Calculation Homework 5

Home Assignment 5 – COMBINED CYCLE with a 2-pressure HRSG

A combined cycle layout with a **double-pressure HRSG** and **supplementary firing** is shown in the figure further below.
Both the gas turbine and the supplementary burner are fired with upgraded biogas. There are no steam extractions from the steam turbine, disregarding also the feedwater tank. There is no steam reheat either.

The gas turbine main characteristics are listed in the following table:

Gas Turbine type	El. Output (MW)	El. Efficiency (%)	Gas flow (kg/s)	Exhaust temp. (°C)
Siemens GT800	**43**	**37**	**122**	**546**

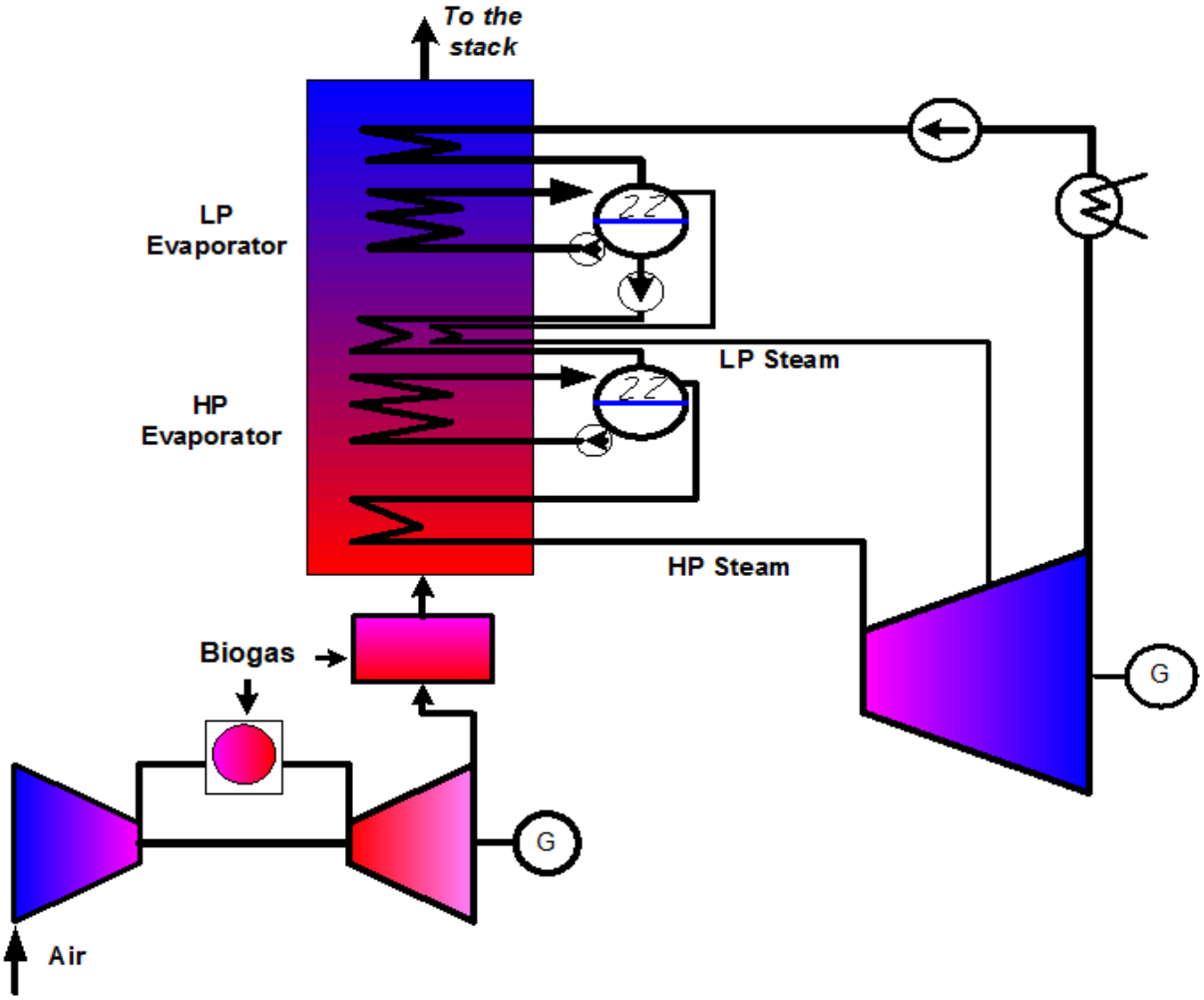
Other necessary parameters and assumptions are listed here below:

Gas content in flue gas throughout the HRSG x = 0.4
Temperature after supplementary firing 600 °C
High pressure (HP) steam after superheat 60 bar, 500 °C
Low pressure (LP) steam after superheat 5 bar, 220 °C
Pinch point temperature difference (LP line) 10 °C
Steam mass flow fraction in HP line 50 % (HP share of total steam flow)
Pressure in the steam condenser 0.1 bar
Mechanical efficiency of steam turbine 0.98
Efficiency of the el. generator for steam turbine 0.97

Neglect the gas flow increase due to supplementary firing, neglect the gas content change!
Assume that the feedwater entering the LP drum is saturated.
Neglect the pump work and assume no pressure losses and no heat losses anywhere.

Hints: *The isentropic efficiency of the steam turbine is not given. However: the HP and LP superheat enthalpy values define a line, which can be continued further to condenser pressure in the h-s diagram, thus graphically finding the real end of expansion in the steam turbine!*
Gas enthalpy values can be applied as per the gas table in the help file.
The task can be solved regardless of the fuel type or fuel properties.

To be calculated:
- Steam mass flow generated in the HRSG for each pressure level [kg/s]
- Stack temperature of the flue gas after the HRSG [ºC]
- Steam turbine net electrical power output [MW]
- Electrical efficiency of the combined cycle [%]



Instructions:

There are two possible ways to handle this assignment (either one or the other):

1) A detailed solution on paper with the input parameters given above, including all equations and all sub-procedures for reaching the final results. Try to fit it into 1 sheet of paper (max two sides). The paper solution can be submitted to a teacher during any SPG class event.

2) A web-based solution, where the assignment is accessed and submitted entirely online in CANVAS. The calculation results - a range of partial and final answers - shall be uploaded directly into CANVAS for an automatic check.

In all cases, the solution procedures and any related questions can be discussed with a teacher during the homework help sessions.

For the online submittal in CANVAS - the assignment should ultimately be solved at 100% correct answers. It remains open and can be restarted unlimited number of times, until solved to 100%. Solving all home assignments in the SPG course with 100% correct answers will provide you with 1.5 credits towards completion of the course (appearing as “ÖVN1” or “Exercise1” in the transcript).