ECN

Energy research Centre of the Netherlands

Allothermal gasification of biomass into chemicals and secondary energy carriers

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Allothermal gasification of biomass into chemicals and secondary energy carriers

Robin Zwart

Motivation for polygeneration

Make more money out of wood

High value product!

Increase the efficiency of wood conversion

Motivation for polygeneration

Outline allothermal gasification towards chemicals and secondary energy carriers

- Motivation for polygeneration

- Allothermal gasification: the MILENA at ECN
- Primary gas cleaning: the OLGA for tar removal

- Possible secondary energy carriers
- Possible chemicals

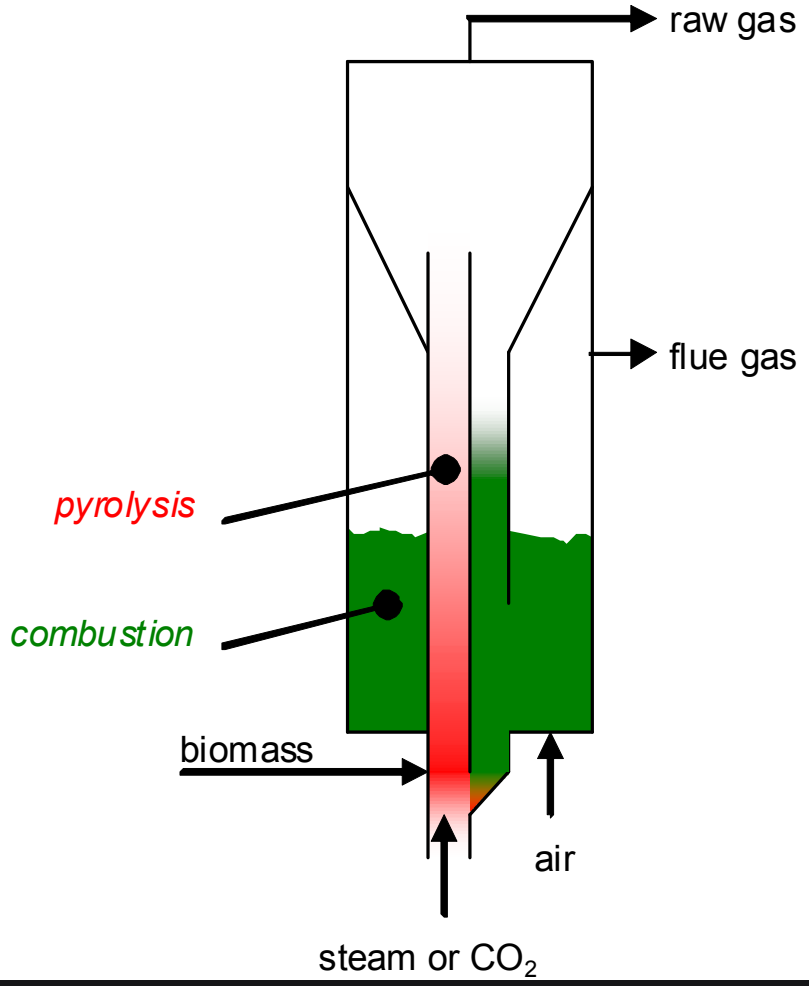
- Polygeneration concept and its feasibility

Allothermal gasification: MILENA at ECN

- Low N_2 in gas
- High methane yield
- Complete conversion
- Fuel flexible

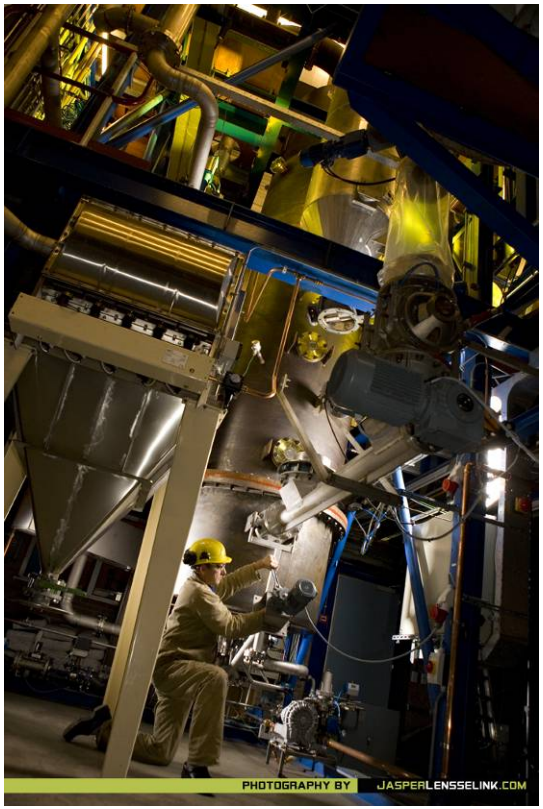
160 kg/hr pilot plant:

- Riser diameter 0.2 m
- Combustor diameter 0.8 m
- Height 8.0 m



Allothermal gasification: MILENA at ECN

25 kW



800 kW

HVC

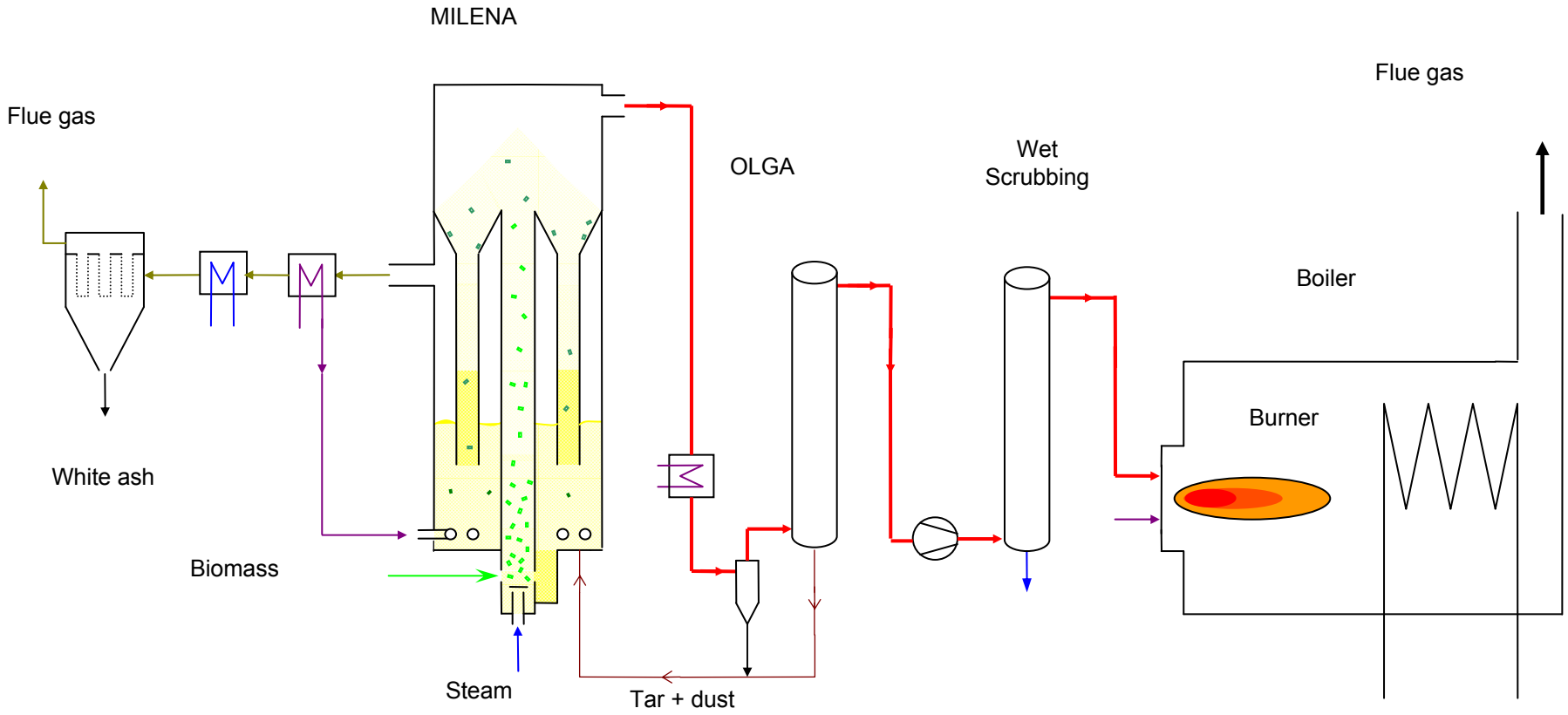
CHP
10 MWth

scheduled for 2012

SNG
50 MWth

scheduled for 2015

Allothermal gasification: MILENA at ECN

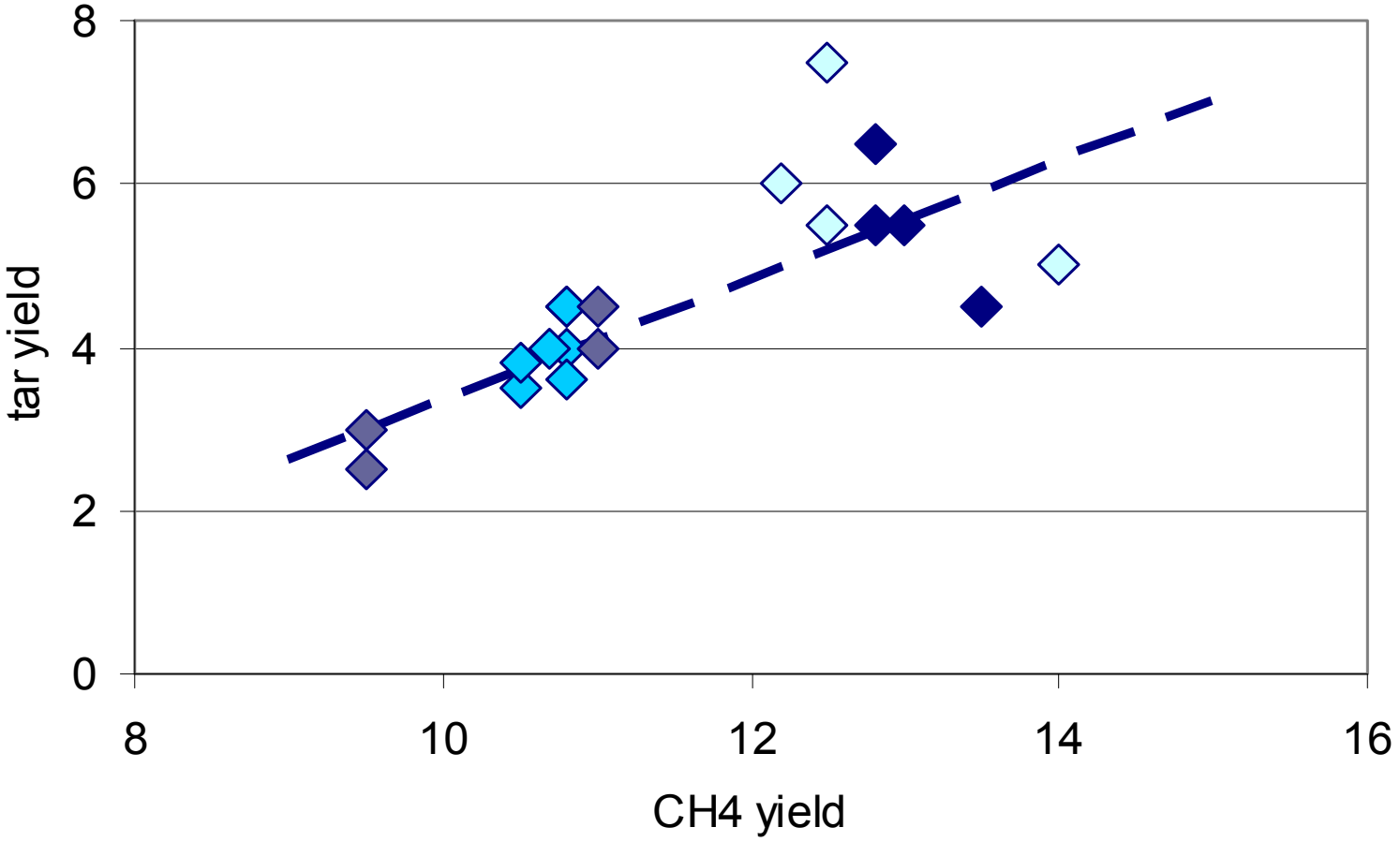


Allothermal gasification: MILENA at ECN

- Approximately 15 tests done, initially directly to the boiler.
- Fuel: wood pellets, throughput 120 and 150 kg/h
- Fluidization agent gasifier: steam (15 kg/h) or air (20 m_n^3/h)
- Bed material -> Sand
- Estimated circulation rate bed material 3000 kg/h (design 6000). Circulation rate can be increased during testing
- Gas composition similar to lab-scale installation (tar content approx. 40 gram/m_n^3

- Issues to be solved:
  - Tar removal required (OLGA), tar condensation in front of burner, OLGA will be ready in **August**.
  - Sand causes friction problems between refractory wall and metal insert, modifications required.

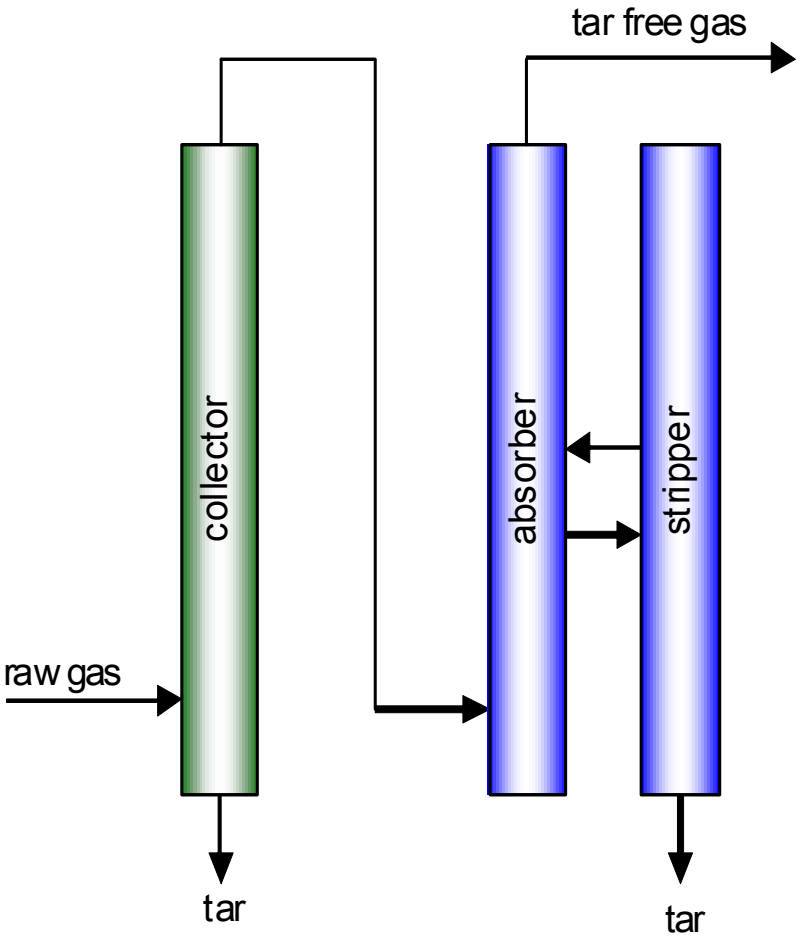
Allothermal gasification: MILENA at ECN



Primary gas cleaning: OLGA for tar removal

- Complete tar removal
- No methane reduction
- Tar recycle to gasifier
- No water condensation
- Fits many types of gasifiers

- Creates freedom for gasifier optimization …



Primary gas cleaning: OLGA for tar removal

DAHLMAN
FILTER TECHNOLOGY

2 m³/h

200 m³/h

2 000 m³/h

25 000 m³/h

Primary gas cleaning: OLGA for tar removal

Component		Downstream MILENA	Downstream OLGA
CO	vol%	30.1	30.6
H2	vol%	32.0	32.5
CO2	vol%	19.2	19.4
O2	vol%	0.0	0.0
CH4	vol%	12.2	12.4
N2+Ar	vol%	0.1	0.1
C2H2	vol%	0.2	0.2
C2H4	vol%	3.9	3.9
C2H6	vol%	0.2	0.2
C6H6	vol%	1.0	0.5
C7H8	vol%	0.1	0.0
Tar	g/mn3	52.1	0.2

Possible secondary energy carriers

- Standard quality substitute natural gas (CH_4)
- High quality substitute natural gas (CH_4, C_2H_6, …)

- C1 chemistry based fuels ($CO+H_2$ → FT diesel, DME, …)
- "The ultimate fuel" (H_2)

- Heat
- Power

All will depend on the scale of operation!

Possible chemicals

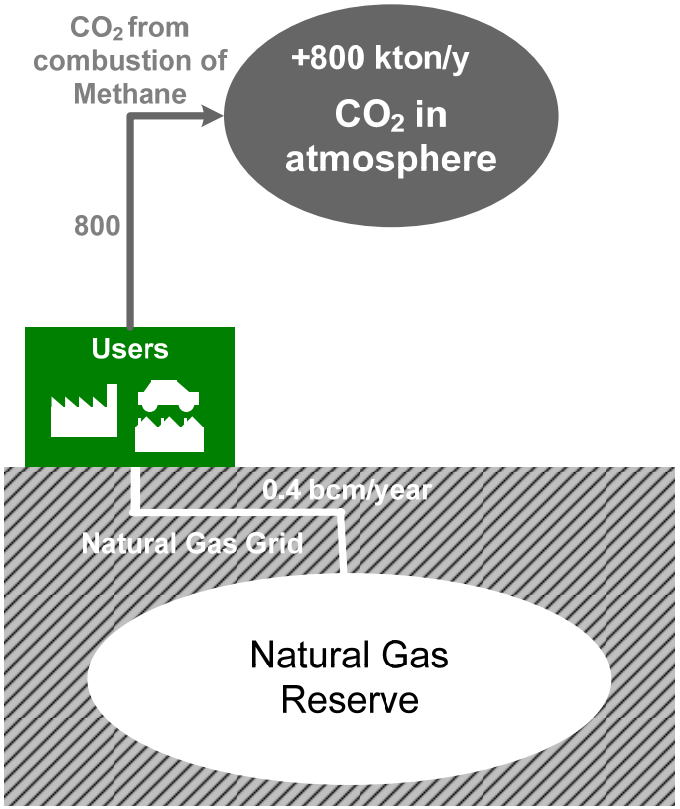
- Acetylene (C_2H_2 for bulk chemistry)
- Ethylene (C_2H_4 for bulk chemistry)

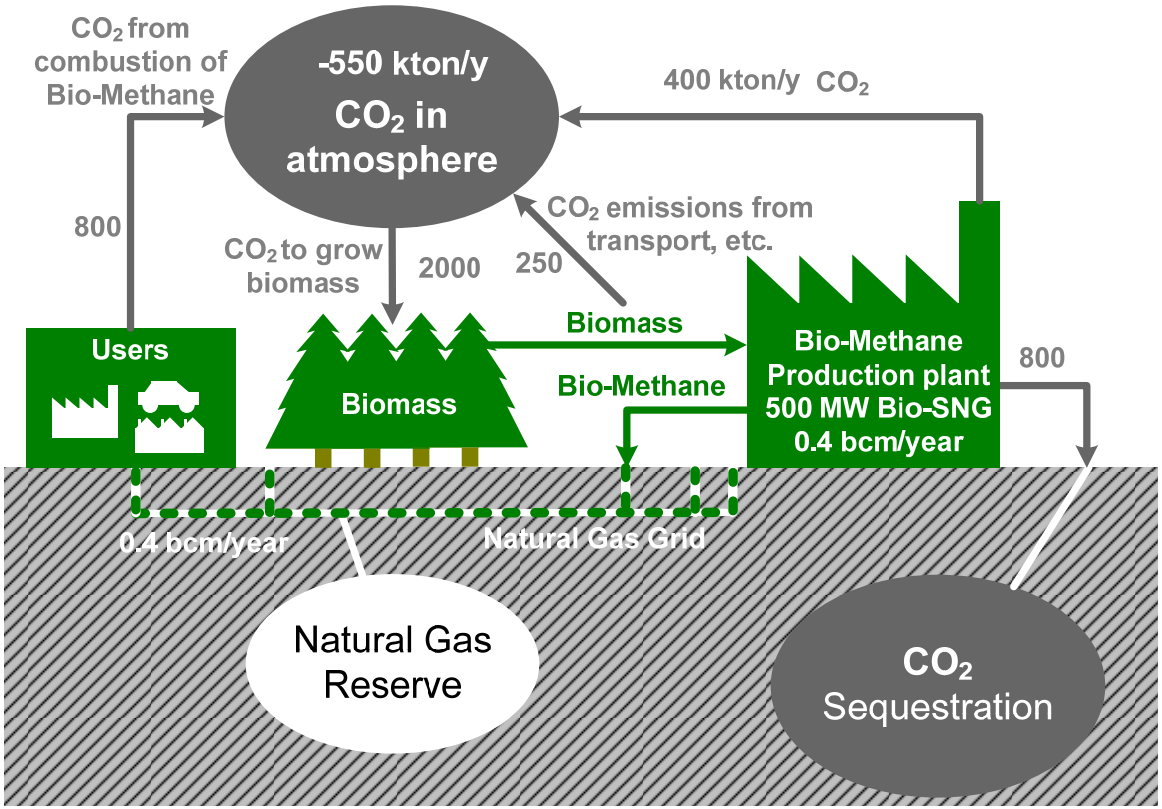
- Benzene (C_6H_6 for bulk chemistry)
- Toluene (C_7H_8 for bulk chemistry)

- Carbon dioxide (CO_2 for greenhouses)

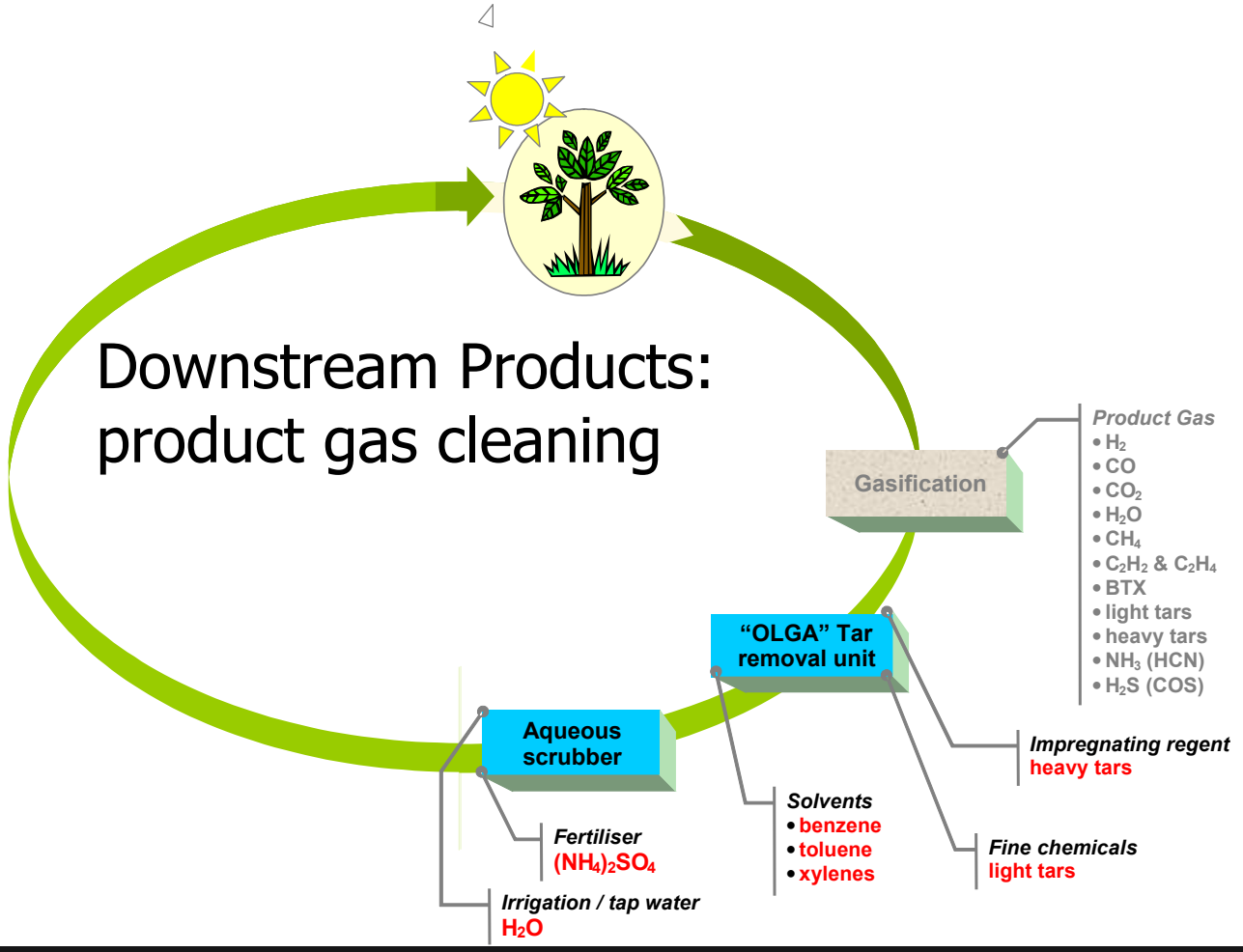
In many systems including a synthesis step, CO_2 removal is implemented for volume reduction or product quality control!

Possible chemicals

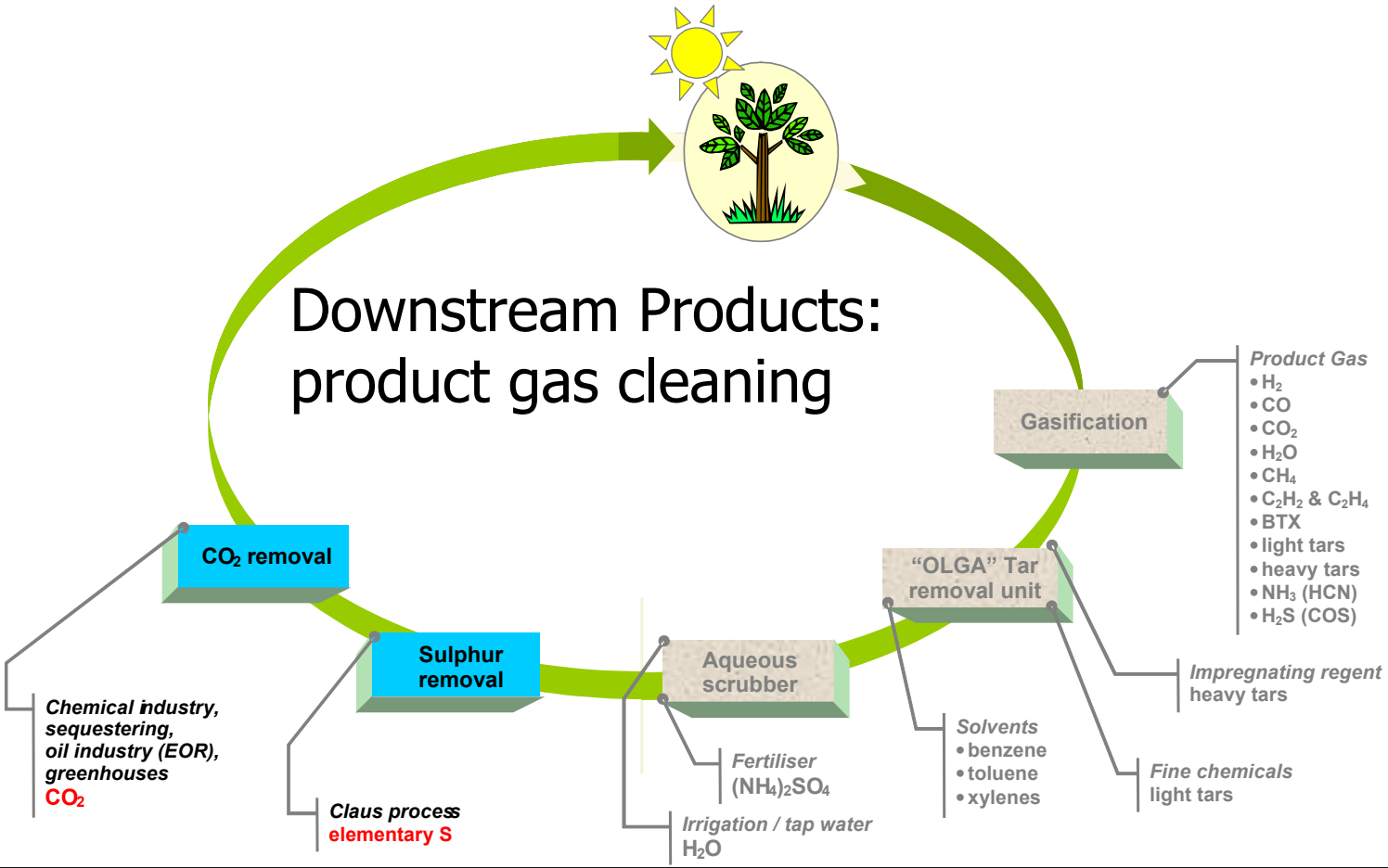




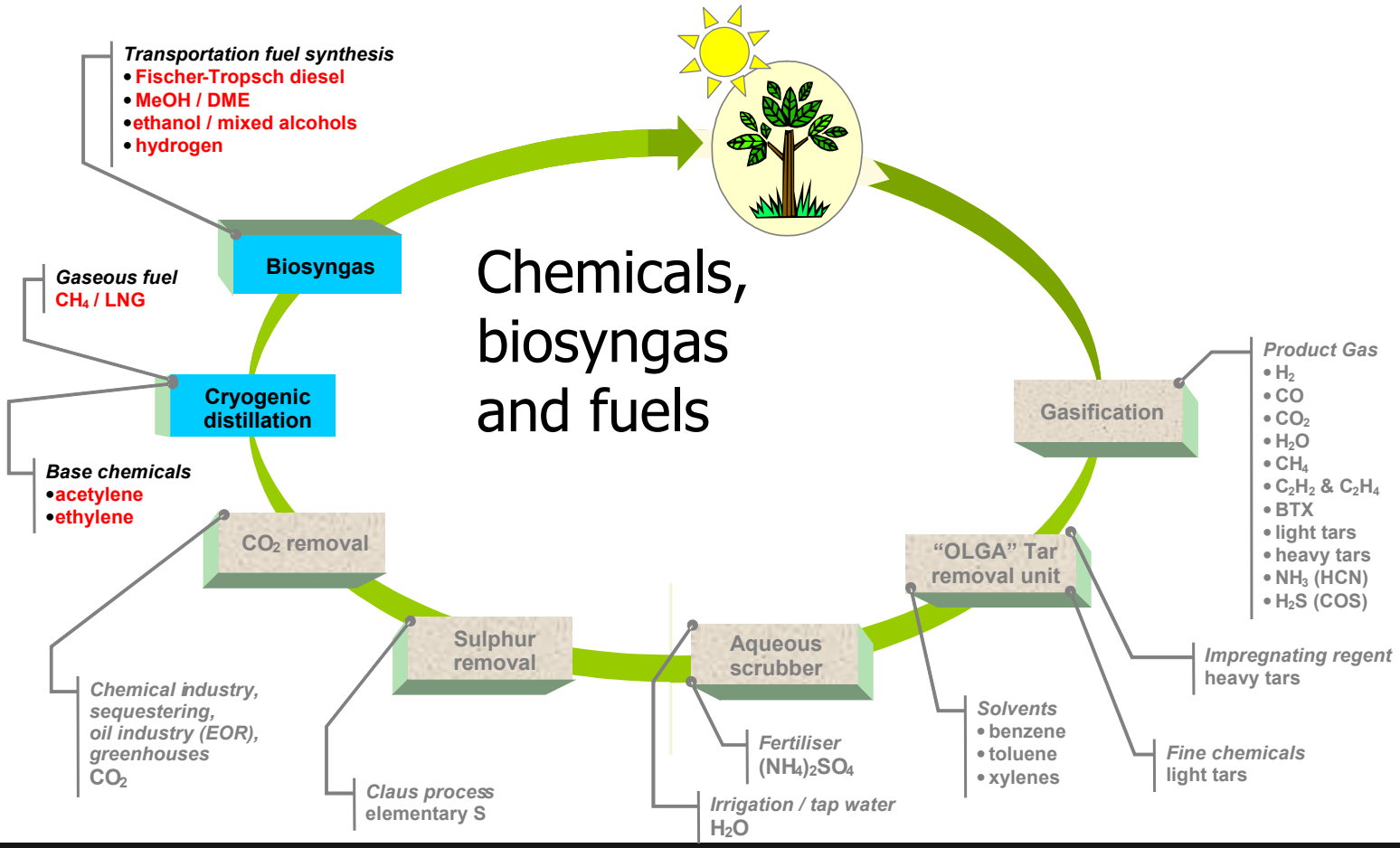
Polygeneration concept



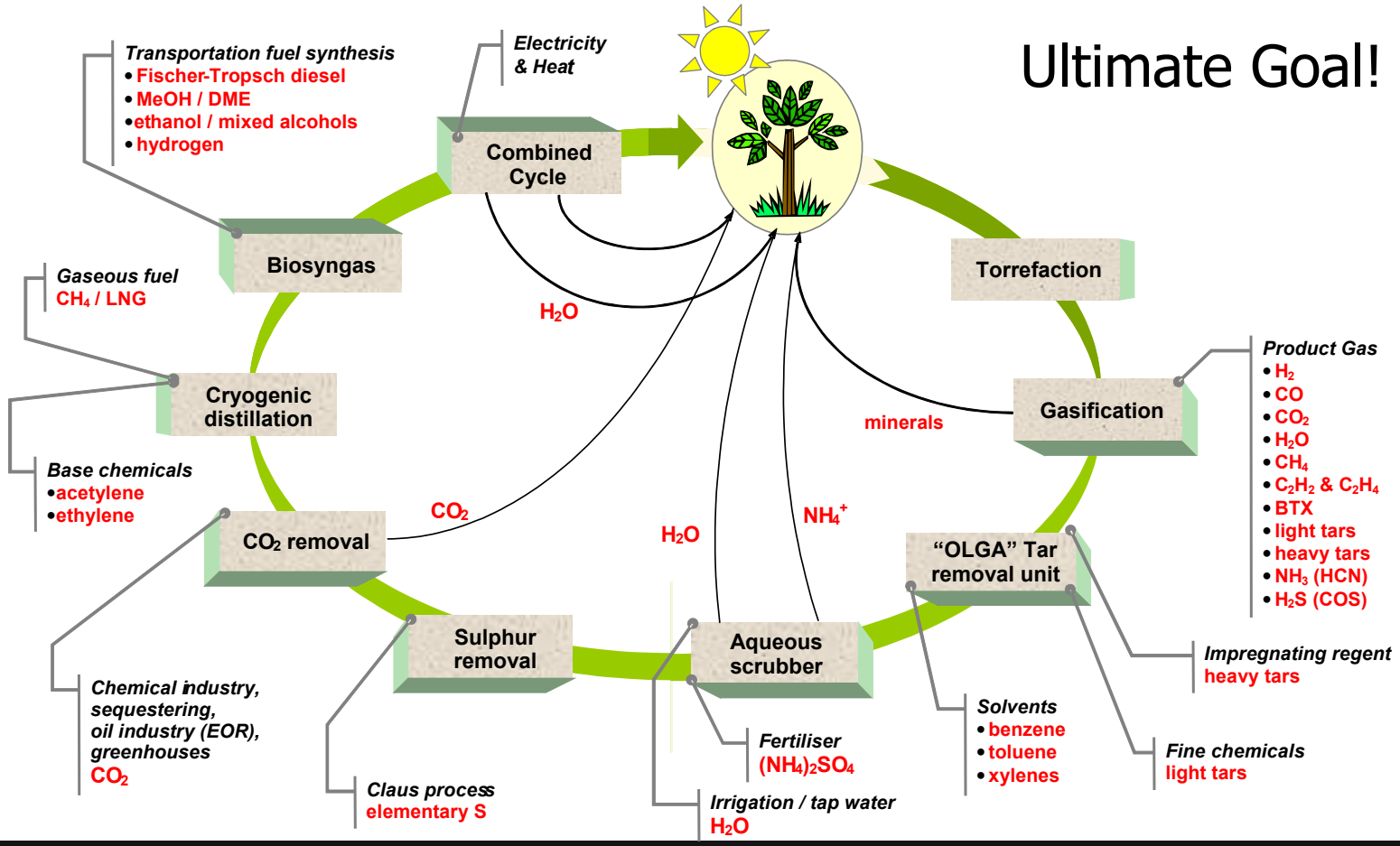
Polygeneration concept



Polygeneration concept



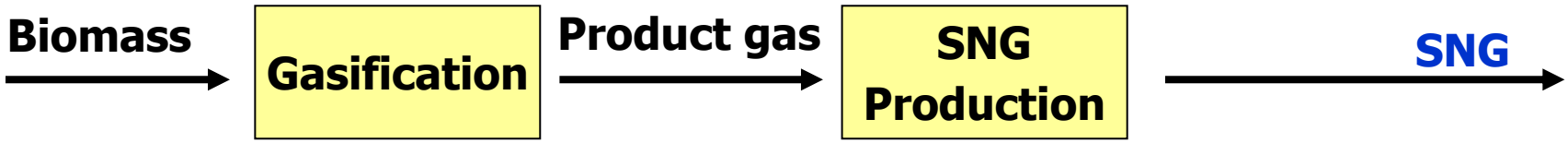
Polygeneration concept



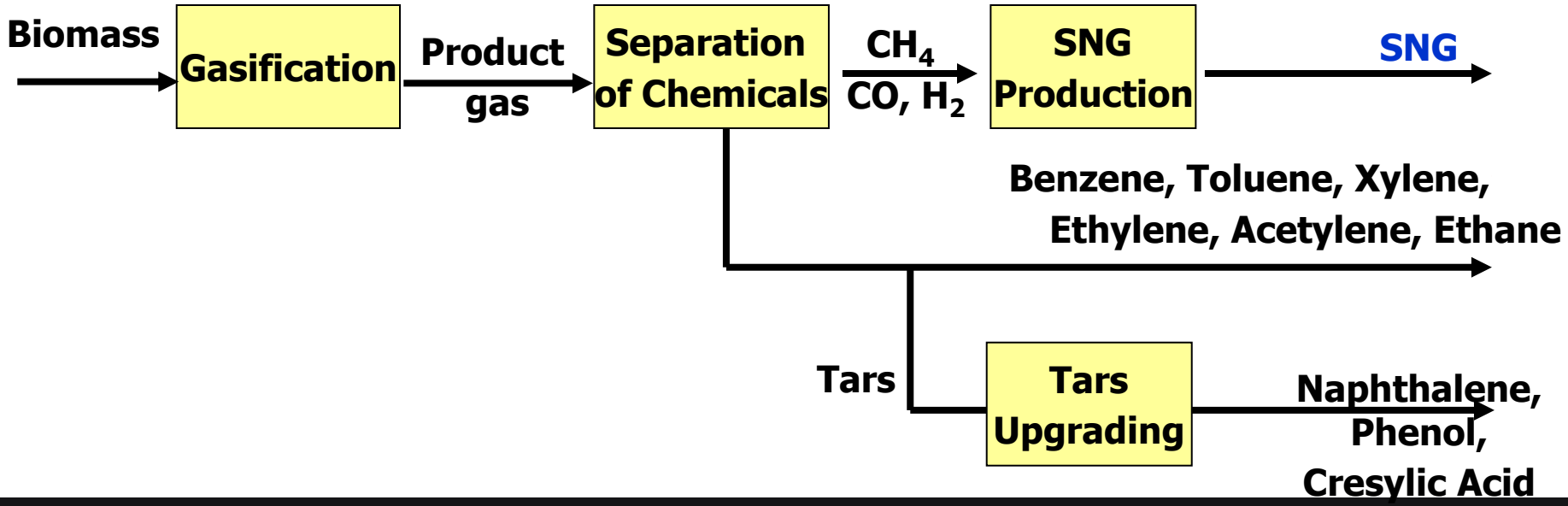
Ultimate Goal!

Feasibility

1. Base Case : SNG Production via low temperature gasification

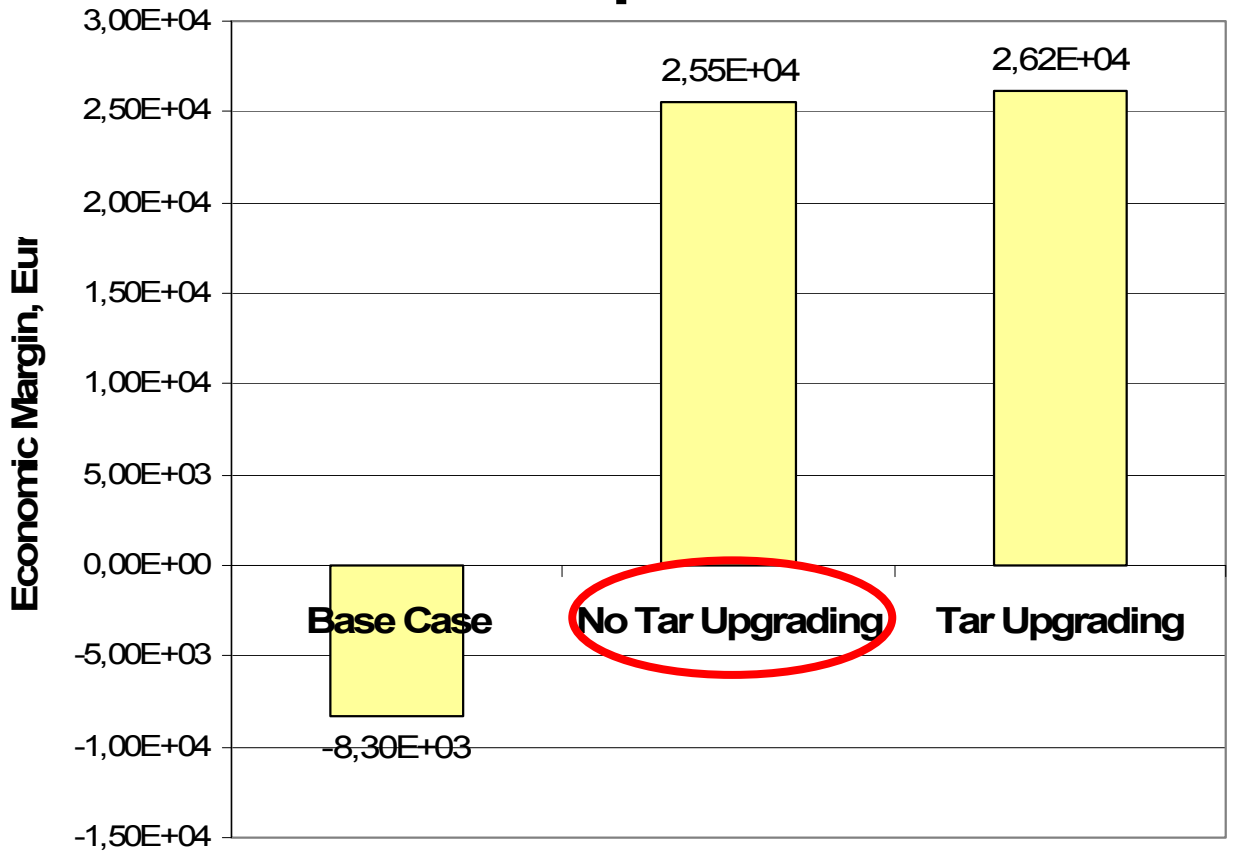


2. Separation of Chemicals



Feasibility

Comparison

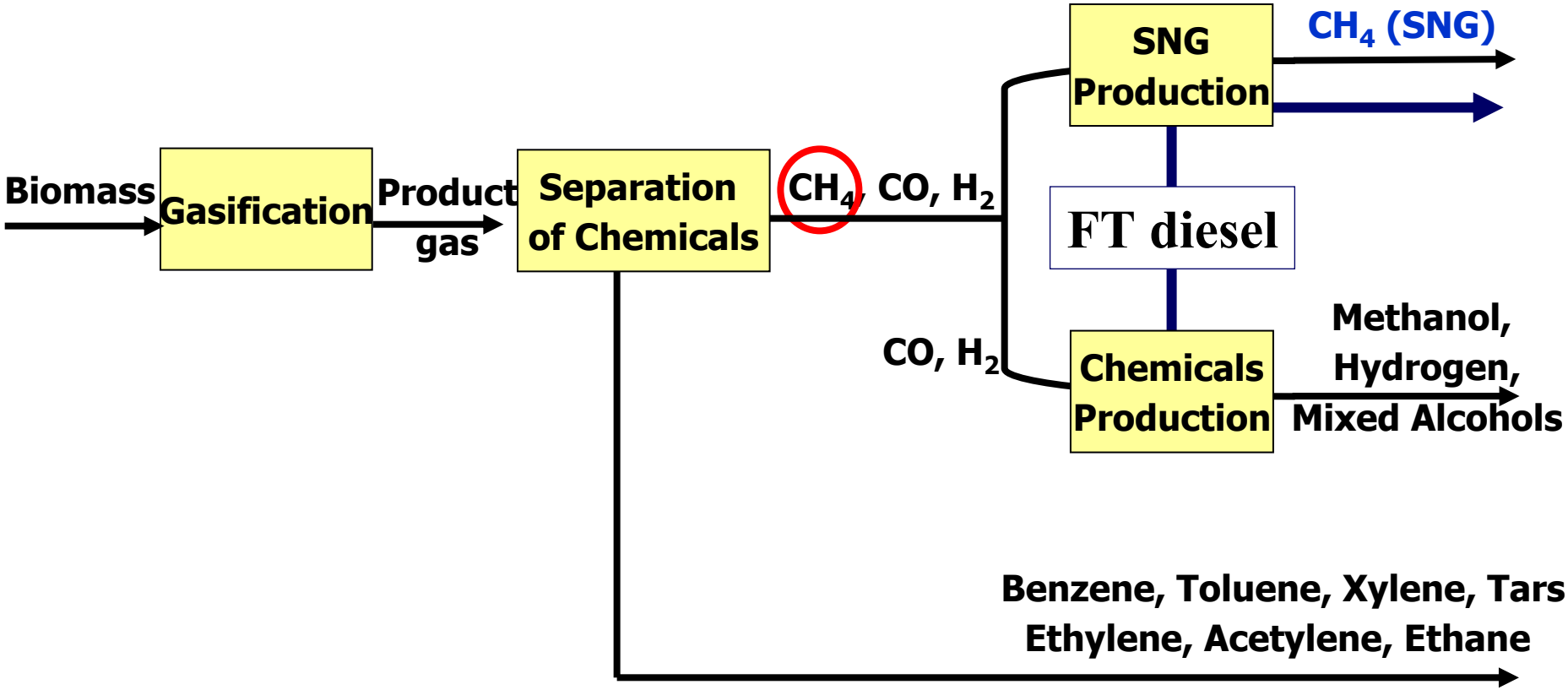


Economic Margin = Sales Revenues – Raw Materials (Biomass)

(on the basis of 100 kg/hr input of biomass)

Feasibility

3. Separation of Chemicals and Catalytic production of Chemicals



Feasibility

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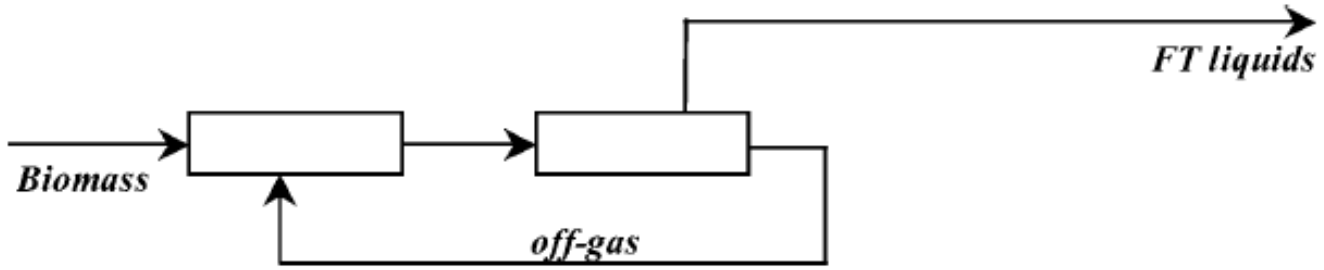


Figure 1. System for the production of Fischer–Tropsch (FT) liquids from biomass.

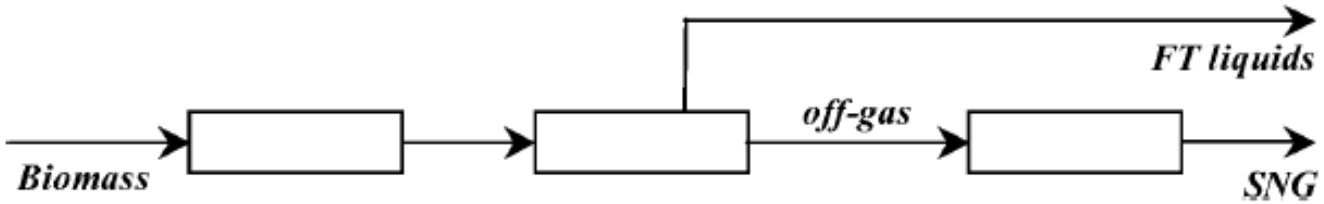
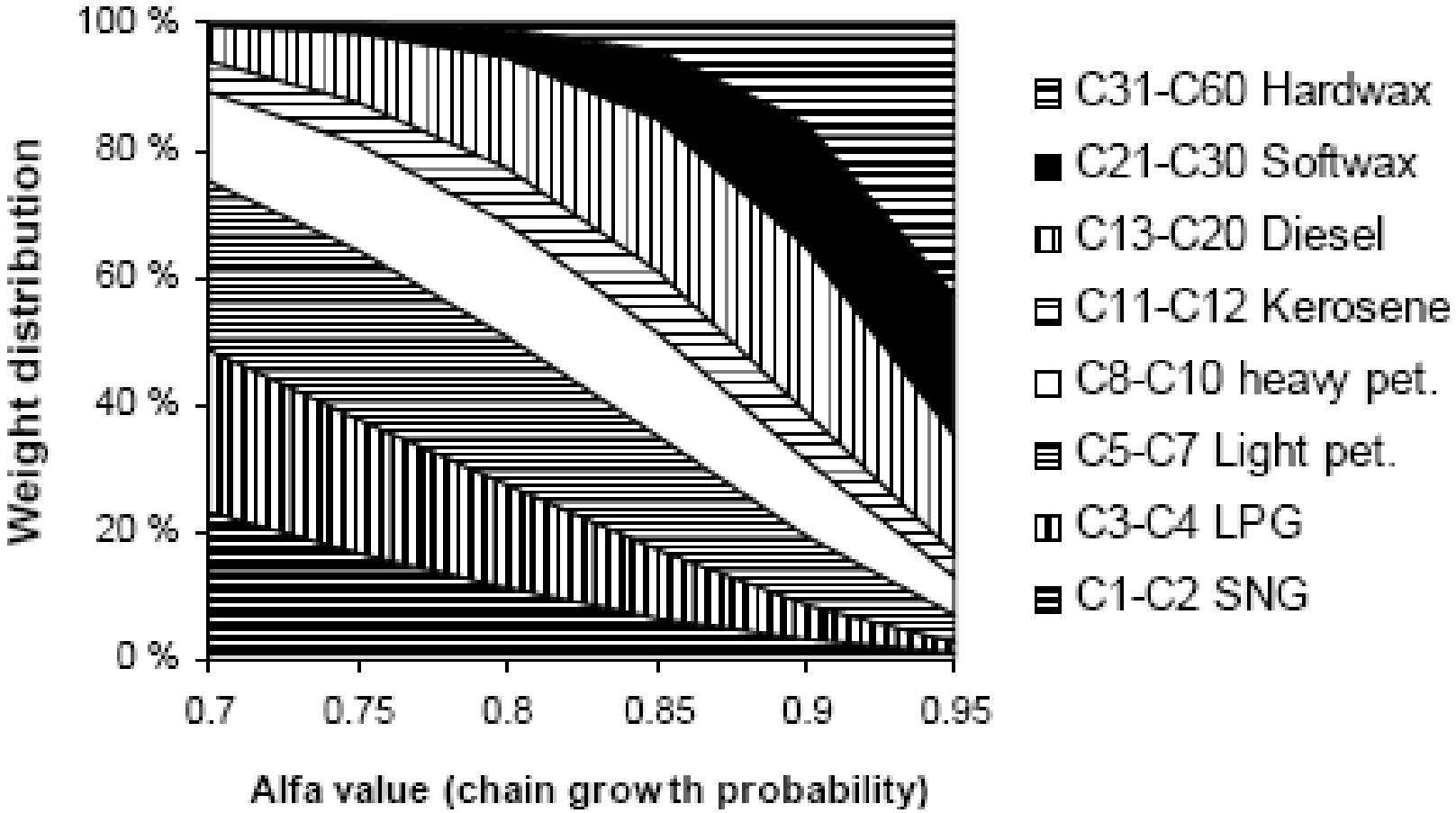


Figure 2. System for the co-generation of liquid FT transportation fuels and synthetic natural gas (SNG) from biomass.

Feasibility



Conclusion

- Polygeneration can be more than co-producing heat/power
- Chemicals can create additional economic margin…
  … though will require significant additional costs
- Fuels can create additional economic margin…
  … and might require less additional costs than thought
- Why work on allothermal gasification and C1 chemistry…
  … when your product gas contains all the interesting stuff?

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publications: www.ecn.nl/publications
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