Bio4Fuels Days
Norwegian Centre for Sustainable Bio-based Fuels and Energy
Hell, October 3 2017

Economics of Two Biofuels Value Chains

Raf Roelant
Process Design Center, Breda, Netherlands

EU project, FP7-NMP: FAST industrialisation by CAtalysts Research and Development
Coordinator: SINTEF

Economics of Biofuels Value Chains

1. Introduction to FASTCARD, PDC
2. Conceptual process design and techno-economic evaluation for the production of biofuels
3. Gas route
4. Liquid route

Introduction: FASTCARD

FAST industrialisation by Catalysts Research and Development

- Funded by European Commission
- Jan. 2014 – Dec. 2017
- 14 partners from 9 countries
- 2 value chains from wood to motor fuels:
  - Gas route
  - Liquid route

Introduction: PDC

Process Design Center

- Consultancy company with main office in Breda, Netherlands
- 30+ years of experience in
  - Energy efficiency
  - Conceptual process design (PROSYN®)
  - Techno-economic evaluation

→ Our task in FAST CARD

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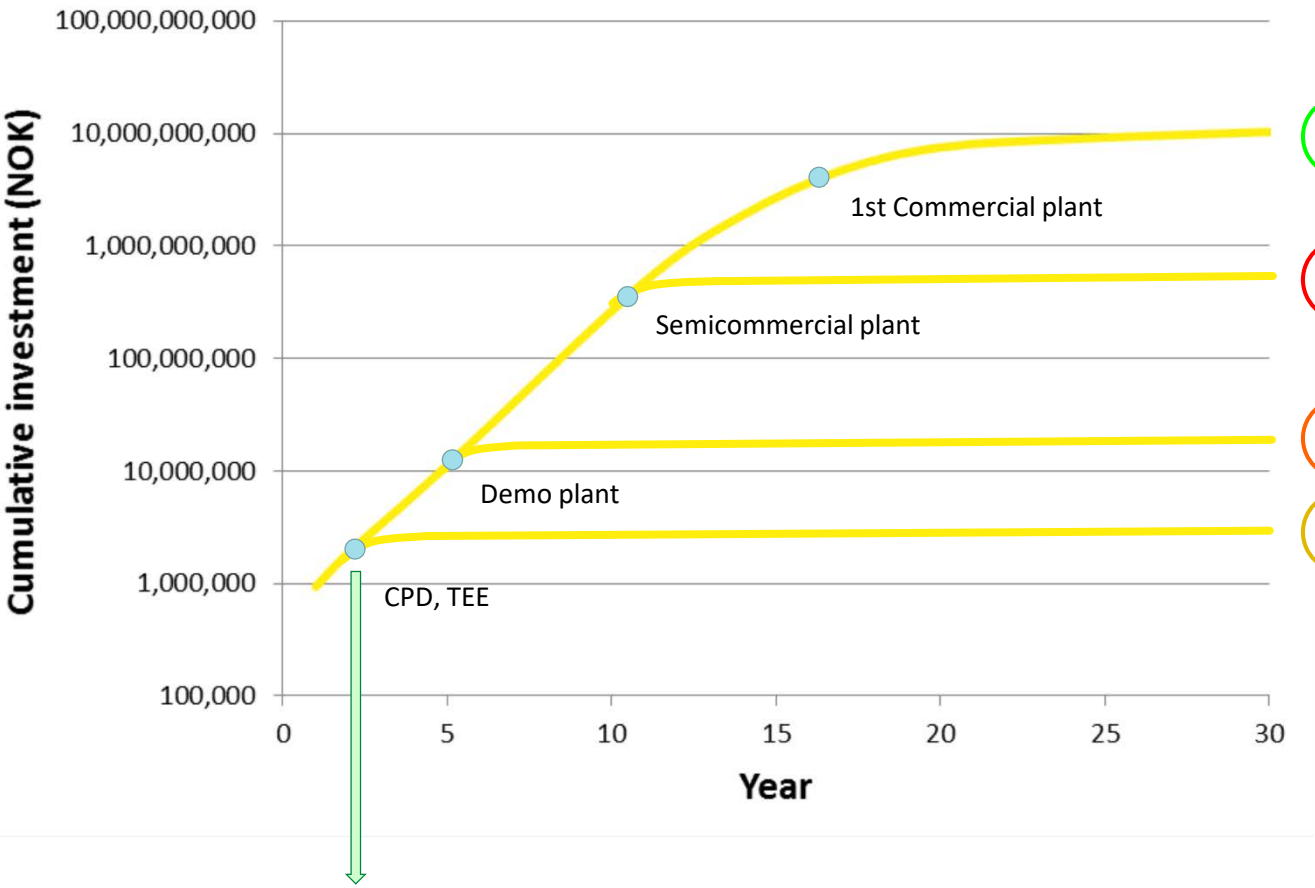
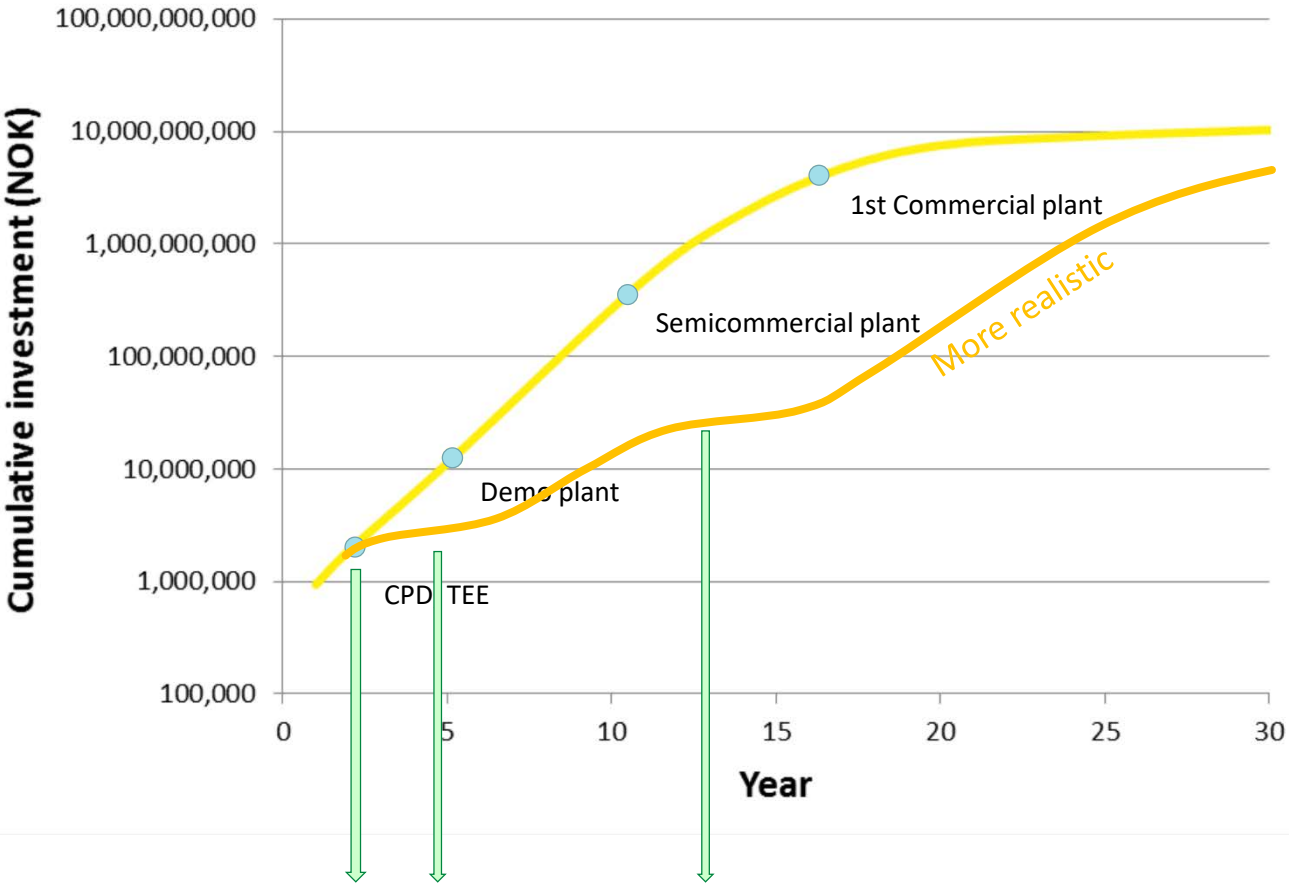
CPD, TEE : WHY?



CPD, TEE: Fast projection of techno-economic performance at industrial scale.

CPD, TEE : WHY?



CPD, TEE: Fast projection of techno-economic performance at industrial scale: steers R&D

CPD, TEE for biofuels

Expensive:

- Biomass growth (E.g., vegetable oils)
- Capital investment for process relative to fuel yield:
  - Catalytic conversions: severe reaction conditions (T, p, chemical)
  - Biochemical conversions: mild reaction conditions, but low reaction rates (anaerobic digestion, fermentation, enzymatic hydrolysis)
- Input of energy or co-reactants (H_2, MeOH, …)

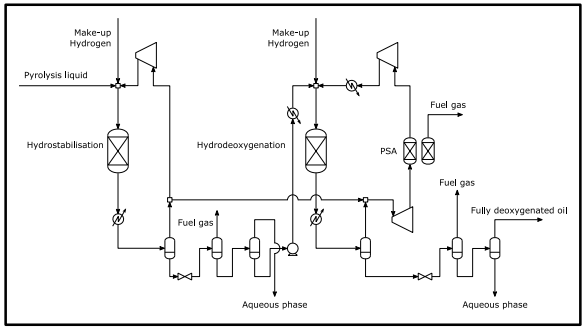
Conceptual Process Design (CPD) and techno-economic evaluation (TEE) helps control 2 of 3 main cost contibutors.

Conceptual process design

Expert knowledge

Calculations

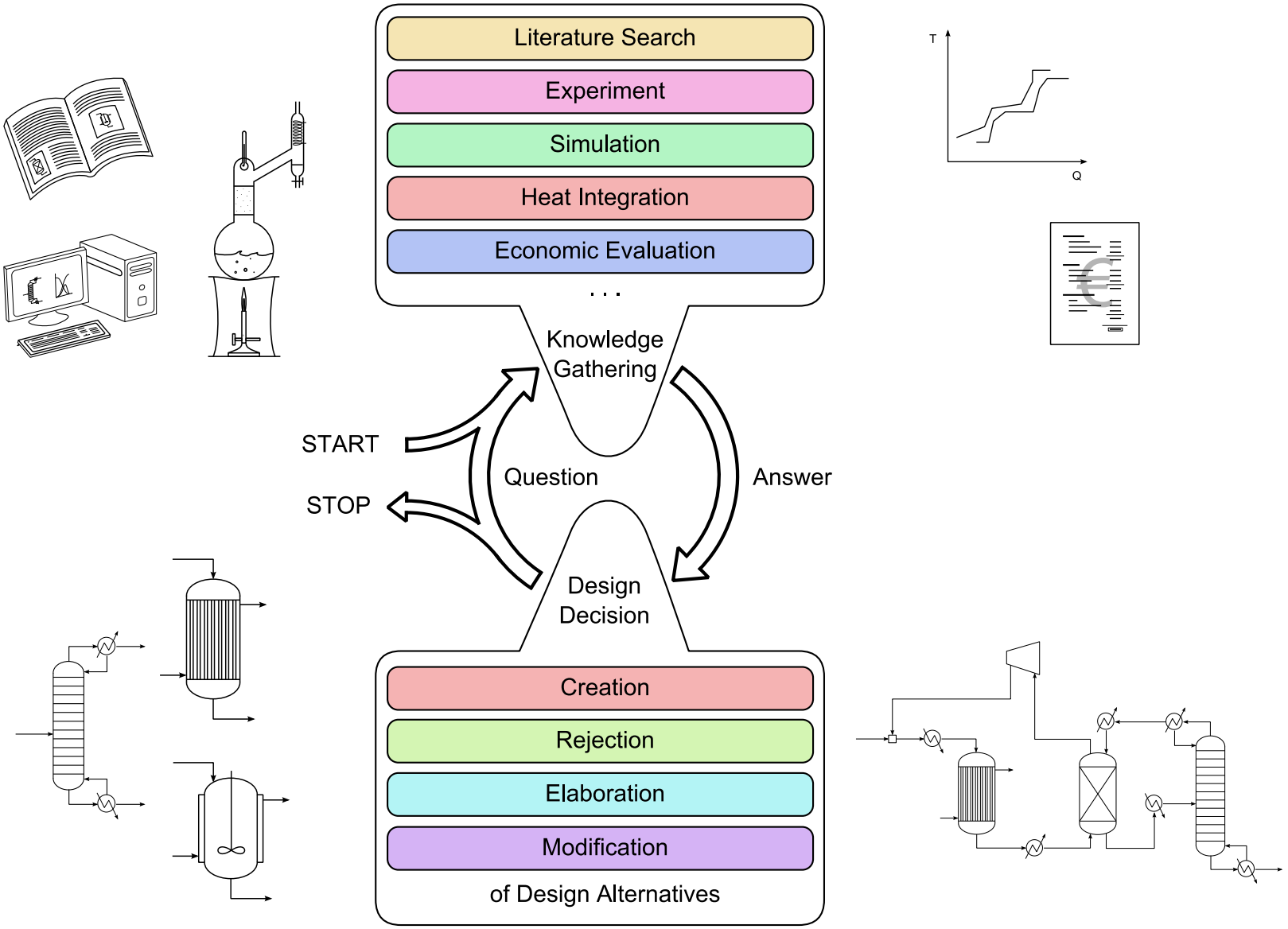
Laboratory data



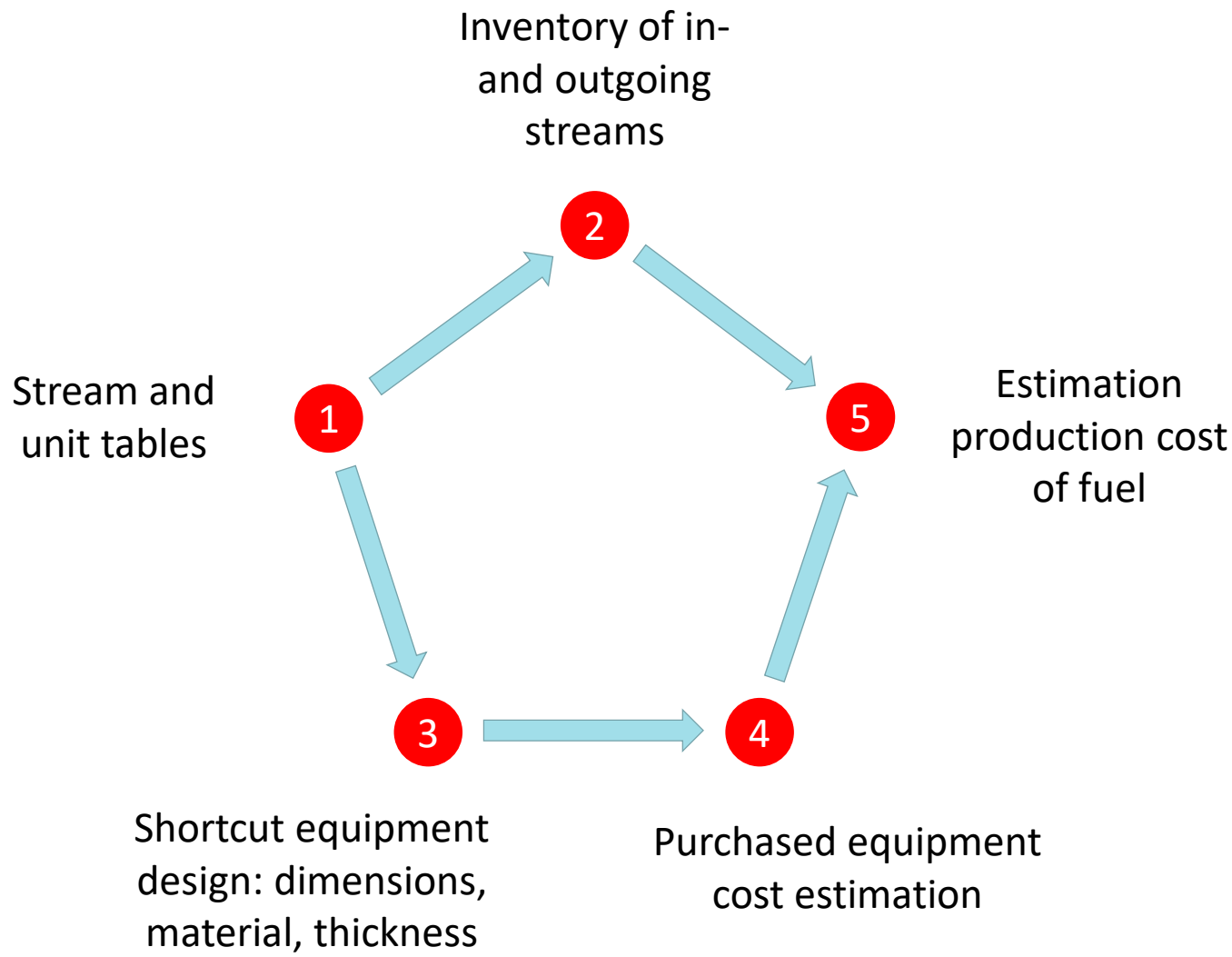
Literature

Process flow diagram
with
stream and unit tables

Conceptual process design



Economic evaluation



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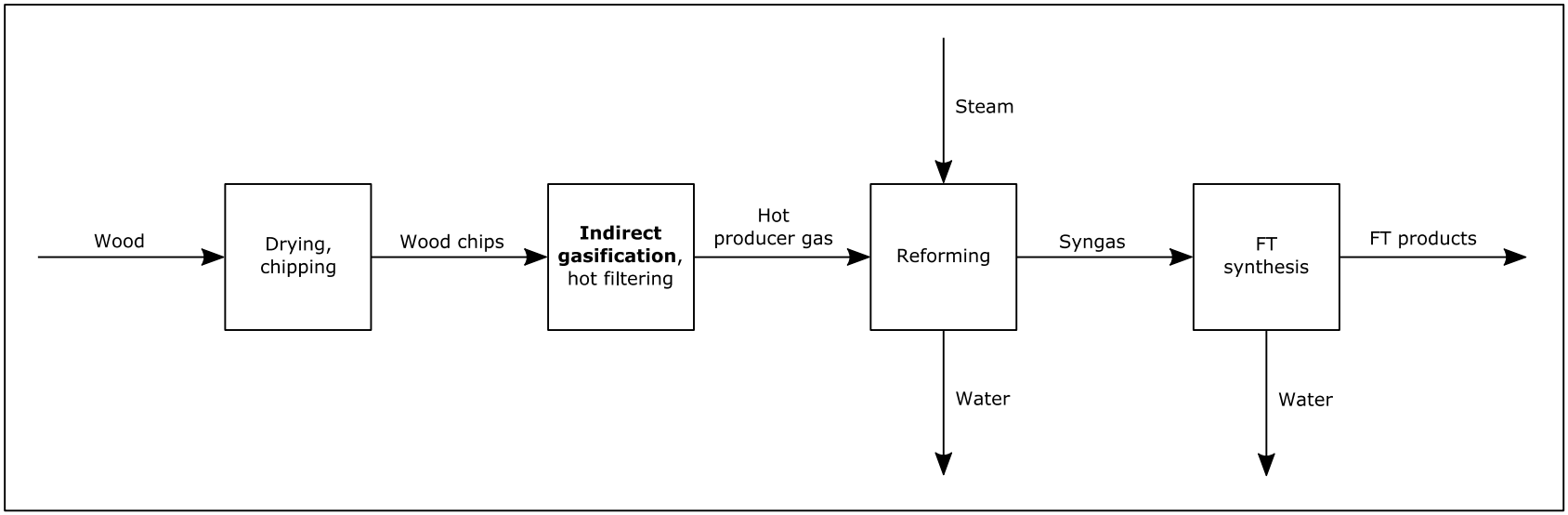
Gas route: diesel from wood



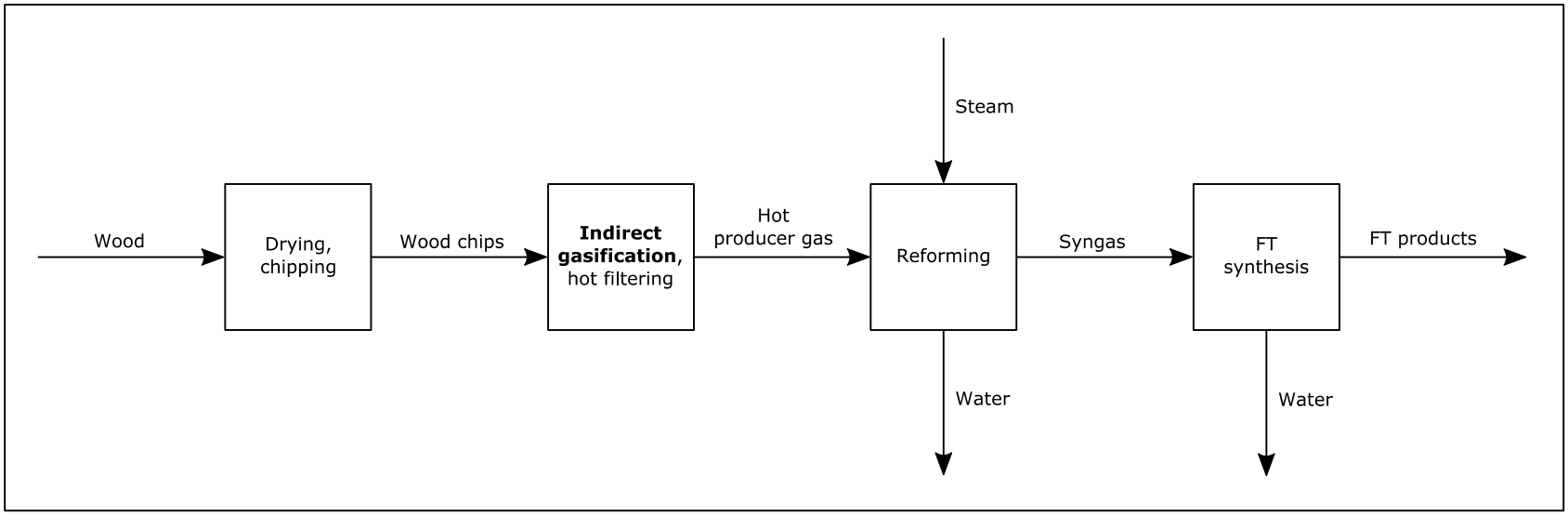
Expensive:

- Biomass growth (E.g., vegetable oils)
- Capital investment related to product yield:
  - Catalytic conversions: severe reaction conditions (T, p, chemical)
  - Biochemical conversions: mild reaction conditions, but low reaction rates (anaerobic digestion, fermentation, enzymatic hydrolysis)
  - Low energy yields
- Input of energy or co-reactants (H_2, MeOH, …)

Process design aimed at

- limiting capital costs: avoiding processing excessive gas volumes
- maximising energy yield

Gas route: diesel from wood



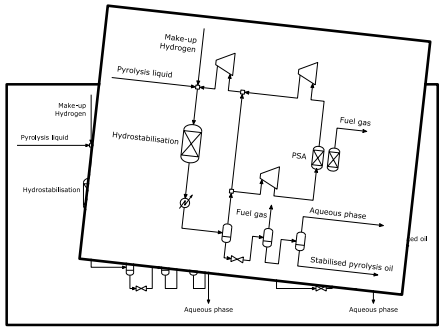
H_2:CO ratio tends to become **superstoichiometric** in FT synthesis loop.
Difficult to reverse: requires reverse water-gas shift at high temperatures with steam addition to avoid coke formation.

→ Avoid H_2:CO ratio becoming superstoichiometric:

- Limit steam/carbon ratio at reforming stage while avoiding coke formation,
- Avoid water-gas shift activity on FT catalyst:

FAST CARD development: Fe-based catalyst with very low WGS activity

Gas route



Final CPDs

Mass and energy balance

Inventory of in- and outgoing streams

1

2

3

4

5

Estimation fuel production cost

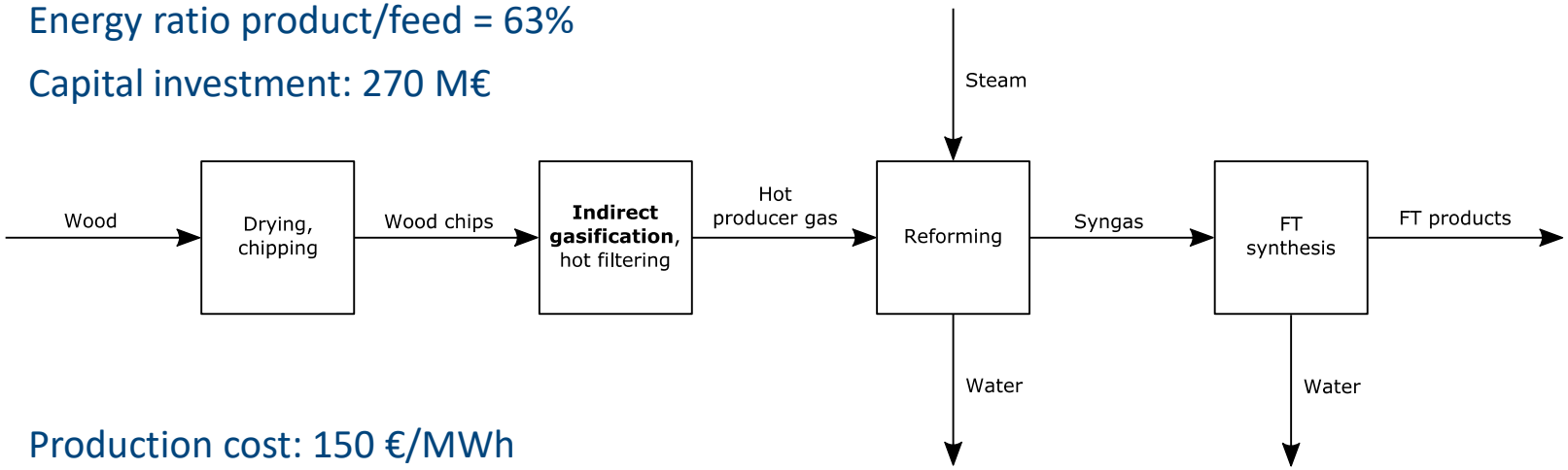
Shortcut equipment design: dimensions, material, thickness

Purchased equipment cost estimation

Gas route (200 MW_{th} wood feed)

Energy ratio product/feed = 63%

Capital investment: 270 M€

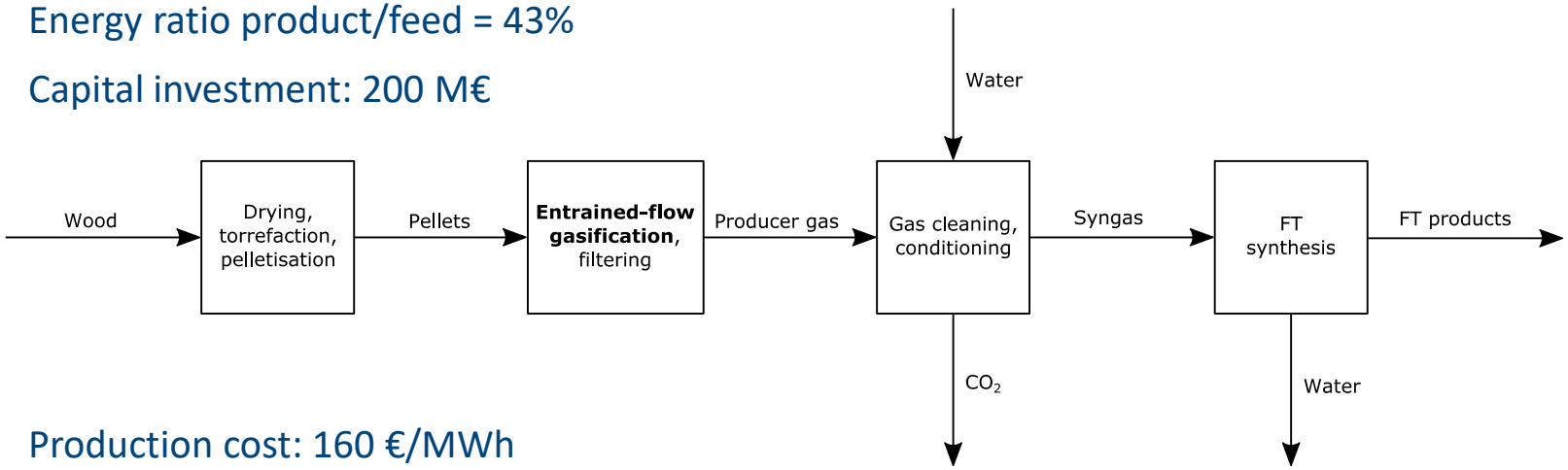


Production cost: 150 €/MWh

Versus

Energy ratio product/feed = 43%

Capital investment: 200 M€



Production cost: 160 €/MWh

Gas route (200 MW_{th} wood feed)

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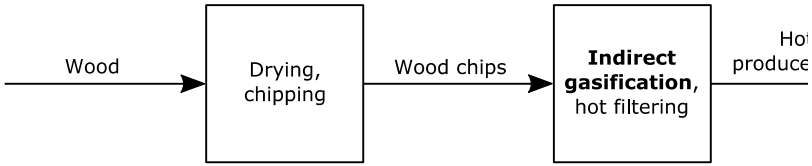

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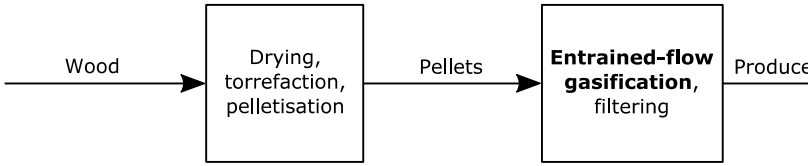

Production cost: 160 €/MWh

About half of production cost due to CAPEX!

Future work should be aimed at reducing CAPEX, e.g., by increasing gasification pressure.

Gas route (200 MW_{th} wood feed)

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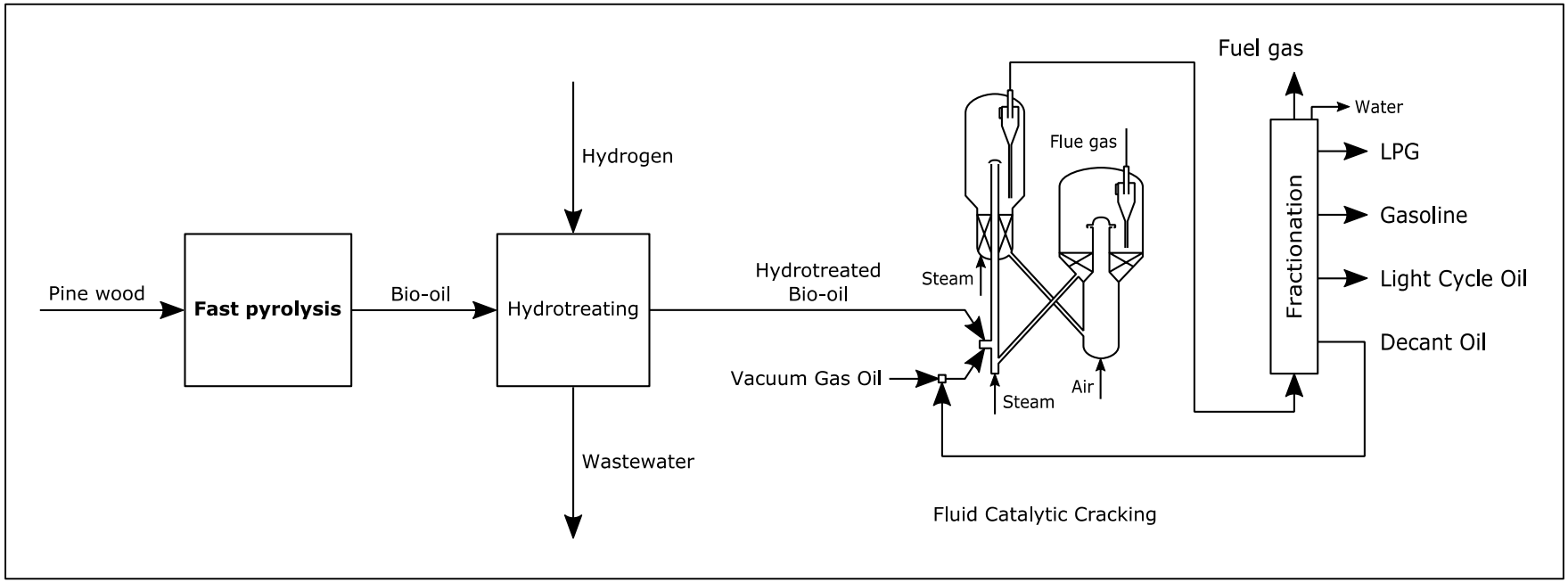
Liquid route



5000 Nm³/d FCC unit
6 to 10 % bio-oil feed

Liquid route

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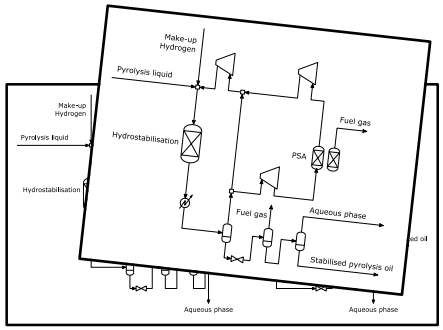
- Input of energy or co-reactants (H_2, MeOH, …)

Process design aimed at reducing hydrogen consumption.

Liquid route



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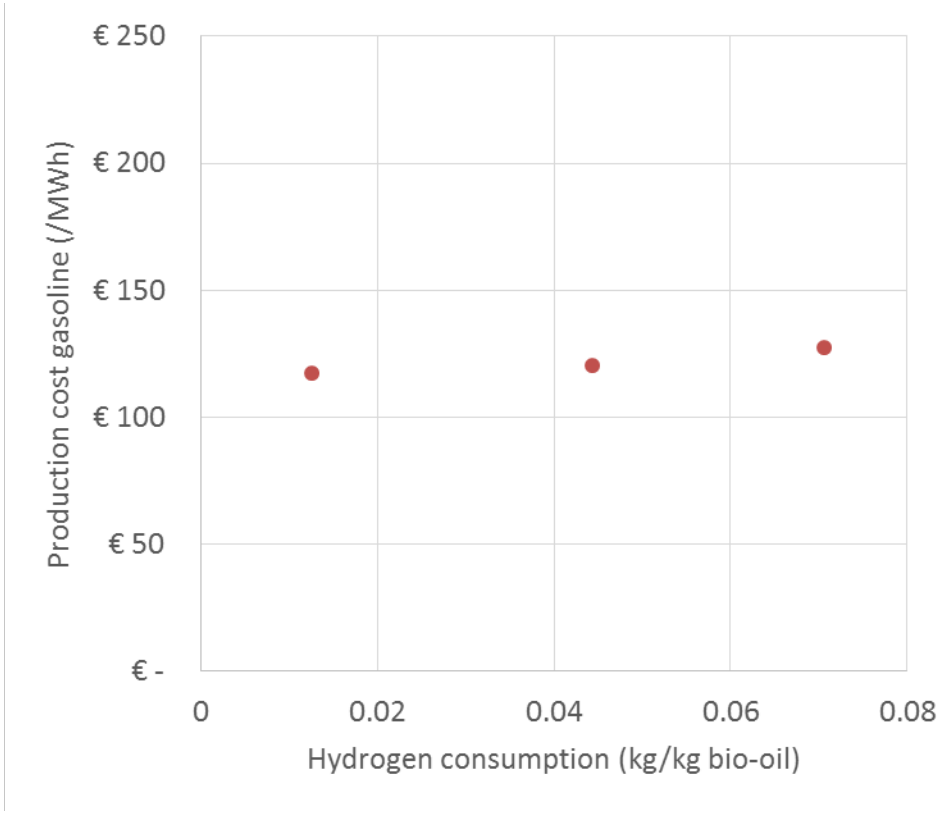
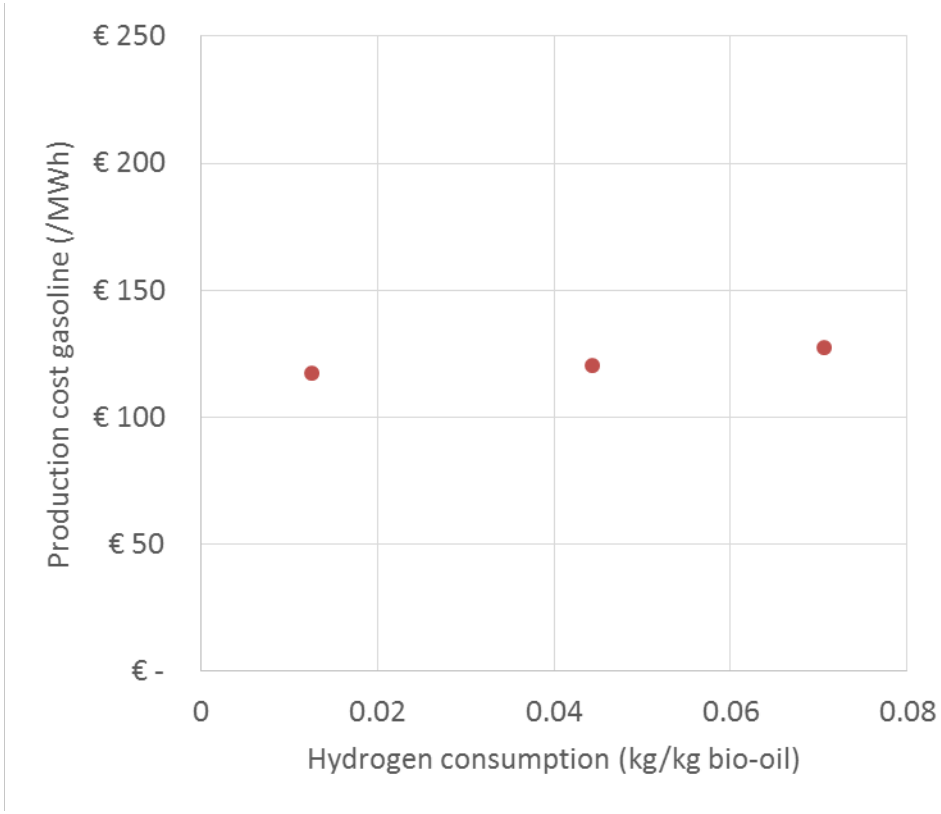
Liquid route (5000 Nm³/d FCC unit with 6 to 10 % bio-oil feed)



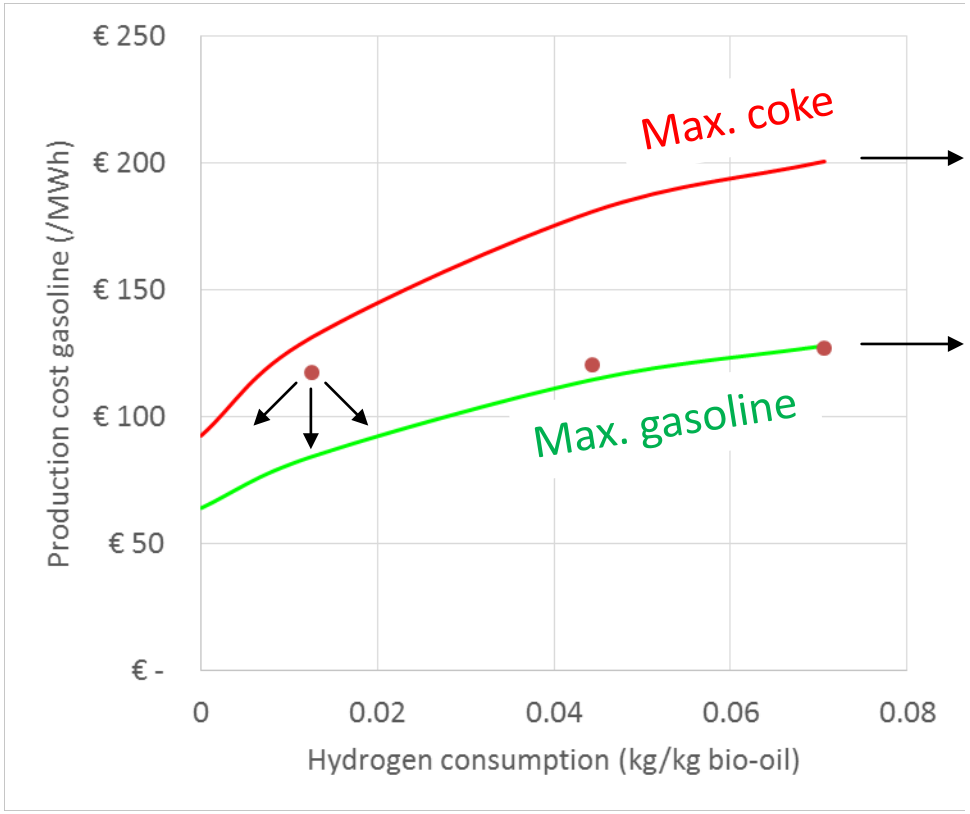
With Co-FCC product distribution measured at Davison Circulating Riser at Repsol, Spain for state-of-the-art catalyst (Futura).

Liquid route (5000 Nm³/d FCC unit with 6 to 10 % bio-oil feed)



Contribution CAPEX very low!

Liquid route (5000 Nm³/d FCC unit with 6 to 10 % bio-oil feed)

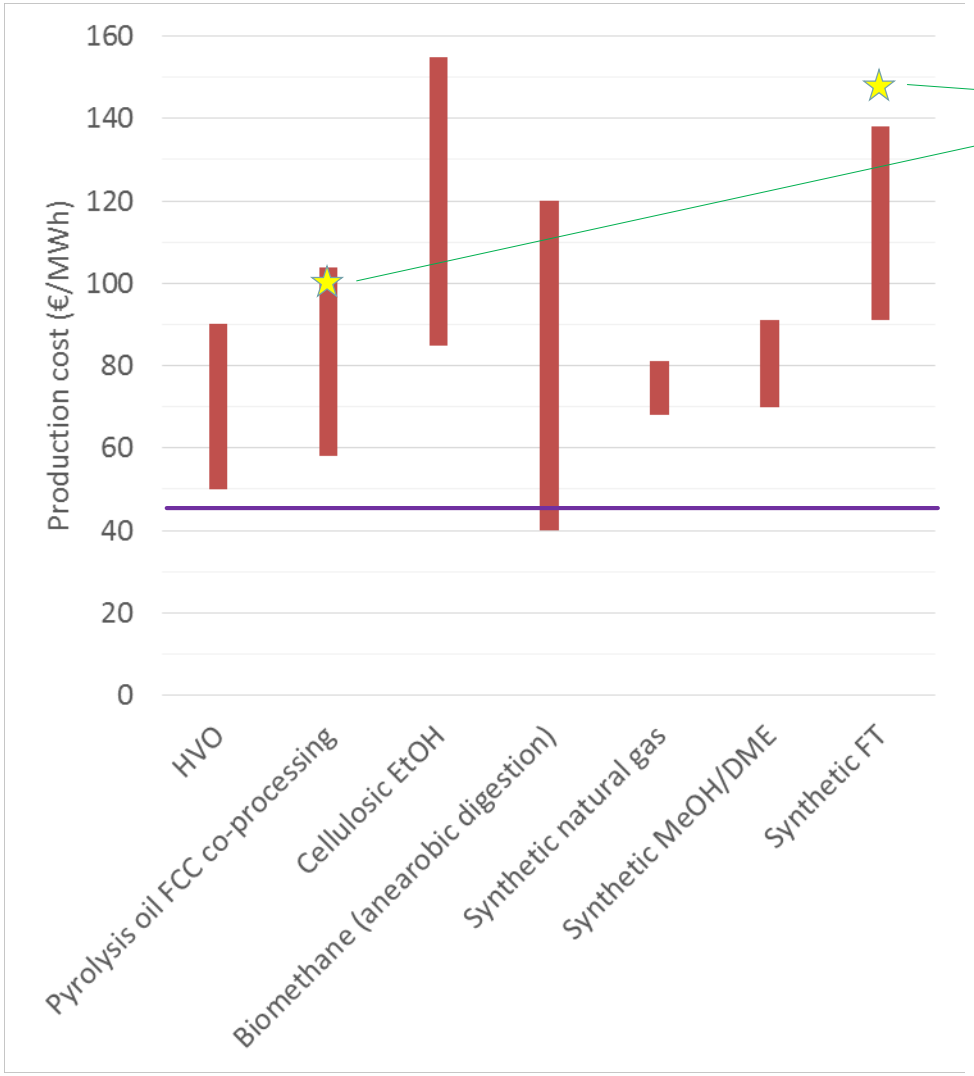


Potential based on atom balances.

Future work should be aimed at

- Co-FCCing raw or merely hydrostabilised pyrolysis oil
- High FCC fuel yields through catalytic, process-technological innovation.

Biobased motor fuel: a helicopter view



EC Sustainable Transport Forum: Sub Group on Advanced Biofuels. Final Report, 2017.

Conclusions

- Comparison gas and liquid route:

	Gas route	Liquid route
Drop-in?	YES	YES
Investment risk	HIGH	LOW
Potential on sustainable production	HIGH: large production scales possible from “any” biomass	LIMITED: Co-FCC: assumes coupling with fossil refining

Long-term potential

Short-term potential

- Government incentives with long-term guarantees needed:
  Probably an excise duty exemption on biofuels.

We thank

1. You for your attention.

2. The European Commission

for its financial support
(FP7 grant 604277).

3. The FASTCARD partners.

FAST CARD

FINAL SEMINAR

Upscaling/Downscaling of Catalysts and Processes

24 January 2018
Repsol Technology Centre, Móstoles, Madrid

- Open seminar for industry and academia
- Not limited to experience in FASTCARD project
- Invited speakers from BTG-BTL, BDI-Bioenergy, SASOL, Johnson Matthey, IFPEN, Repsol, Grace

More info and registration:
http://www.sintef.no/en/events/fastcard-final-seminar/