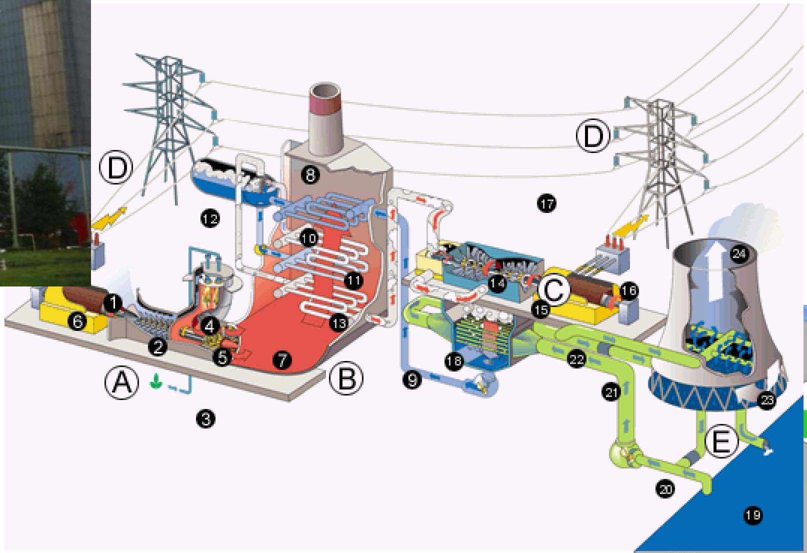
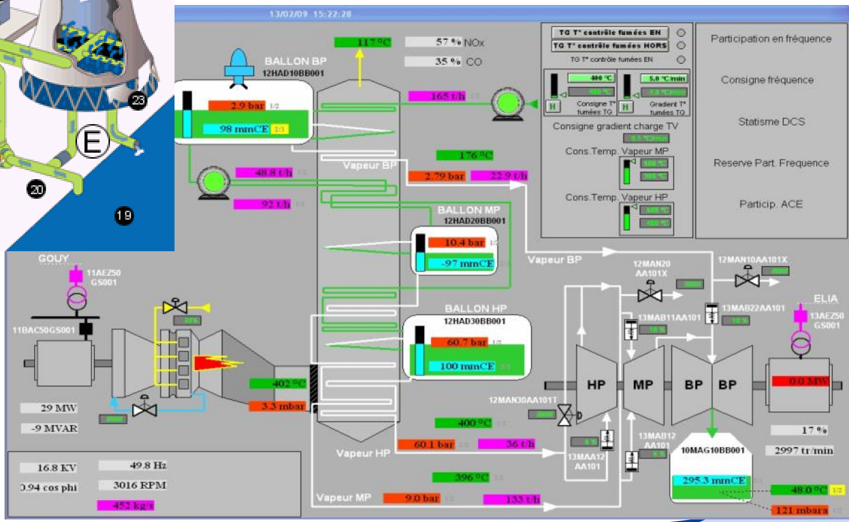
MECA 2150 : PROJECT

Modelisation of GT, ST, CCGT and cooling tower



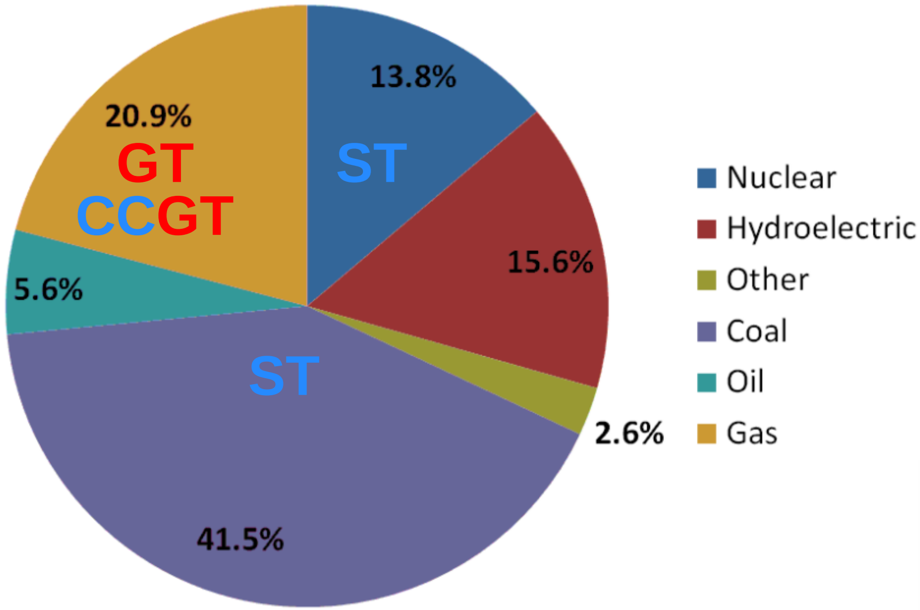
Drogenbos (ENGIE)



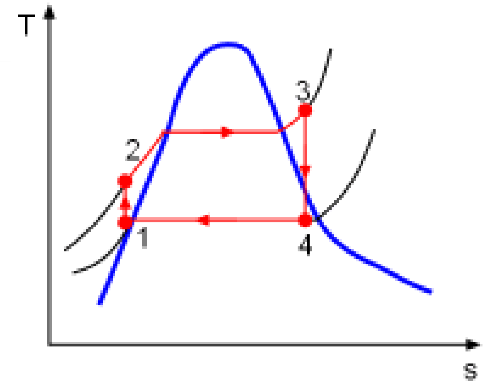
25/09/2017
Gauthier LIMPENS

Introduction

➔ Context

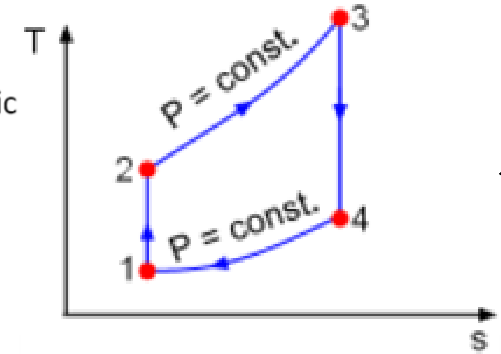


World electricity production



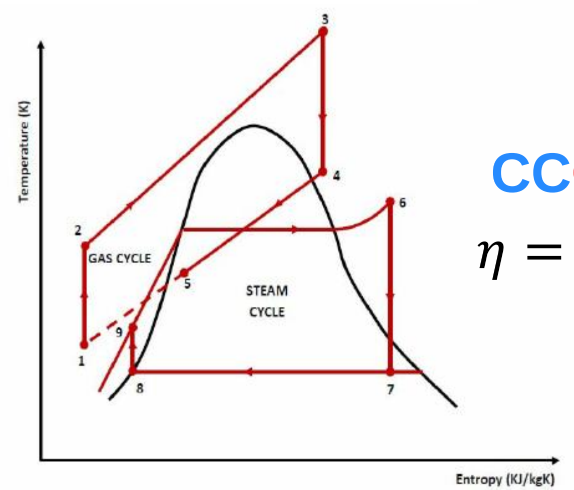
ST

$\eta = 33 \rightarrow 40\ \%$



GT

$\eta = 35 \rightarrow 43\ \%$



CCGT

$\eta = 52 \rightarrow 60\ \%$

>76% world electricity production comes from **thermal cycles**

Introduction

➔ Project goal :

- Perform an in-depth thermodynamic study of a thermal cycle power plant, in order to :
  - Determine performances in the energy and exergy point of views of the different parts of the cycle
  - Draw T-s and h-s diagrams of the different cycles and heat exchangers
  - Study the impact of several parameters on the performances of the cycle

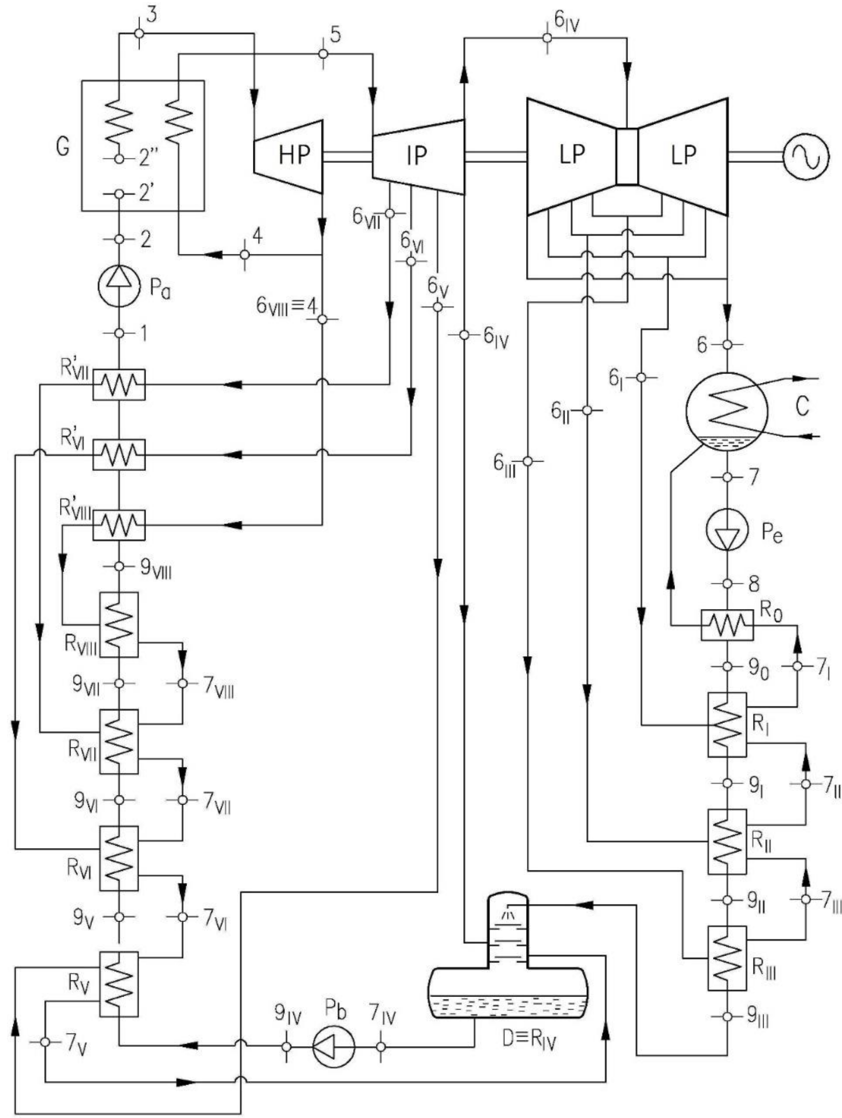
➔ Project structure :

- The project is divided in four parts :
  - Steam turbine (**ST**) power plant combining reheating and feed-heating for different fuels. It should be used in sub and super critical modes with a degazificator.
  - Gas turbine (**GT**) power plant cycle
  - Combine cycle gas turbine (**CCGT**) power plant with 3 pressure levels
  - Cooling tower for **ST** and **CCGT**
- The model will be developed with Matlab.

Thermal cycles : Steam turbine

DATA	
River temperature	15 [°C]
Max. temperature within the boiler	525 [°C]
Max. steam pressure	200 [bar]

- Why these data are relevant?
- Which parameters are also relevant, what are the associated data and their numerical values?
- Which input are required?



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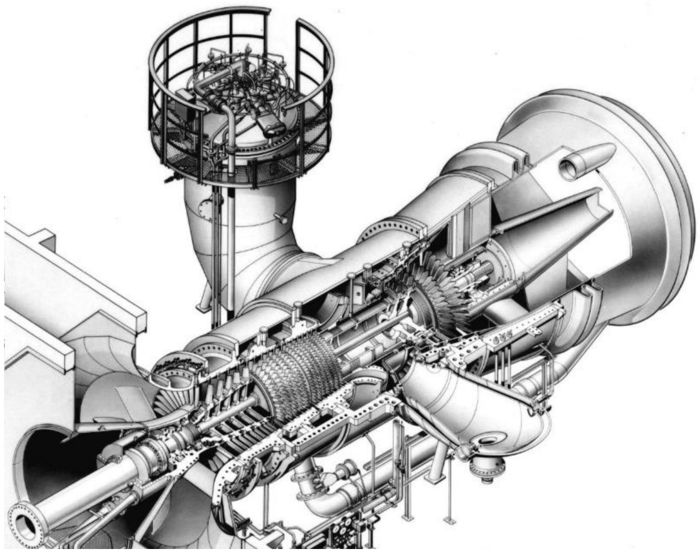
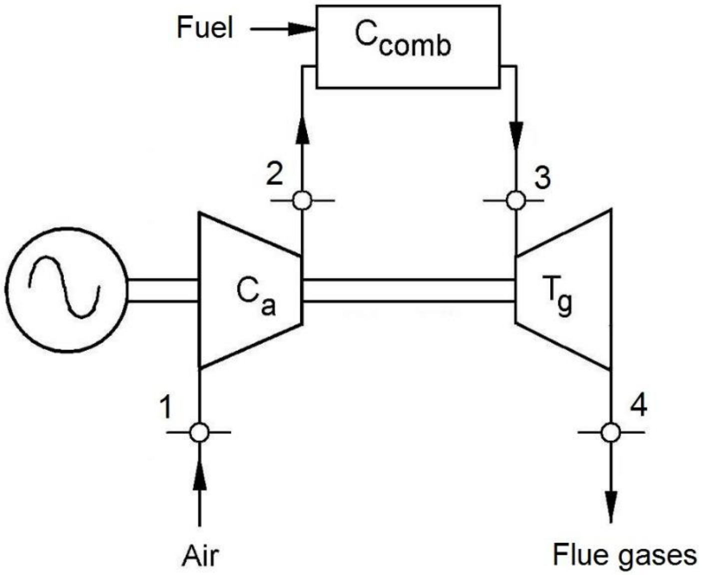
Thermal cycles : Gas turbine

DATA	
Air temperature	15 [°C]
Max. temperature	1050 [°C]
Compression ratio	10 [-]

- Why these data are relevant?
- Which parameters are also relevant, what are the associated data and their numerical values?
- Which input are required?

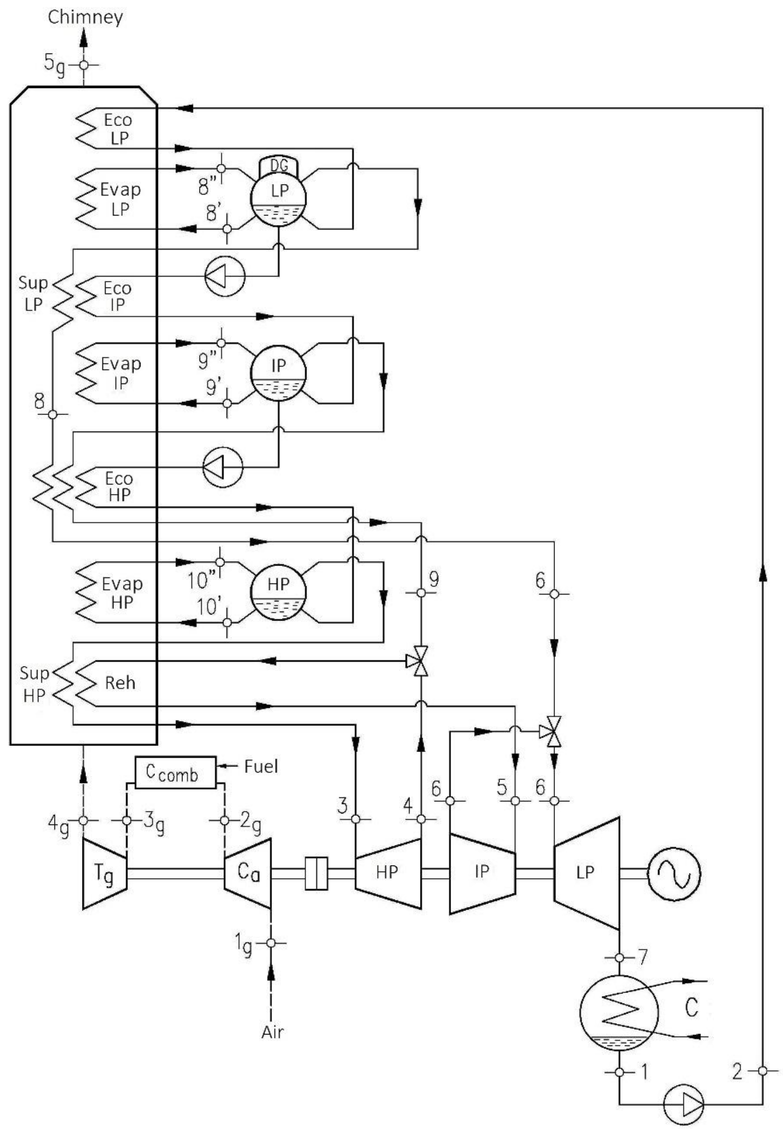




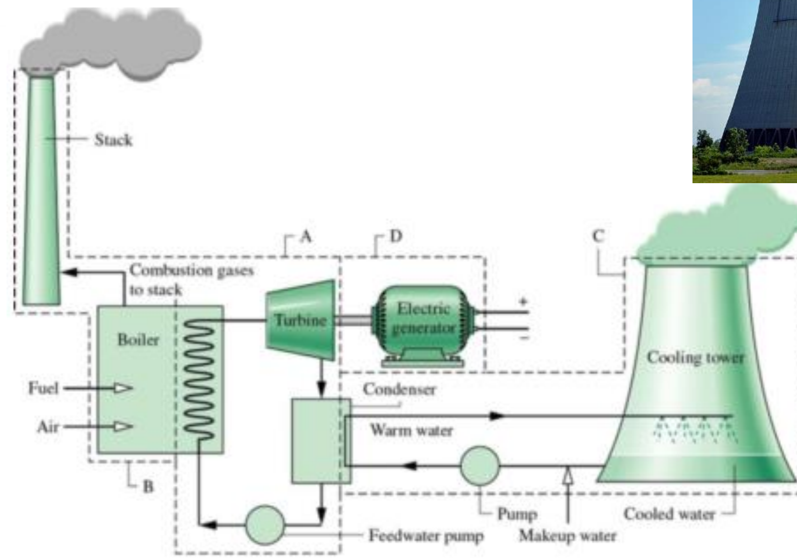
Thermal cycles : CCGT - three pressure level

DATA	
Steam pressure (HP)	122.8 [bar]
Steam pressure (HP)	27.3 [bar]
Steam pressure (LP)	3.6 [bar]
ST elec. power	153.8 [MW]
GT elec. power	283.7 [MW]

- Why these data are relevant?
- Which parameters are also relevant, what are the associated data and their numerical values?
- Which input are required?



Humid air analysis

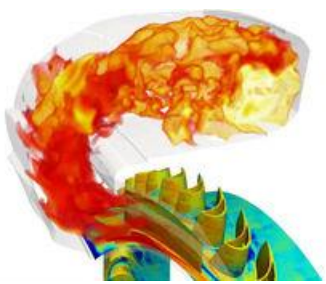


➔ Design of cooling tower :

- What are the required flows?
- What are the thermodynamic states?

➔ Combustion :

- What is the required amount of fluids?
- What is the exhaust gas composition?



➔ Computation of the dew point at the chimney

- What is the value?
- What is the risk and what should be provided to avoid the risk?

Organisation

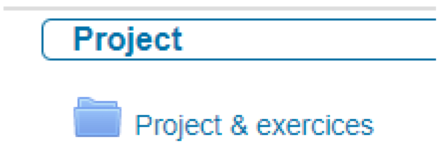
➔ Group :

- 2 students

➔ Input :

- Xsteam : thermodynamics state of liquid and gaseous water
- Janaf : heat capacity of various gas (CO2, CO, O2 N2…)
- Psychrometrics : thermodynamics state of humid air

➔ Support :



- Facultative exercices (on moodle):
  - Cycles
  - Combustion
- Consulting (see appendix 2):
  - Group forum (whenever) : Discussion between each group and me.
  - Consultation : Thursday 10h45-12h45 in room a.078 (Stévin). Scheduled by myself based on questions on group forum.
- Informations :
  - Via moodle. Please check directly on moodle (not on your mails)

Evaluation

➔ Code (40%):

- The code must be done in matlab and respect a given structure (see appendix 3)
- Automatic computation of the code will occur (20%), I will check your graphs (20%).
- Exact signature and an example of computation code will be given later.
- Codes will be compared. Similarities will be sanctioned.

➔ Report (30%):

- Explain your assumptions, methodology to an expert with a synthetic 6 pages (3 sheets without cover & appendix) report. Add 1-2 pages per cycle with only graphes without comments (T-s, h-s, pie charts, steam generator and heat exchangers).

➔ Oral (30%):

- 10 minutes presentations on the strenght and the innovative part of your work
- 5-10 minutes Q-A.
- Previous group will attend actively the next one.

➔ Submissions

- Planning including jalons date, duration and description for S3 (see appendix 1)
- Code, report and updated planning will be given back on moodle Friday S13 (14-12)
- Orals will occur on S14 and will be scheduled on S12.

Planning

➔Milestones (Ms) :

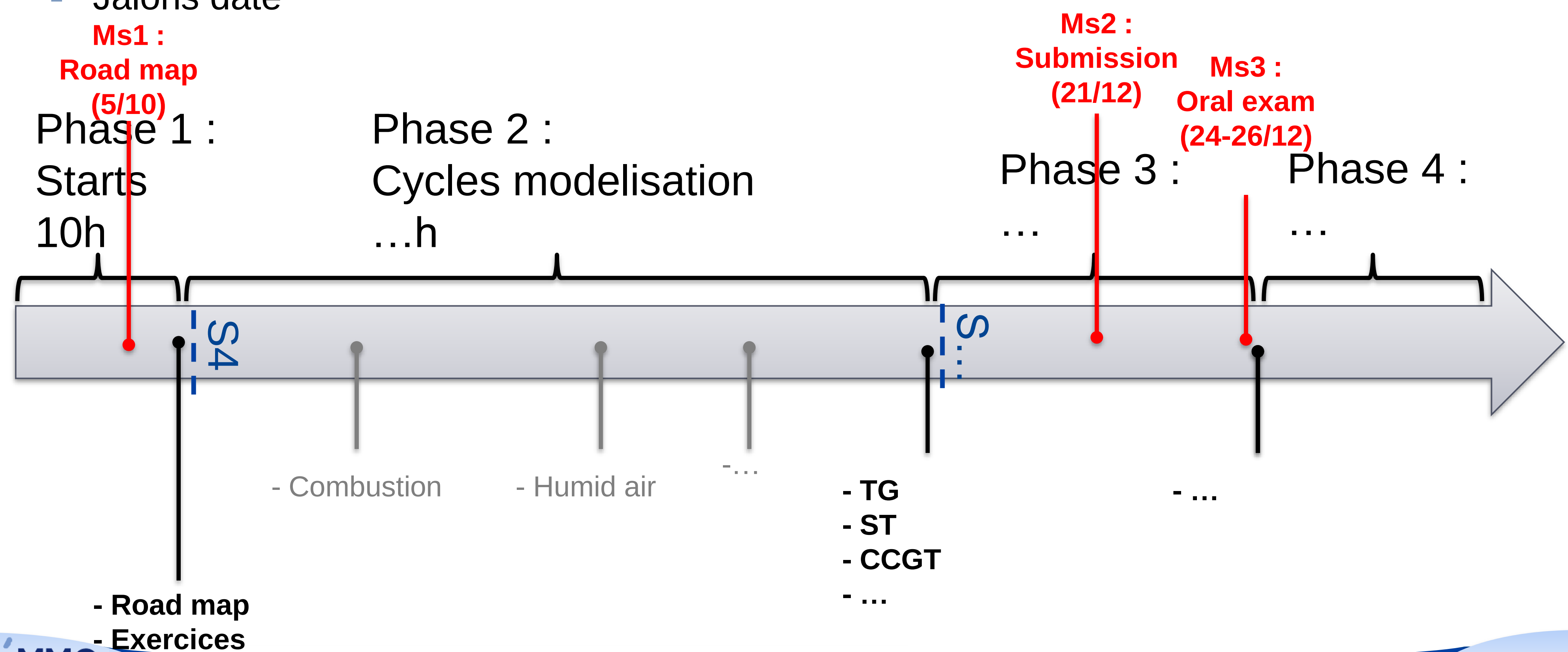
- Ms1 : Road map (1 page) see appendix 1
- Ms2 : Code + report (6 pages) submission
- Ms3 : Oral examination

APPENDIX

APPENDIX 1 : Planning example

➔ Road map must include :

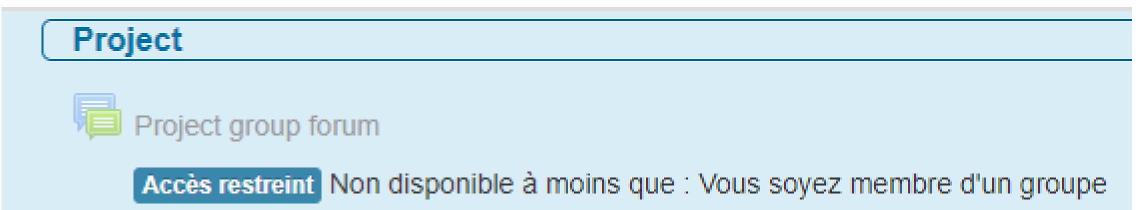
- Jalons description
- Approximal duration per jalon
- Jalons date



APPENDIX 2 : Group forum and consultation

➔Use :

- I recommend to use this template for the forum :
  - 1 topic = 1 problem domain (exchanger/ heat feeders / combustion ...)
  - For each topic, make a short question (I know what is hard for you).
  - Use pictures/graphics that you can upload on the thread, it worths.
- Please be assertiveness, a question well asked will be faster to answer.
- I will answer your questions or I will schedule an appointment to help you during the consultation session.



APPENDIX 3 : Code structure

➔Folder structure :

- 1 folder with the name : « *LMECA2150_1718_Gr**X*** », where ***X*** is your group number
- In this folder,
  - You must include these functions : CCGT.m, GT.m, ST.m, janaf.m, Xsteam.m
  - You can include other function with the name you want

APPENDIX 3 : Code structure

Functions will be provided in week 4 (S4)

➔ Signature :

- These are the minimum required. Your fonction can include more parameters (input/ouput).
- Use nargin to have default value of input. You may check input arguments and return a warning if a value seems unrelevant (ex : -300°C)

```
function [ETA DATEN DATEX DAT MASSFLOW COMBUSTION] = GT(P_e,options,display)
% GT Gas turbine modelisation
% GT(P_e,options,display) compute the thermodynamics states for a Gas
% turbine based on several inputs (given in OPTION) and based on a given
% electricity production P_e. It returns the main results. It can as well
% plots graphs if input argument DISPLAY = true (<=> DISPLAY=1)
%
% INPUTS :
% P_E = electrical power output target [W]
% OPTIONS is a structure containing :
%   -options.k_mec [-] : Shaft losses
```

```
function [ETA DATEN DATEX DAT MASSFLOW COMBUSTION] = ST(P_e,options,display)
% ST Steam power plants modelisation
% ST(P_e,options,display) compute the thermodynamics states for a Steam
% power plant (combustion, exchanger, cycle) turbine based on several
% inputs (given in OPTION) and based on a given electricity production P_e.
% It returns the main results. It can as well plots graphs if input
% argument DISPLAY = true (<=> DISPLAY=1)
%
% INPUTS :
% P_E = electrical power output target [W]
% OPTIONS is a structure containing :
%   -options.nsout     [-] : Number of feed-heating
```