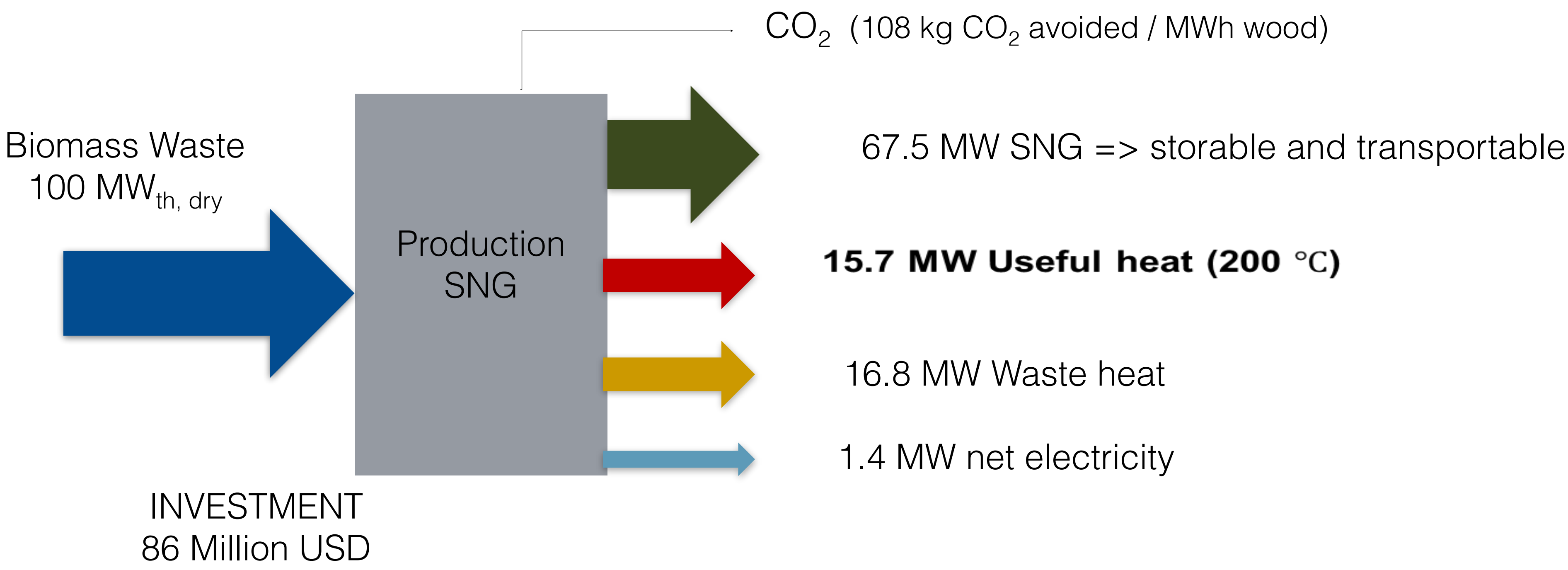
Thermo Chemical Biomass Conversion

Biorefinery concepts

François Maréchal

IPESE
Industrial Process and Energy Systems Engineering
EPFL Valais-Wallis
CH - 1950 Sion

The green boiler => use of the renewable resource



- **Co production of biofuel from wood**
  - **Synthetic natural gas, methanol, DME, F-T fuels**
  - **CO2 capture**
  - **Exothermic => Heat supply**
  - **Cogeneration of Heat**

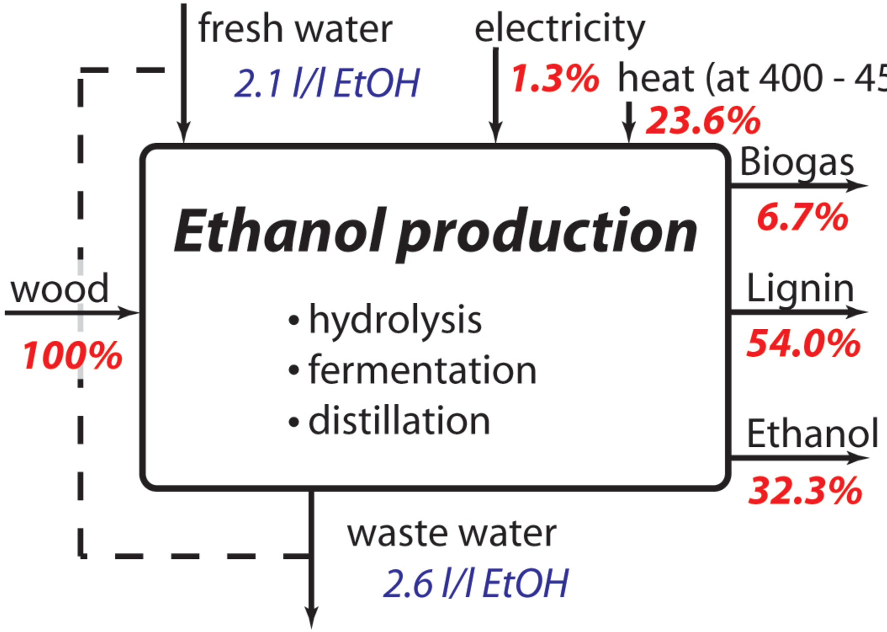
COST OF HEAT

25 $/MWh (- 47 $/MWh)*

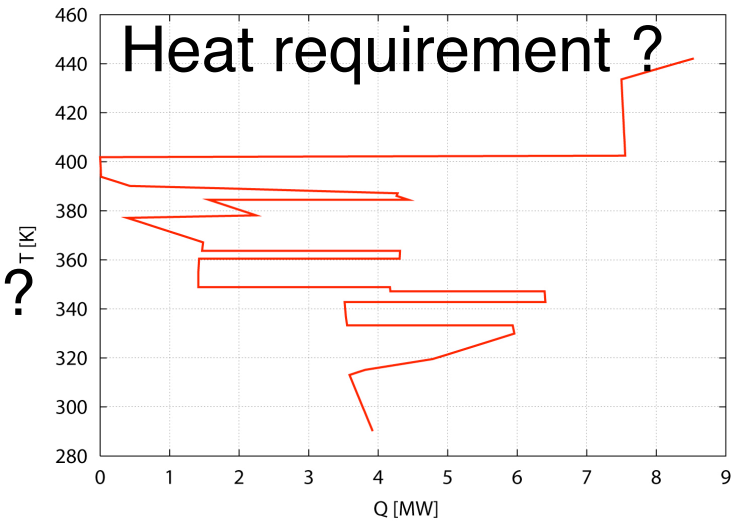
** with CO2 tax*

With market price of WOOD (40$/MWh) and NG (65 $/MWh) and with CO2 taxes (80 CHF/ton), also for capture
8000 hours/year of operation

Ethanol production from lignocellulosic biomass:



Waste Biomass ?

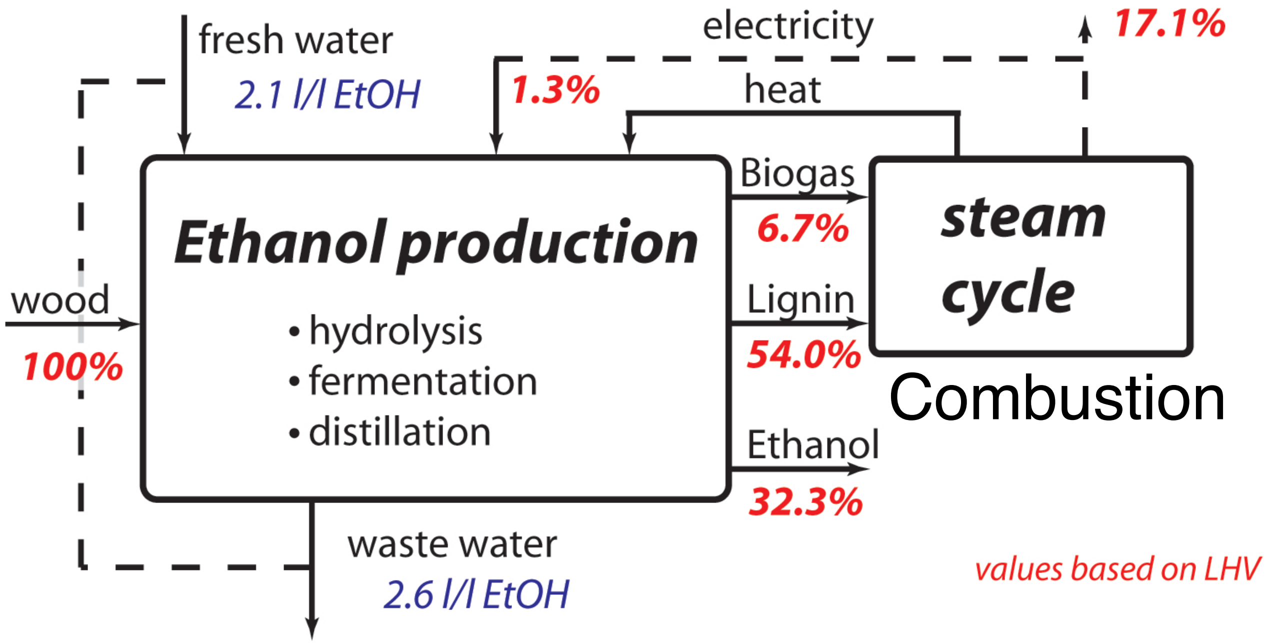


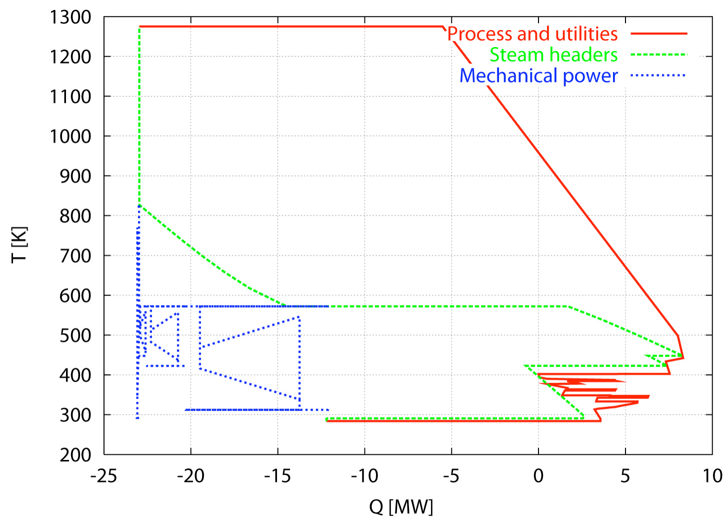
values based on LHV

input: 58 $MW_{th,wood}$

Site integration: process couplings
EtOH & SNG

Ethanol production from lignocellulosic biomass:





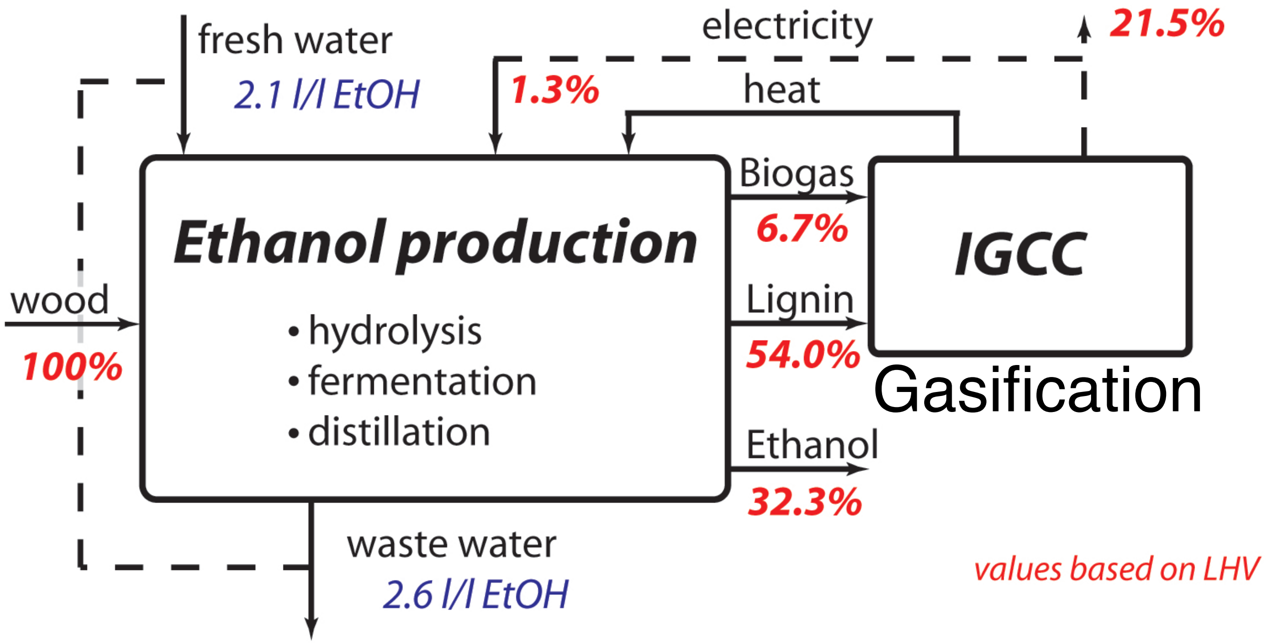
input: $58\ MW_{th,wood}$

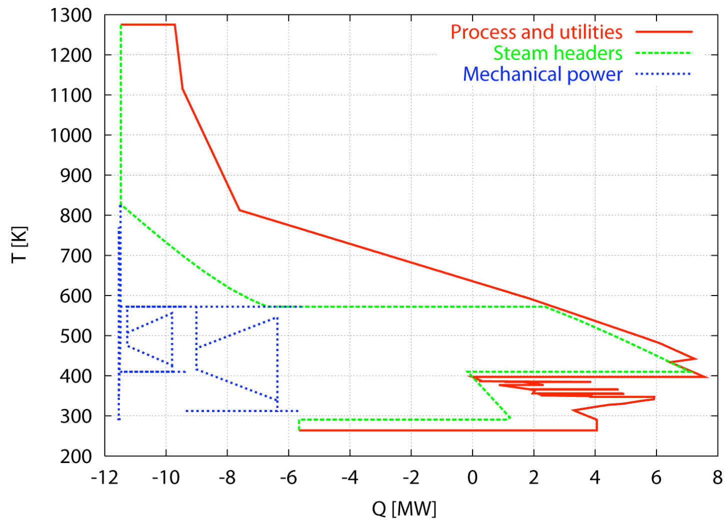
		steam cycle
Input	wood	100 %
Output	ethanol	32.3 %
	SNG	-
	electricity	17.1 %
chem. efficiency ($\Delta\eta_{NGCC}$=55%)		62.3 %
total efficiency		49.4 %

Energy balance for different process integration options (without seed train, non-optimised).

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Ethanol production from lignocellulosic biomass:



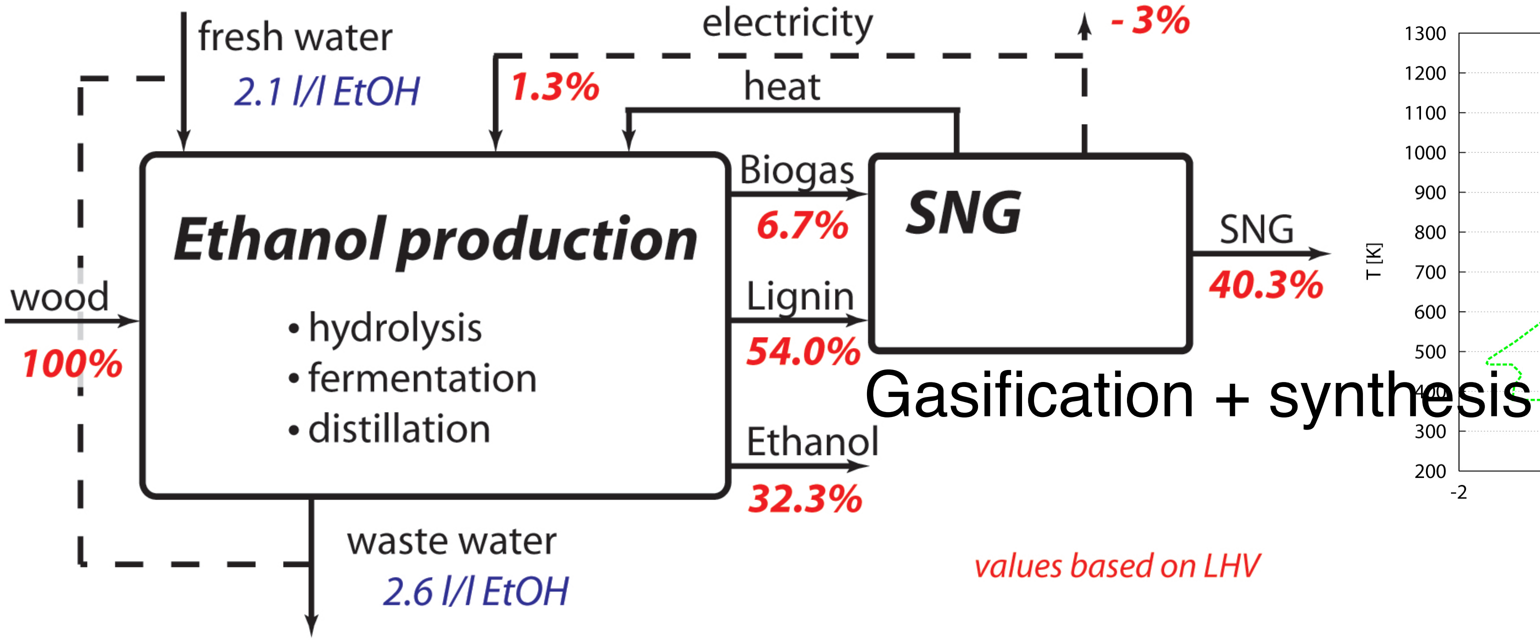


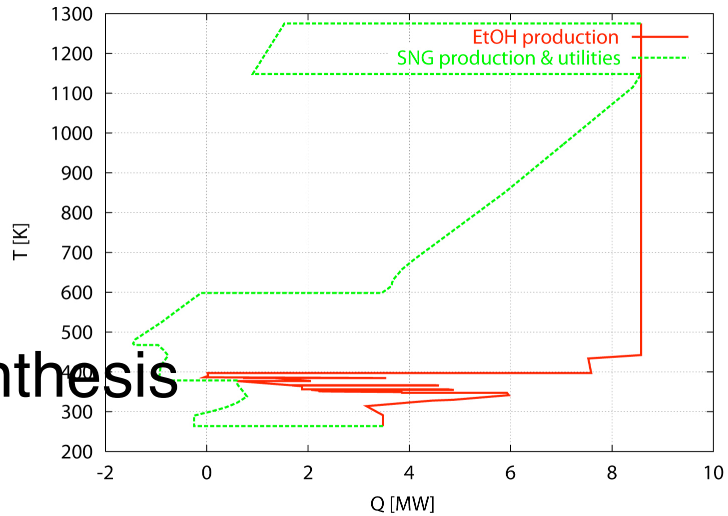
input: $58\ MW_{th,wood}$

		steam cycle	IGCC
Input	wood	100 %	100 %
Output	ethanol	32.3 %	32.3 %
	SNG	-	-
	electricity	17.1 %	21.5 %
chem. efficiency ($\Delta\eta_{NGCC}$=55%)		62.3 %	70.0 %
total efficiency		49.4 %	53.8 %

Energy balance for different process integration options (without seed train, non-optimised).

Ethanol production from lignocellulosic biomass:



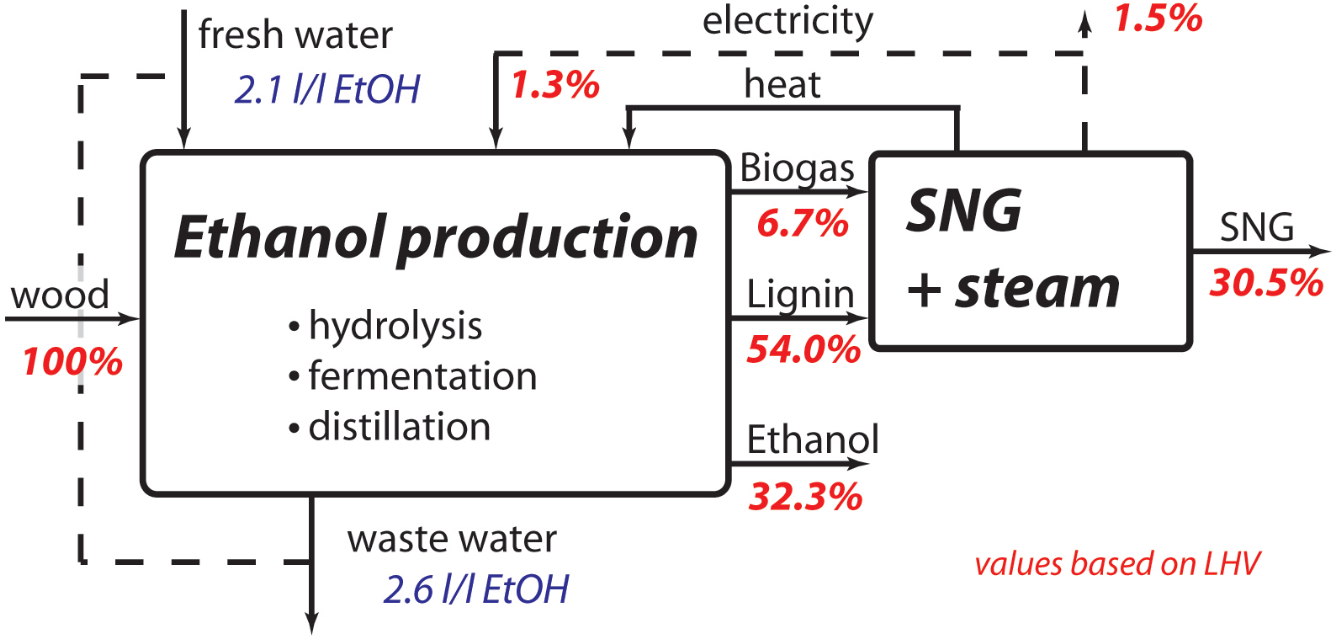


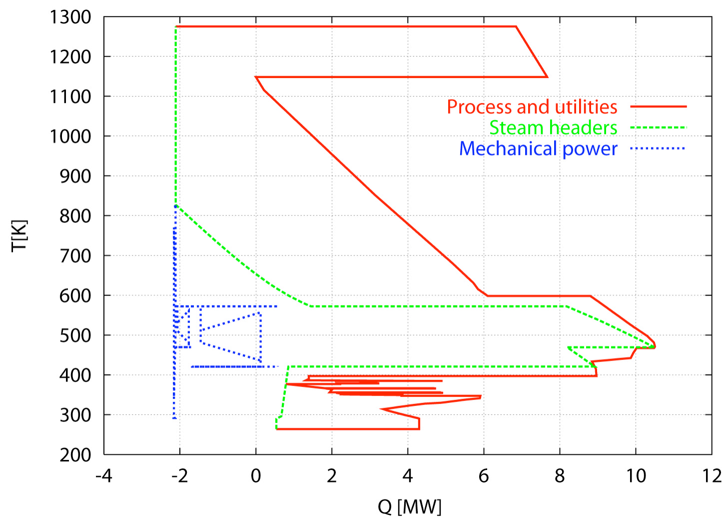
input: $58\ MW_{th,wood}$

		steam cycle	IGCC	SNG
Input	wood	100 %	100 %	100 %
Output	ethanol	32.3 %	32.3 %	32.3 %
	SNG	-	-	40.3 %
	electricity	17.1 %	21.5 %	-3.0 %
chem. efficiency ($\Delta\eta_{NGCC}$=55%)		62.3 %	70.0 %	67.3 %
total efficiency		49.4 %	53.8 %	70.5 %

Energy balance for different process integration options (without seed train, non-optimised).

Ethanol production from lignocellulosic biomass:





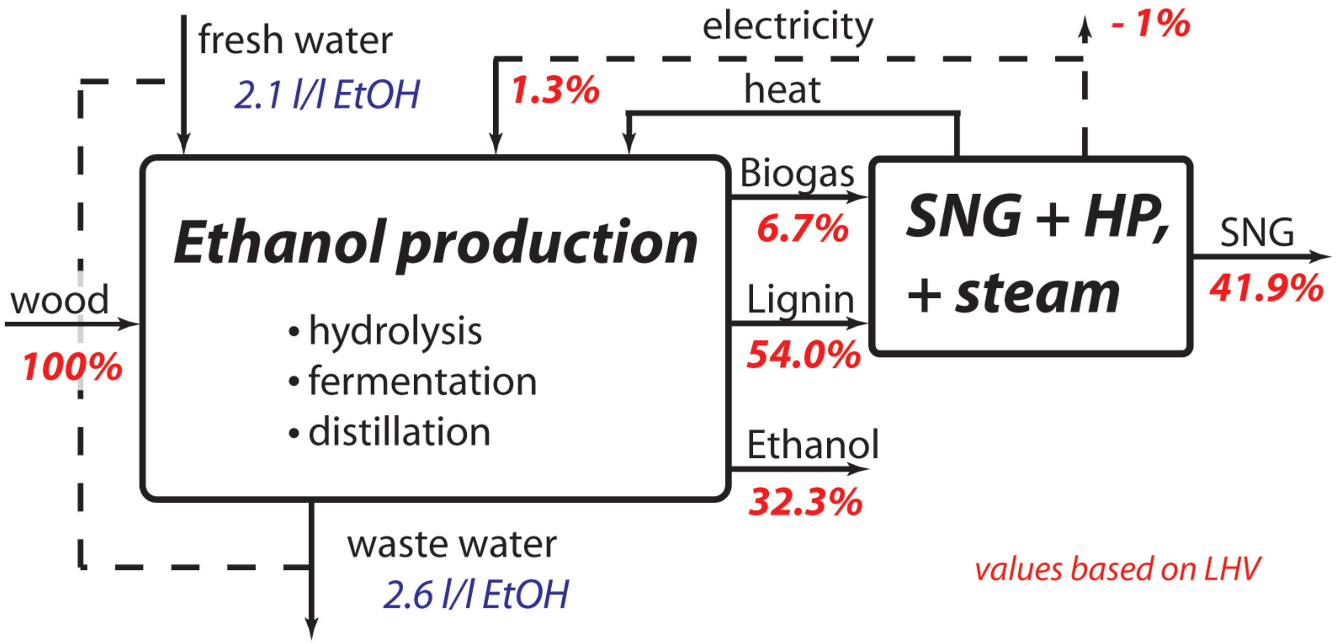
input: 58 $MW_{th,wood}$

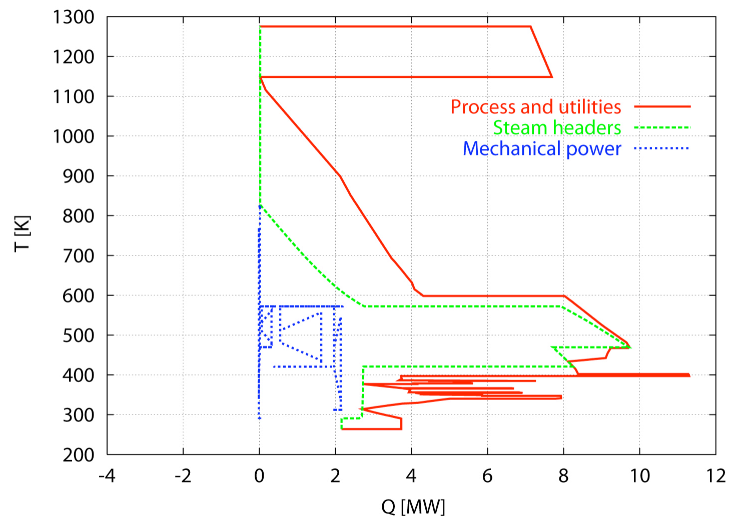
		steam cycle	IGCC	SNG	+ steam
Input	wood	100 %	100 %	100 %	100 %
Output	ethanol	32.3 %	32.3 %	32.3 %	32.2 %
	SNG	-	-	40.3 %	30.5 %
	electricity	17.1 %	21.5 %	-3.0 %	1.5 %
chem. efficiency ($\Delta\eta_{NGCC}$=55%)		62.3 %	70.0 %	67.3 %	65.3 %
total efficiency		49.4 %	53.8 %	70.5 %	64.2 %

Energy balance for different process integration options (without seed train, non-optimised).

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Ethanol production from lignocellulosic biomass:





input: 58 $MW_{th,wood}$

		steam cycle	IGCC	SNG	+ steam	+ HP
Input	wood	100 %	100 %	100 %	100 %	100 %
	ethanol	32.3 %	32.3 %	32.3 %	32.2 %	32.2 %
Output	SNG	-	-	40.3 %	30.5 %	41.9 %
	electricity	17.1 %	21.5 %	-3.0 %	1.5 %	-1.0 %
chem. efficiency ($\Delta\eta_{NGCC}$=55%)		62.3 %	70.0 %	67.3 %	65.3 %	72.3 %
total efficiency		49.4 %	53.8 %	70.5 %	64.2 %	73.1 %

Energy balance for different process integration options (without seed train, non-optimised).

Conclusions

- Waste heat of thermo-chemical process can be used to supply the heat to biochemical processes
  - fuel production efficiency : from 33% to 74%
- Unconverted biomass can be processed by thermochemical processes
- Combined heat and fuel concept is a breakthrough in terms of energy efficiency of biochemical processes
- Do not burn waste biomass when combined fuel production can be envisaged.