TECHNICAL CONSIDERATIONS AND BENEFITS OF INSTALLING COMBINED CYCLE POWER PLANTS ON OFFSHORE OIL & GAS PRODUCTION FACILITIES

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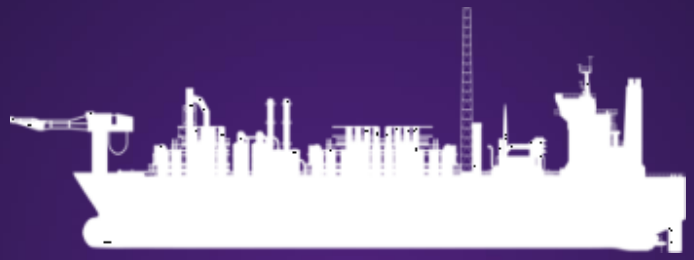
OFFSHORE COMBINED CYCLE

Designs for new build applications or existing asset optimization

Platform



FPSO

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Together we make the difference and protect our climate
by significant CO_2 reduction on oil platforms and FPSOs

Green Impact

- Combined cycle application increases efficiency and leads to a significant emission reduction
- Example: CO_2 output reduction by up to 110.000 t / year, when converting 2 simple cycle GTs into combined cycle plant
  (~ 5.000 to/a CO_2 savings per 1 green MW generated from the ST)

Further key benefits

- OPEX reduction and monetization of fuel gas savings
- Modular design fast and easy installation in offshore conditions
- Ultra light weight solution, offshore single lift and plug & play
- Small footprint w/ negligible impact on standard FPSO
- Flexible, reliable and highly efficient power and heat supply

Offshore Combined Cycle
ST Size of 20MW to 40MW

- 5,000 x **20** = 1,000,000 ton/a CO2
  Asset life 25+yrs = 25,000,000
- 5,000 x **40** = 2,000,000
  Asset life 25+yrs = 50,000,000

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Offshore Combined Cycle
Impact of a Lower Carbon Footprint

ULCC Module

-------savings*-------

CO_2 110.000
tons /a

Fuel 20-30
Mio. Sm^3/a

OPEX 5' – 7'
$/a

-------savings-------

Designed to master offshore challenges

Siemens design of the combined cycle power plant has been optimized to solve typical offshore challenges with focus constructability, maintainability, motions, footprint and weight. It has been enhanced for retrofit application beyond gas turbines on existing oil platforms or new offshore plants to provide green electrical power and heat e.g. on FPSOs, LNG or Methanol hubs.

- **~ 50%** smaller footprint **important due to limited space availability**
- **~ 50%** weight reduction **important for existing platforms**
- **~ 70%** plant efficiency for Power & Heat Provision**

- **Easy offshore installation** with lego bricks in single lift design
- **Optimized maintenance** concepts resulting in high plant availability

* Savings compared with existing Offshore Combined Cycle and related CO_2 taxes/certificates.
**The process can be adjusted to the power and heat requirements of the compressor and oil module.

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Ultra Light Combined Cycle can be provided in various configurations
based on Siemens Inhouse Engineering and OEM Equipment

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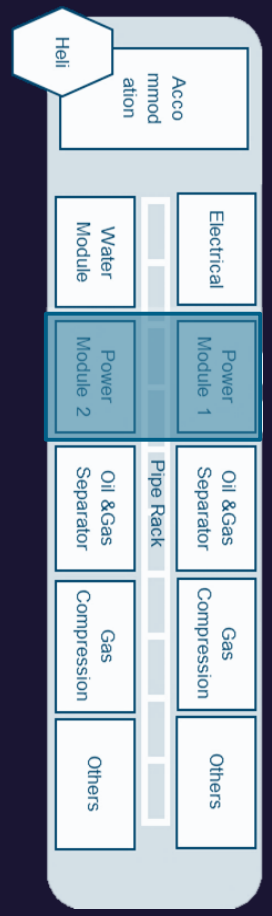
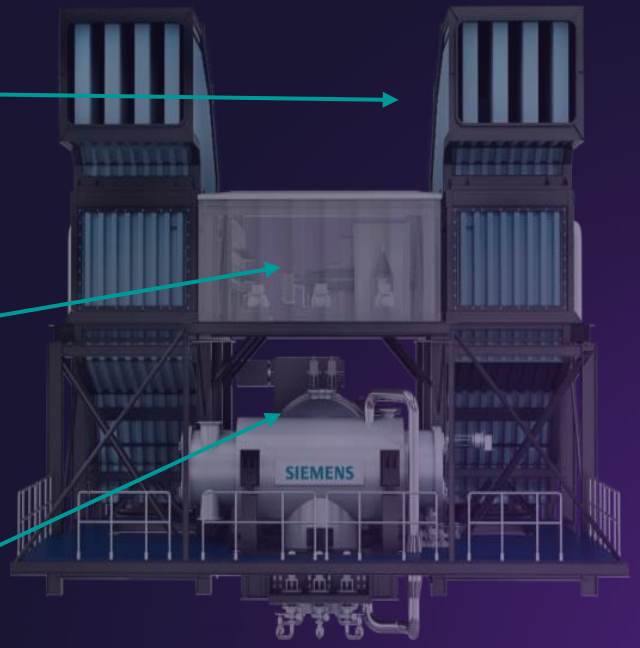


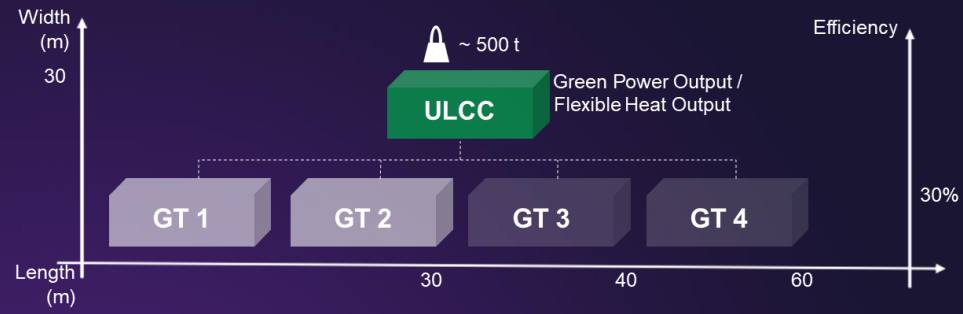
HRSG
Heat Recovery Steam Generator

BoP Module
Balance of Plant Module

ST Module
Steam Turbine and Condenser



Select your power module



- Power and Heat Supply
- Space Availability
- Degree of Modularity
- Flexibility in Operation
- Consolidation of Combustion – (EMDs)

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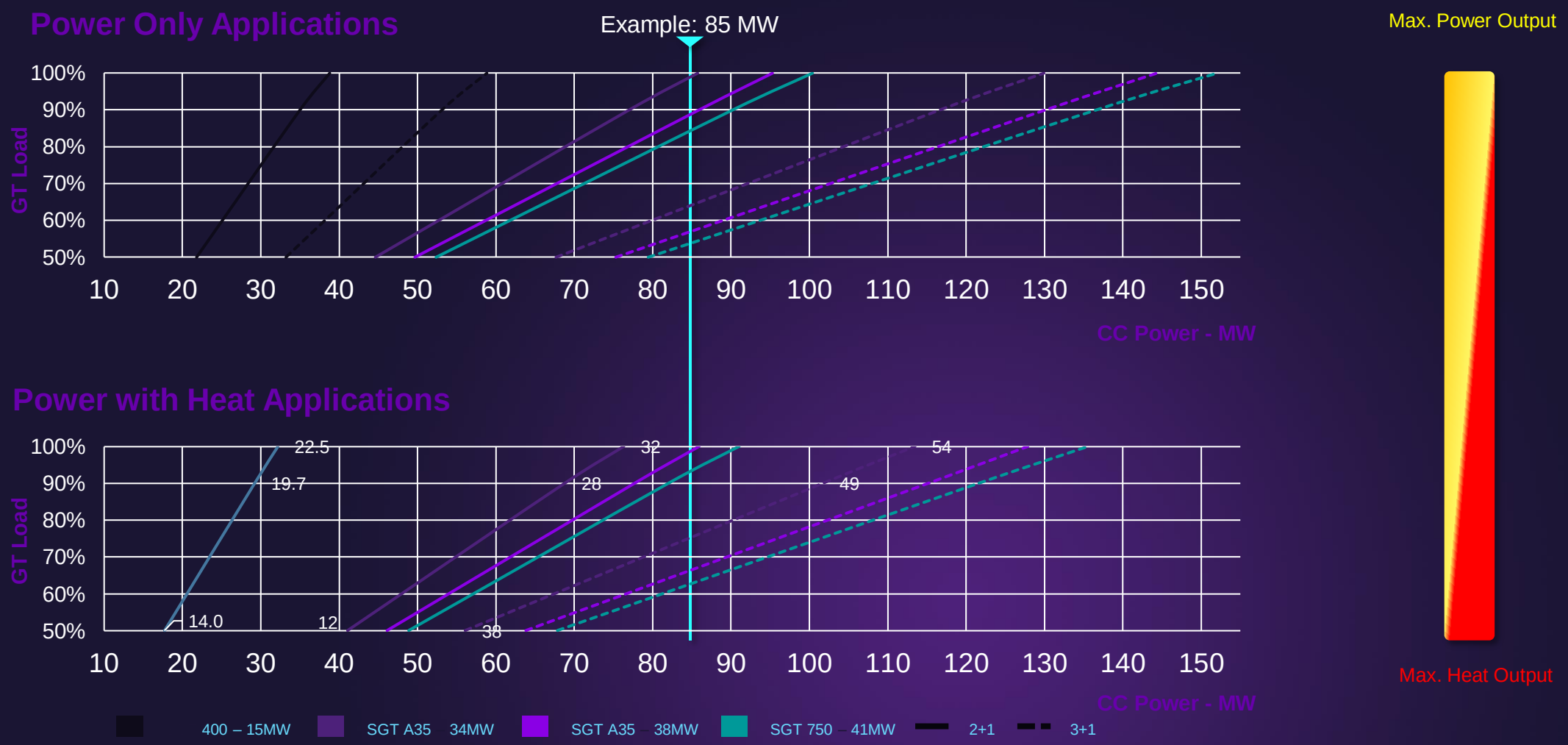
POWER and HEAT MODULE

Designed with flexible blocks to fit your application



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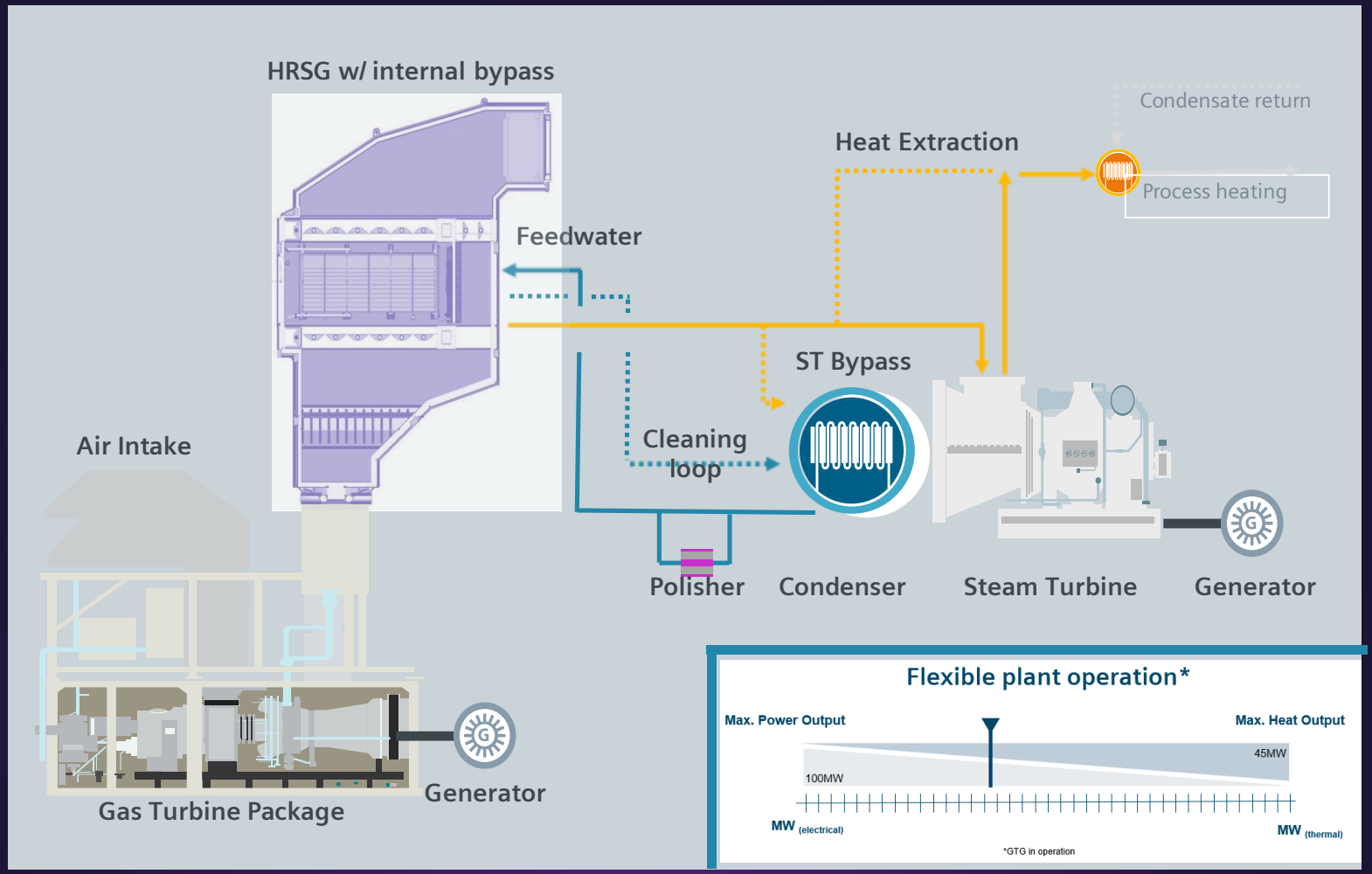
Ultra light combined cycle is “hermetically closed and provides maximum flexibility between heat and power supply

- Low complexity of the water-/steam cycle with highest operational flexibility.
- OTSG internal bypass stack allows operation of gas turbines only.
- Steam turbine bypass system allows 100% heat provision to oil separation process.
- Smart heat extraction allows maximum flexibility in balancing heat and power provision.
- Water savings because all drains are led to hotwell of condenser.
- No sky vent, only ST bypass station: no water loss during start-up/shutdown and reduce noise impact.



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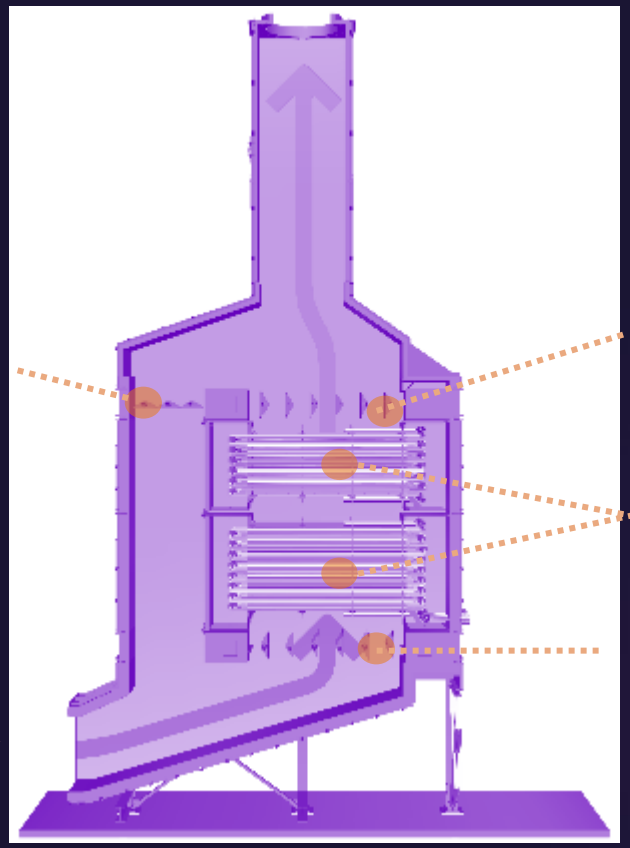
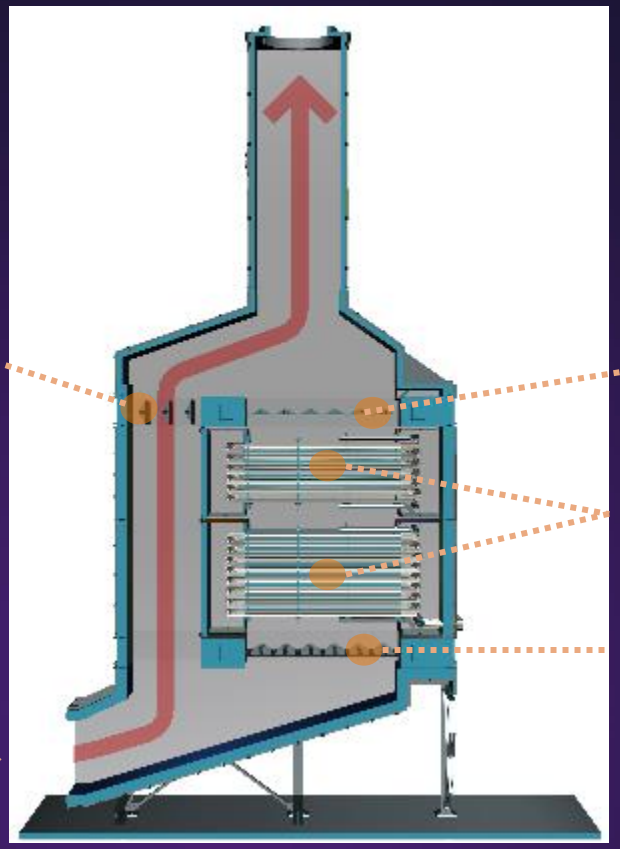
Continuous gas turbine operations
Internal by-pass feature

Heat Recovery Operations



Single Cycle Operations



Saving plot space and increasing power plant flexibility

N.B. internal by-pass not suitable in combination with duct firing

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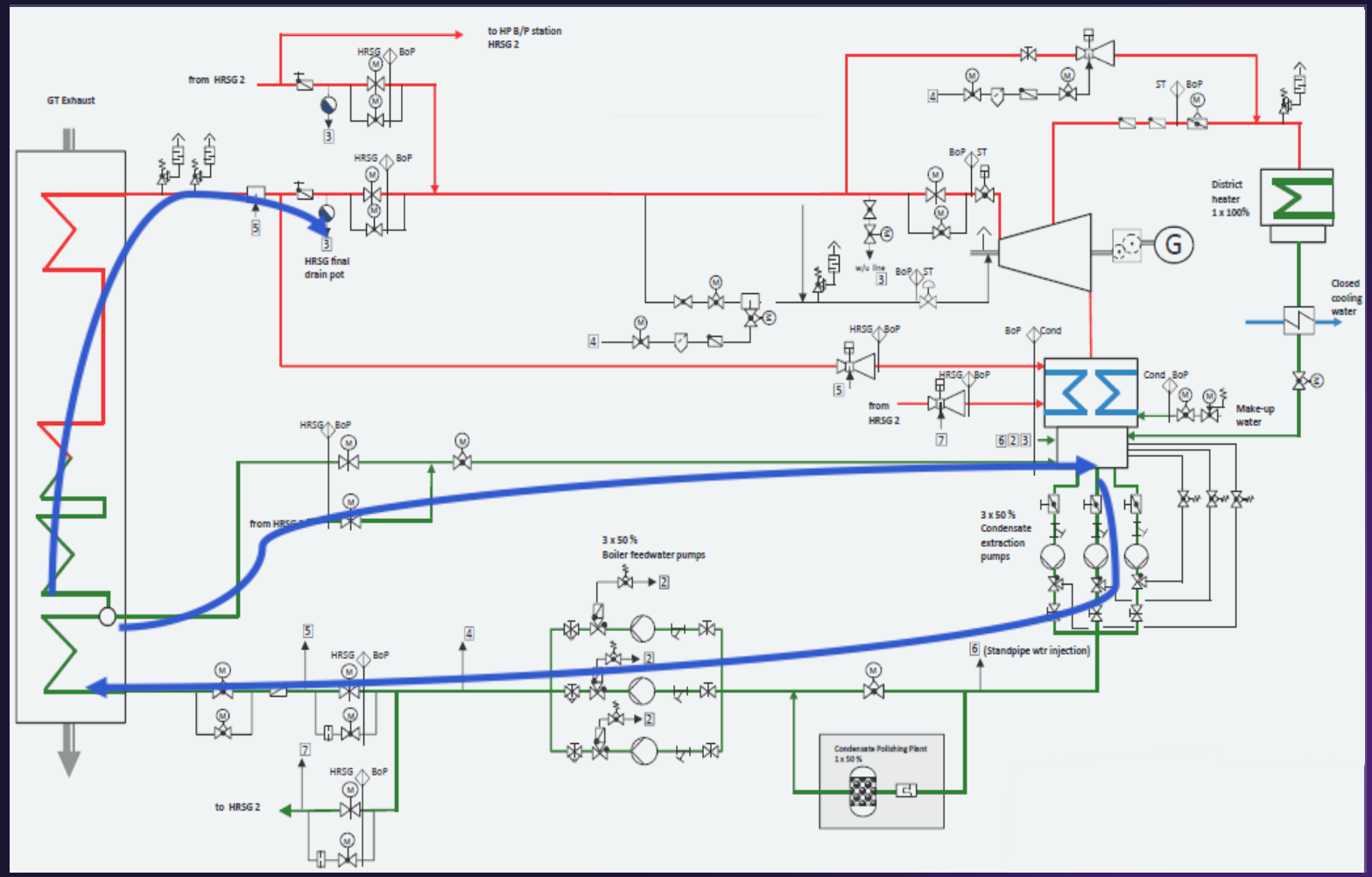
Water Preparation Phase



Preparation Phase:

1. First part of ECO is filled by BFP and the drain at the intermediate header is opened, so water is drained to hotwell
2. Some water might get over the syphon tubes into the rest of the bundle, this water is drained by drip leg at outlet and led to hotwell
3. Circulation of water is maintained, going over the polisher, until iron level is low enough
4. Circulation is stopped by closing the BFW CV and drains, the HRSG is now ready for GT ignition

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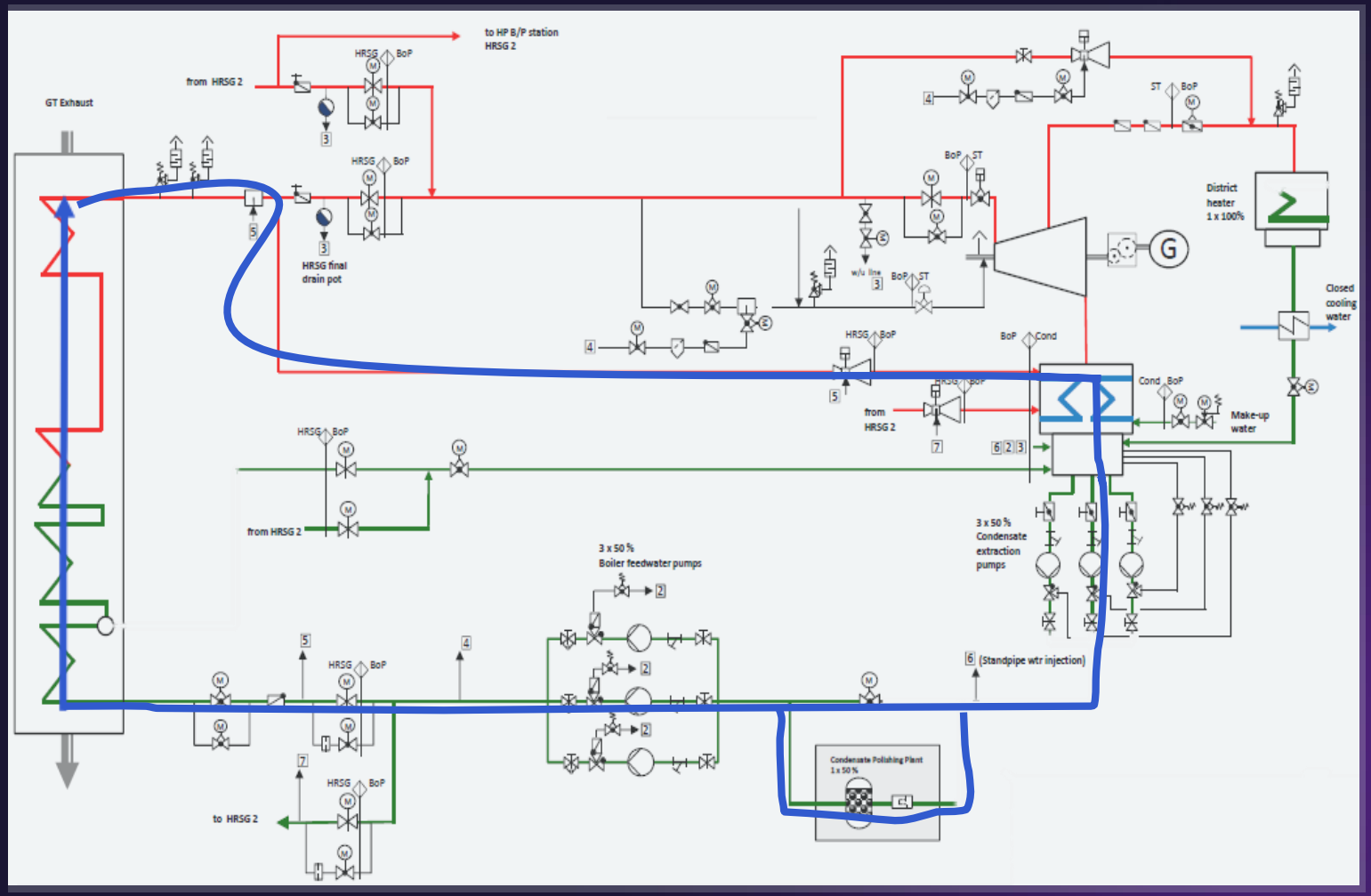
Warming Phase.



Warm - phase:

1. GT is started, ignited and ramped up
2. As soon as "GT flame on" signal is available, BFW CV is set to 100% flow
3. While water starts to fill the EVAP bundle, first steam is generated and enters the main steam line
4. When temperature at HRSG outlet starts to rise or 40% of EVAP bundle has been filled FW control is switched to HRSG steam outlet temperature control, setpoint: actual ST start-up temperature
5. Steam bypass station has two controls: maintain min flow of 30%, until first time ST start-up pressure is reached: then switch to pressure control at ST start-up value

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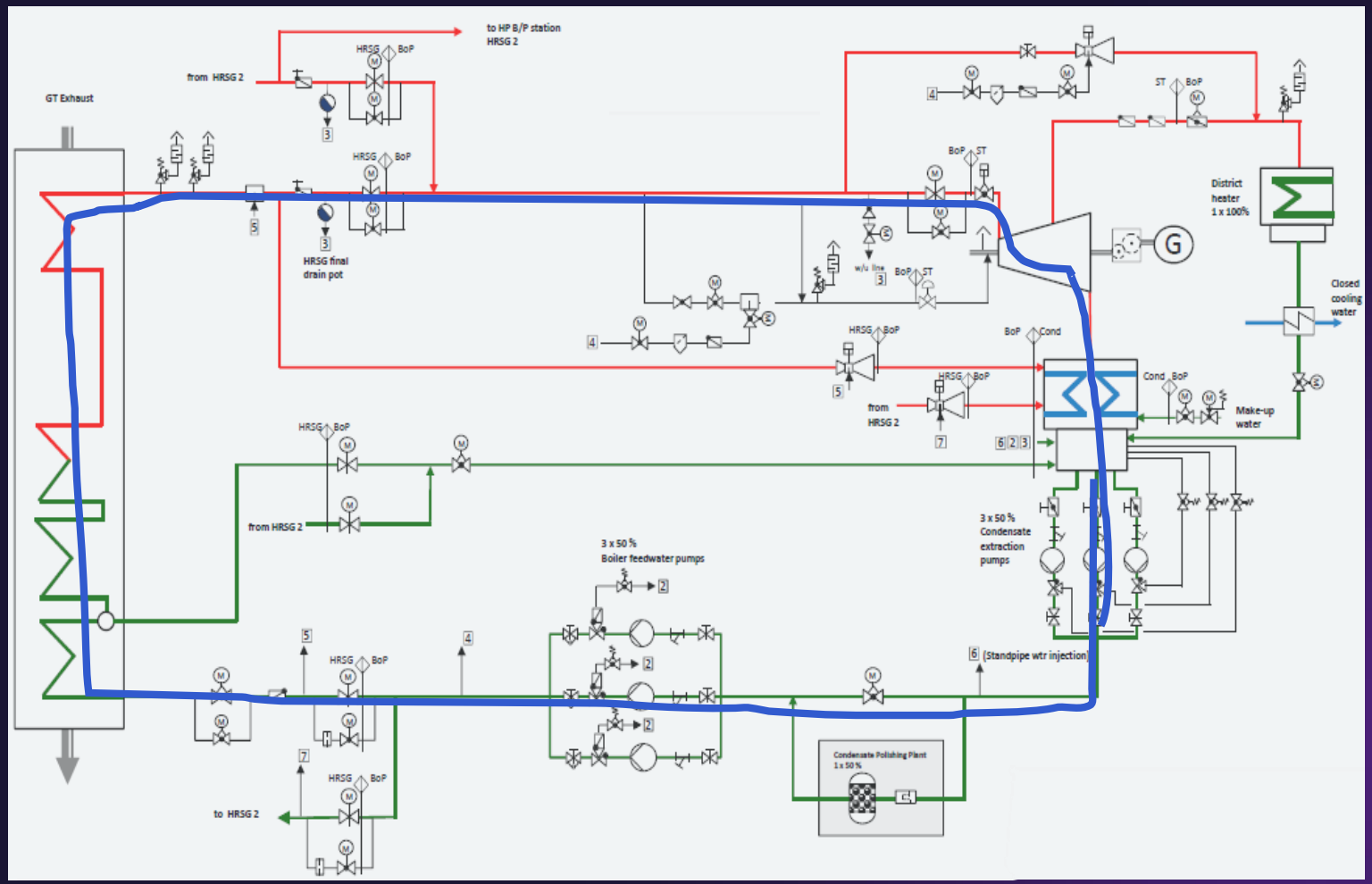
Operation Phase



In Operation:

1. Steam temperature and pressure are met to start up ST
2. IPCV is opened and ST is warmed up
3. ST is started up, as soon as ST can be ramped up, the bypass setpoint is raised to actual pressure Steam pressure rises according allowable ramp for the ST while bypass station closes (ramp rate is controlled by bypass)
4. IPCV maintains floor pressure, ST is in sliding pressure mode
5. HRSG FW control is set to constant volume flow towards ST

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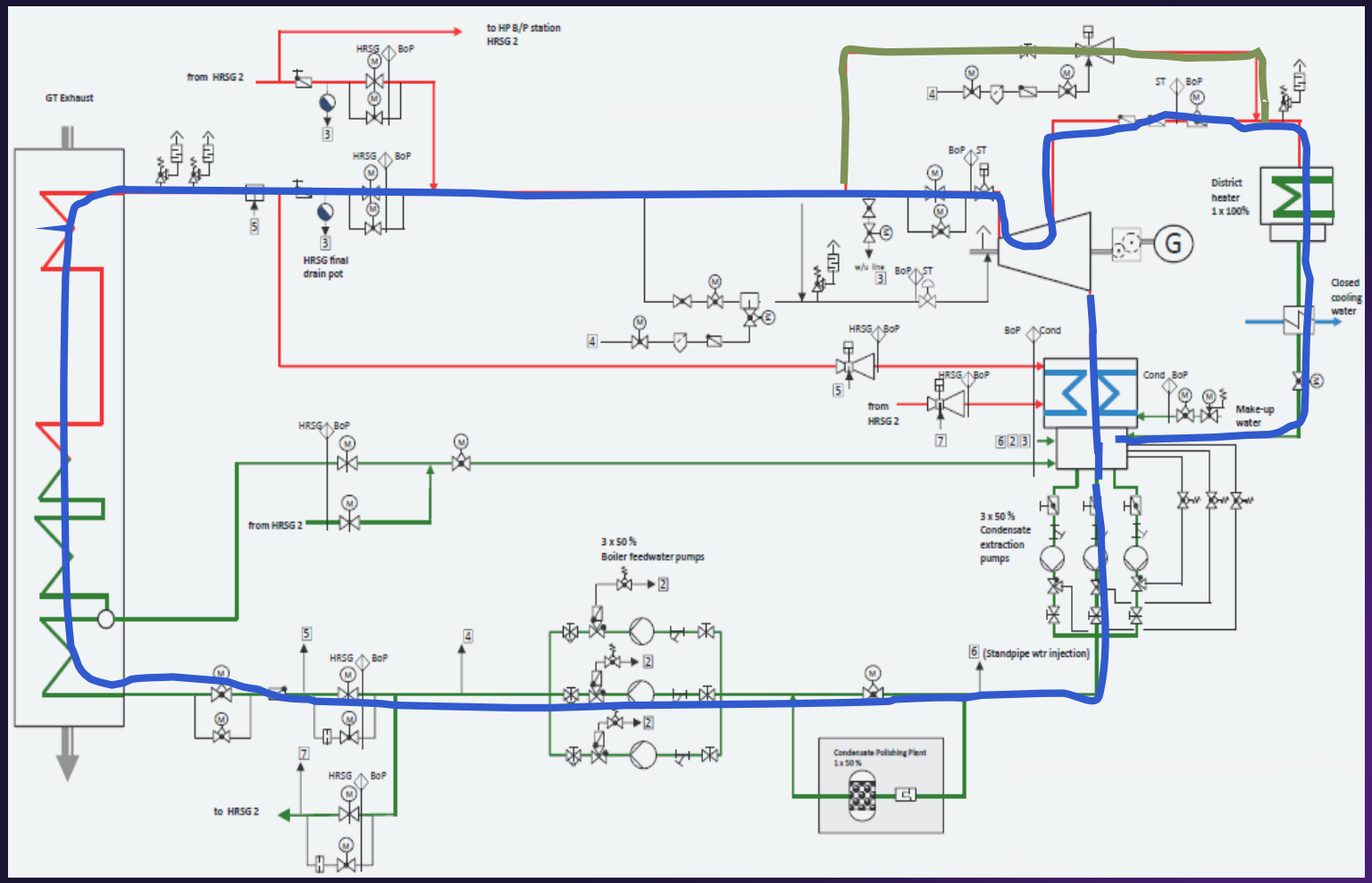
Heat Extraction and By-Pass



Heat Extraction:

1. Heat can be extraction from the ST casing during normal operation.
2. During shut-down of the ST heat can be extraction from the main steam line upstream of the ST.
3. 2 x 100% process heat exchangers are required per pressure level.

Emergency case:

1. In case of leakage of the process steam exchanger (non double wall exchanger):
2. Inductivity in the condensate system will increase and the condensate polisher will be started
3. Alarm will be available in the DCS system and an automatic switch-over to the heat exchanger in stand-by will be initiated

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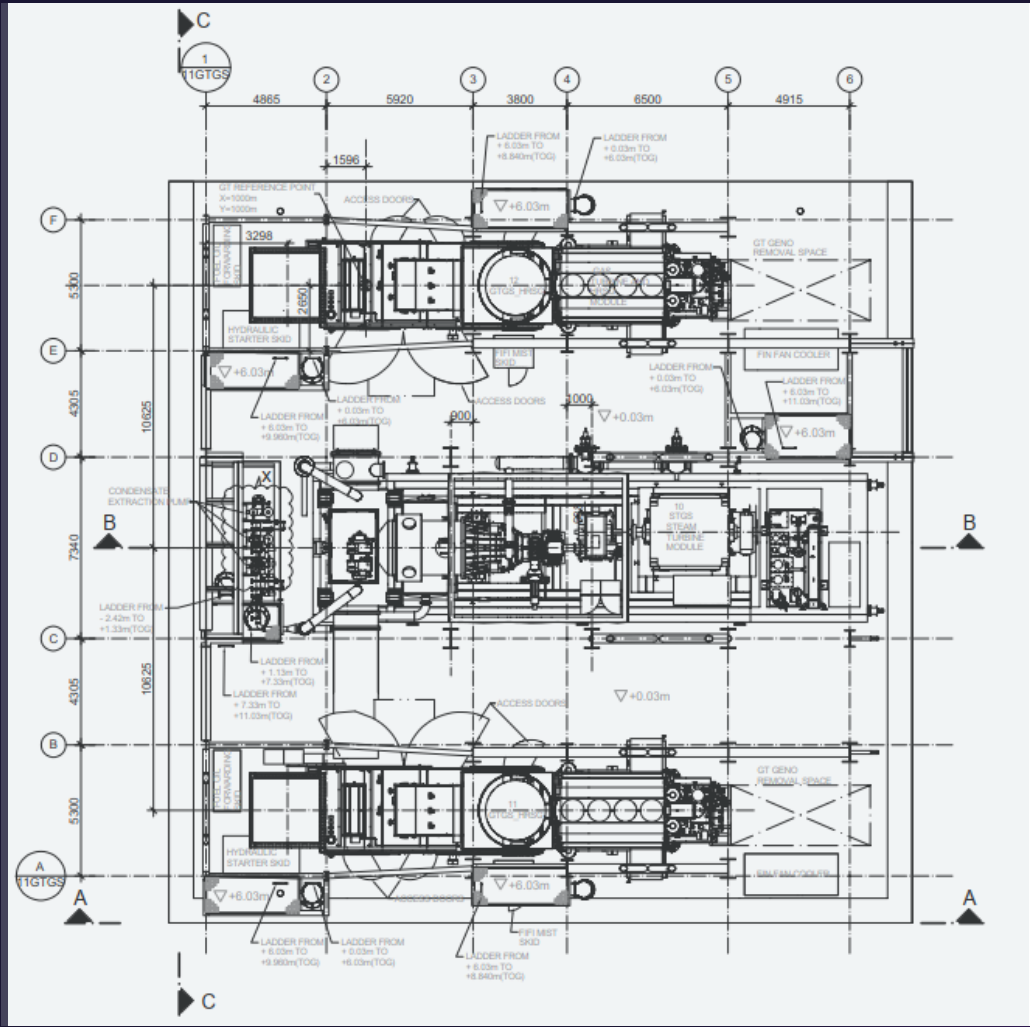
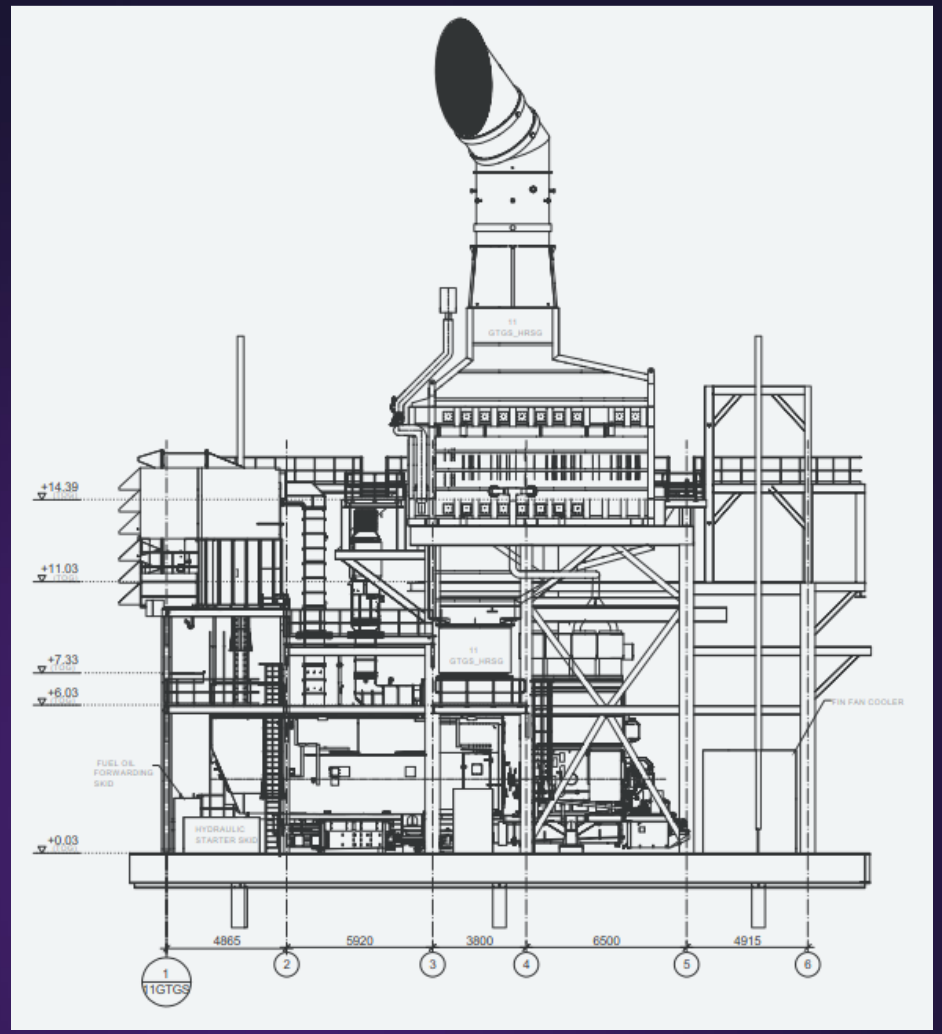
ULCC typical layout with a plant configuration of SCC-A35 2+1 ~30M x 30M





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Ultra Light Combined Cycle
Weight lists and footprint

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Weights

Brownfield consideration of weight

Components	Weights 2x1 operational	Weights 3x1 operational	Weights 4x1 operational
GTG Package & Auxiliaries	354	531	708
HRSG	183	275	366
STG Package & Auxiliaries	251	229	251
BoP Module	243	263	295
Electrical Equipment	24	24	24
I&C	1	1	1
Total weight, base [ton]	1.056	1.323	1.645

Footprint

2x1	3x1	4x1
length x width	length x width	length x width
30m x 30m	**30m x 40m**	**60m x 30m**

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Combine Cycle Solutions
Reference Project: Shell Appomattox (Gulf of Mexico) – 175K BPD

In operation since 2019
150 MW Power plant including Aeroderivative Gas turbines and 40 MW STG.

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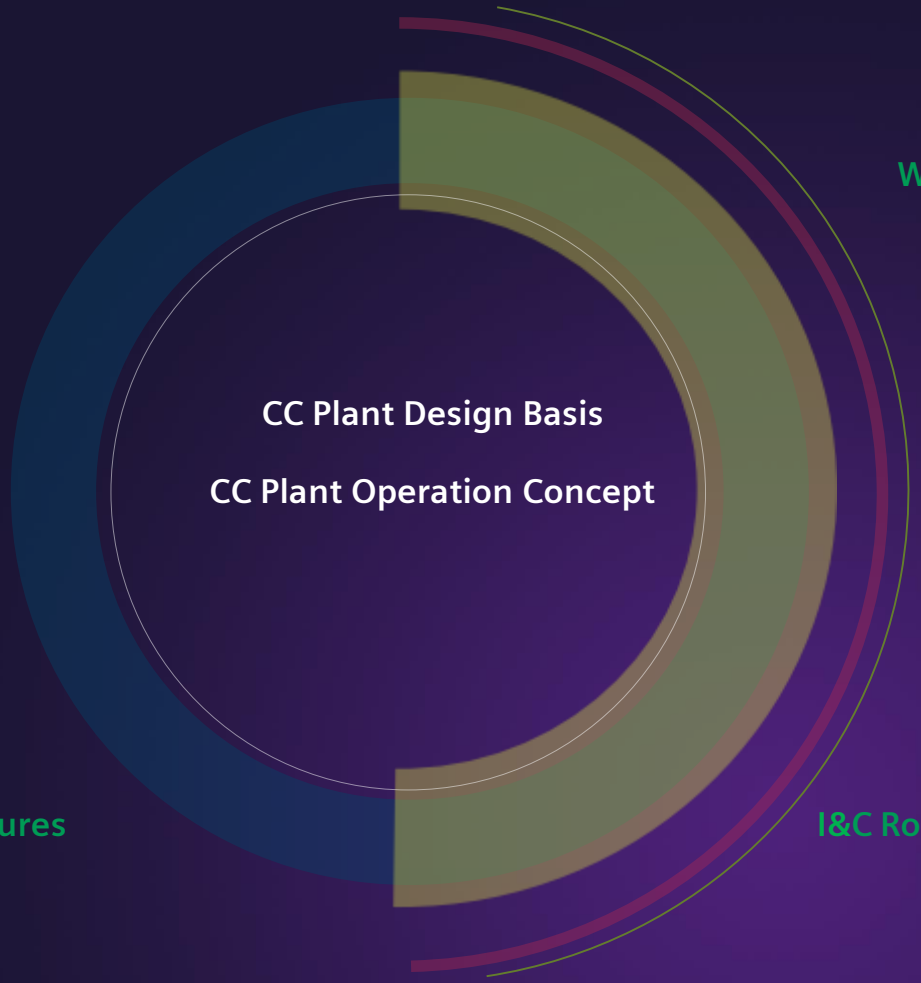
FORM to FUNCTION and FUNCTION to FORM

The equipment utilized in a combined cycle power plants are long-lived in the onshore space, and thus the evolution to offshore, although uncommon, is not unprecedented.



Scope of Supply

Division of Responsibility

Terminal Points and Integration

Arrangement & Mechanical Interfaces

Performance Values and Test Procedures

Weight and Distribution

Single Line Diagram & Electrical Stability

Water Balance & Make-up

Parasitic Loads

I&C Robustness and Responsiveness

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