

## Korea Process Simulation Olympiad 2019 Problem Statement

**Title: Feasibility study of NGCC (Natural gas combined cycle) power plant**

### 1. Background:

According to the IAE (International Energy Agency), global energy demand is projected to increase by more than 25% by 2040 and may increase by more than 50% if energy efficiency improvements are not attempted. Korea is also building plans to generate more electricity using renewable energy, natural gas and other resources in anticipation of the increasing trend of energy demand. Of course, the plan should consider not only generating capacity but also environmental issues, including carbon dioxide emissions, air pollution and fine dust as well.

Recently Traditional coal-fired power plants have a negative image due to air pollution and fine dust problems, despite their cost advantages. Therefore, the introduction of NGCC (natural gas combined cycle) power plant, which considered to be cleaner than coal-fired, is more likely to be reviewed.

### 2. Problem:

Your company owns several coal power plants and generated electricity has traded with KEPCO(Korea Electric power Corporation).

Assume that your company executives asked your team to execute the feasibility study of building of a new NGCC (Natural gas combined cycle) power plant.

Your team must perform the following minimum tasks to achieve the goal

- Complete process configuration & material balance of 800MW NGCC power plant by using published papers and process simulation
- The new power plant has carbon capture and compression facilities.
- Steam turbine and HRSG (Heat recovery steam generator) for the new power plant will be equipped.
- Perform economic analysis which include TIC (Total investment cost), annual operating cost and IRR (Internal rate of return)
- Carry out sensitivity analysis to predict break-even point of the project due to changes in electricity rates

#### 2.1 Product Capacity & Specifications

Net power generated: To be designed. (Net power = Gross power – power consumption)  
Operating hrs. : 8000 hrs/ yr

2.2 Natural gas Feed Spec.: .

Natural gas will be supplied for KOGAS and the feed spec. is al below ;

Component	Vap. vol %
Nitrogen	0.04
Methane	89.26
Ethane	8.64
Propane	1.44
i-Butane	0.27
n-Butane	0.35

OSBL Temperature: 15 C

OSBL Pressure: 18 barg

2.3 Air supply conditions : 80 C, 1 barg

2.4 CO<sub>2</sub> capture

CO<sub>2</sub> capture solvent : 30wt% MEA solution

Amount of captured CO<sub>2</sub>: min. 90 mol% from feed of carbon capture process

OSBL conditions : 45C, 50 barg

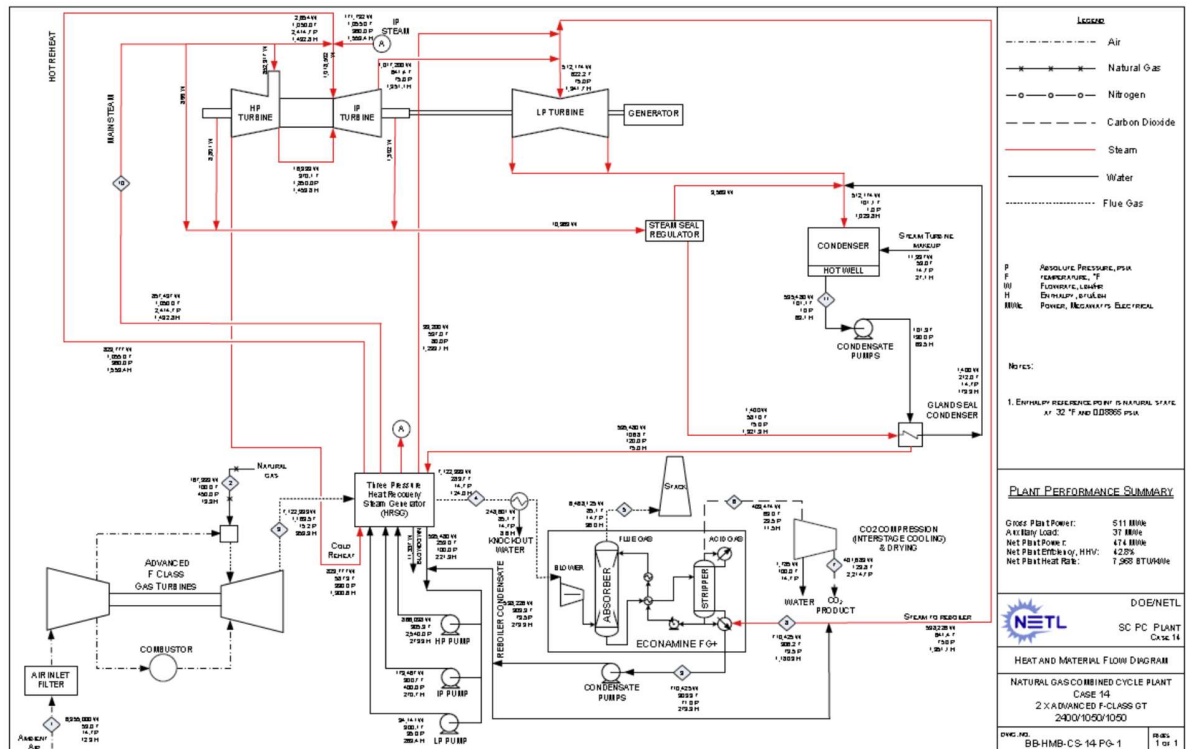
2.5 Utility conditions

CW (supply/ return) 32 C / 42 C

BFW 80 C/ 1 barg

## 2.6 Process configuration:

The below process scheme is an excerpt from NETL report.



Ref) Exhibit 5-22 , "Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity, Rev. 2a, Sep. 2013, DOE/NETL-2010/1397"

## 2.7 Combustor:

Complete combustion of natural gas takes place in combustor.  
Excess O<sub>2</sub> supply is expected.

## 2.8 Economic conditions:

Natural gas price : 14 \$/mmbtu  
Electricity sales price : 0.11 \$/kwh  
Circulated cooling water cost : 0.03 \$/m<sup>3</sup>  
99.5wt% MEA cost : 1.5\$/kg  
Annual operating hours: 8000 hrs  
Power plant operating duration : 40 yrs

### **3. Report**

Applicants need to submit the final report which contains simulation validation report with schematic drawing and material balance, equipment list and economic analysis.

#### **3.1 Process flow diagram (PFD) with material/energy balances for NGCC**

Snapshots of flow sheet of major process simulators are acceptable. Temperature, pressure, flow rate and composition of each stream must be indicated on the PFD. Heating or cooling duty of each equipment should be indicated also.

If, the simulator does not produce a flow diagram, applicants can draw it on major drawing software like Microsoft VISIO, Excel or AutoCAD.

Unit of measure should be metric

#### **3.2 Process description**

Description of your process should be required.

#### **3.3 Economic analysis**

Estimate total investment cost and annual operating cost for the power plant based on given information and your assumptions. Also, you could estimate minimum required electricity price for profit through sensitivity analysis

Note) The stack cost will not be included in cost estimation.

### **4. References**

The process scheme and cost estimation can be done with the following references

- Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity, Rev. 2a, Sep. 2013, DOE/NETL-2010/1397
- Process Equipment Cost Estimation final report, Jan. 2002, DOE/NETL-2002/1169
- If the required data is not in the provided information, proceed with assumptions.