DTU

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Comparison of different biorefinery systems integrating the electricity, heating and transport sector

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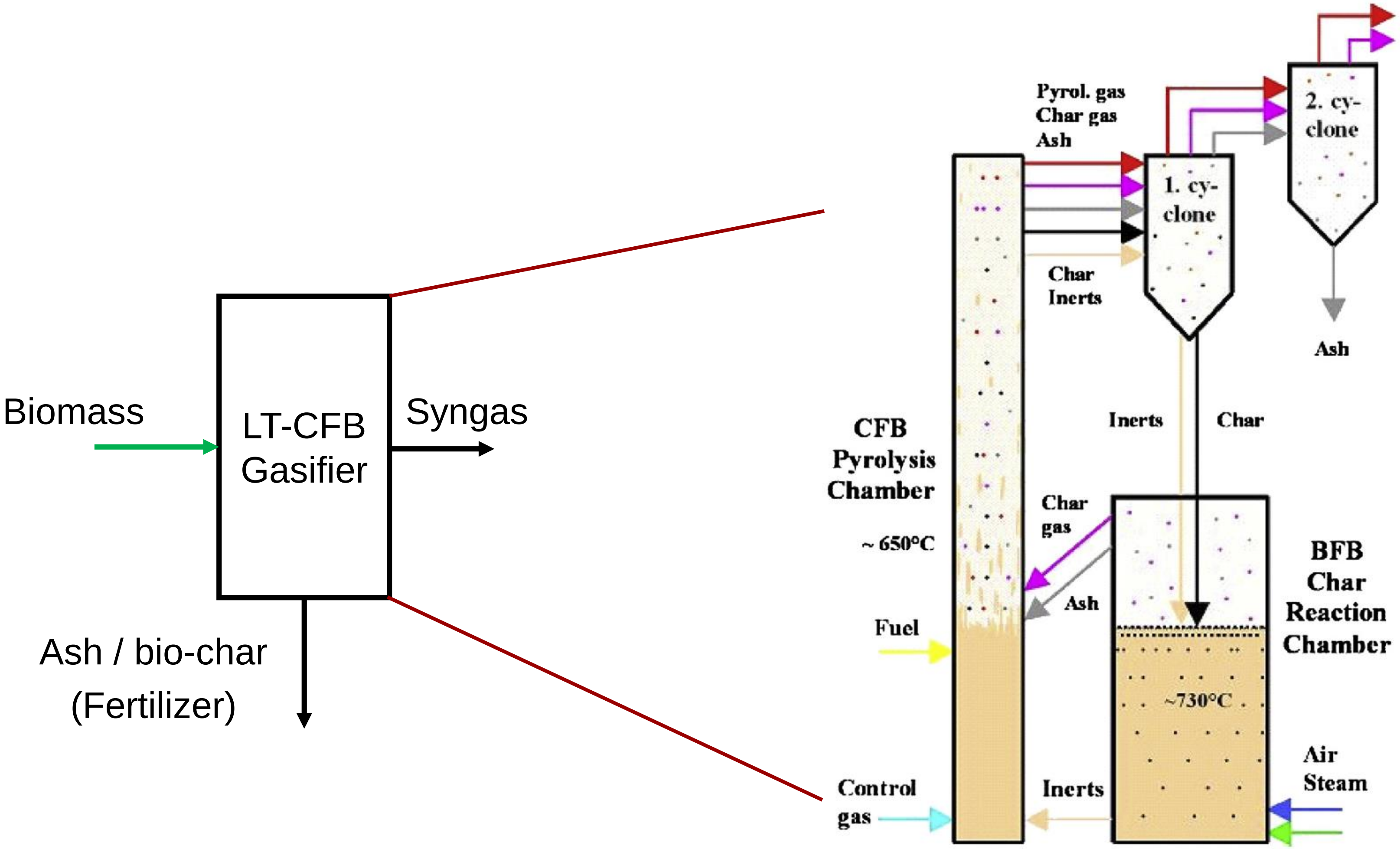
Background

- Thermochemical conversion of sustainable biomass to biofuels in biorefineries is a promising route for producing new, fossil-free fuels for the maritime sector
- Using agricultural residues, like e.g. wheat straw, manure etc. enables sustainable biofuel production
- Biorefineries can be designed to either co-produce electricity or use electricity for boosting the biofuel production
- Additional heat production can be used for supplying process heat or district heating

The LT-CFB gasifier



Low temperature circulating fluidized bed (LT-CFB) gasifier

Developed at DTU

Owned and scaled up by DONG Energy / Ørsted

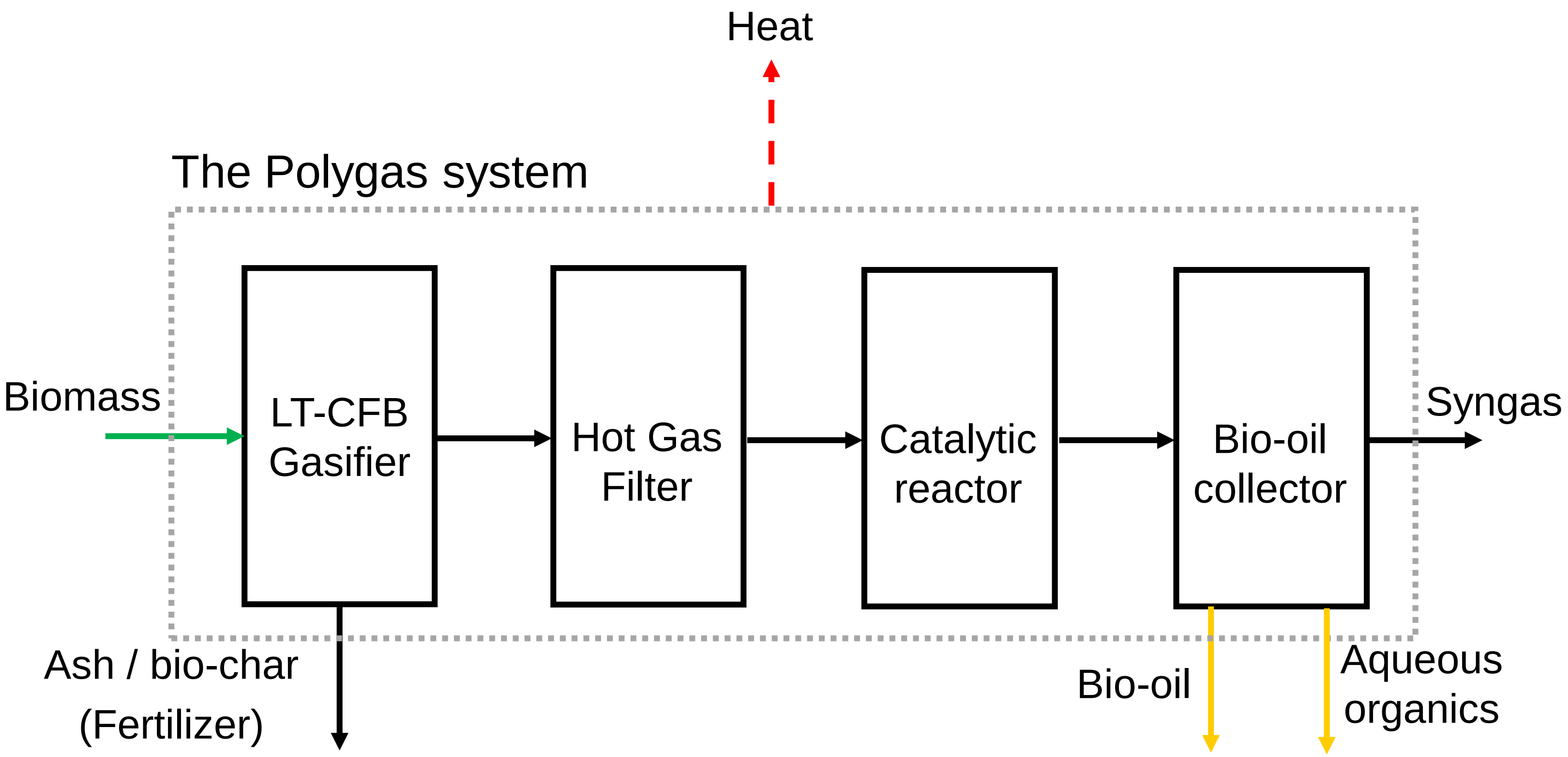
Designed to gasify agricultural residues

Bio-ashes showed good fertilizer properties

High tar content in gas

The PolyGas project funded by

Energiteknologisk udvikling og demonstration



Untreated bio-oil has:
- High oxygen content
- High acidity

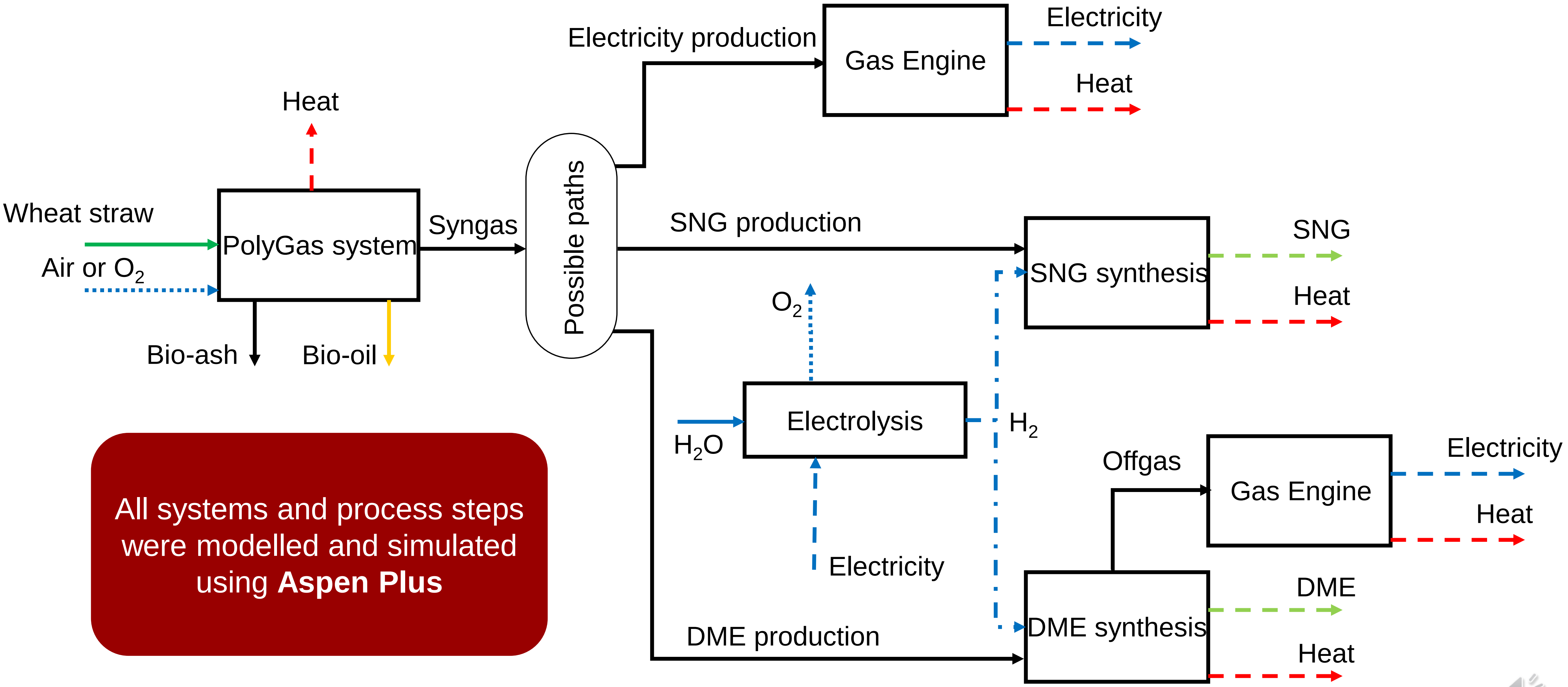
Deoxygenation of tars on catalyst:
- Lower O-content
- Lower acidity
- Enhancement of oil properties

After condensation of tars, two separated phases are collected

Bio-Oil (**Product**, 2 – 5 wt.% water)

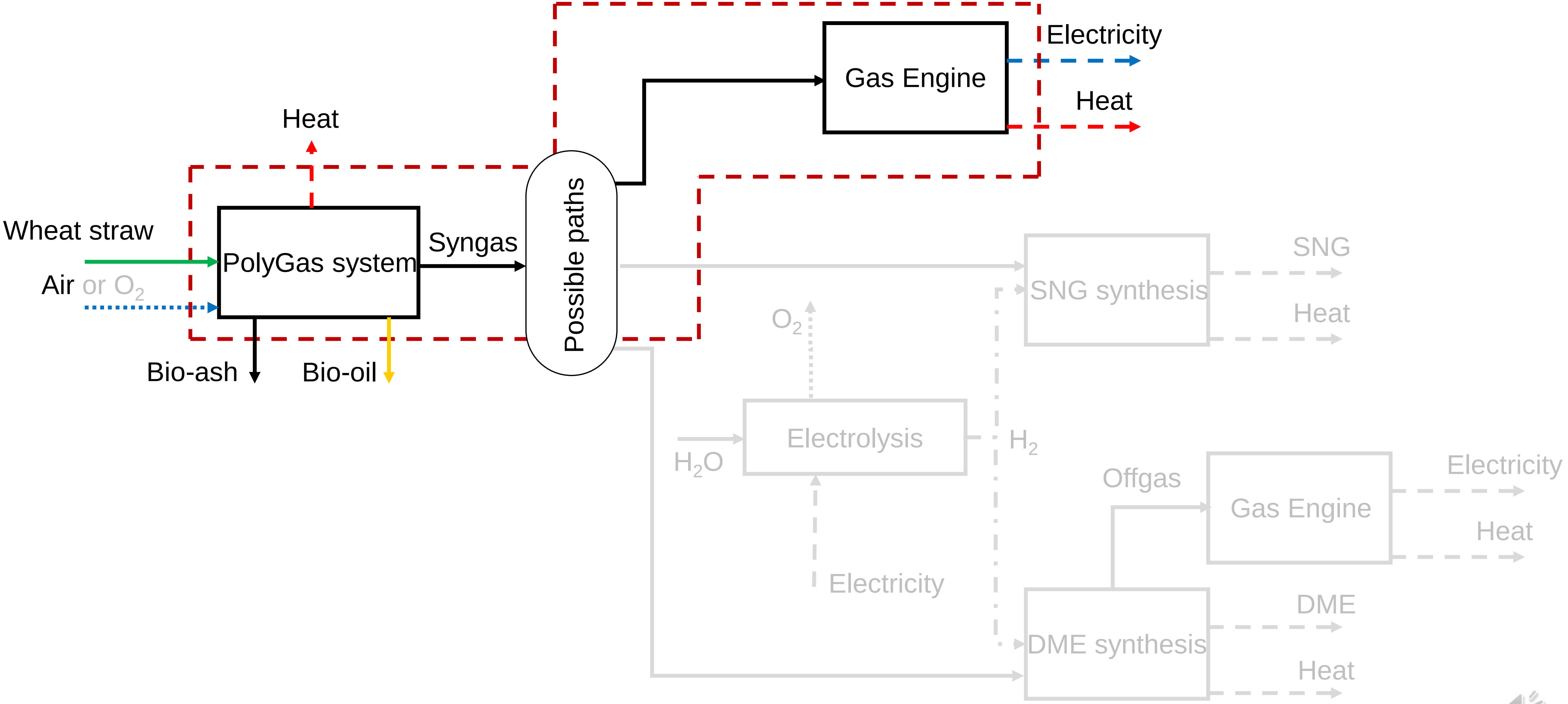
Aqueous organics (80 – 95 wt. % water)

Investigated systems

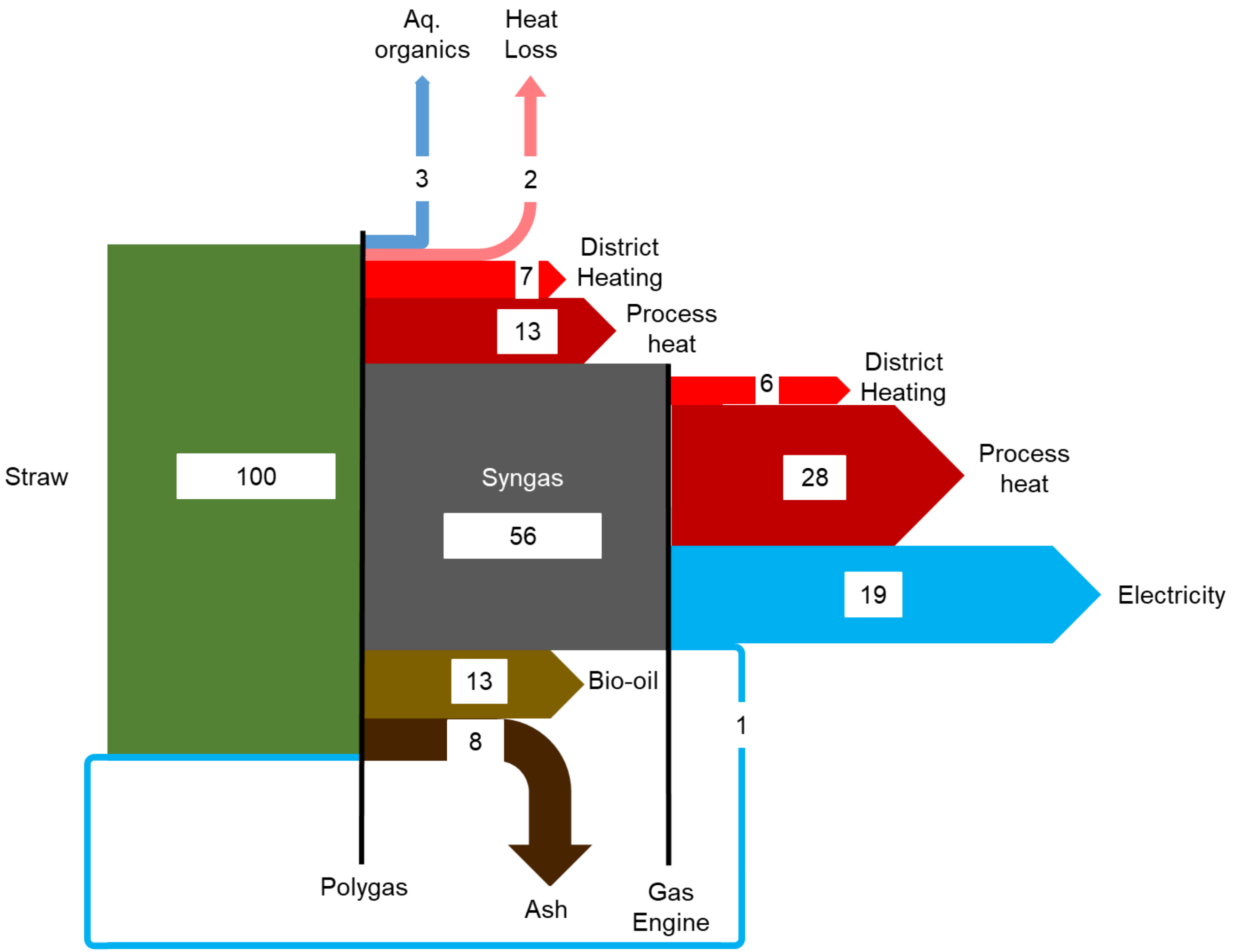


All systems and process steps were modelled and simulated using **Aspen Plus**

Investigated systems: Electricity production

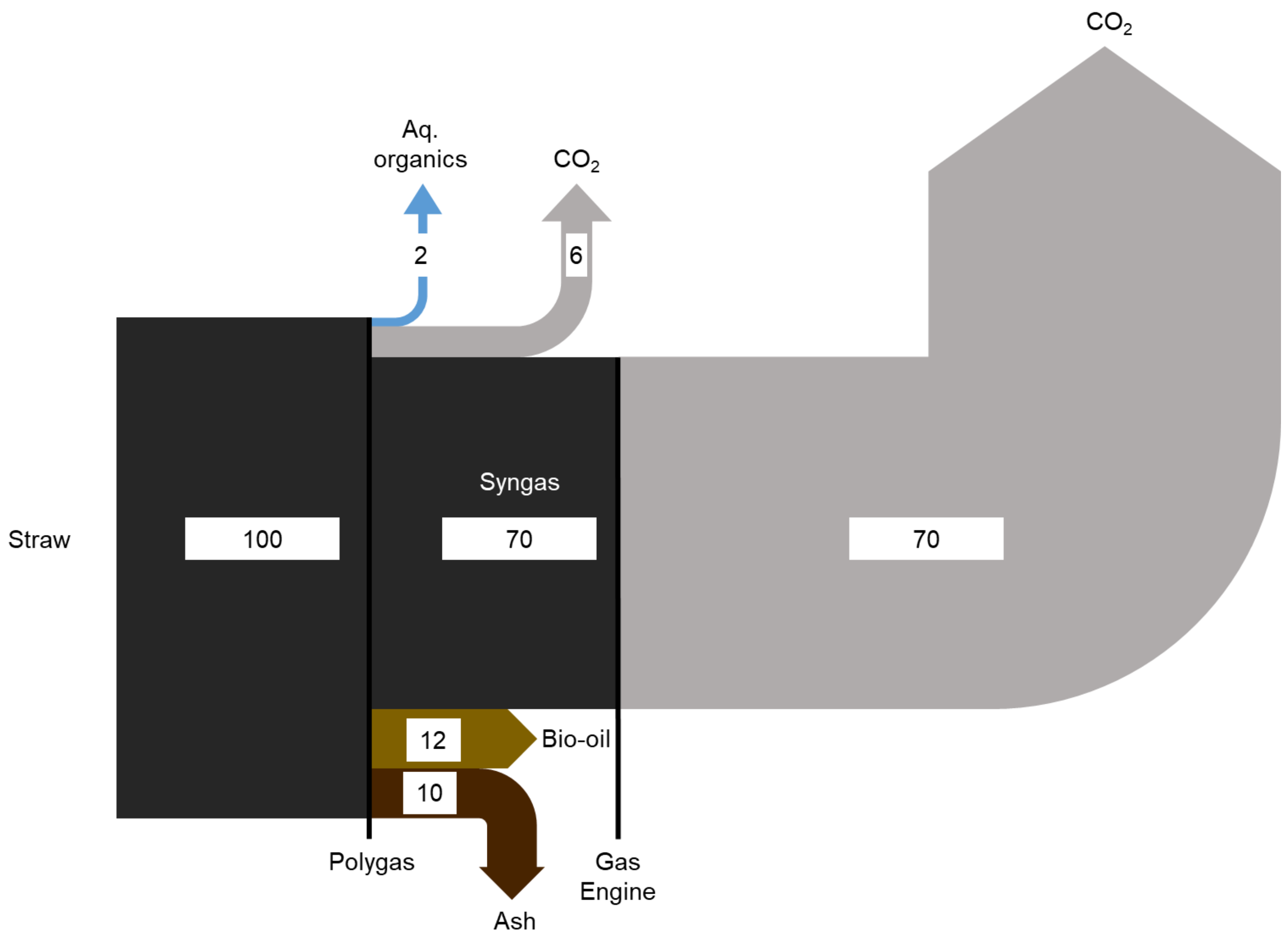


Electricity production – Energy flows & efficiency



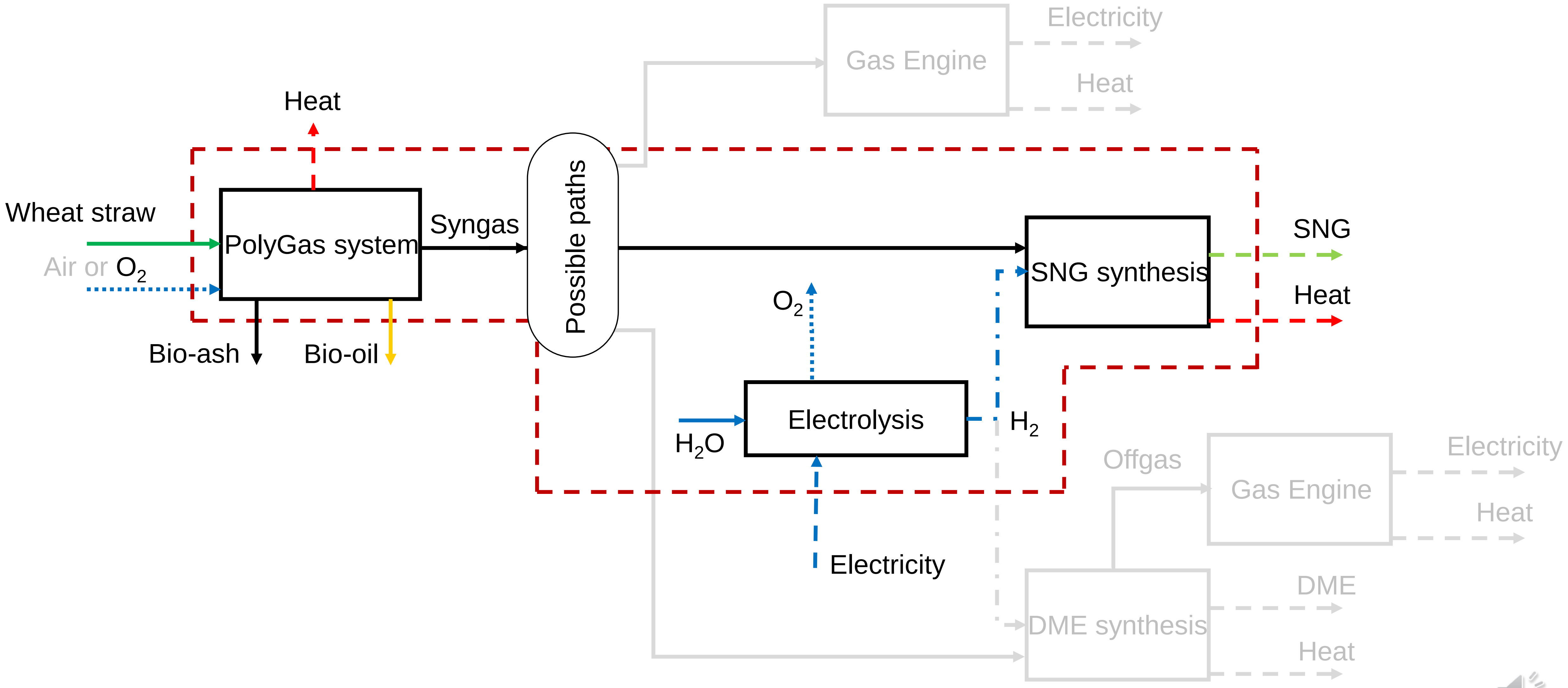
Efficiencies	
Bio-oil/Input	13.4 %
Electricity/Input	19.2 %
Energy efficiency w/o heat	**32.6 %**
Process heat/Input	40.4 %
DH/Input	12.8 %
Total energy efficiency	**85.8 %**

Electricity production – Carbon flows & efficiency

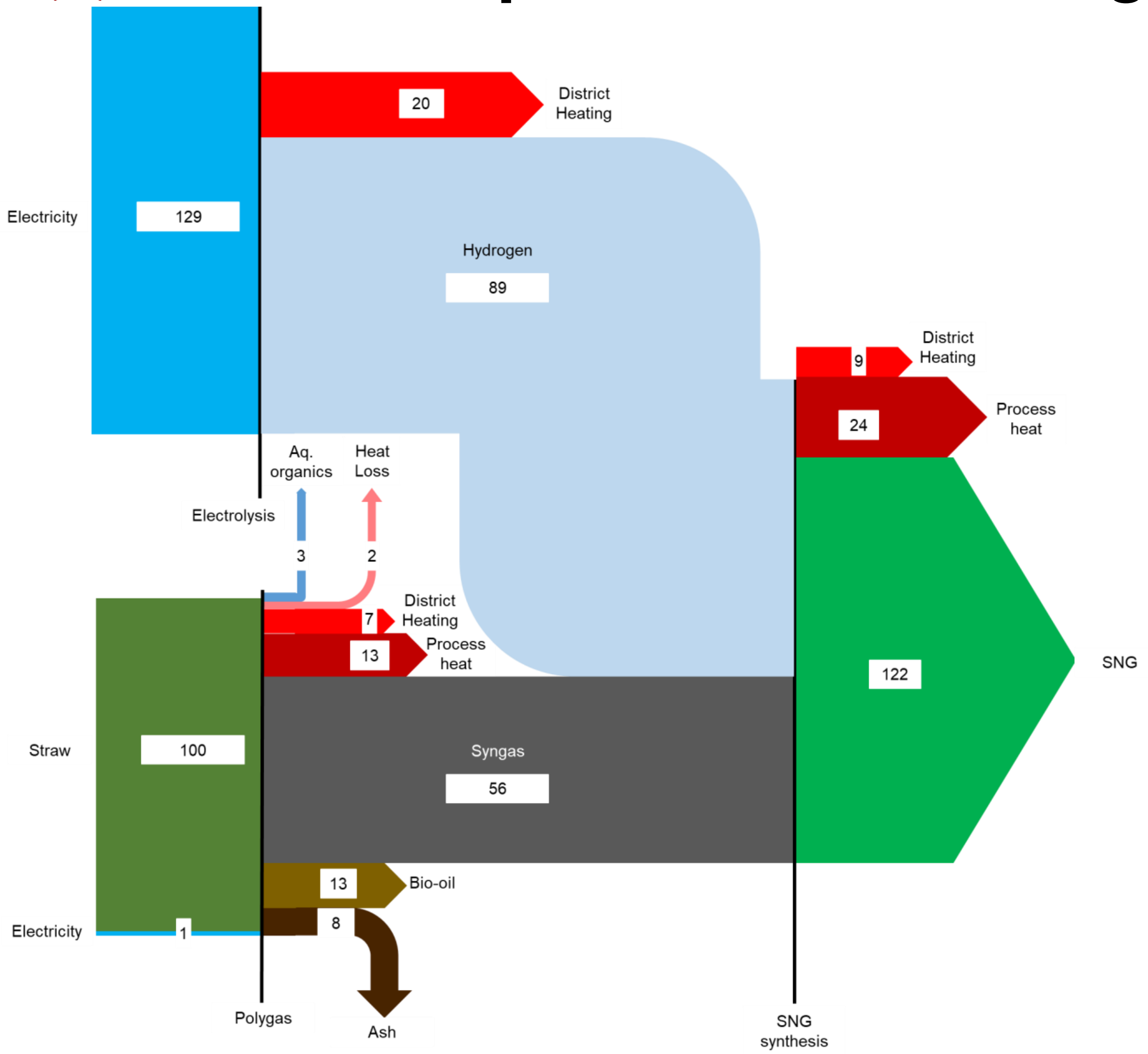


Efficiencies	
Bio-oil/Input	13.4 %
Electricity/Input	19.2 %
Energy efficiency w/o heat	**32.6 %**
Process heat/Input	40.4 %
DH/Input	12.8 %
Total energy efficiency	**85.8 %**
Carbon to Ash	10.0 %
Carbon to biofuels	11.7 %
Carbon efficiency	**21.7 %**

Investigated systems: SNG production

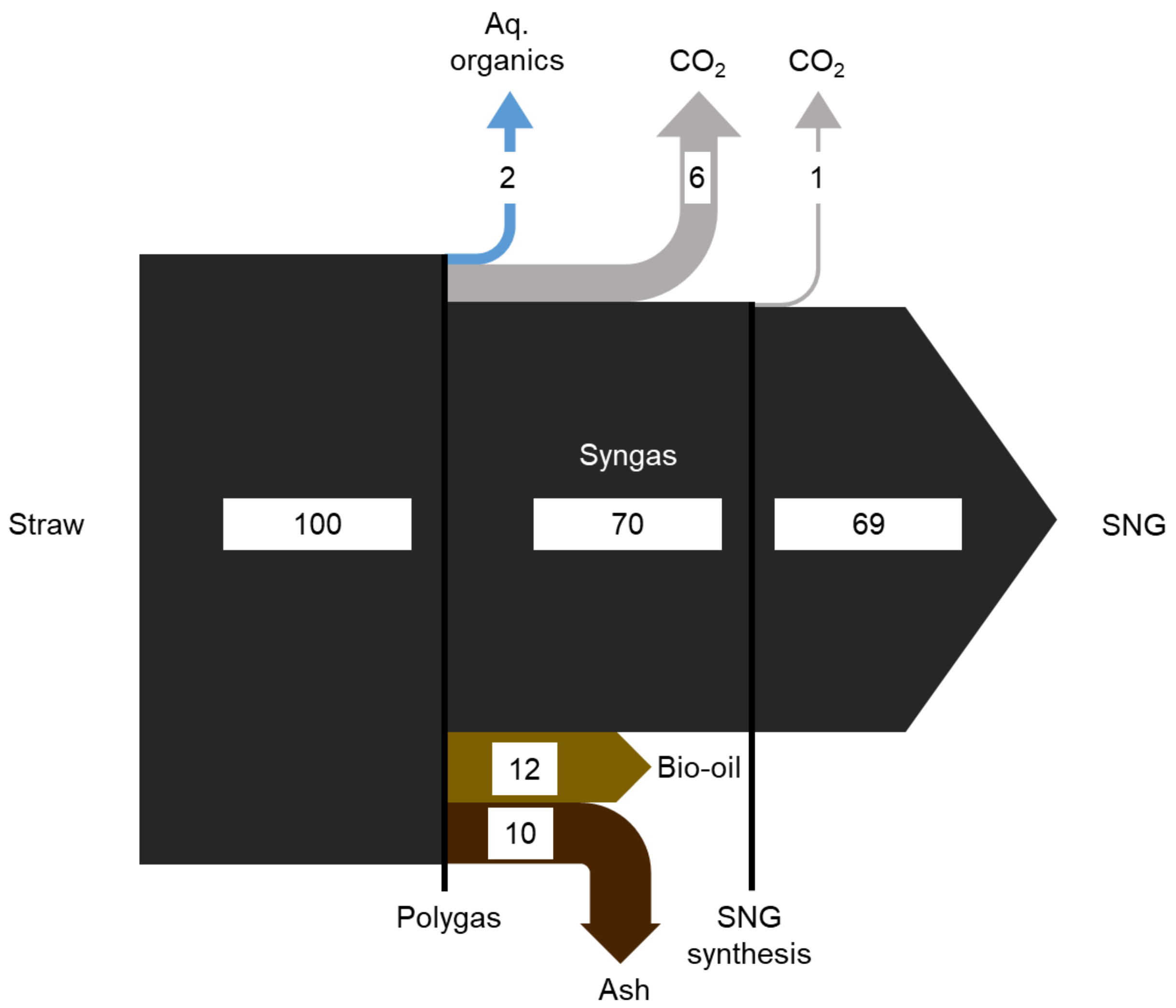


SNG production – Energy flows & efficiency



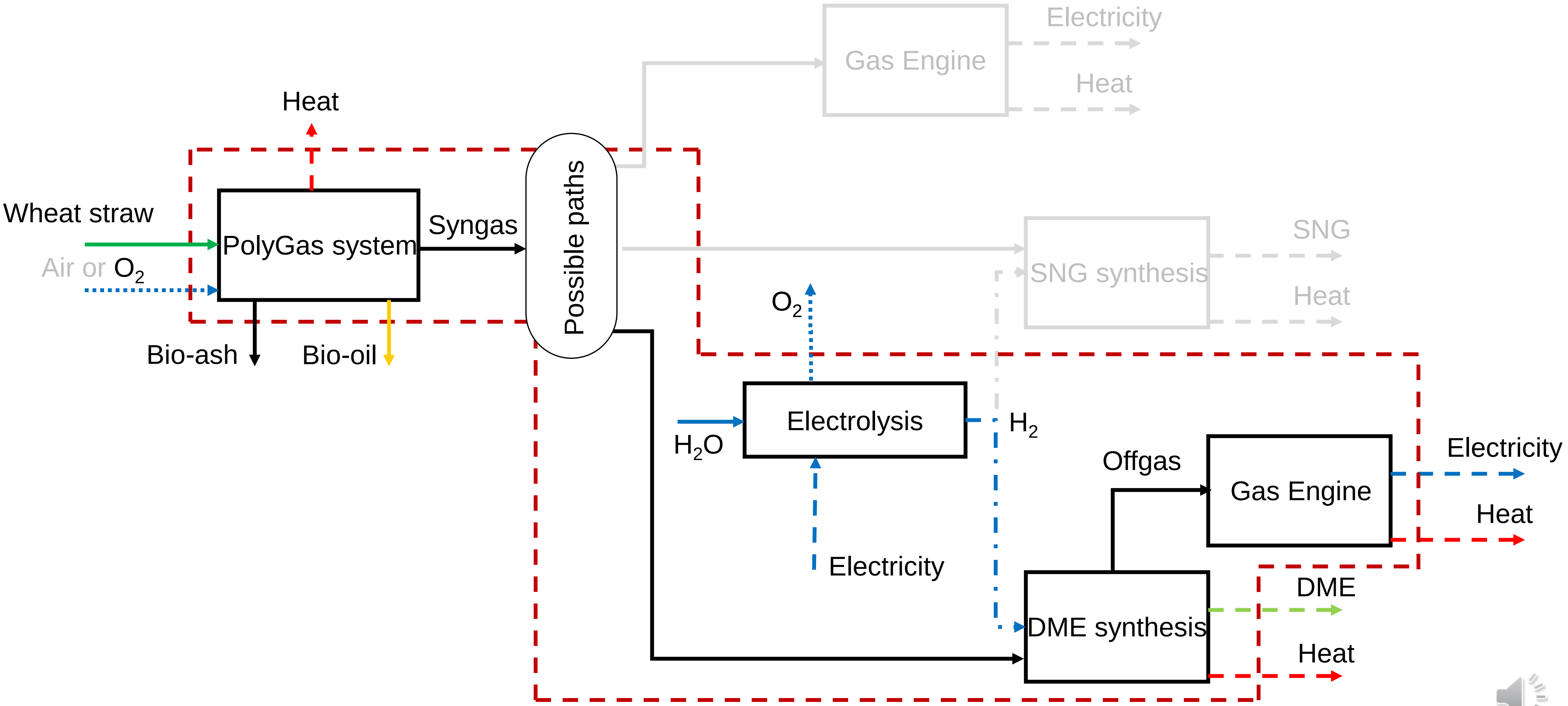
Efficiencies	
Bio-oil/Input	5.9 %
SNG/Input	53.1 %
Energy efficiency w/o heat	**59.0 %**
Process heat/Input	16.1 %
DH/Input	15.5 %
Total energy efficiency	**90.5 %**

SNG production – Carbon flows & efficiency

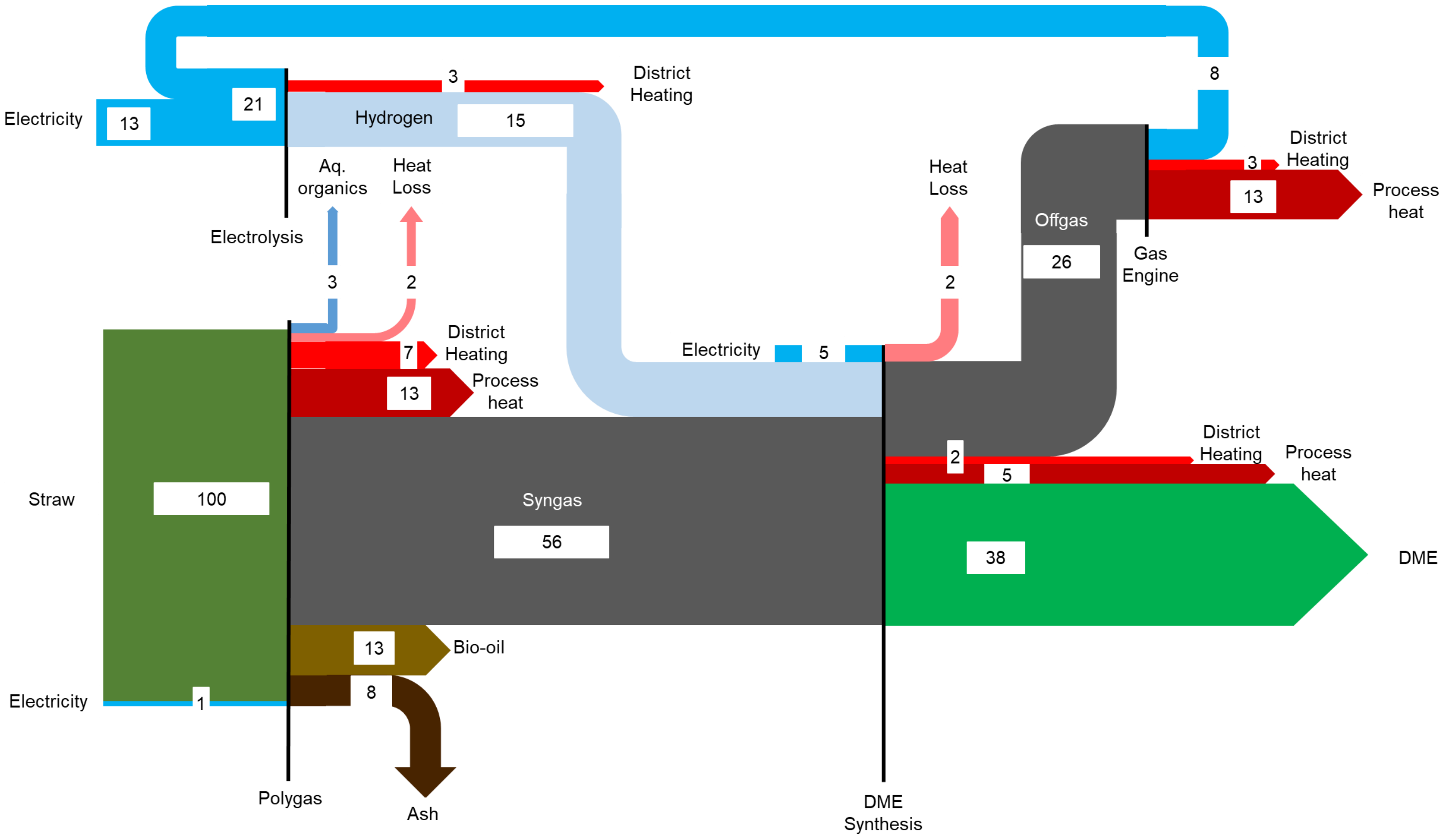


Efficiencies	
Bio-oil/Input	5.9 %
SNG/Input	53.1 %
Energy efficiency w/o heat	**59.0 %**
Process heat/Input	16.1 %
DH/Input	15.5 %
Total energy efficiency	**90.5 %**
Carbon to Ash	10.0 %
Carbon to biofuels	81.4 %
Carbon efficiency	**91.4 %**

Investigated systems: DME production

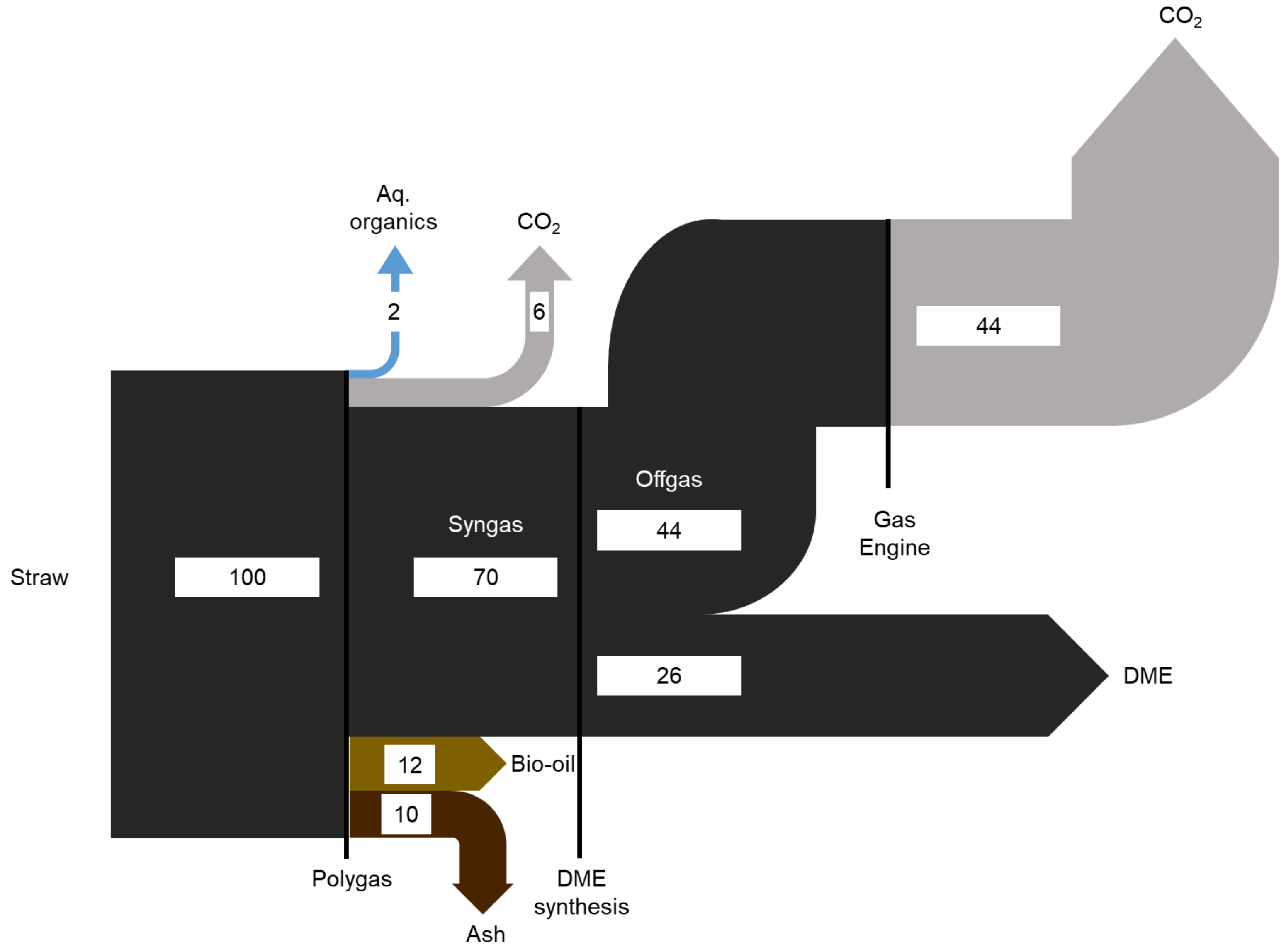


DME production – Energy flows & efficiency



Efficiencies	
Bio-oil/Input	11.4 %
DME/Input	32.4 %
Energy efficiency w/o heat	**43.7 %**
Process heat/Input	26.3 %
DH/Input	12.9 %
Total energy efficiency	**83.0 %**

DME production – Carbon flows & efficiency



Efficiencies	
Bio-oil/Input	11.4 %
DME/Input	32.4 %
Energy efficiency w/o heat	**43.7 %**
Process heat/Input	26.3 %
DH/Input	12.9 %
Total energy efficiency	**83.0 %**
Carbon to Ash	10.0 %
Carbon to biofuels	37.8 %
Carbon efficiency	**47.8 %**

Conclusions

Electricity production

- $\eta_{w/o\ heat}$ = 32.4 %
- η_{tot}= 85.8 %
- η_{Carbon} = 21.7 %

+ Simple system
+ Good overall energy efficiency

- Very low carbon efficiency
- High share of heat production (>50 %)

SNG Production

- $\eta_{w/o\ heat}$ = 59.0 %
- η_{tot}= 90.5 %
- η_{Carbon} = 91.4 %

+ Very high carbon efficiency
+ High share of bio-oil + SNG production

- High amount of electricity used for electrolysis
- SNG not very suitable for Diesel engines

DME production

- $\eta_{w/o\ heat}$ = 43.7 %
- η_{tot}= 83.0 %
- η_{Carbon} = 47.8 %

+ DME is a very suitable for Diesel engines
+ DME as liquid fuel has higher selling prices compared to gaseous fuels

- Most complicated system layout
- Conversion of CO_2 and hydrocarbons needs additional process steps

Thank you for your attention!

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