MEMO

Project:	**Overview: Fertiliser Audit in Vietnam**
Subject:	**Generic Understanding of the fertilizer facility for energy audit**
Date:	**2023.12.21**
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Fertilizer Products

Urea – 800,000 tons/year NPK - 300,000 tons/year

The letters "NPK" on a fertilizer label stand for nitrogen, phosphorus, and potassium, the three primary nutrients plants need to grow. For example, 5-10-5 of NPK stands for 5% nitrogen, 10% phosphorus, and 5% potassium.

Nitrogen (N) is a building block for growing new stems and leaves, plus it is a necessary part of chlorophyll, which makes the leaves green and helps plants photosynthesize.

Phosphorus (P) is needed for developing flowers, fruits, and root systems.

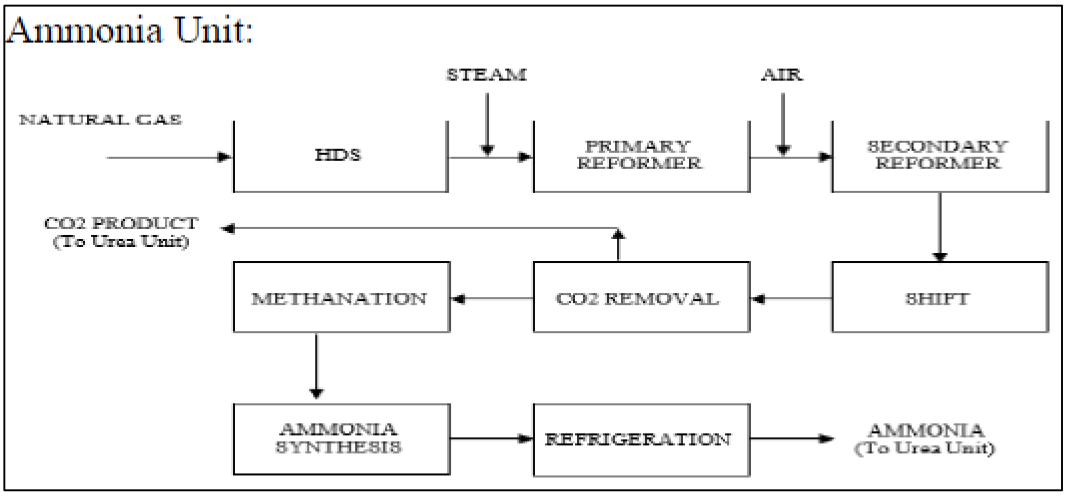
Potassium (K) keeps roots healthy and also aids flowers and fruits.

Process Plants

This section summarizes a brief understanding of all the process plants. It also mentions the major raw materials along with major process steps. The three plants are described as follows:

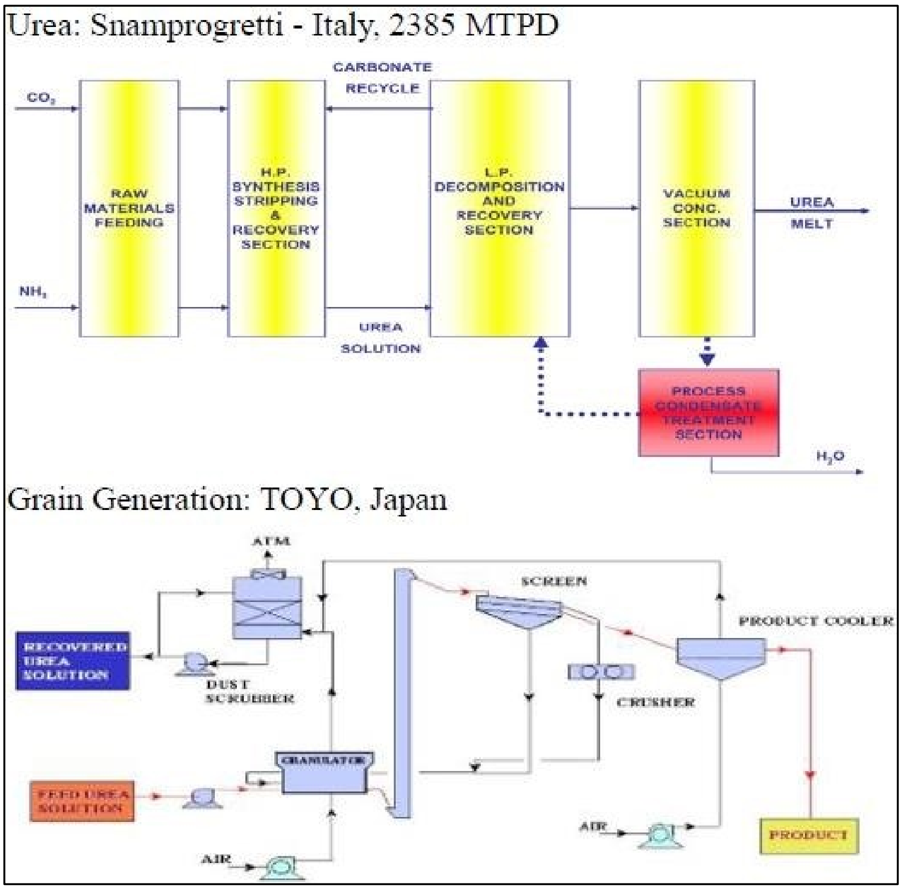
1.1 Ammonia (NH3)

- Feedstock
  - Natural gas as feed (for Hydrogen in Ammonia (NH3))
  - Natural Gas as Fuel
  - Ambient Air (for Nitrogen in Ammonia (NH3))
- Process
  - Step 1: Removal of sulfur compounds *(HDS unit)*
  - Step 2: Catalytic reforming of desulphurization gas to produce synthesis gas *(Reforming Unit)*
  - Step 3: Conversion of Carbon Dioxide CO2 to Carbon Monoxide (CO) *(Shift reaction Unit)*
  - Step 4: Removal of Carbon Dioxide -Goes to Urea Plant- (*Absorber & Stripping unit)*
  - Step 5: Carbon oxides are converted to Methane (*Methanation Unit)*
  - Step 6: Synthesizing ammonia from hydrogen and nitrogen (*Ammonia Converter)*
  - Step 7: Cooling of Ammonia *(Refrigeration Unit)*



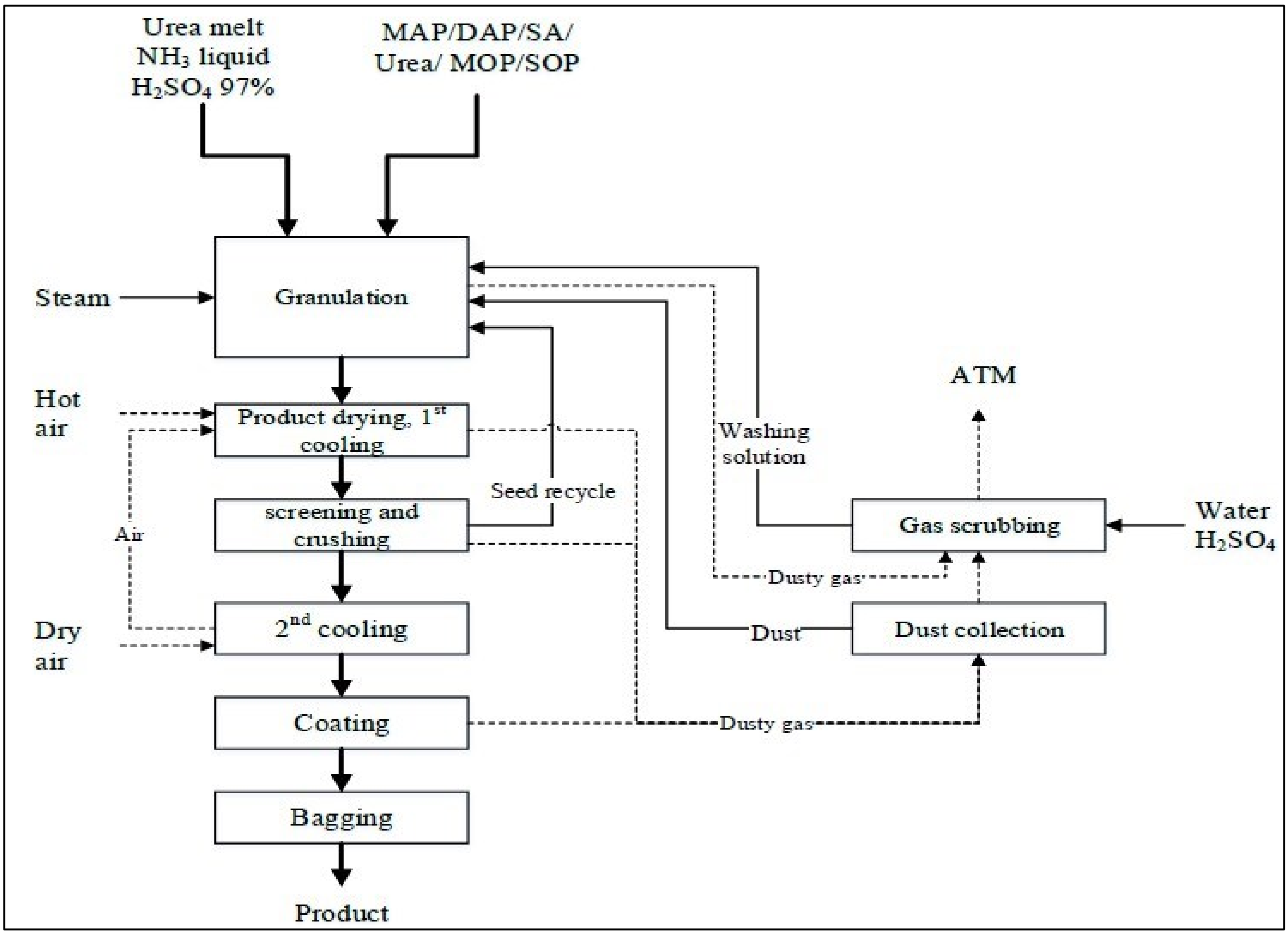
1.2 Urea (46% nitrogen)

- Feedstock
  - Carbon Dioxide from Step 4 in Ammonia Plant
  - Ammonia from Step 7 in Ammonia Plant
- Process
  - Step 1: Mixing of Ammonia & Carbon Dioxide *(High Pressure -Urea synthesis unit)*
  - Step 2: Purification & Recovery of Urea *(Medium Pressure)*
  - Step 2: Purification & Recovery of Urea *(Low Pressure)*
  - Step 3: Concentrating the urea molten liquid *(Concentration Unit)*
  - Step 4: Solidifying the urea liquid - (*Grain Generation Unit- Separate Plant*)



1.3 NPK -

- Feedstock
  - Depending on the ratio of NPK, the feedstock changes
  - Urea/Ammonia/Sulphuric Acid/ MOP or SOP (Potash compounds) /MAP or DAP (Ammonium Phosphates compounds)
  - Feedstock can be imported into the facility.
- Process
  - Step 1: Handling of Solids
  - Step 2: Handling of Liquids
  - Step 3: Mixing of Solids and Liquids in the granulator *(Granulation Unit)*
  - Step 4: Drying of Granulated NPK (*Drying & Cooling Unit*)
  - Step 5: Classification of NPK particles (*Screening and crushing unit*)
  - Step 6: Secondary Cooling of NPK (*Air conditioning unit*)
  - Step 7: Final cooling of NPK *(Cooling and coating Unit)*
  - Step 8: Packaging & Delivery of fertilizer *(Bagging Unit)*
  - Step 9: Recovery of fertilizer dust collection *(Cyclones Unit)*
  - Step 10: Scrubbing of the process gas *(Scrubbing Unit)*
  - Step 11: Collection of condensates from the process *(Collecting Unit)*

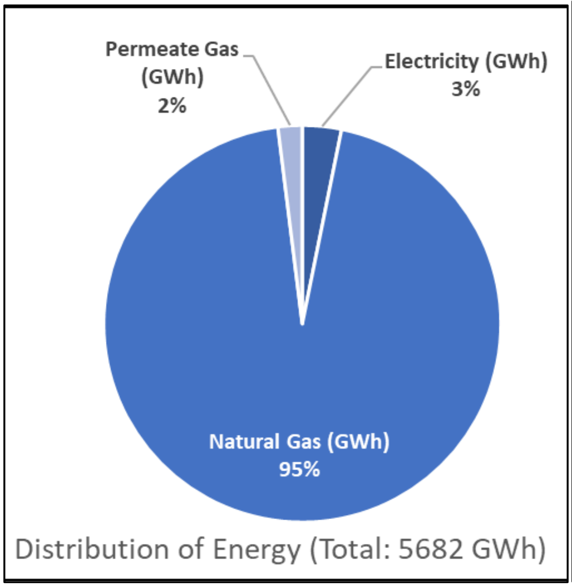


Annual Energy Consumption – Based on available Data

This section presents an overall energy mapping of the entire facility based on the two available documents. **Table *1*** and **Figure *1*** (left) present the annual consumption of three major types of energy types used in the facility. The most dominant energy type was Natural gas, which comprised of 95% of the total energy consumption. It should be pointed out that out of this 95%, a significant portion is used a feedstock (approx. 65%-70%), while the rest is used as a fuel. It was followed by Electricity and Permeate gas, representing the remaining consumption. The numbers are based on average annual numbers from 2018-2022.

Table 1: Annual Consumption of Energy Types in the facility (based on average numbers from 2018-2022)

Energy Type	Units	Annual Consumption (Average of 2018-2022)
Electricity	(GWh)	174
Natural Gas	(GWh)	5200
Permeate Gas	(GWh)	108
Total	**(GWh)**	**5682**



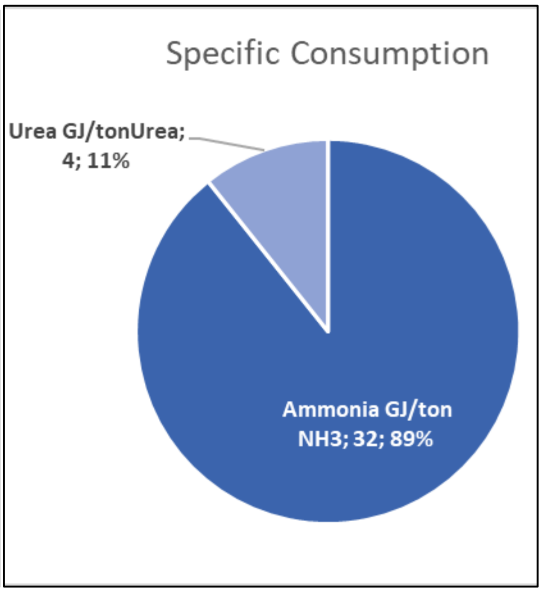


Figure 1: Distribution of Energy Type at the entire facility (2018-2022) (Left);
Specific Energy Consumption for Ammonia & Urea (2018-2020) (Right).

Having known the total energy consumption of the site, the energy division of the process plants are described. **Figure *1*** (right) describes the energy required to produce 1 ton of ammonia and urea. The data was only available for ammonia and urea. It is expected that some energy consumption should also correspond to NPK, but that data was not available.

Figure *2* presents the design capacities – based on Natural Gas flow rate. The maximum energy consumers are the combustion chambers and reformers.

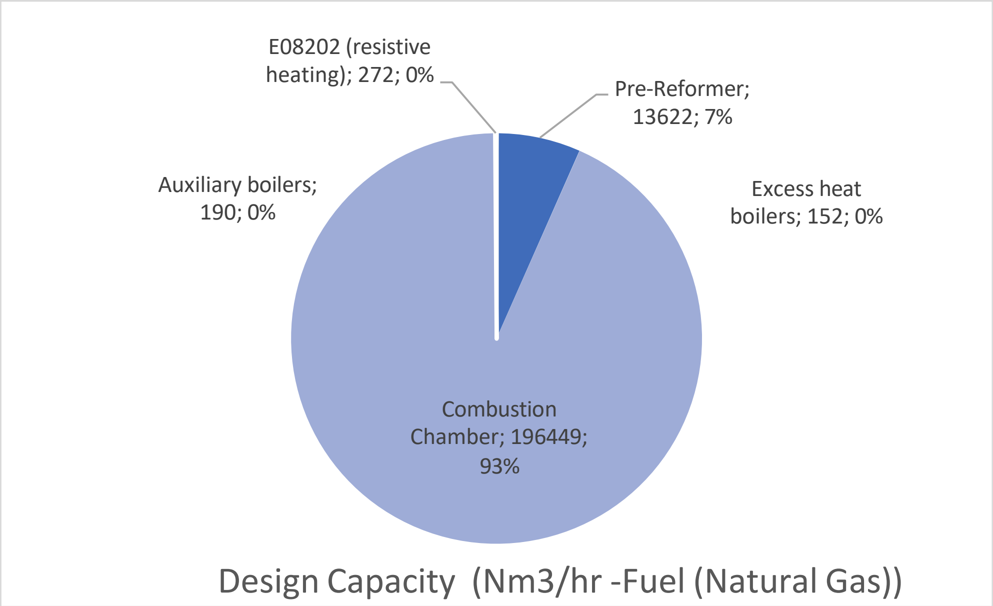


Figure 2: Distribution of Natural Gas Consumption - Based on design capacities.

1.4 Benchmarking

The International Energy Agency (IEA) showed the world's best available technology (BAT) for ammonia production is 28 GJ/t ammonia, which corresponds to a carbon footprint of 1.6 t/t ammonia[1]. This shows that the Vietnam Ammonia plant presently has a scope of increasing the energy efficiency by 14%. A study monitoring the efficiencies of 50 ammonia plants showed the best plants in each group (lower, medium, and higher capacity) have energy efficiency rates ranging from 29.5 GJ/t NH_3 to 30.6 GJ/t NH_3[2]. This again shows that the present ammonia plant has a scope for improvement when compared with other ammonia plants of around 6-7%.

Major Energy Savings Observations & Potentials

1.5 Process:

a. Part of the steam produced in the ammonia plant is used for electricity production, while part of it is for process heating.
b. Natural Gas Reforming is a super energy intensive process. The impact of delta P (change of pressure) across the reformer determines the specific energy consumption of ammonia should be optimised.
c. Steam to carbon ratio also gives a good measurement of energy efficiency, which should be checked. Most of the steam reforming ammonia plants maintain S/C ratio of 3.3 to 3.5 but excess steam requires energy and later steam condensate has to be treated. Therefore, lowering the S/C ratio to 3.0 or even lower has the benefit of saving of steam and thus energy.
d. Ammonia Convertors delta T (change of temperature) across the beds has to be optimised for an optimum specific energy consumption.

[1] Ammonia Production Processes from Energy and Emissions Perspectives: A Technical Brief
[2] https://www.ajer.org/papers/v2(7)/N027116123.pdf

e. The saturation of natural gas using hot condensates upstream of the primary reformer can be assessed. This measure leads to a reduction of steam injection demanded by steam reforming and thus the possibility of reducing steam generation of the auxiliary boiler.
f. Recovery of residual heat from the stacks – Urea Plant Scrubber
g. Monitoring of vacuum technology

1.6 Equipment

Heat Exchangers

a. There is a high possibility that energy is lost due to heat exchange (exergy loss) in several heat ex- changers because the heat flow in the heat exchangers is not flowing as per the 2^{nd} law of thermo- dynamics. Therefore, a **PINCH ANALYSIS** makes a lot of sense for the most optimum **heat integration**, if this has not been done in the last several years.
b. Fouling of heat exchangers is a common occurrence and should be checked.
c. In the primary reformer convection section better design (plate type) heat exchanger with a larger sur- face resulted in higher heat recovery and its utilisation needs to be explored.

Boilers

a) Preheating of boiler feed water is to be checked for optimum energy utilization.
b) The efficiency of the auxiliary and excess heat boilers should be monitored and checked with the design numbers.
c) Complete recovery of heat from flue gases of the boiler.
d) Recover waste heat from cooling systems of the boiler.

Combustion chambers

a) The efficiency of the combustion chambers should be monitored and checked with the design numbers.
b) Air to-fuel ratio can be checked in the combustion chambers for monitoring efficiency.
c) Preheating of combustion air
d) Combustion control can be checked, if it is operated manually. An automatic control system can be proposed for the combustion equipment in the auxiliary boiler and primary reformer.

Compressors

a) Monitoring of efficiency on ammonia refrigeration compressors – Driven by steam turbines
b) Air Compressor unit to be checked for energy efficiency.
c) Recovery of heat from compressor Unit.
d) Variable frequency Drive control when operating at part loads.

Wet Bulb Cooling towers

a) Fans run mostly at fixed speeds. A variable frequency drive might be necessary.
b) Check for the range, approach, and effectiveness of the cooling tower. The effectiveness should be around 75%.
c) The cycles of concentration, which is also known as concentration ratio, is a ratio of the total dissolved solids in the circulating water of a cooling tower to the total dissolved solids in the makeup water.
d) Depending on the temperature of the return water, a part load of the same can be diverted to dry cooling towers.

Pumps

a) There are huge pumps that might be installed at the site up to (3-5 MW).

b) Trimming the size of large pumps to meet the low load requirement, installing variable frequency drives (VFDs) and changing the drive of some small capacity steam-driven pumps to motor drive have improved efficiency. It has been established that smaller pumps and turbines are more efficient if driven by power than steam.

c) Air Compressor unit to be checked for energy efficiency.

d) Recovery of heat from the compressor Unit.

Rotary Drier

a) Heat losses are generally very significant in a rotary drier because of large exergetic destruction.

b) The process parameters like air flow rate, water content, drier rotation speed etc should be monitored.

c) Studies have revealed that a dryer inclination of 1°, heat flow rate of 180 m^3/h, and dryer rotation speed at 10 rpm were the most optimal drying conditions.

Miscellaneous:

a. There would be a large number of steam traps in the plant – whose working should be checked.

b. Collection of condensates from the steam traps- for both heat and water recovery. Generally, this condensate is pure and can be used as boiler-feed water.

c. Thermal losses, caused by insulation conditions, mainly located in the reformer, furnace and main pipelines, including ammonia refrigerated pipelines can be evaluated.

d. In general, there would be a lot of low- temperature heat sources that would be going to the cooling tower. A potential heat pump solution could be explored for lifting the temperature and its probable use in the process heating. Also, potential could be explored for making electricity out of it via organic Rankine cycle or Kalina cycle.

e. Monitoring of energy and process performance indicators can be first identified, and then proper digital sensor technology could be installed for better management of energy performance.

1.7 Future Potentials

a) Green ammonia: besides the fossil-fuel based pathways currently in use, ammonia can also be synthesized using renewable electricity and **water electrolysis (TRL – 7-9)** and/or **electro-chemical-route (TRL – 1-3)** and/or **biomass gasification (TRL – 6-8)** to produce syngas for the Haber-Bosch process.

b) Potential of carbon capture solutions after the CO_2 unit.

1.8 Important information- Ammonia energy & Process

Table 4. Breakdown of energy use for a typical natural gas-based ammonia plant

Technology	Natural gas GJ/t-NH_3	Heat input/output GJ/t-NH_3
Primary reformer feed	20.4 – 22.3	
Primary reformer fuel	7.2 – 9	3 – 4.5
Waste heat boiler		-5 – -6
Shift and CO_2 removal		0.8 –1.2
Synthesis loop		-2.5 – -3
Auxiliary boiler	0.3 – 3.5	-0.2 – -3
Turbines/compressors		3.9 – 6.3
Others (e.g., flare)	0.2 – 0.7	
Total	28.1 – 35.5	0

*Negative values represent net steam generation

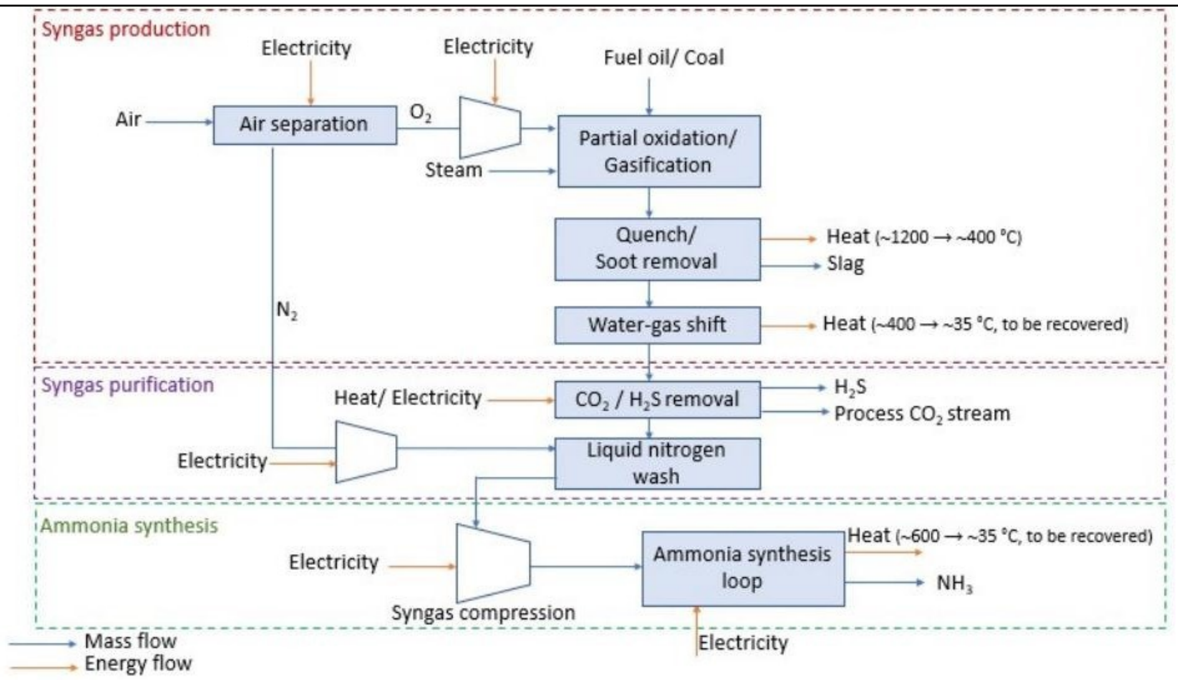


Figure 5. Typical process flowsheet for partial oxidation/gasification of heavy feedstocks

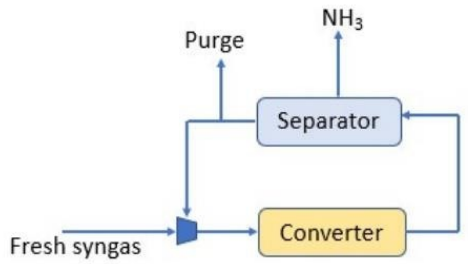


Figure 6. Typical ammonia synthesis loop configuration

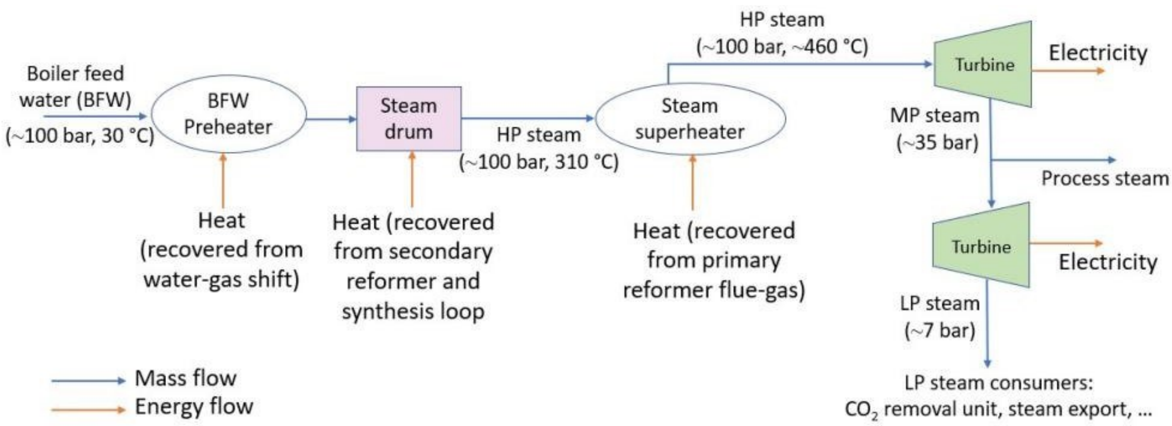


Figure 7. Typical steam system flowsheet of the steam reforming process