

# Bio Energy with CO<sub>2</sub> Capture and Storage (BECCS): conversion routes for negative CO<sub>2</sub> emissions

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# ECN

*Energy research Centre of the Netherlands*

***“ECN develops high-level knowledge and technologies for a sustainable energy system and transfers those to the market”***

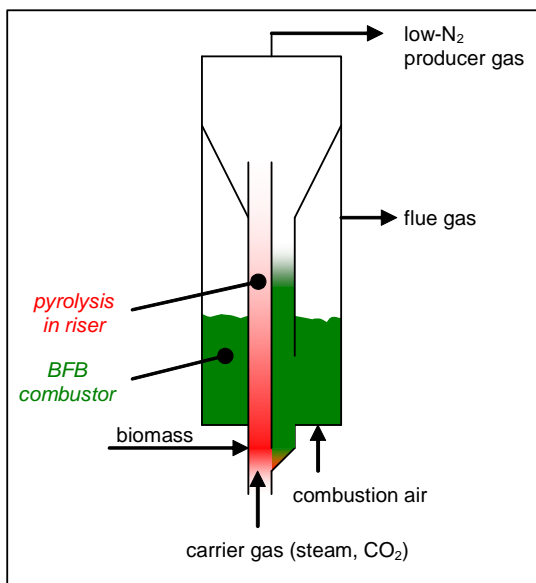


## ECN in brief

- ECN is the largest, independent, market oriented and innovative Dutch energy research institute
- 84 M€/a turnover (2008)
- 690 employees (~630 fte)
- 500 scientific publications/reports each year;  
10-15 international patents each year
- (Inter)national co-operation with companies, universities and research institutes

# MILENA Indirect Gasifier

- two integrated reactors for gasification and combustion
- essentially  $N_2$ -free producer gas
- complete conversion
- high methane yield, suited for SNG-production



MILENA principle



MILENA, 5 kg/h,  
2004



MILENA, 160 kg/h,  
2008



# OLGA Tar Removal

- commercialised by Dahlman ([www.dahlman.nl](http://www.dahlman.nl))
- modified to deal with tars from different gasifiers
- can reduce tar dew point below 0°C
- scrubber/stripper principle



OLGA at ECN,  
2 nm<sup>3</sup>/h



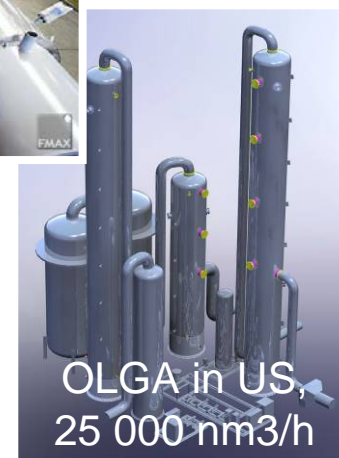
OLGA at ECN,  
200 nm<sup>3</sup>/h



OLGA in France,  
2000 nm<sup>3</sup>/h

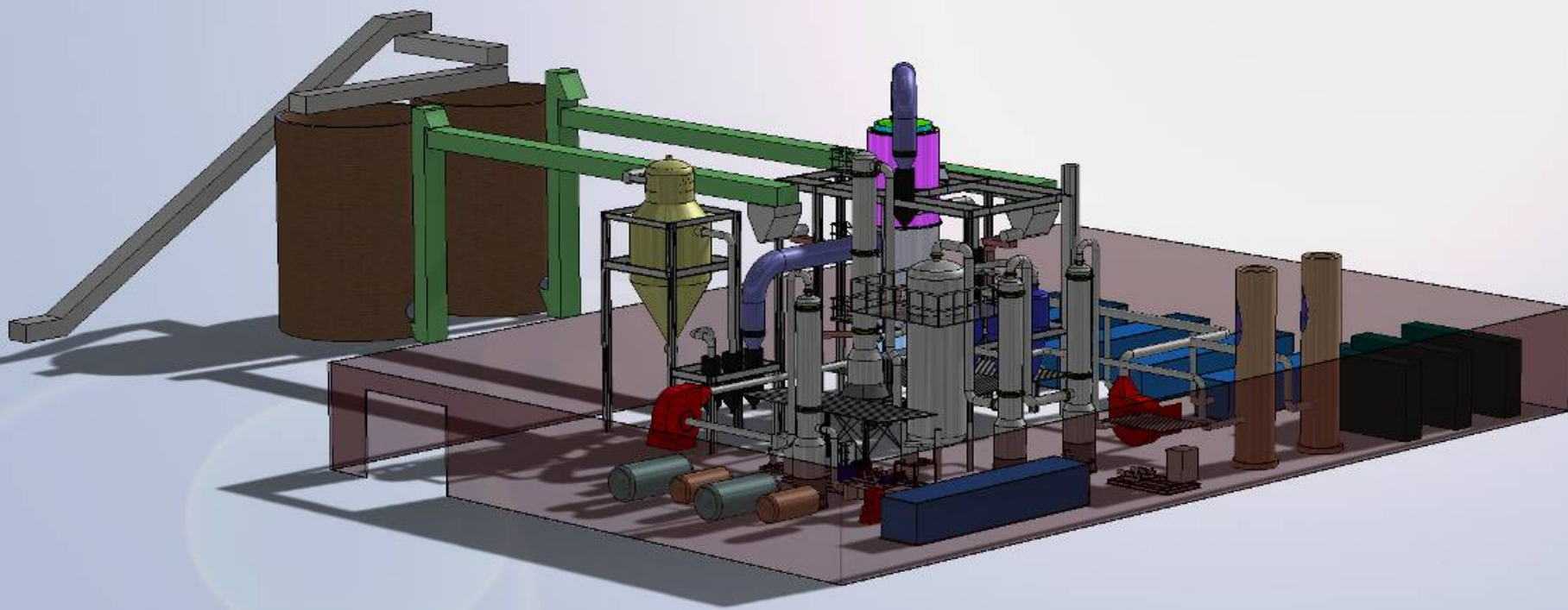


OLGA in Portugal,  
2000 nm<sup>3</sup>/h

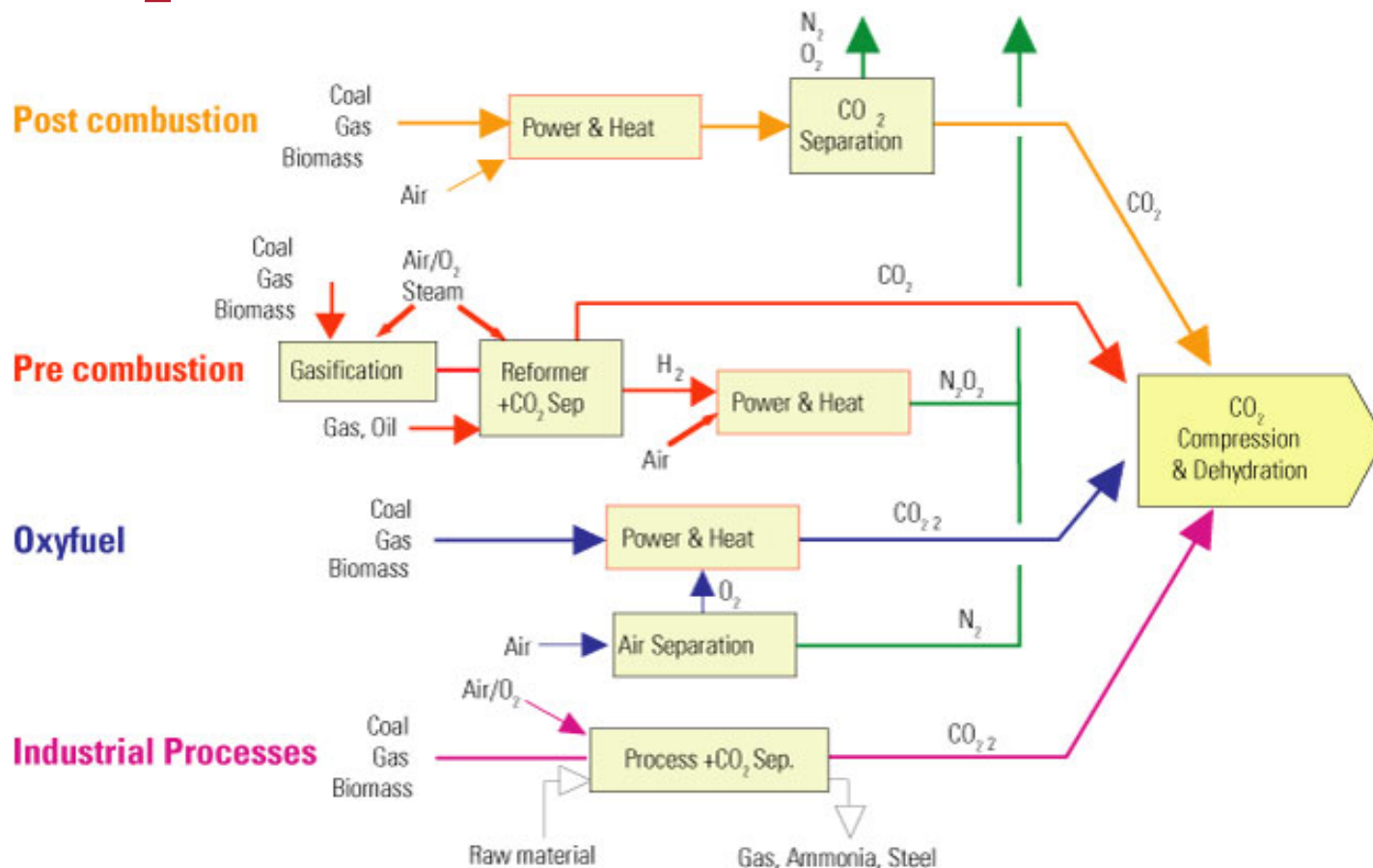


OLGA in US,  
25 000 nm<sup>3</sup>/h

# Preparations for 10 MW<sub>th</sub> Bio CHP plant

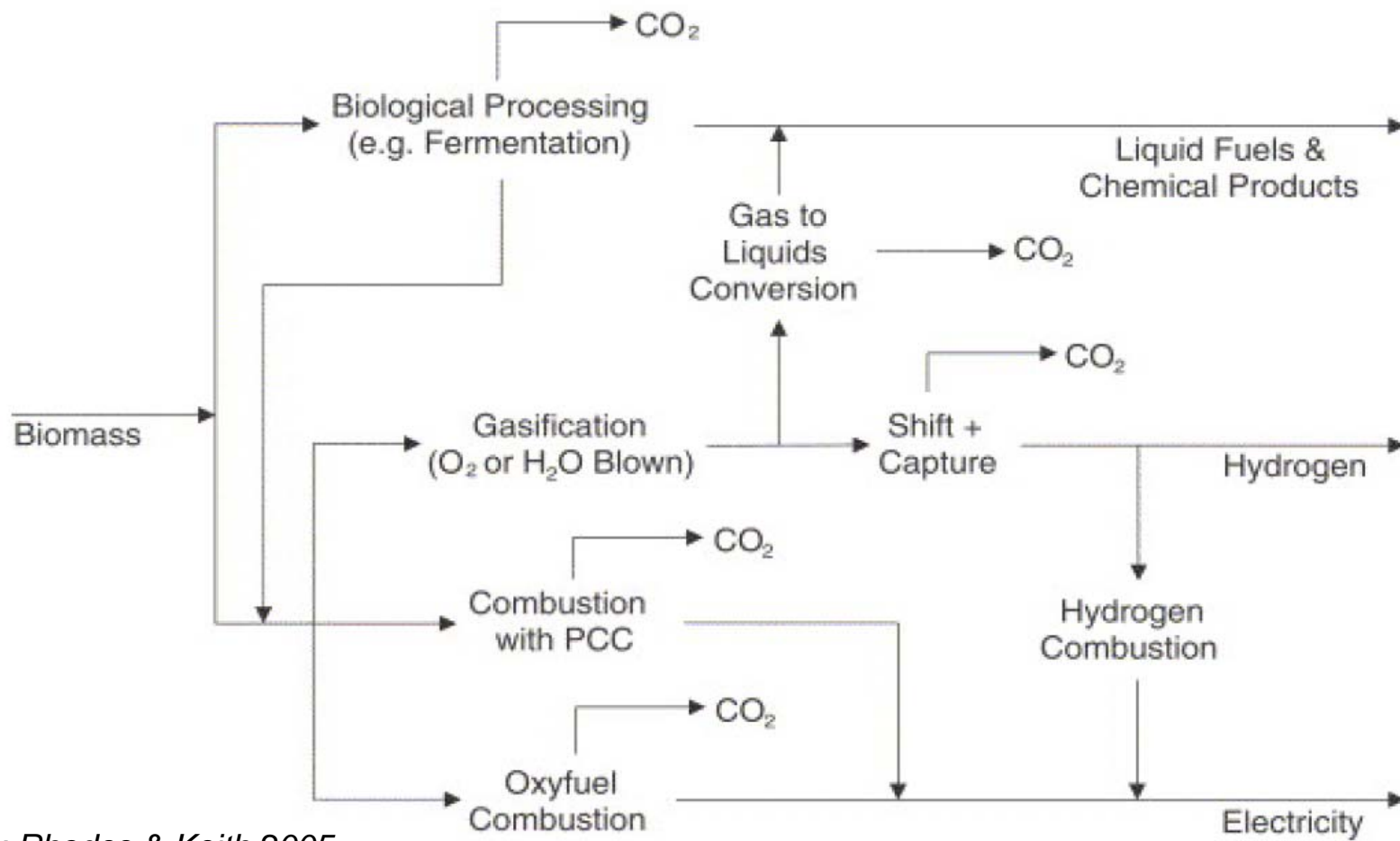


# CO<sub>2</sub> capture and storage (CCS)



Source: IPCC Spec. Report, 2005

# Bio Energy with CCS (BECCS)



Source: Rhodes & Keith 2005



## BECCS research at ECN

- BECCS research is multidisciplinary collaboration between different units:
  - Biomass, Coal & Environmental research
  - Hydrogen & Clean Fossil Fuels
  - Policy Studies
- Research topics:
  - Mapping sources & sinks, LCA, public perception
  - Policy measures & incentives
  - Assessment conversion routes

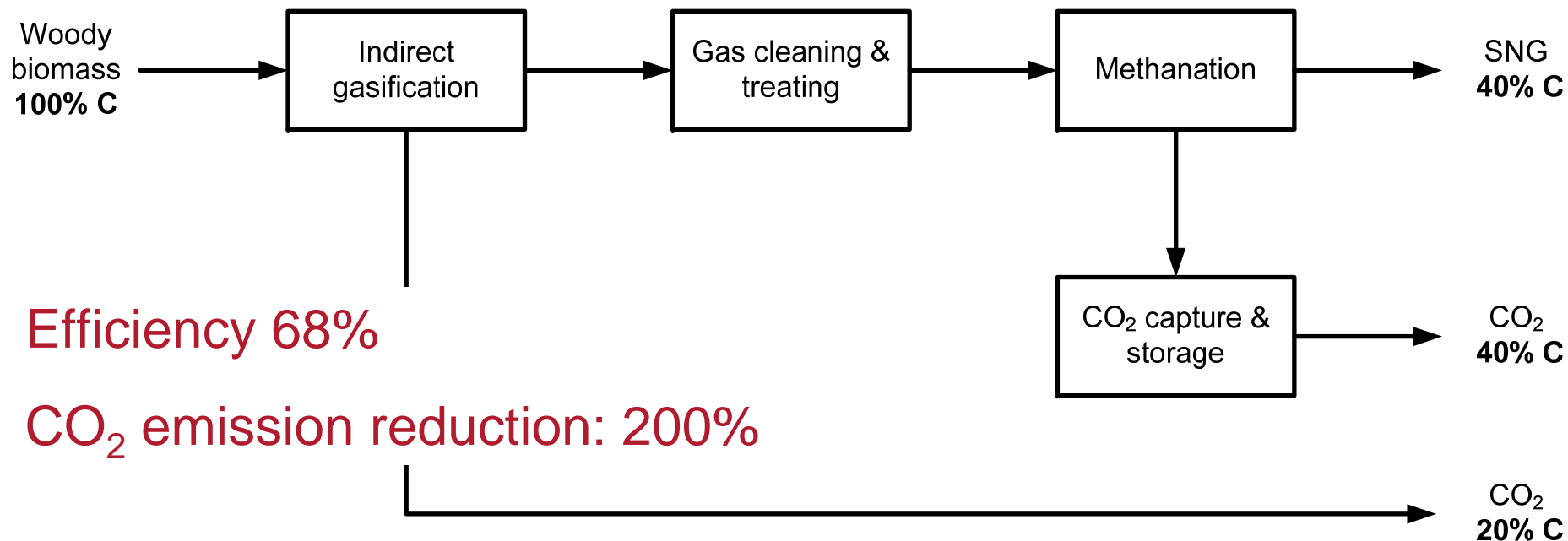
## Study objectives

- Fossil fuel fired power plants with CCS ultimately only mitigate 80-90% of current CO<sub>2</sub> emissions
- Bio Energy with CCS (BECCS) offers opportunities for net atmospheric CO<sub>2</sub> reduction
- CCS combined with production 2<sup>nd</sup> generation biofuels: BioSNG, FT-diesel, Bio-ethanol from lignocellulose
- Biofuels cover costs atmospheric CO<sub>2</sub> mitigation
- Investigate conundrum:  
low efficiency → high CO<sub>2</sub> mitigation

## Starting points calculations

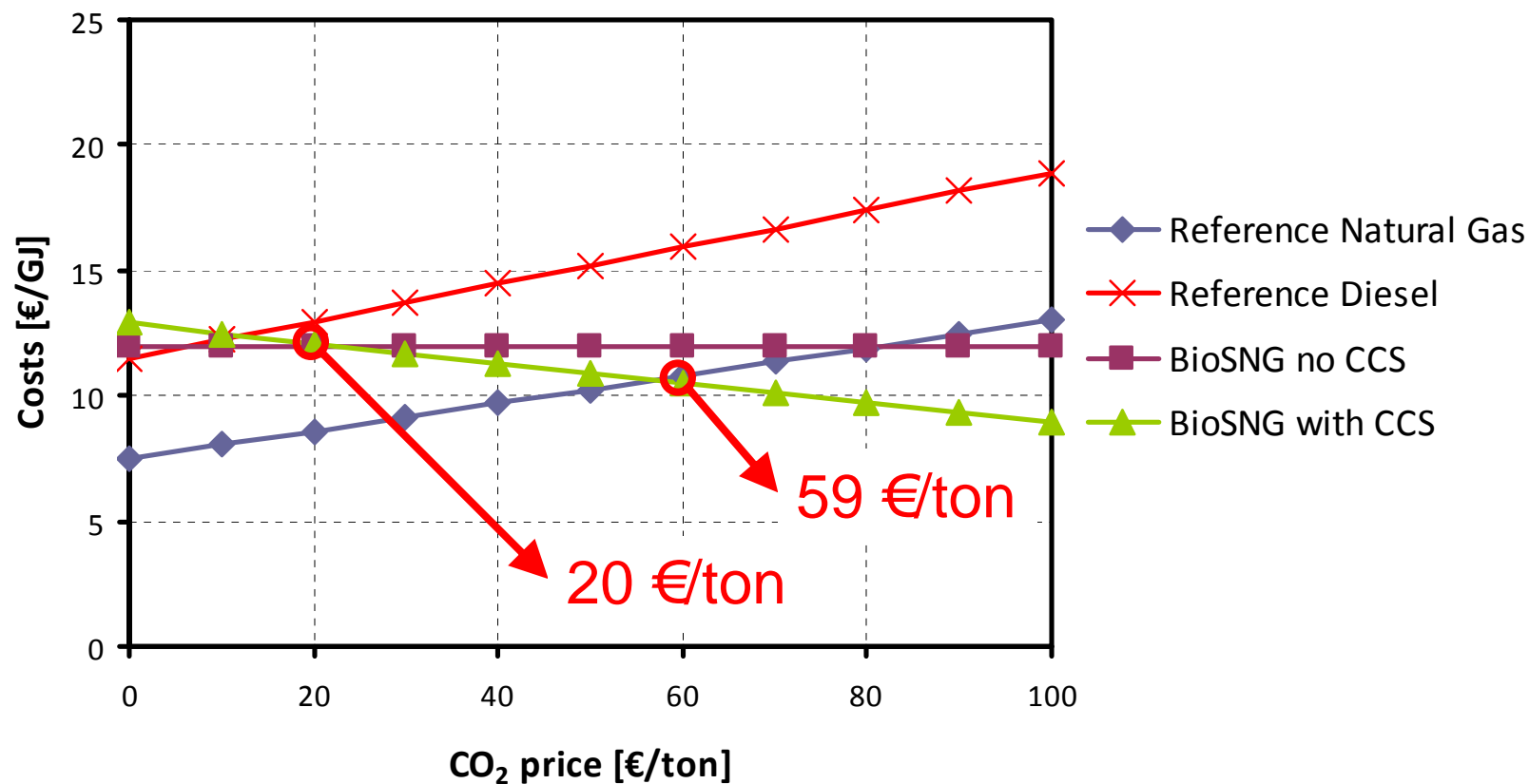
- Plant size  $\sim 500 \text{ MW}_{\text{th}}$  input
- Boundary limit at plant level  $\rightarrow$  No LCA
- Result: Biofuel production w/o CCS  $\rightarrow$   $\text{CO}_2$  neutral
- Plants simulated using AspenPlus
- Costing:
  - Spring 2009
  - Greenfields, overnight
  - N<sup>th</sup> plant, North-western Europe

# Substitute Natural Gas (SNG)

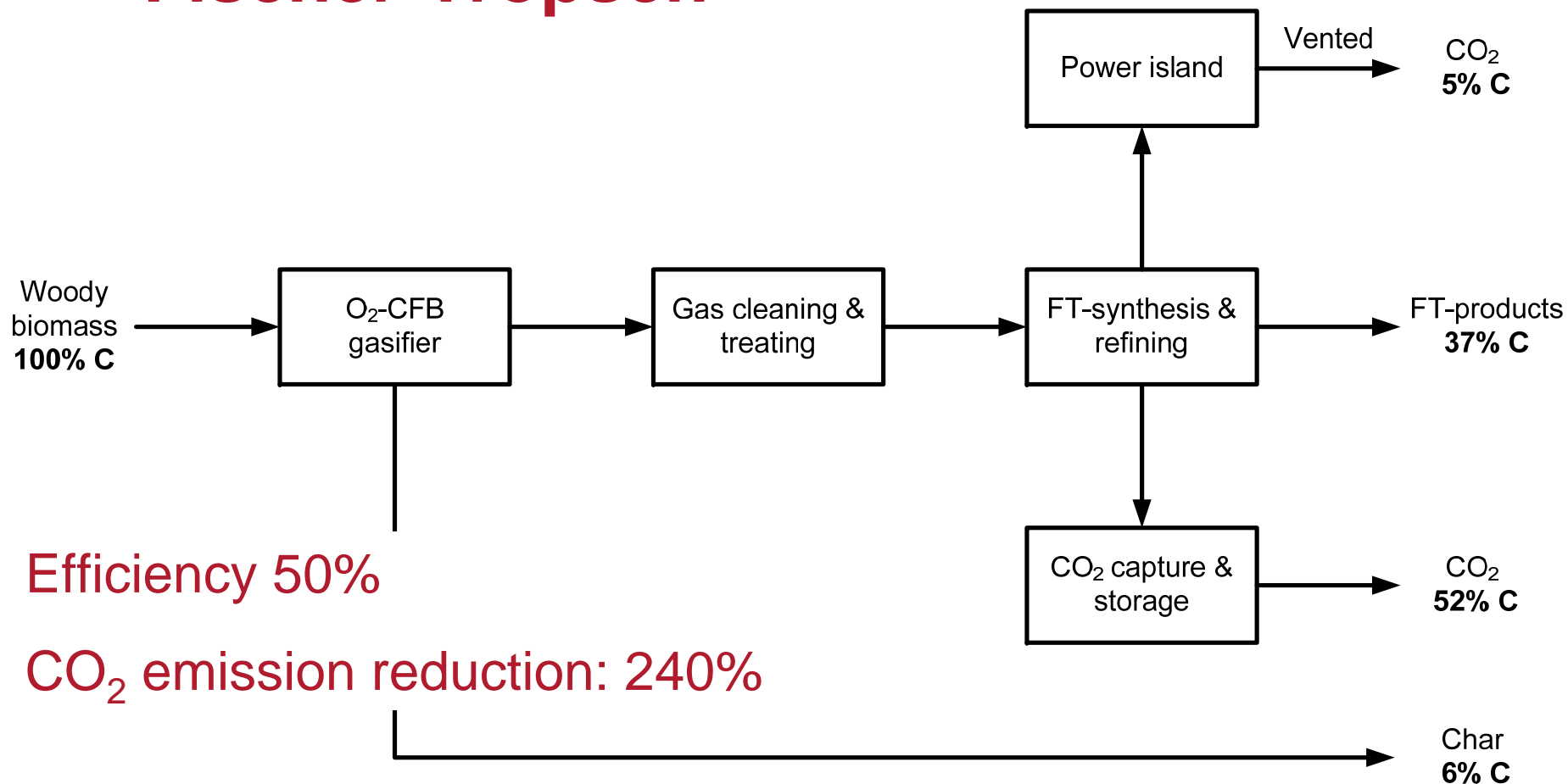




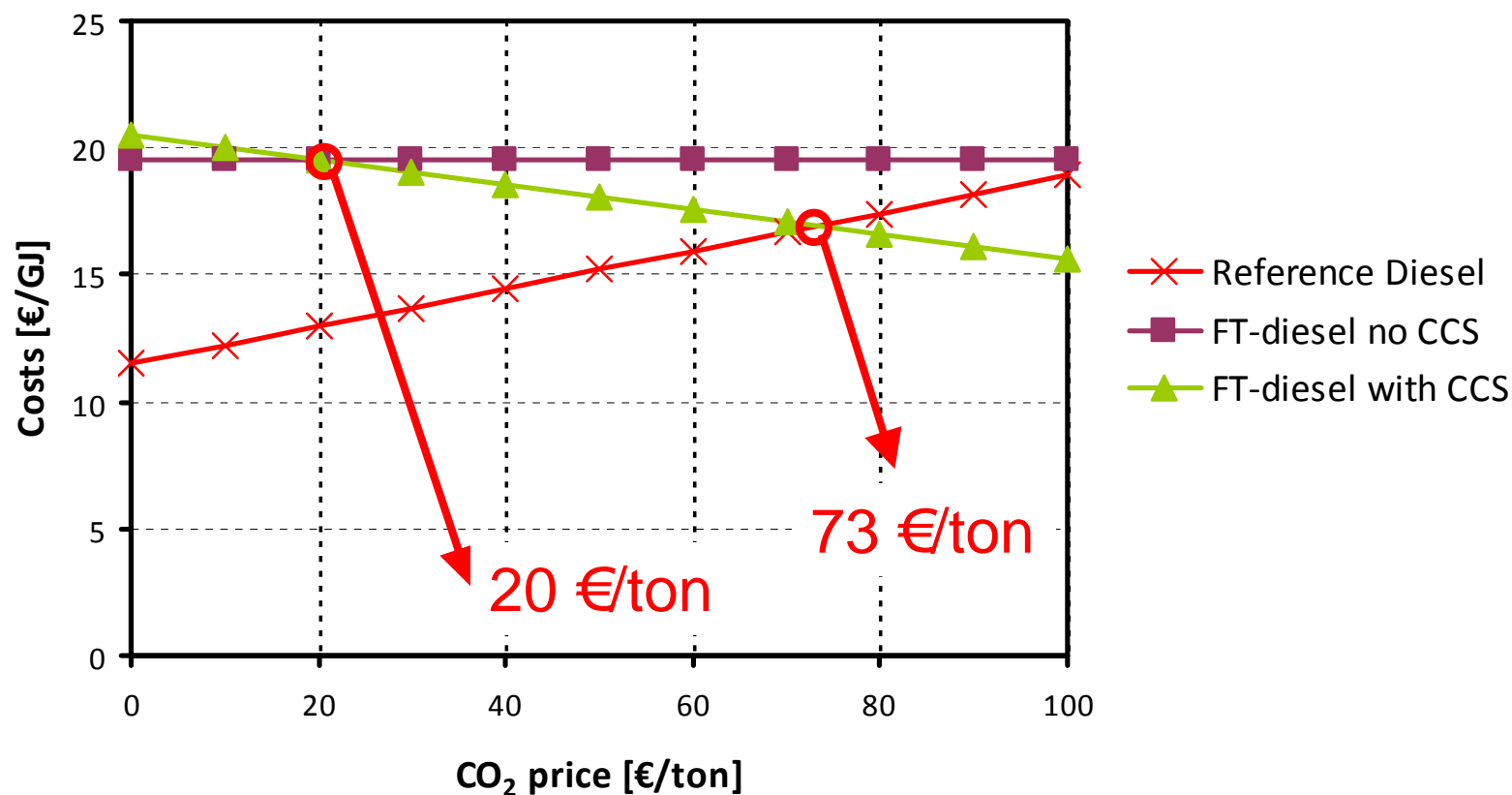
# Substitute Natural Gas (SNG)



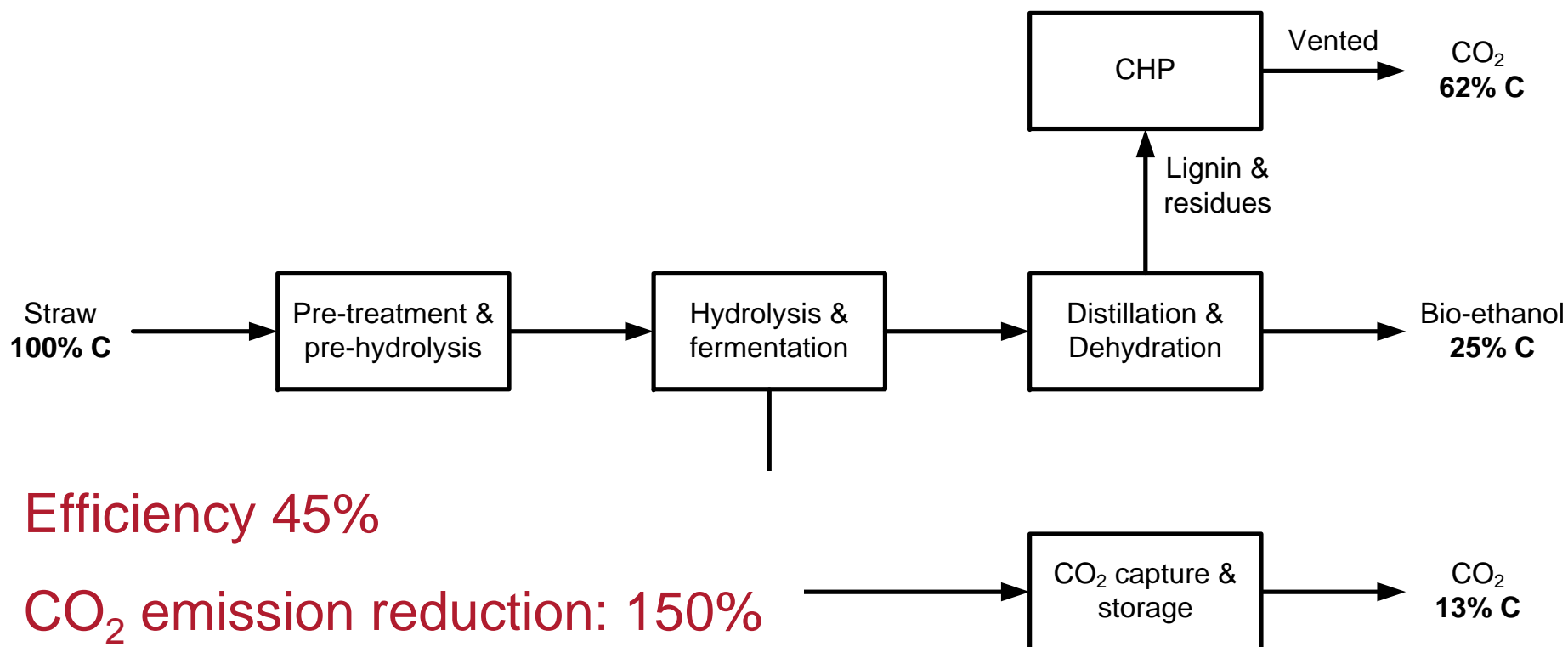
# Fischer-Tropsch



# Fischer-Tropsch



# Bio-ethanol from lignocellulose

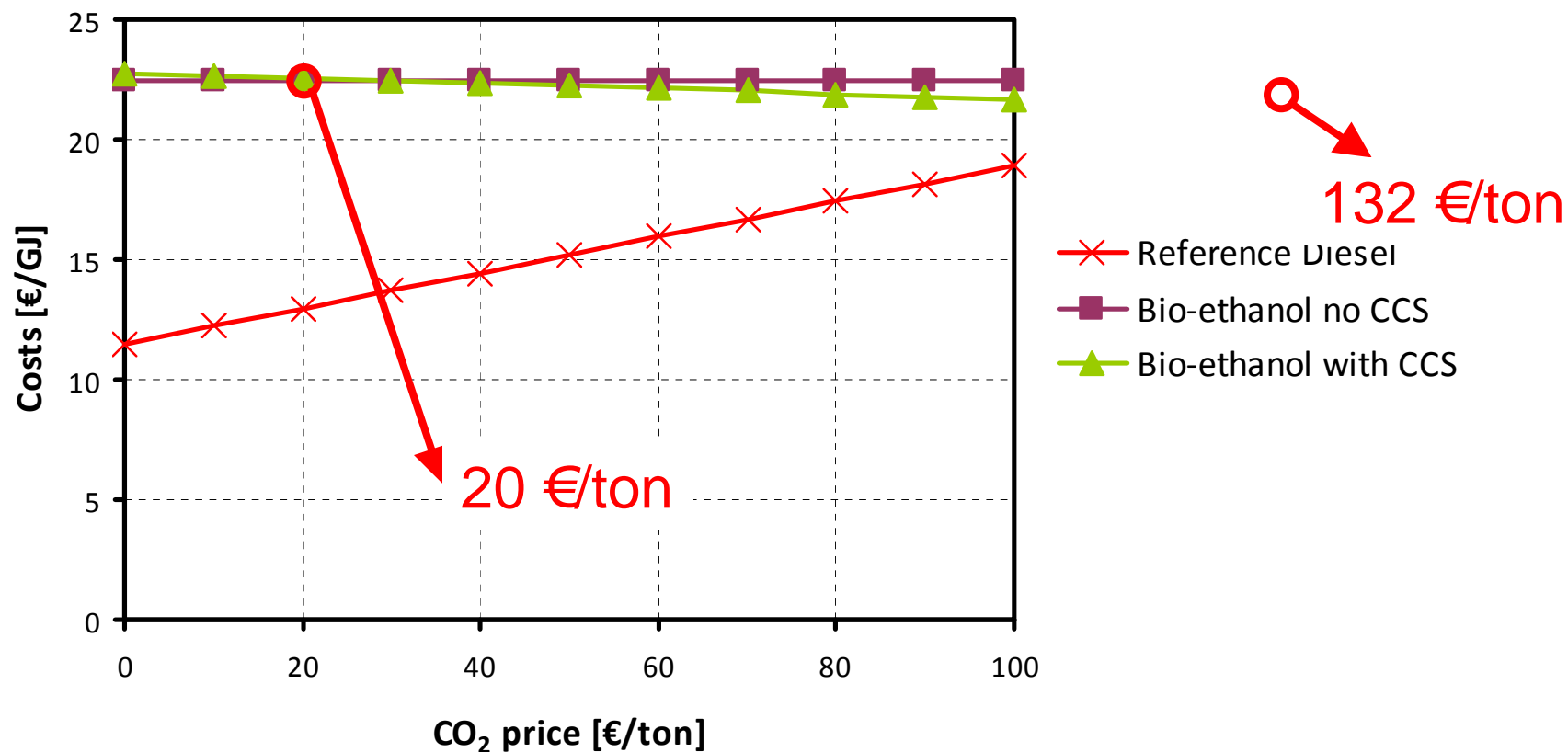


Efficiency 45%

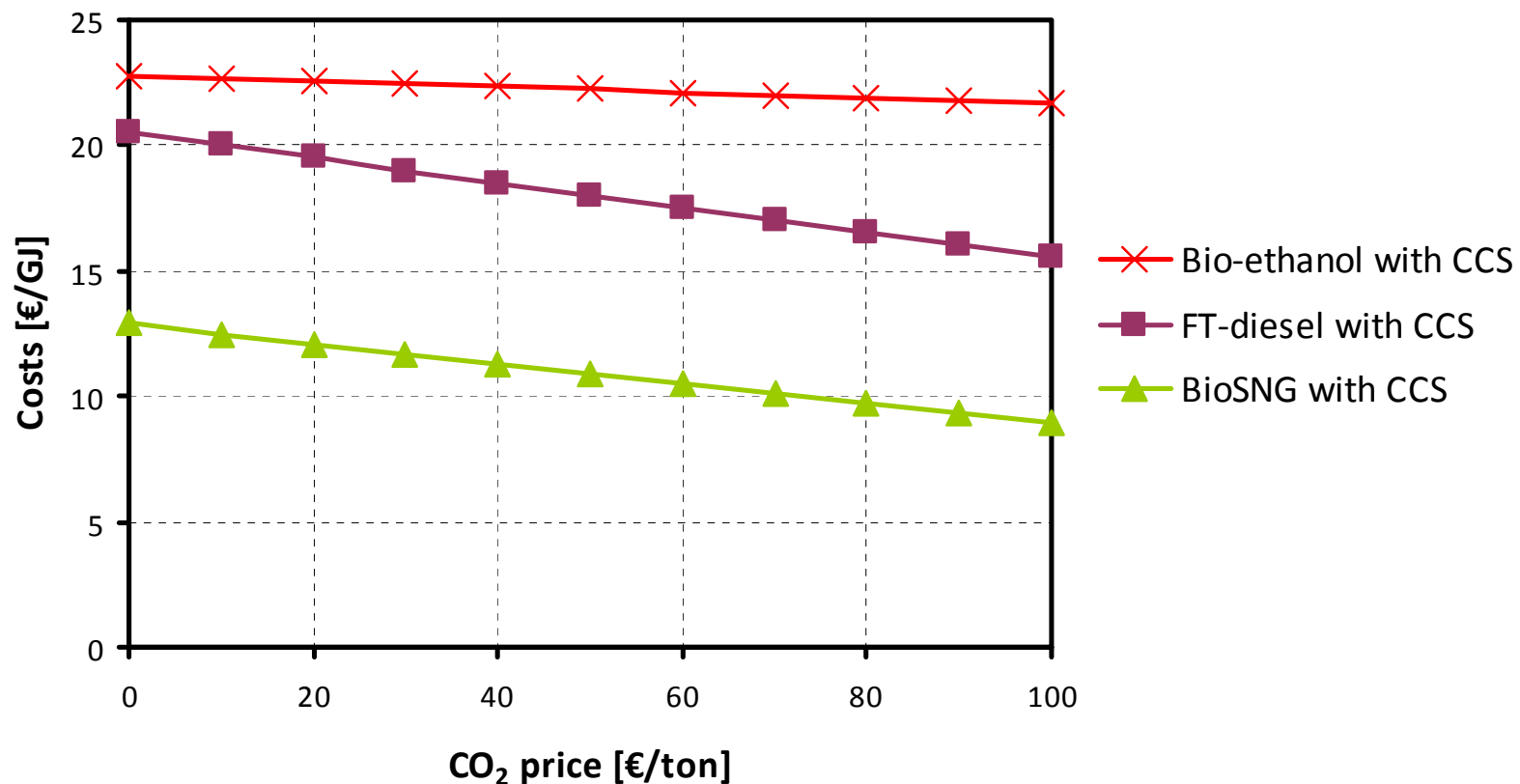
CO<sub>2</sub> emission reduction: 150%



# Bio-ethanol from lignocellulose



# Results biofuels with CCS



## Conclusions

- Incremental costs CO<sub>2</sub> capture and storage are low; CO<sub>2</sub> separation must be implemented regardless of application CCS
- Efficiencies and production costs may vary significantly; commodity prices reference fuels determine total CO<sub>2</sub> abatement costs
- CO<sub>2</sub> abatement costs for BioSNG and FT-diesel competitive with CCS in fossil fired power plants
- Hurdle: adaptation of biomass in 3<sup>rd</sup> phase European Union Emission Trading Scheme (EU-ETS)

## Questions

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publications: [www.ecn.nl/publications](http://www.ecn.nl/publications)

fuel composition database: [www.phyllis.nl](http://www.phyllis.nl)

tar dew point calculator: [www.thersites.nl](http://www.thersites.nl)

IEA bioenergy/gasification: [www.ieatask33.org](http://www.ieatask33.org)

Milena indirect gasifier: [www.milenatechnology.com](http://www.milenatechnology.com)

OLGA tar removal: [www.olgatechnology.com](http://www.olgatechnology.com)

SNG: [www.bioSNG.com](http://www.bioSNG.com) and [www.bioCNG.com](http://www.bioCNG.com)