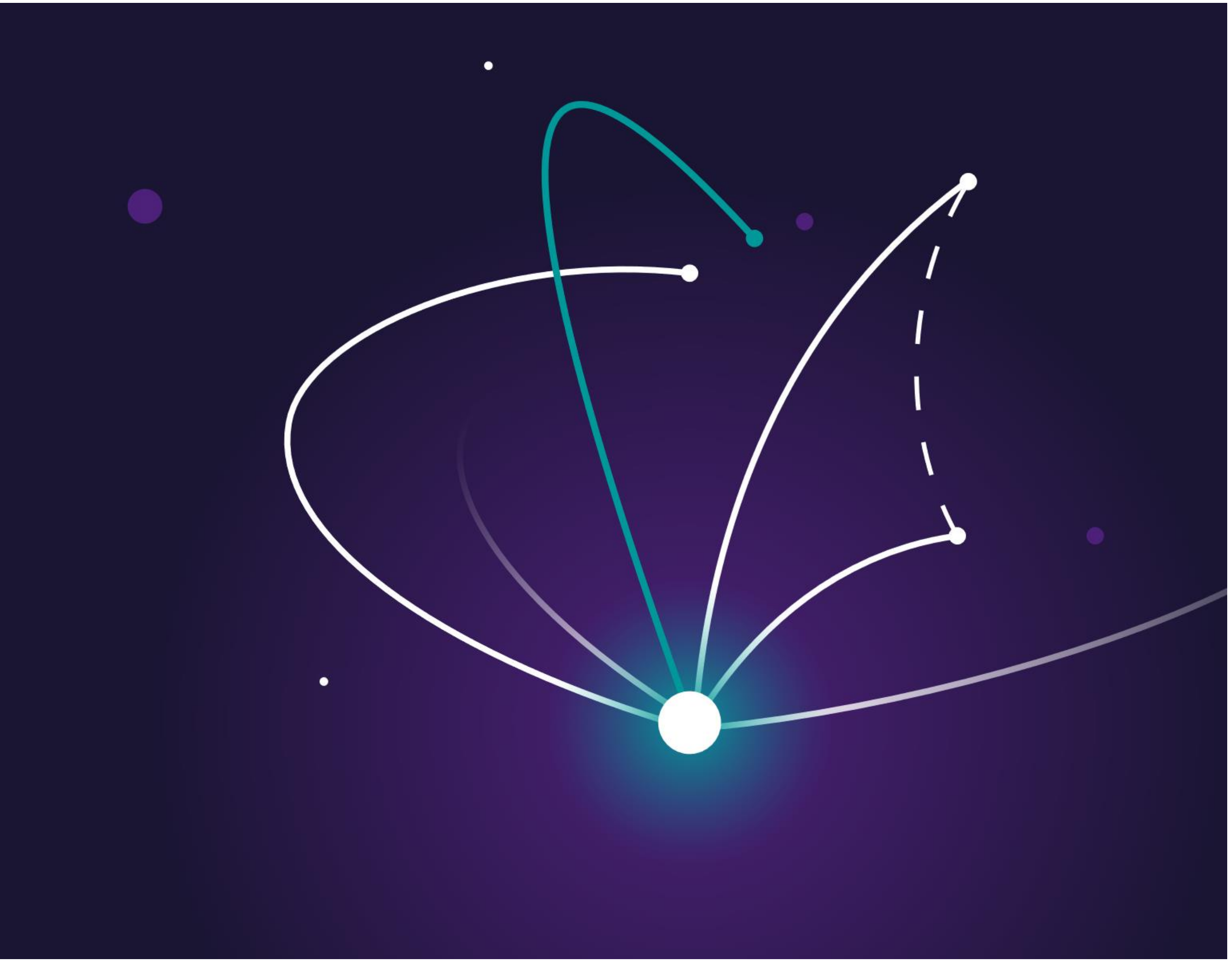
Aim of the heat pump:

- Provide additional thermal power at the expense of electricity
- Improve total efficiency of the plant
- Allow for coverage of peak heat demand and transition period improving overall plant performance
- Decrease heat discharge to the environment
- Lower overall emissivity of the plant

Case	dP_{el}, MWe	dQ_{DH}, MWth	$d\eta_{tot}$, p.p.	$d\eta_{el}$, p.p.
no HP	0.0	0.0	0.0	0.0
HP	-2.5	+8.0	+1.5	-0.5

Thank you for your attention



Dr. eng. Isidor Giglmayr
e-mail: isidor.giglmayr@siemens-energy.com
telefon: (+43) 664-830-18-85

Mgr inż. Władysław Jaroszuk
e-mail: wladyslaw.jaroszuk.ext@siemens-energy.com
telefon: (+48) 668-176-928