Production of Ammonia

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Selection of process

Energy Consumption and CO2 emissions for different feedstock

Energy source	Process	Energy GJ/ton NH_3	CO_2 emissions t/ton NH_3
Natural Gas	Steam reforming	28	1.6
Water	Electrolysis	34	0
Naphta	Steam reforming	35	2.5
Heavy Fuel Oil	Partial oxidation	38	3.0
Coal	Partial oxidation	42	3.8

Amount of feedstock and heating value for different feedstock.

Feedstock	Amount of feedstock	HHV GJ/ton NH_3	Feedstock price NOK/ton NH_3
Natural Gas	353.18 kg/ton NH_3	-17.7	414.87
Electrolysis	7.69 MWh/ton NH_3		2360.83
Nitrogen enriched air	0.160 MWh/ton NH_3		49.12
Coal	528.89 kg/ton NH_3	-17.35	282.31

Calculated Prices and profits for different feedstock

(With ammonia price of 2321 NOK/ton)

Feedstock	Price	Feedstock price NOK/ton NH_3	Profit NOK/ton NH_3
Natural Gas	1.175 NOK/kg [14]	414.87	1906.27
Electrolysis + NEA	0.307 NOK/kWh[8]	2409.95	-88.55
Coal	0.534 NOK/kg[2]	282.31	2038.83

- Based on energy consumption there is an advantage using methane which also has the lowest carbon emissions among the fossil feedstocks.
- electrolysis process is good for being the green alternative, but the huge requirement for electric power makes hydrogen from electrolysis non beneficial.
- The coal and heavier hydrocarbon feedstocks will be discarded due to high energy requirements and carbon emissions

Selected Process : Using Methane

Implementation of design using DWSIM

Design Method

Choose Components :

1. Methane
2. Water
3. Carbon monoxide
4. Carbon dioxide
5. Hydrogen
6. Nitrogen
7. Ammonia

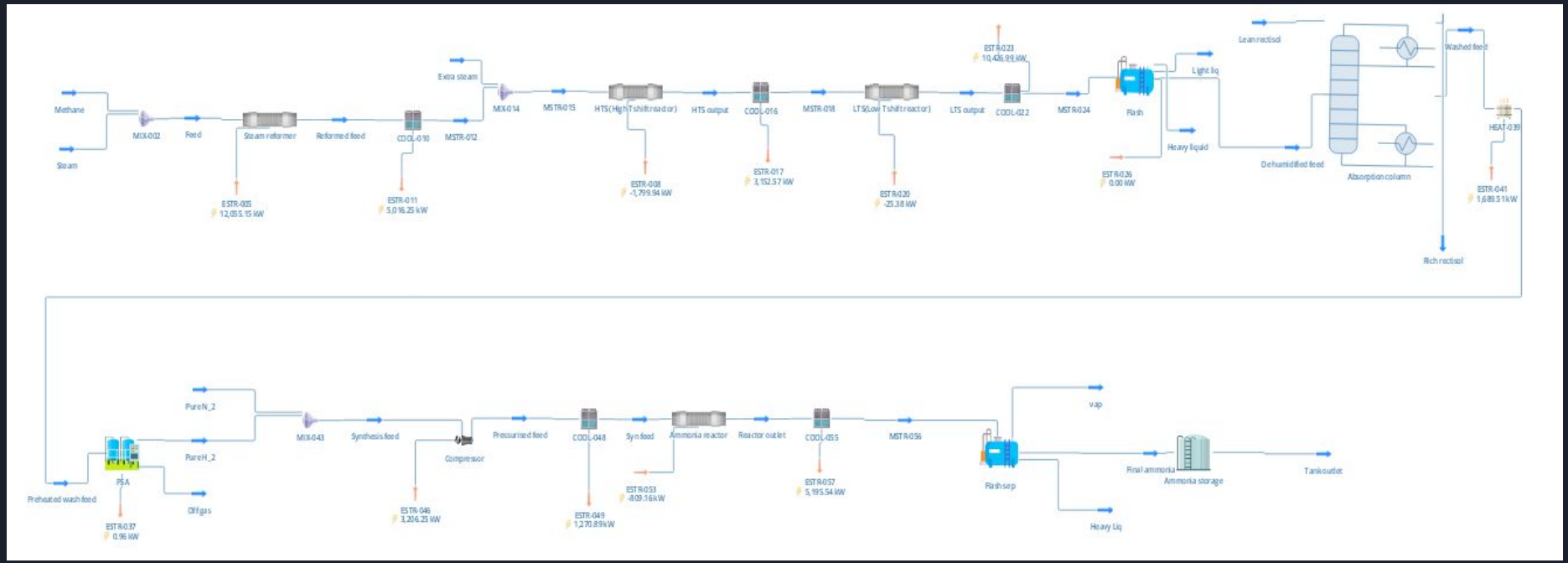
Choose Fluid Package:

- Peng - Robinson

Reaction sets :

1. Water gas shift reaction
2. Steam reforming reaction
3. Haber bosch process

Process Flow Diagram



Steam Reformer

Compound	Amount
Methane	0.52896287
Water	0.47103713
Hydrogen	0
Nitrogen	0
Ammonia	0
Carbon monoxide	0
Carbon dioxide	0
Methanol	0

Feed

Compound	Amount
Methane	0.040999116
Water	0.010543423
Hydrogen	0.7113431
Nitrogen	0
Ammonia	0
Carbon monoxide	0.23711437
Carbon dioxide	0
Methanol	0

Output

Shift Reactor

Compound	Amount
Methane	0.020177649
Water	0.51304053
Hydrogen	0.35008637
Nitrogen	0
Ammonia	0
Carbon monoxide	0.11669546
Carbon dioxide	0
Methanol	0

Feed

Compound	Amount
Methane	0.020177649
Water	0.39730362
Hydrogen	0.46582327
Nitrogen	0
Ammonia	0
Carbon monoxide	0.00095854784
Carbon dioxide	0.11573691
Methanol	0

Output

Gas liquid Separator

Compound	Amount
Methane	0.020177649
Water	0.39730362
Hydrogen	0.46582327
Nitrogen	0
Ammonia	0
Carbon monoxide	0.00095854784
Carbon dioxide	0.11573691
Methanol	0

Feed

Compound	Amount
Methane	0.033239382
Water	0.0079811988
Hydrogen	0.76736219
Nitrogen	0
Ammonia	0
Carbon monoxide	0.0015790467
Carbon dioxide	0.18983818
Methanol	0

Output

Absorption Column

Compound	Amount
Methane	0.033239382
Water	0.0079811988
Hydrogen	0.76736219
Nitrogen	0
Ammonia	0
Carbon monoxide	0.0015790467
Carbon dioxide	0.18983818
Methanol	0

Feed

Compound	Amount
Methane	0.038720103
Water	0
Hydrogen	0.95931094
Nitrogen	0
Ammonia	0
Carbon monoxide	0.0019620031
Carbon dioxide	9.5053329E-17
Methanol	6.9587606E-06

Output

PSA

Compound	Amount
Methane	0.038720103
Water	0
Hydrogen	0.95931094
Nitrogen	0
Ammonia	0
Carbon monoxide	0.0019620031
Carbon dioxide	9.5053329E-17
Methanol	6.9587606E-06

Feed

Compound	Amount
Methane	1.5627823E-05
Water	0
Hydrogen	0.99998437
Nitrogen	0
Ammonia	0
Carbon monoxide	0
Carbon dioxide	0
Methanol	0

Output

Ammonia Reactor

Compound	Amount
Methane	1.171824E-05
Water	0
Hydrogen	0.74982017
Nitrogen	0.25016812
Ammonia	0
Carbon monoxide	0
Carbon dioxide	0
Methanol	0

Feed

Compound	Amount
Methane	1.5082684E-05
Water	0
Hydrogen	0.53443477
Nitrogen	0.17843846
Ammonia	0.28711168
Carbon monoxide	0
Carbon dioxide	0
Methanol	0

Output

Flash Separator

Compound	Amount
Methane	1.5082684E-05
Water	0
Hydrogen	0.53443477
Nitrogen	0.17843846
Ammonia	0.28711168
Carbon monoxide	0
Carbon dioxide	0
Methanol	0

Feed

Compound	Amount
Methane	1.2579696E-06
Water	0
Hydrogen	0.0011353185
Nitrogen	0.00019854347
Ammonia	0.99866488
Carbon monoxide	0
Carbon dioxide	0
Methanol	0

Output

Result

Name	Mass Flow (kg/h)	Temperature (C)	Pressure (bar)
De humidified feed	10574	50	14.9364
Reactor outlet	8650.29	425	199.964
MSTR-056	8650.29	-80	149.964
Synthesis feed	8650.29	199.805	25
Pressurised feed	8650.29	573.47	200
Syn feed	8650.29	425	200
Reformed feed	7200	1099.85	15
MSTR-012	7200	420	15
Feed	7200	1099.85	15
Pure N_2	7115.4	200	25
Pure H_2	1534.89	200	25
Tank outlet	3847.14	-80	149.964
Final ammonia	3847.14	-80	149.964
Methane	3600	1100	15
Steam	3600	1100	15
Washed feed	2072.48	-60.7467	25

Material Streams

Thank you!