Universiteit Utrecht

Copernicus Institute of Sustainable Development

International markets for advanced biofuels - recent trends, outlook and main uncertainties

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Copernicus Institute of Sustainable Development – Utrecht university

Skog & Tre Konferansen 1 June 2018

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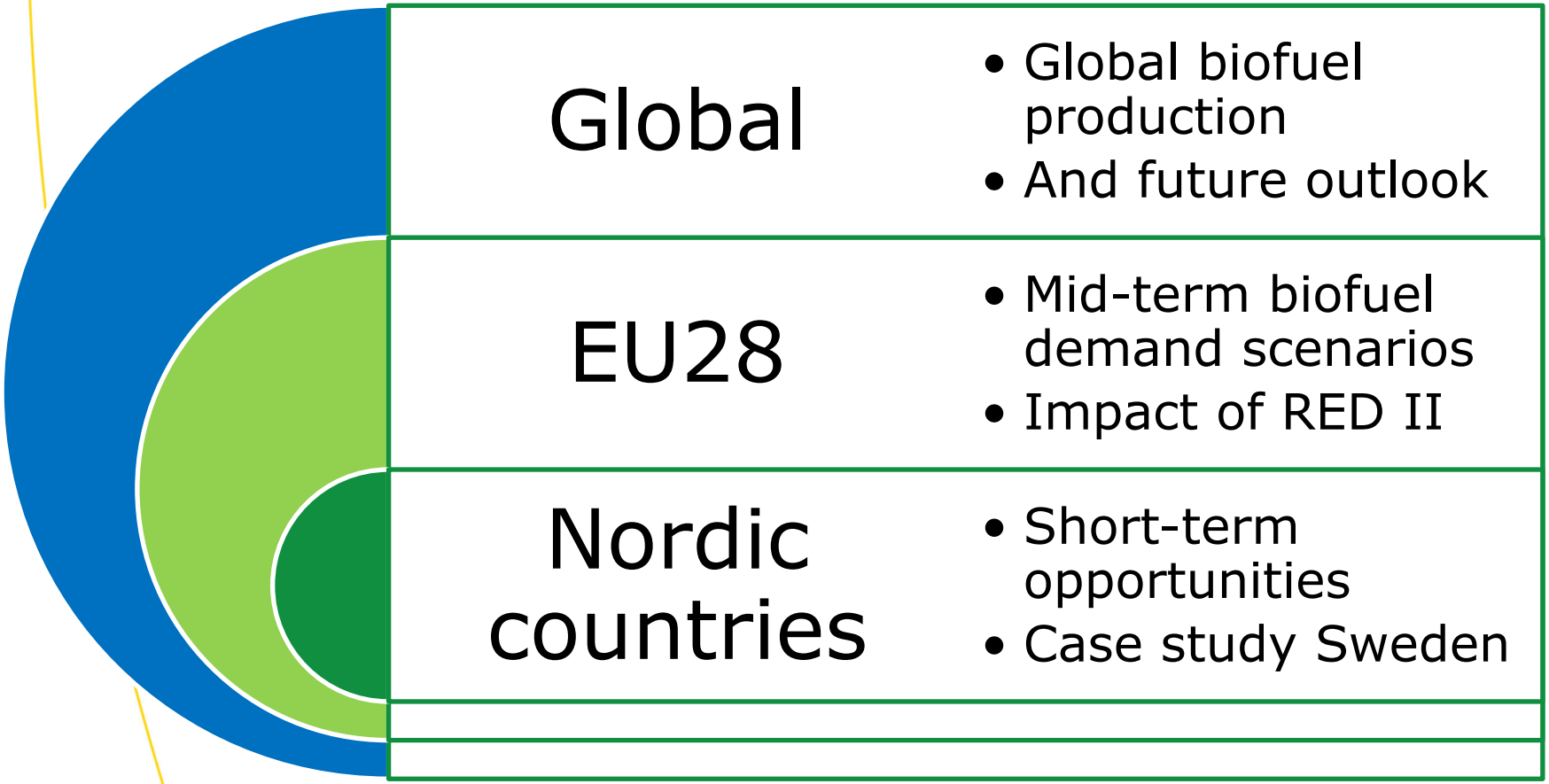
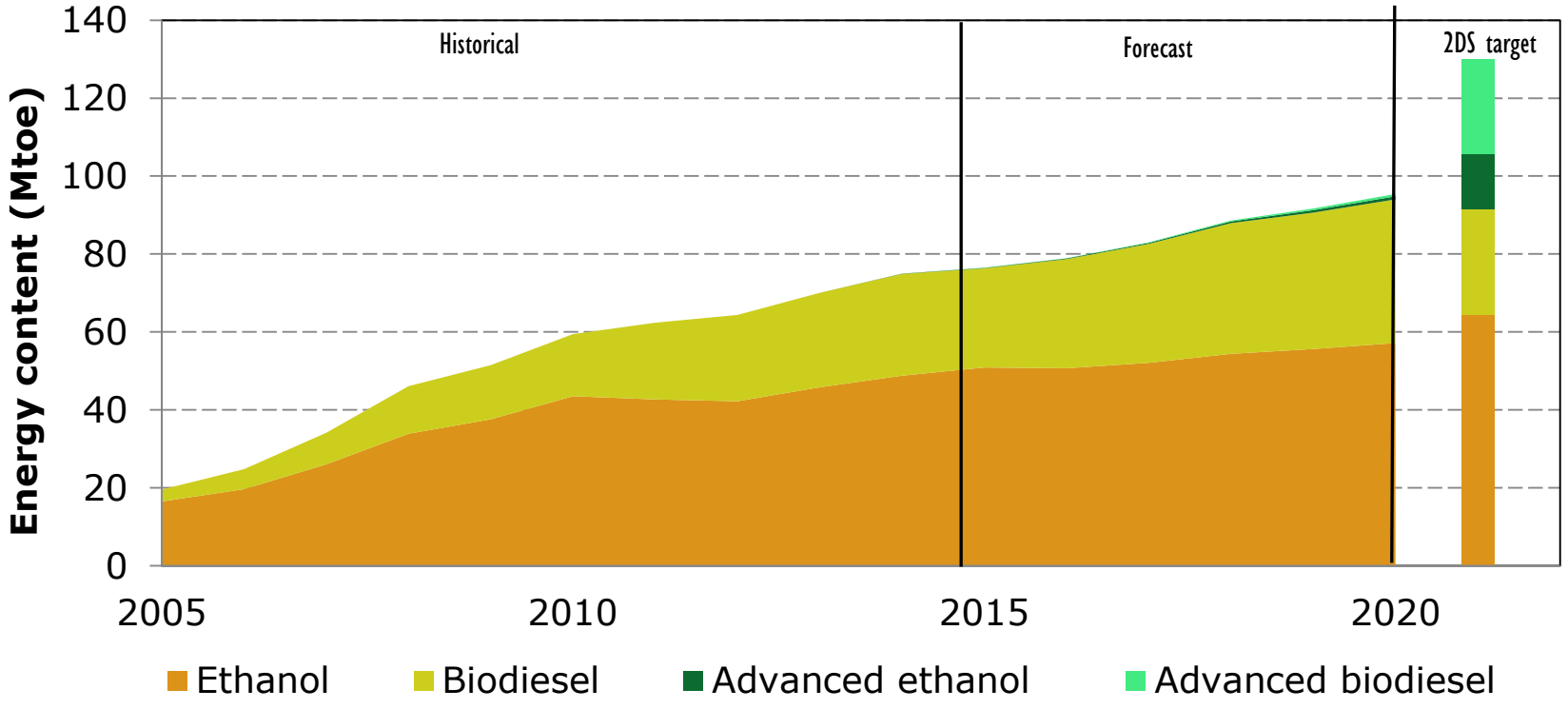
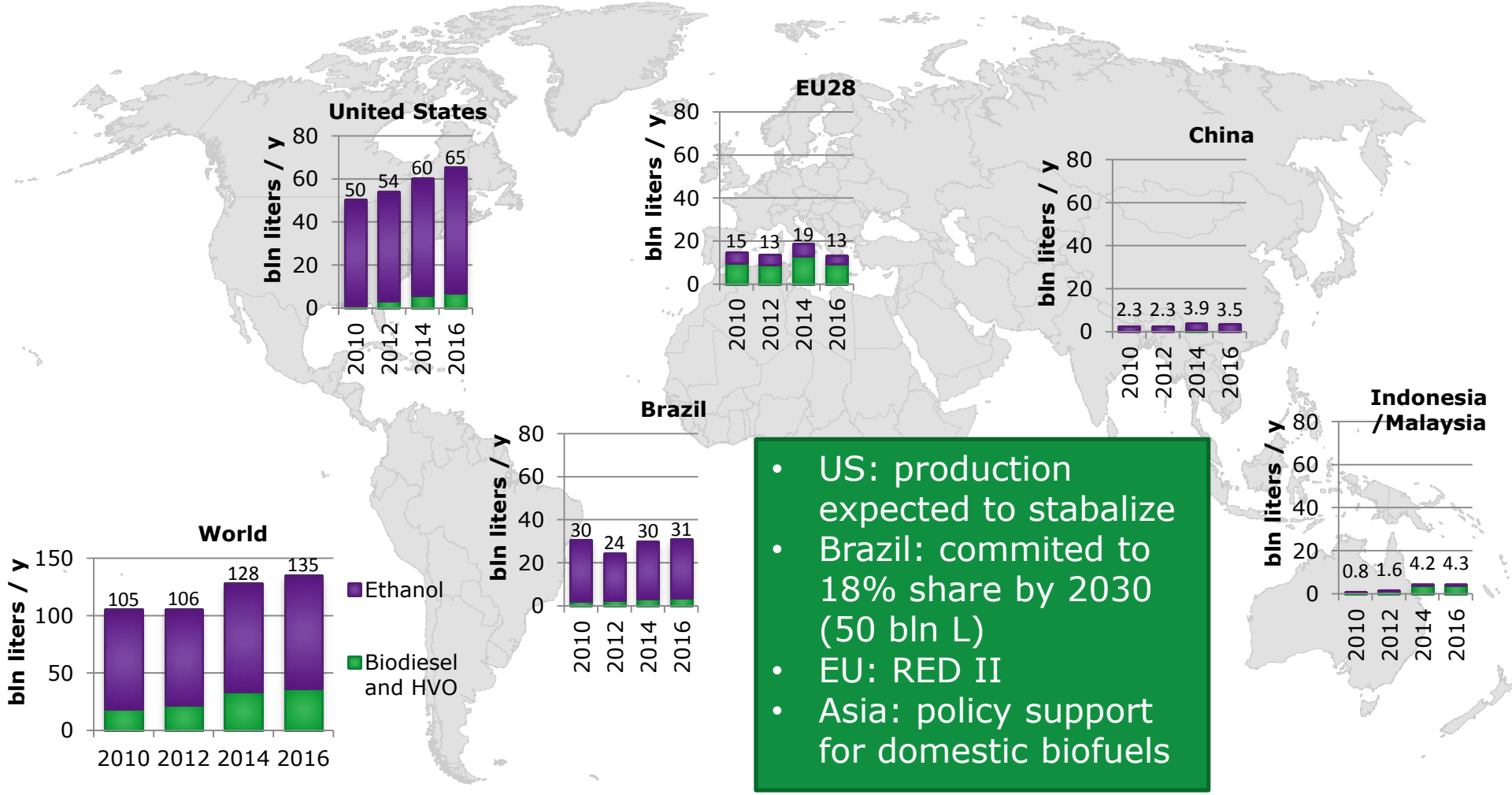

Global
• Global biofuel production
• And future outlook
EU28
• Mid-term biofuel demand scenarios
• Impact of RED II
Nordic countries
• Short-term opportunities
• Case study Sweden

Global: biofuel production



International Energy Agency (2017), Tracking Clean Energy Progress 2017, OECD/IEA, Paris

Global: biofuel production and key production regions

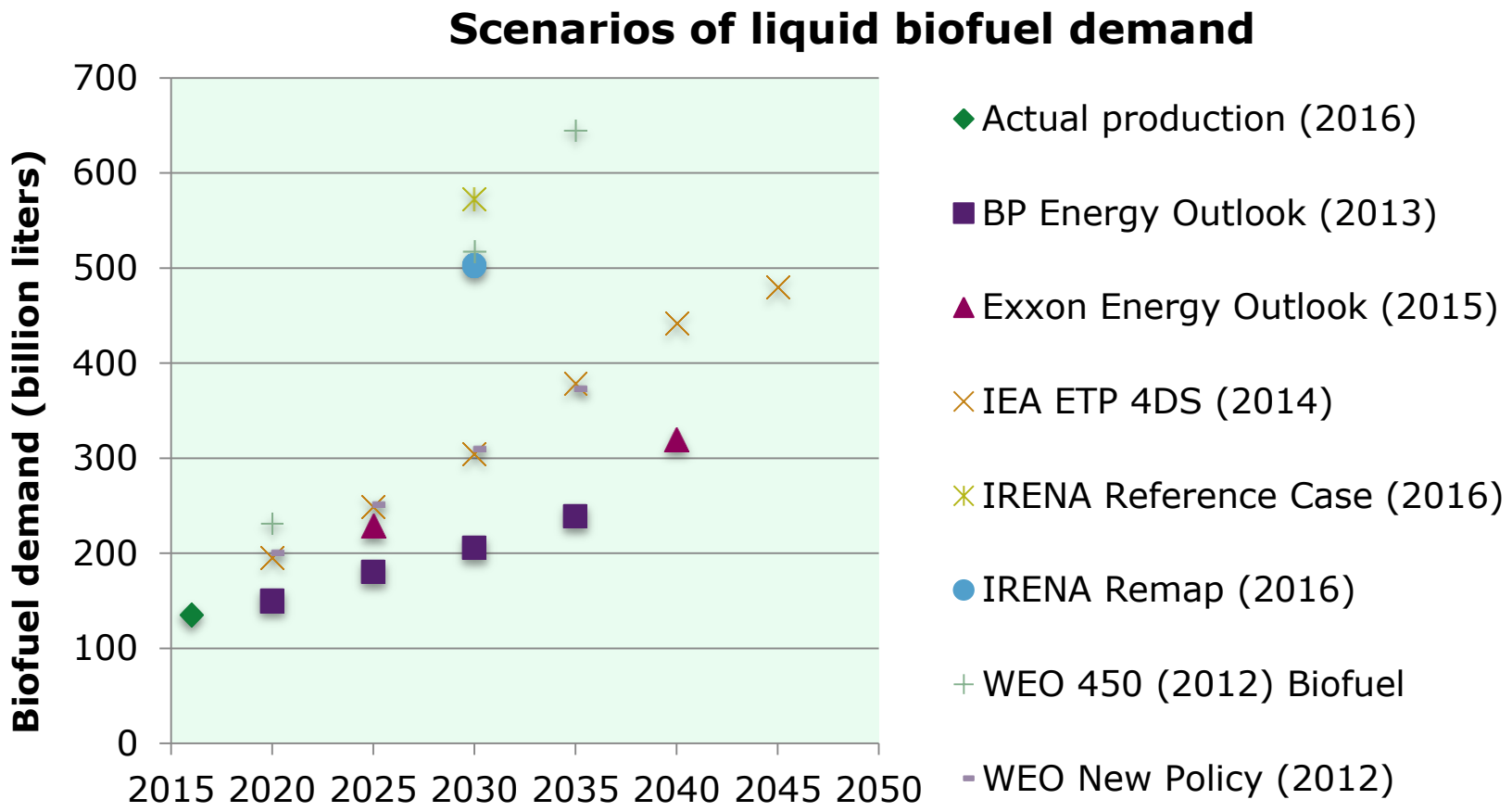


- US: production expected to stabalize
- Brazil: commited to 18% share by 2030 (50 bln L)
- EU: RED II
- Asia: policy support for domestic biofuels

Data: REN21 (2011 – 2017 reports)

Global: future biofuel demand could still increase substantially

2035: 77-378% increase compared to 2016



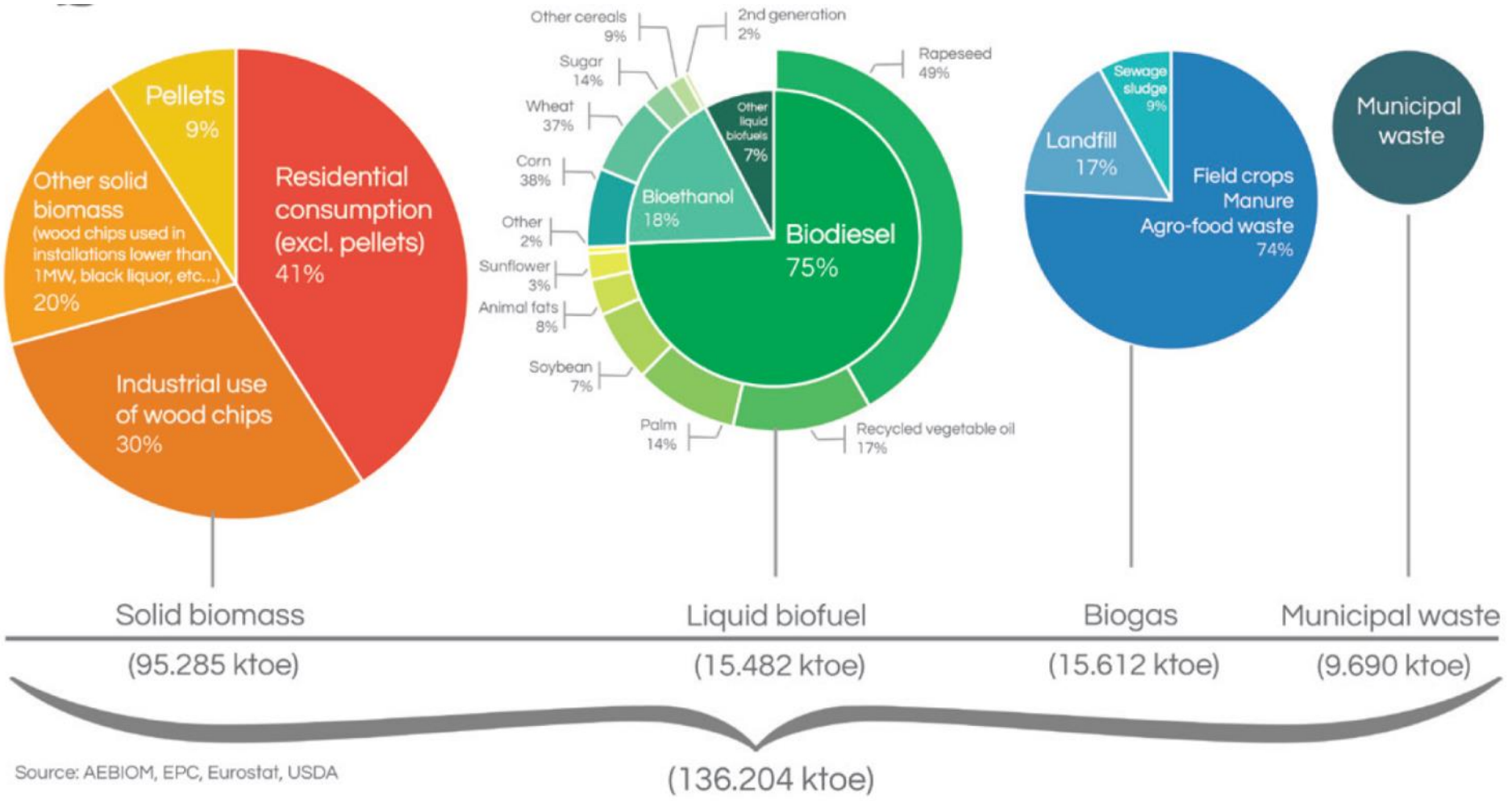
Source: IRENA (2016) INNOVATION OUTLOOK ADVANCED LIQUID BIOFUELS

Global projections provide limited insights in biofuel trade flows, technology development and regional (support) policies

EU: a revised energy directive

	RED-I	RED-II *(proposal)*
Targets	• 10% biofuels in 2020, *applying to each MS* • 0.5% voluntary target advanced biofuels	• 1.7→6.8% for cat. 1-5 fuels, *applying EU-wide* • Subtarget: 0.5→3.6% for cat-1 (advanced) biofuels)
Caps	• 7% on food-based biofuels	• 7.0→3.8% for cat-6 (food-based) biofuels • 1.7% for cat-2 fuels
Sectors *(In the nominator)*	• Road and rail	• Road, rail • Aviation and marine with a 1.2 multiplier
GHG threshold	• - 50% • - 60% post 2015 installations • Fossil fuel: 83.8 CO_{2eq}/MJ	• -50% for pre-2015, • -60% for post 2015 • -70% for post 2021 • Fossil fuel: 94 CO2eq/MJ *(iLUC factors remain the same)*

EU: Bioenergy landscape (2015)

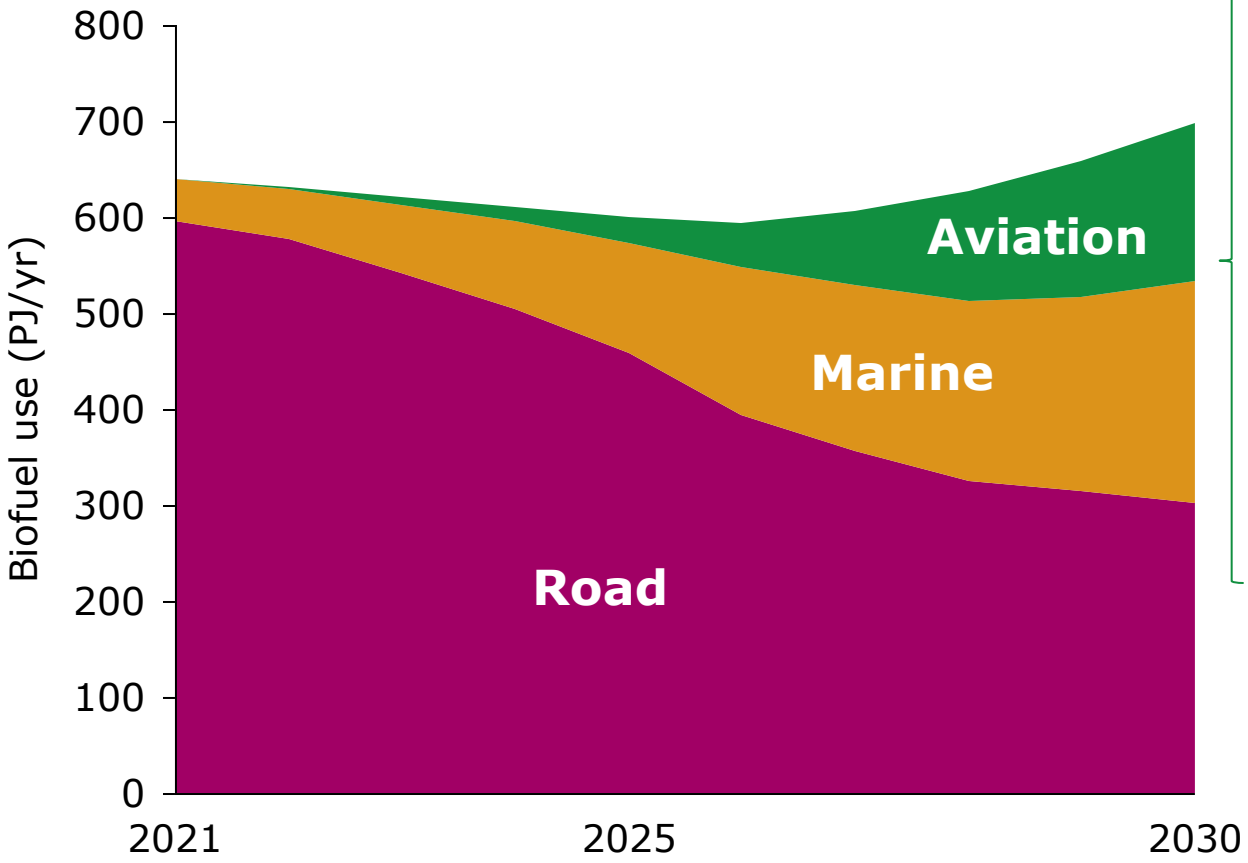


AEBIOM 2017

7

EU: Biofuel use projections in transport sector 2021-2030

Marine and aviation biofuels driven by multiplier and cost of fossil fuels (jet-A, marine gasoil)



Implications in 2030

- 160-260 PJ (3.8-6.1 Mt) RJF
- 6-9% of total EU jet fuel consumption
- 12-19 Mt CO2-eq reductions

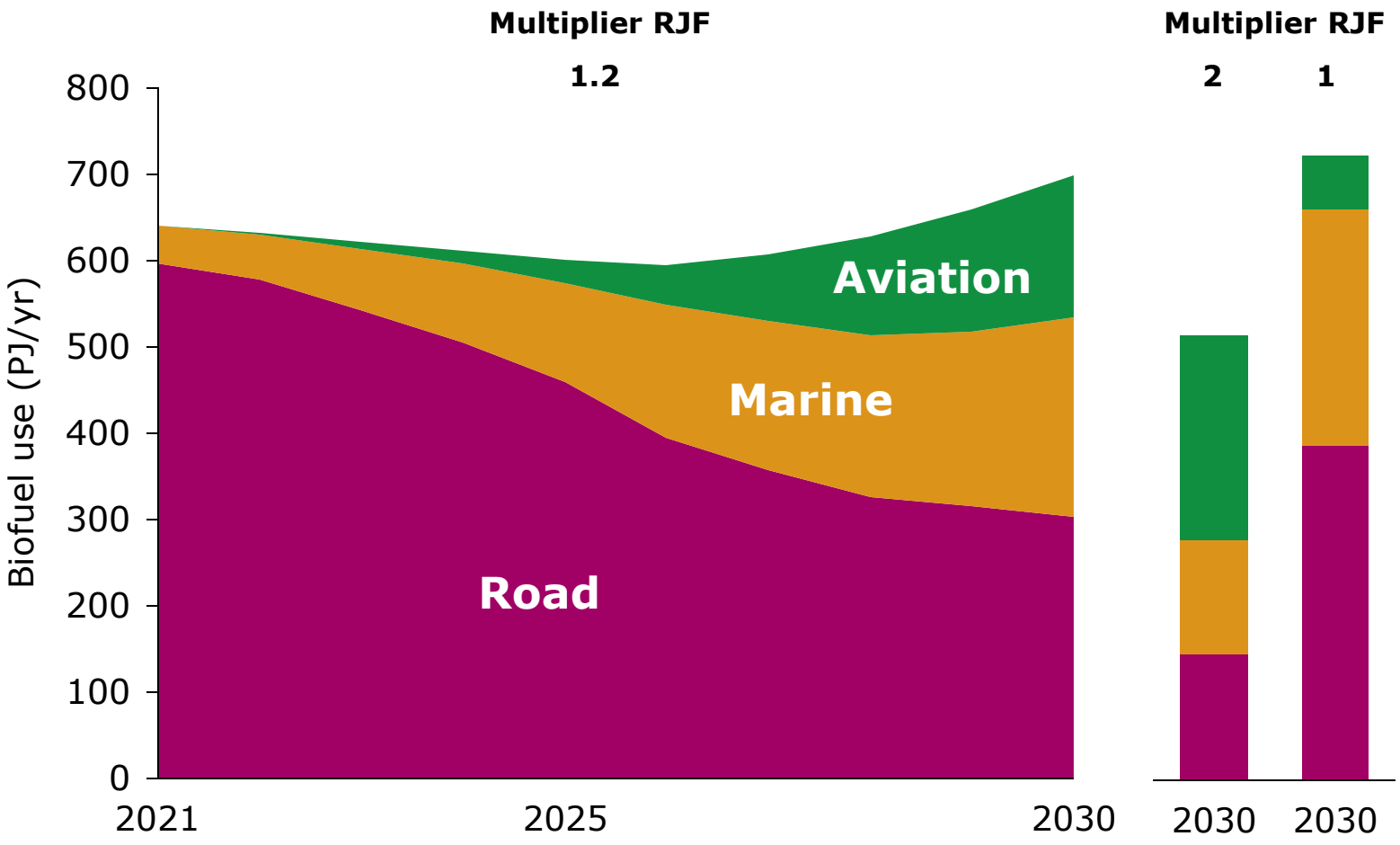
Additional cost RJF over 2021-2030

- 7.7-11 B€ over 10 years
- 1.0-1.4 €/departing intra-EU passenger

Forthcoming publication: De Jong et al. (2018), please do not cite, as preliminary

EU: The multiplier mechanism affects the distribution among end use sectors and the total biofuel production

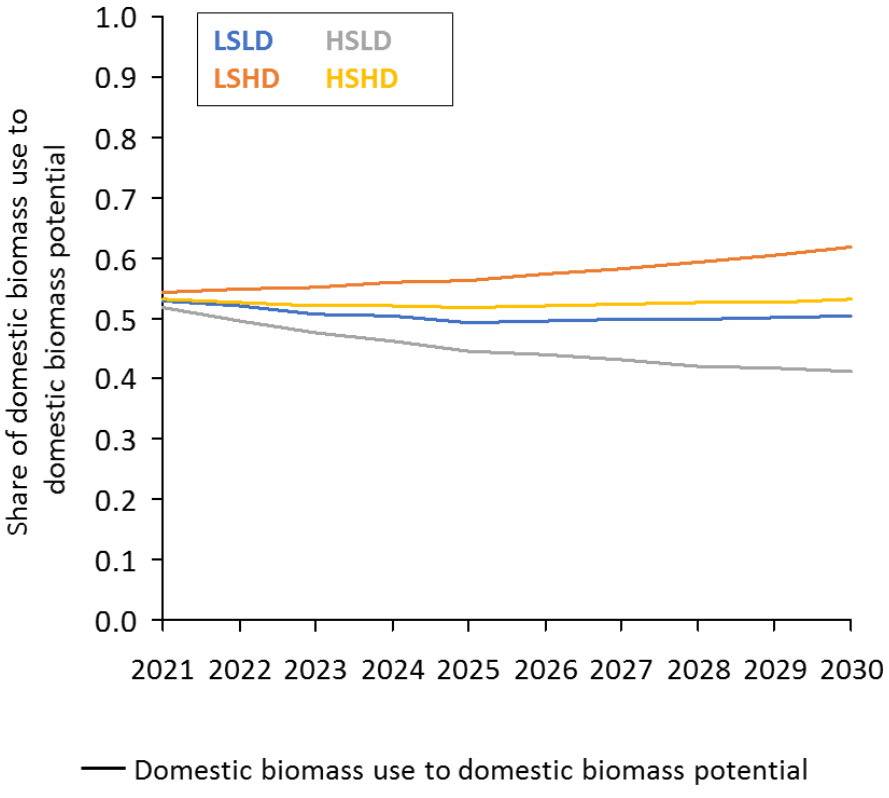
Biofuel use projections in EU transport sector 2021-2030



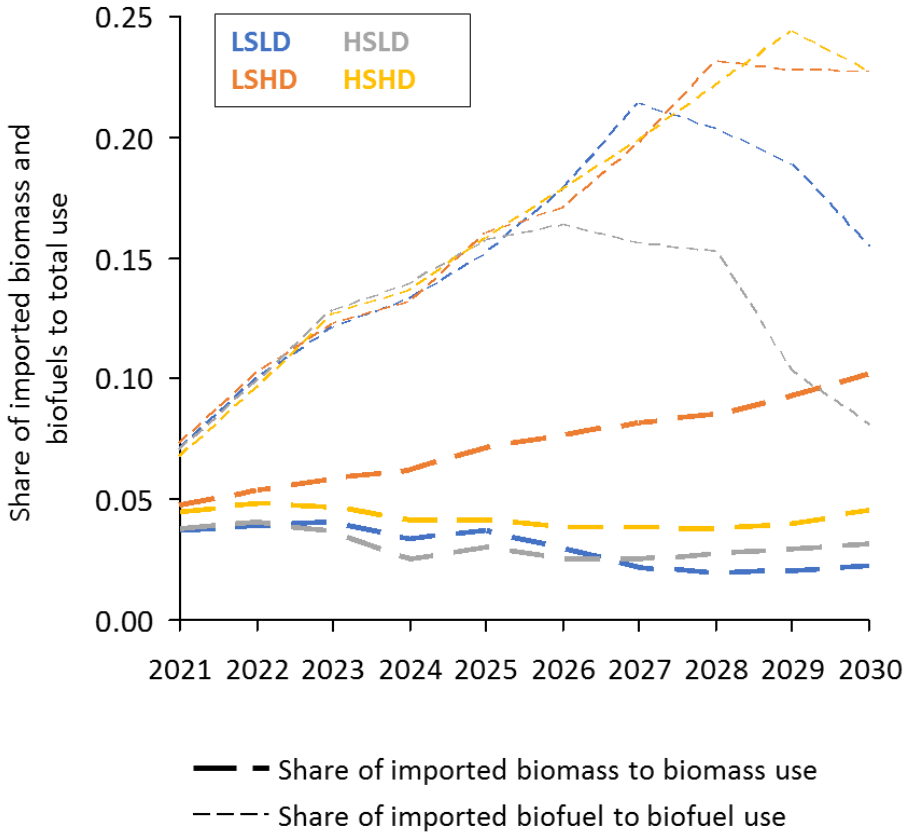
Forthcoming publication: De Jong et al. (2018), please do not cite, as preliminary

EU: biofuel imports could still grow substantially

Domestic biomass



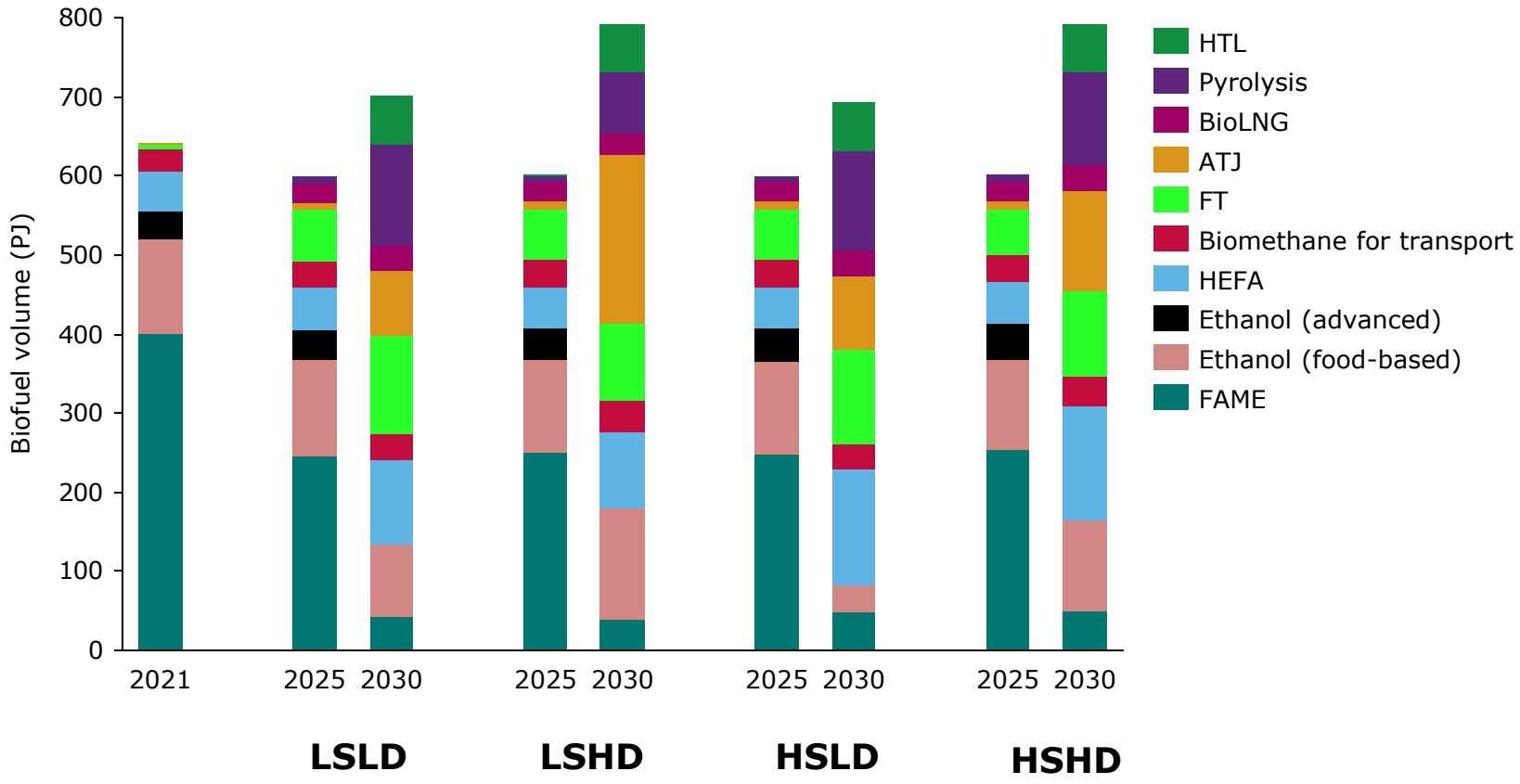
Imported biomass and imported biofuel



Forthcoming publication: De Jong et al. (2018), please do not cite, as preliminary

Biofuel imports could increase up to 25% of gross inland consumption

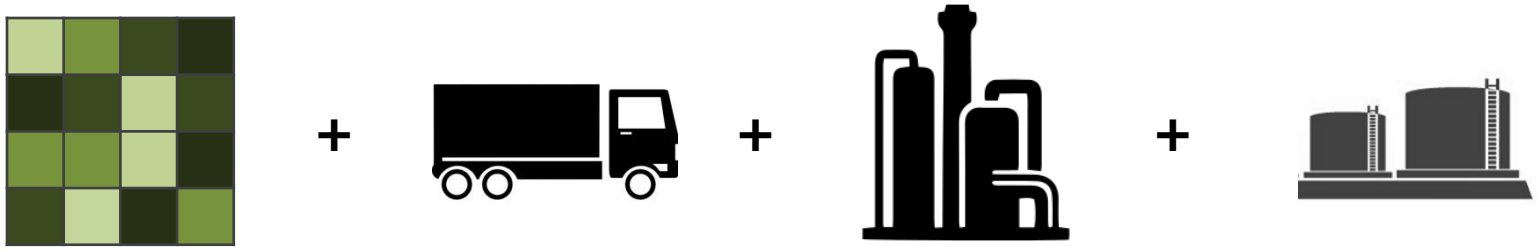
EU: Biofuel mix by conversion technology and feedstock type



Forthcoming publication: De Jong et al. (2018), please do not cite, as preliminary

Nordic countries: Case study Sweden

The case : optimize biofuel supply chain in Sweden



Feedstock + **Upstream transport** + **Conversion** + **Downstream transport and handling**

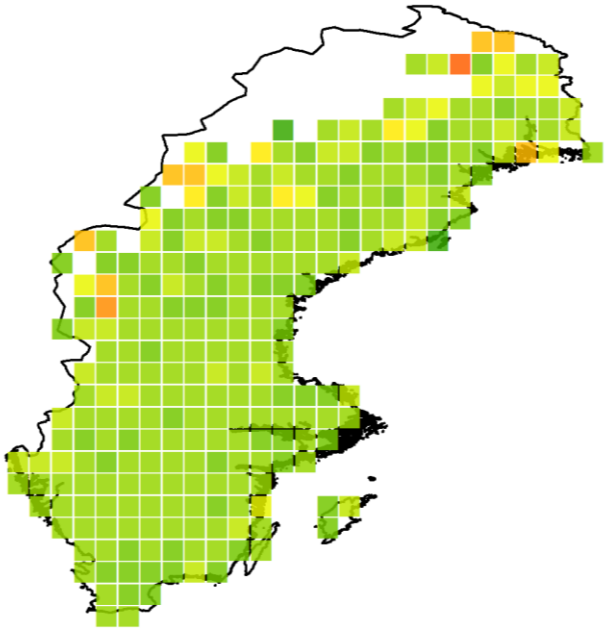
Total biofuel production cost

De Jong et al. (2017)

SE: Smart site selection and economies of scale

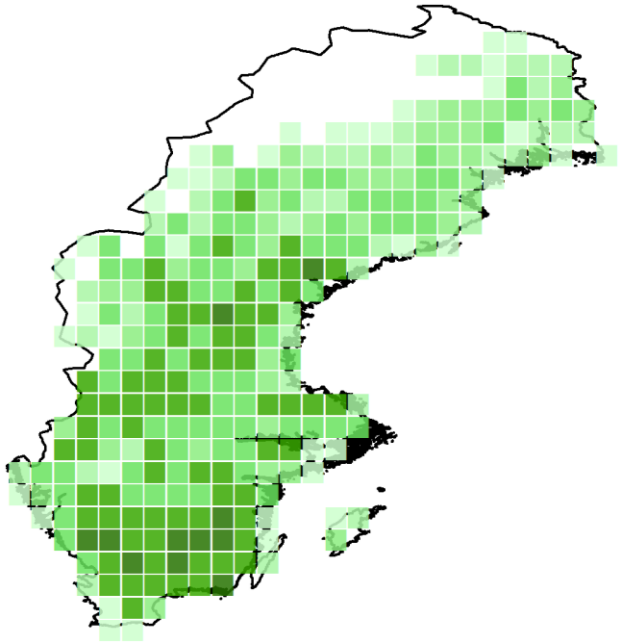
Biomass cost, supply and competing demand

Production cost



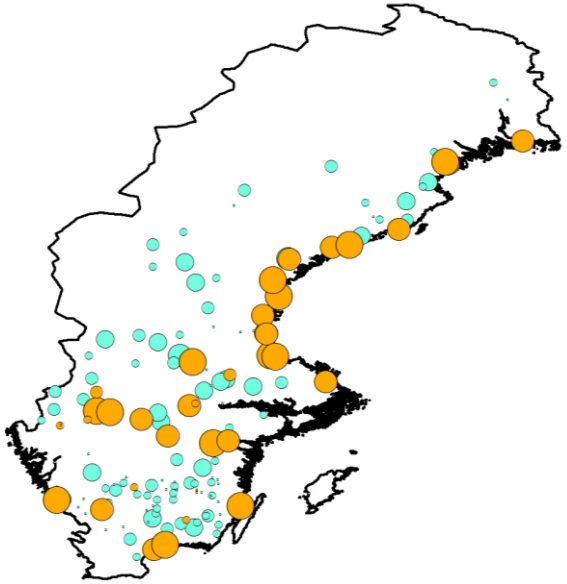
Cheap Expensive

Supply



Low supply High supply

Competing demand



High demand Low demand

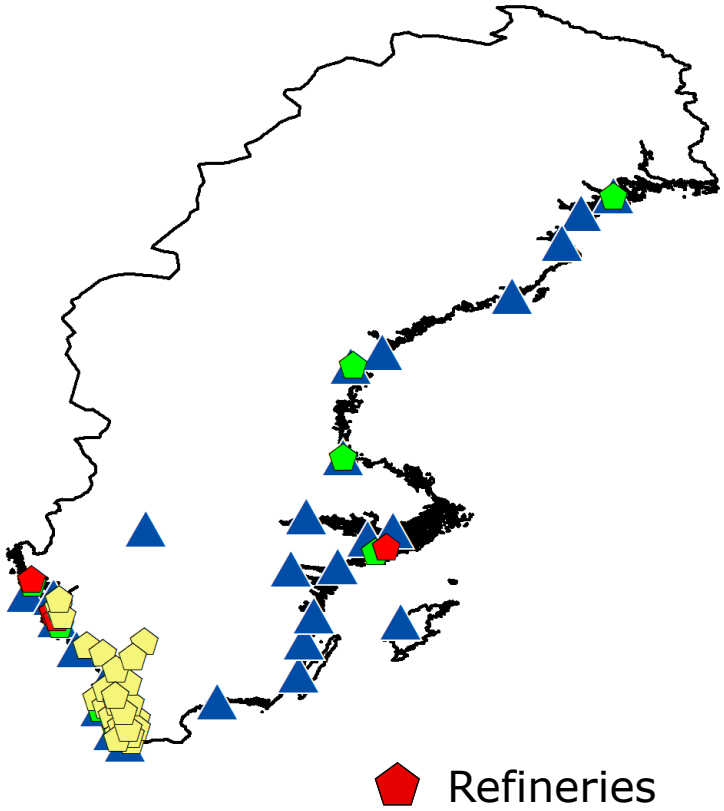
Trade-off: feedstock cost-supply vs competing demand

SE: Integration with existing industries

Refineries

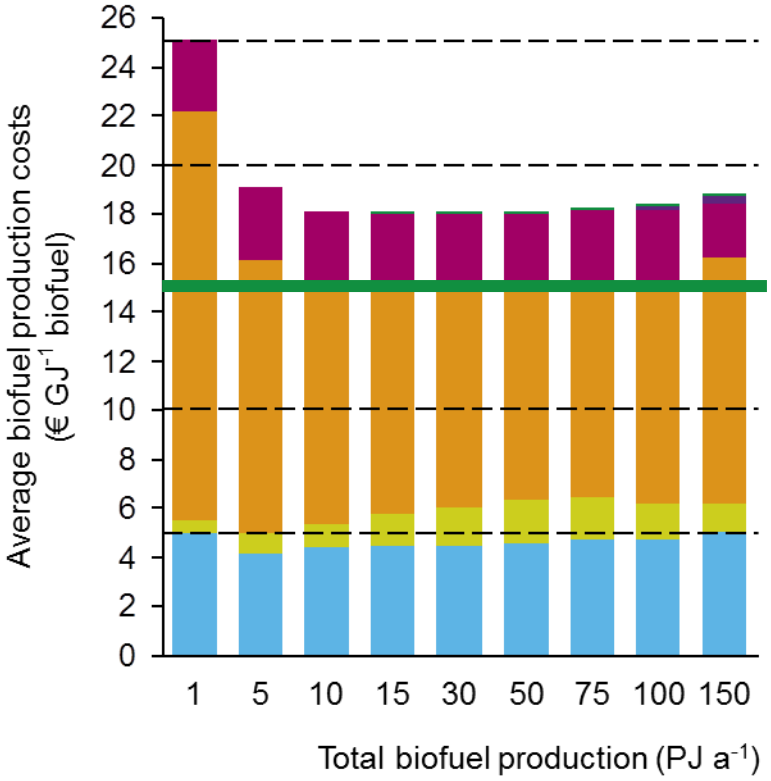
Pulp mill

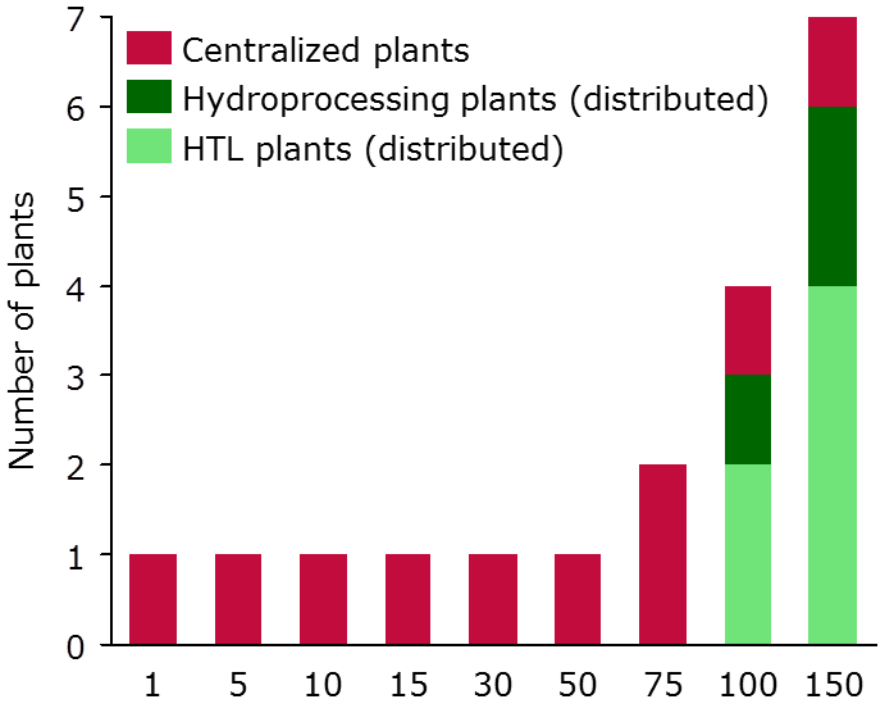
Sawmills



Trade-off: integration benefits vs location

SE: Results for different demand scenarios

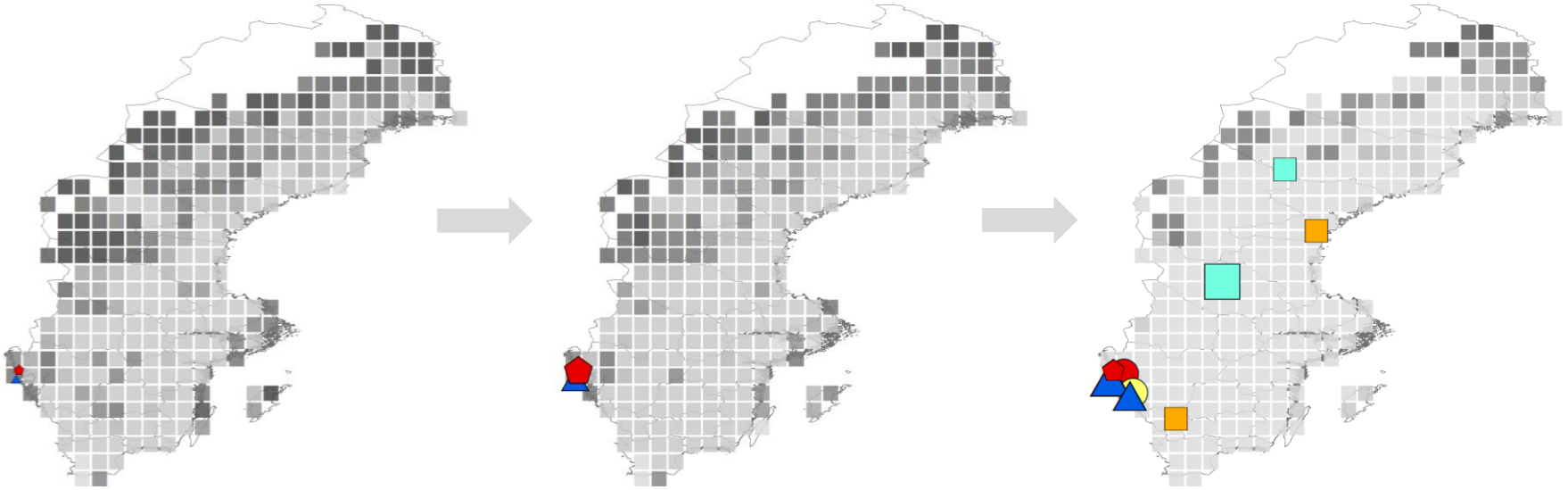




Downstream transport
Intermediate transport
Hydrogen/natural gas purchase
Conversion cost (CAPEX & OPEX)
Upstream transport
Feedstock cost
Fossil fuel benchmark

SE: Results for different demand scenarios

1 PJ a^{-1} **50 PJ a^{-1}** **150 PJ a^{-1}**



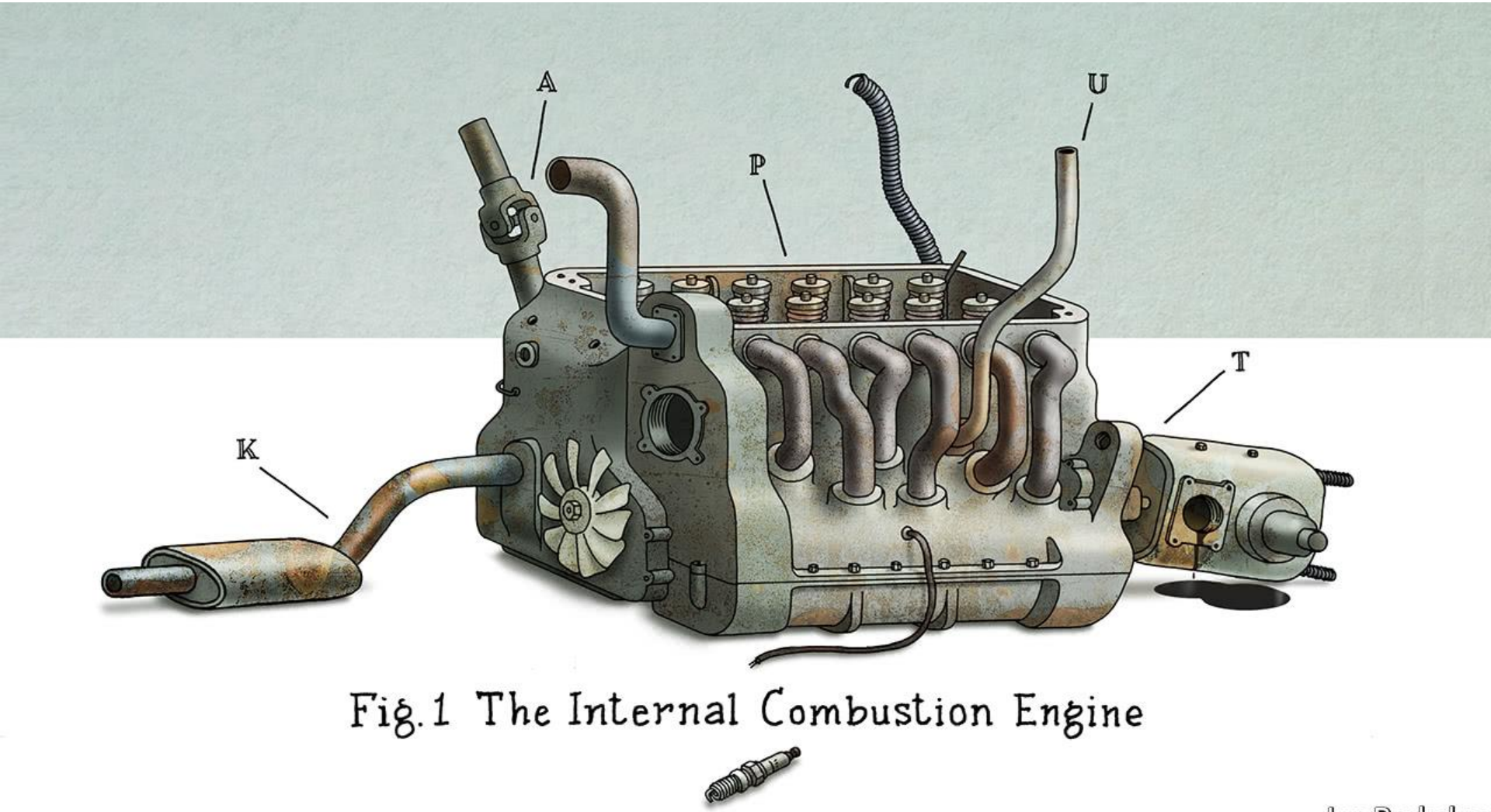
HTL plant

Centralized plant

Hydroprocessing plant

Blending terminal

Are (advanced) biofuels needed?



The Economist, Aug 12th 2017

Conclusions

- Low carbon liquid transportation will be needed still for many decades to meet long term climate targets
- And play a central role in sectors that have little alternatives for decarbonisaton on the longer term including heavy duty transport, aviation and shipping
- Upscaling of advanced biofuel production needs to be accelerated substantially
- Smart site selection, supply chain design and integration with existing industries can further improve its economic feasibility

Thank you for your attention

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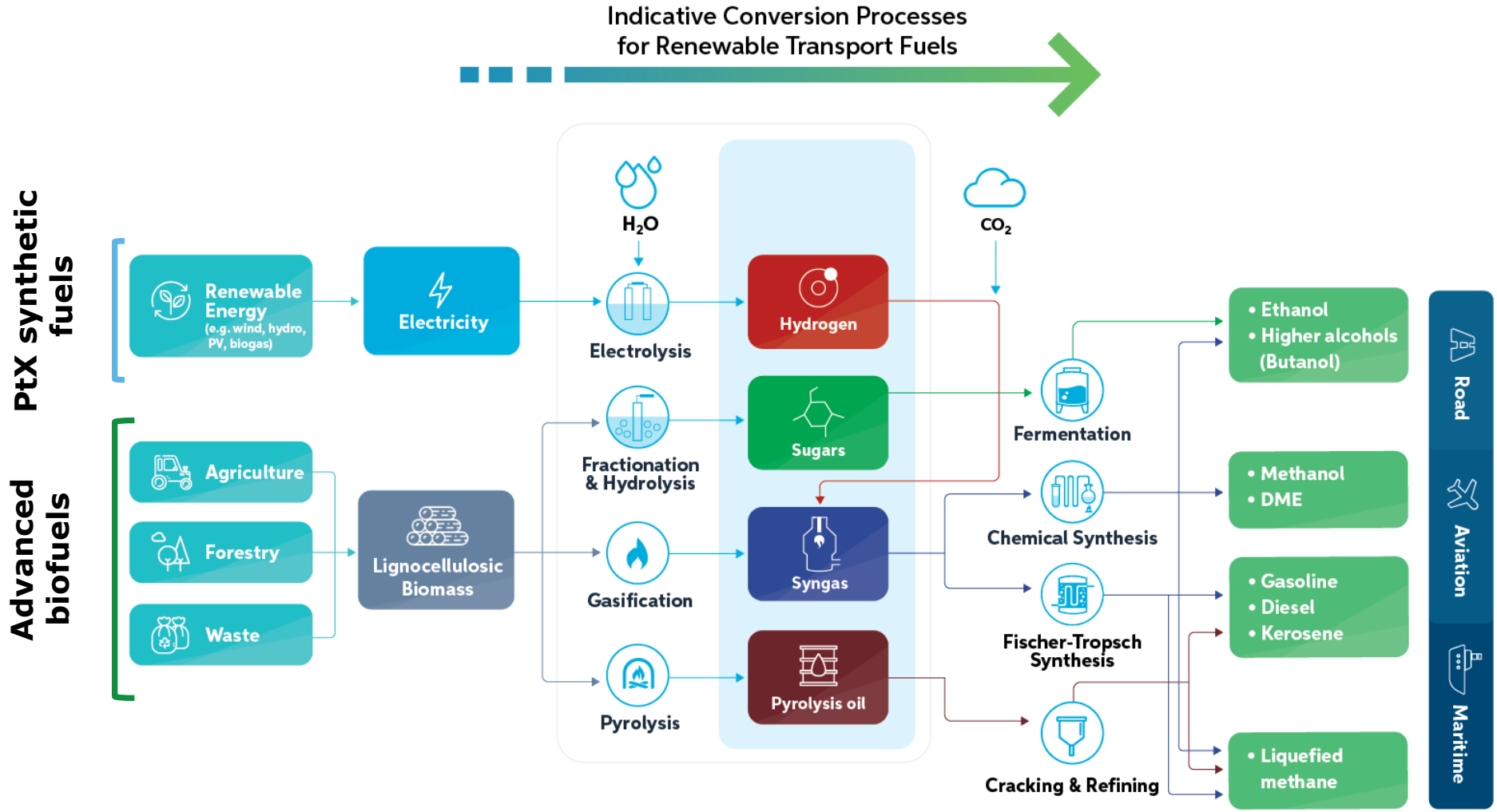
Utrecht University

Extra slides

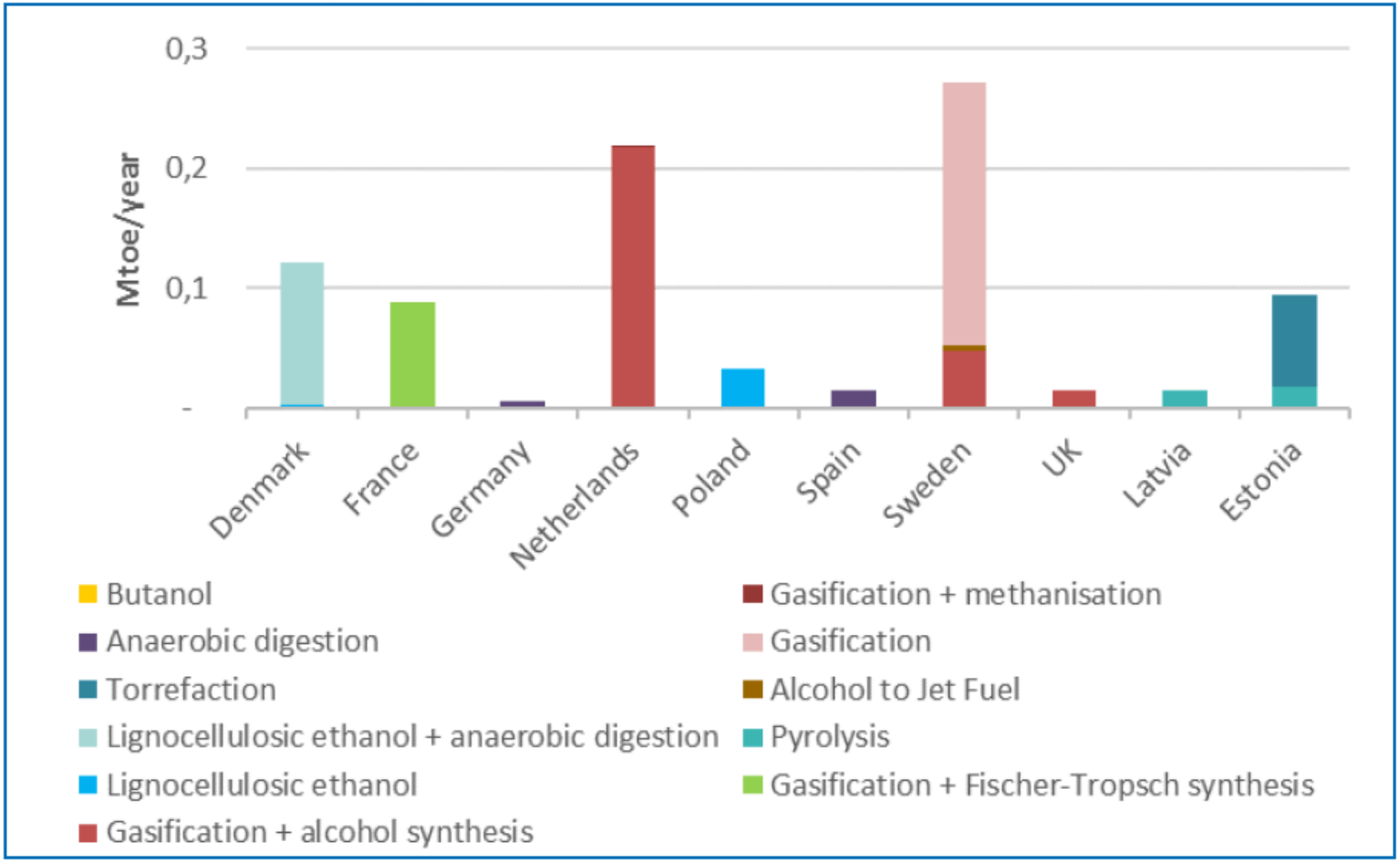
Advanced biofuels and other liquid renewable fuels



Source: ADVANCEFUEL (www.ADVANCEFUEL.eu)

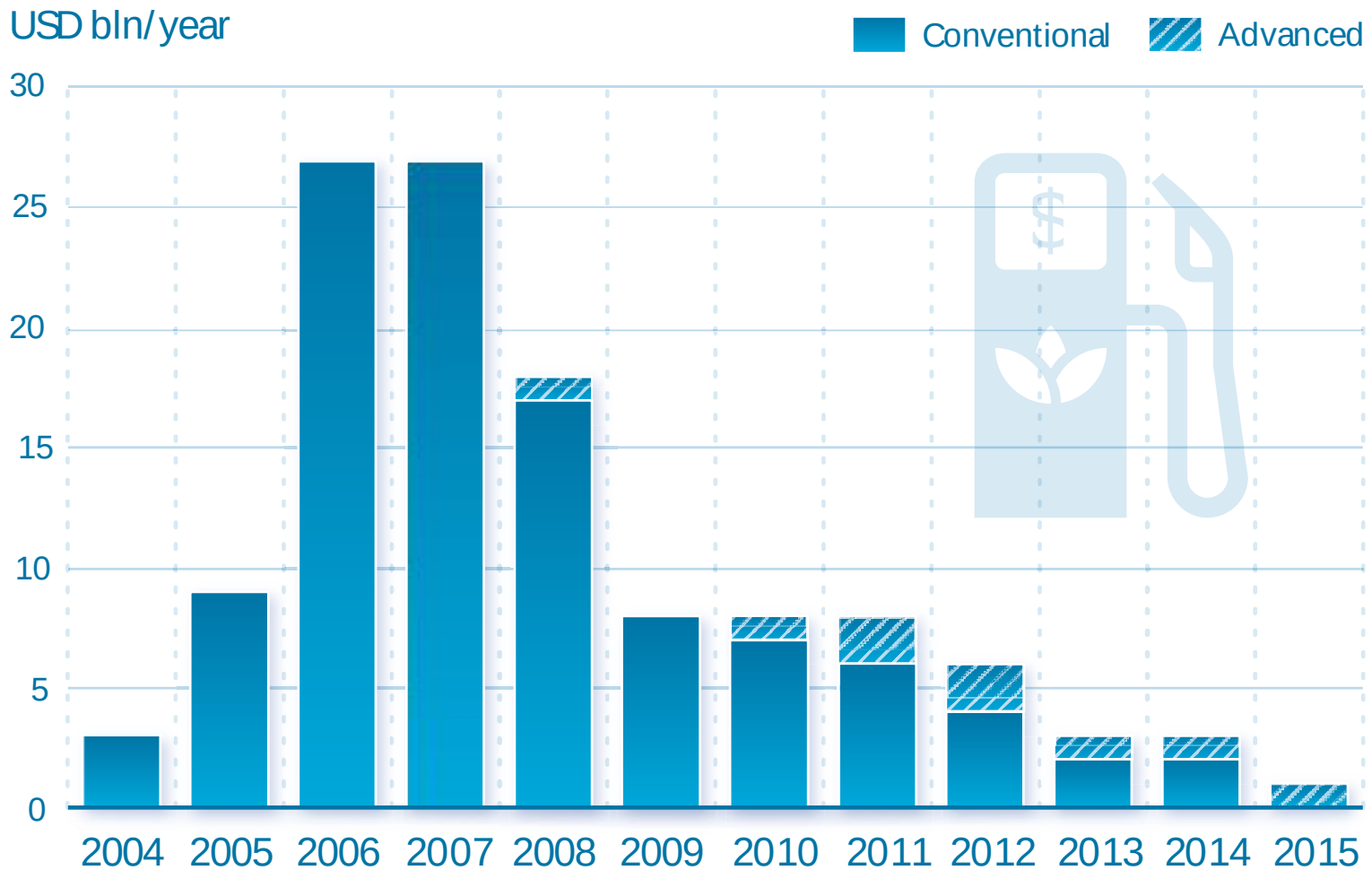
Planned advanced biofuel capacity in the EU to 2020

Production capacity is expected to be close to 0.8 Mtoe (35 PJ/a) with a total investment of € 4.5 – 5.0 billion



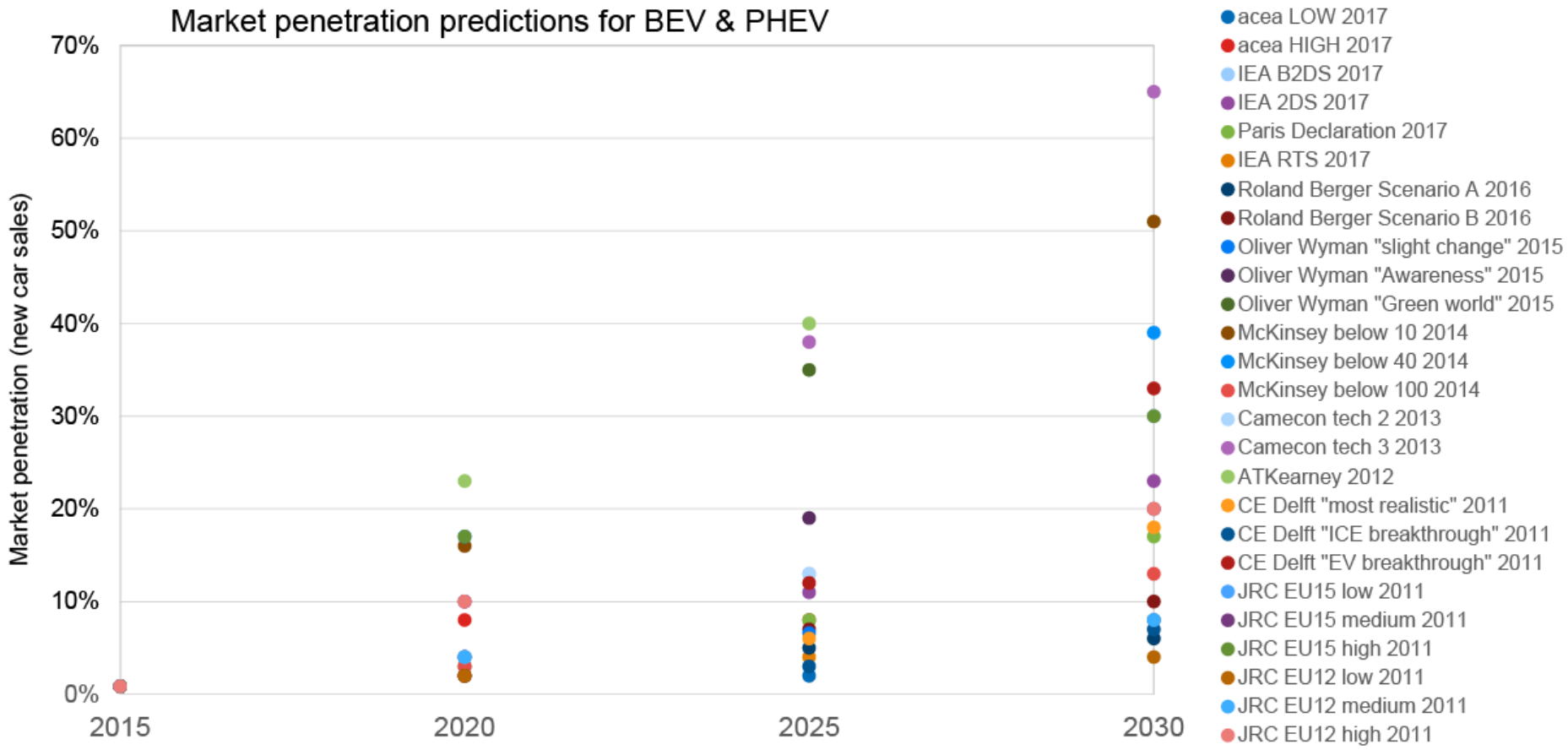
Source: Baker et al. 2017 (European Commission, DG R&I)

Declining global investments in biofuels



Source: IRENA (2016) INNOVATION OUTLOOK ADVANCED LIQUID BIOFUELS

Global market penetration of BEH & PHEV



A European bioenergy model was used to study the effect of the Winter Package on biofuels in the EU28

Demand for biomass

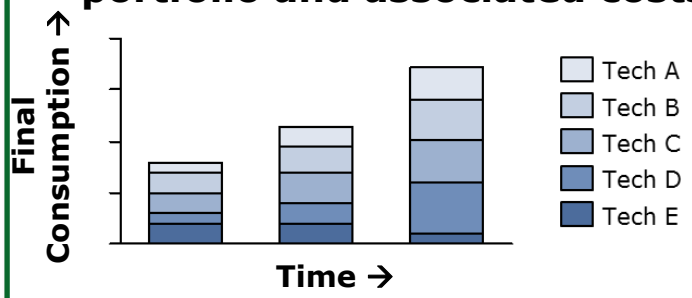
Input data
- Techno-economic and LCA data
- Biomass potentials
- RED Winter package
- Technological learning

ECN
Your energy. Our passion.

RESolve-Biomass model
Cost optimization model for EU-28 from 2005-2030 developed by Energy Centre Netherlands (ECN)

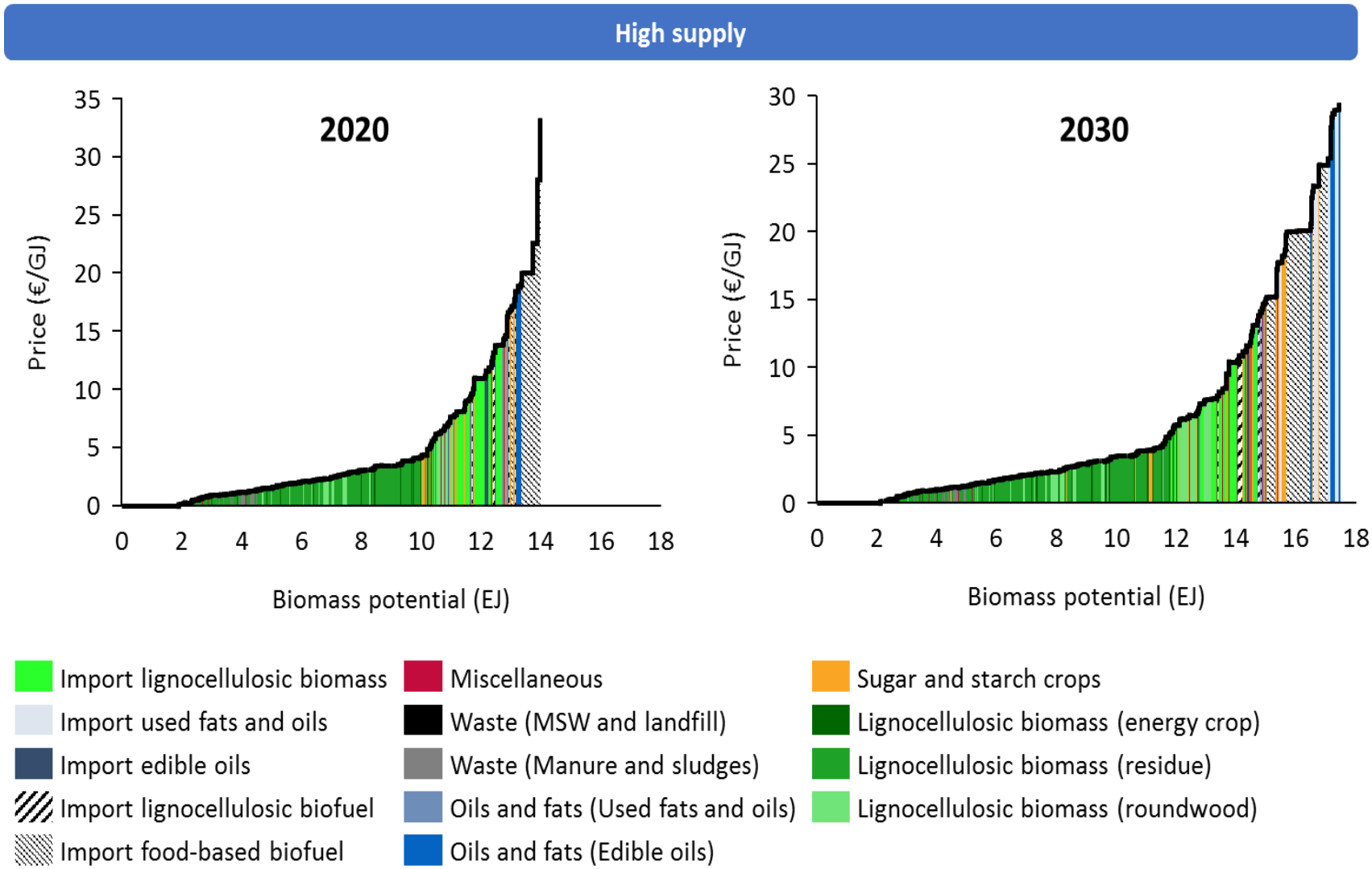
Deployment scenarios
- Low/high biomass supply **(LS / HS)**
- Low/high biomass demand **(LD / HD)**

Outcome: Feedstock/technology portfolio and associated costs



Forthcoming publication: De Jong et al. (2018), please do not cite, as preliminary

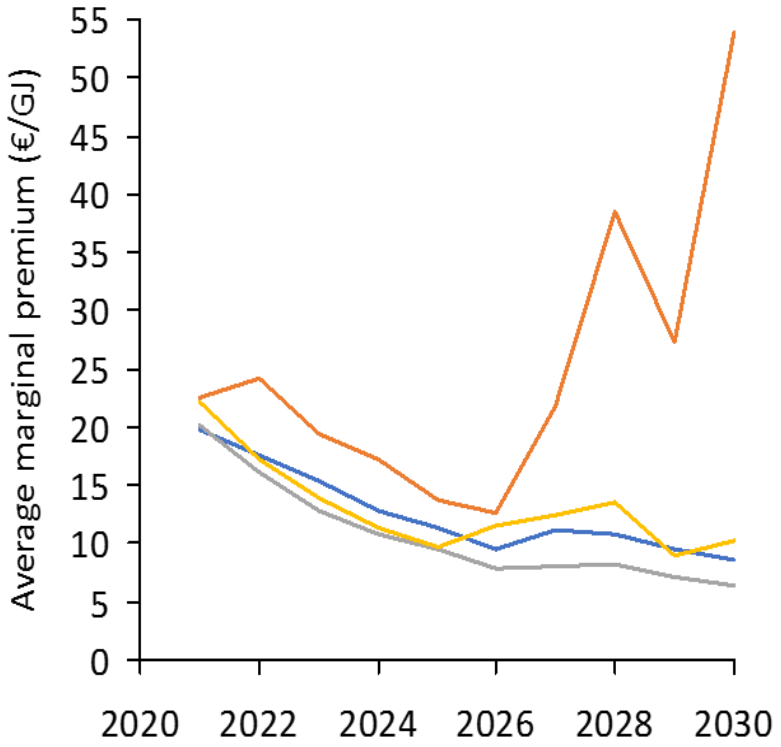
Feedstock supply cost



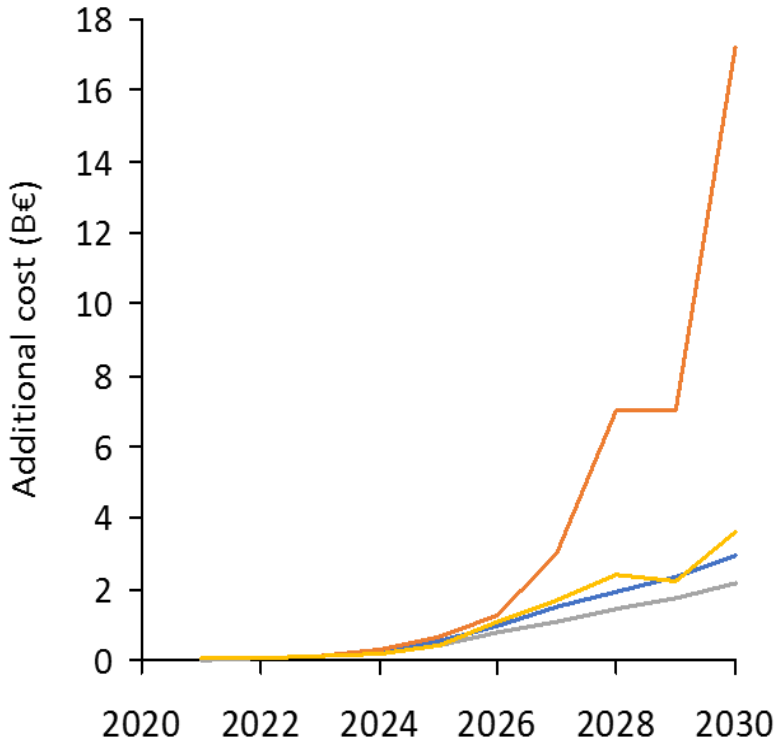
Forthcoming publication: De Jong et al. (2018), please do not cite, as preliminary

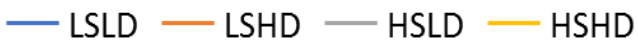
Additional cost: renewable jet fuels (RJF)

Average annual premium for RJF



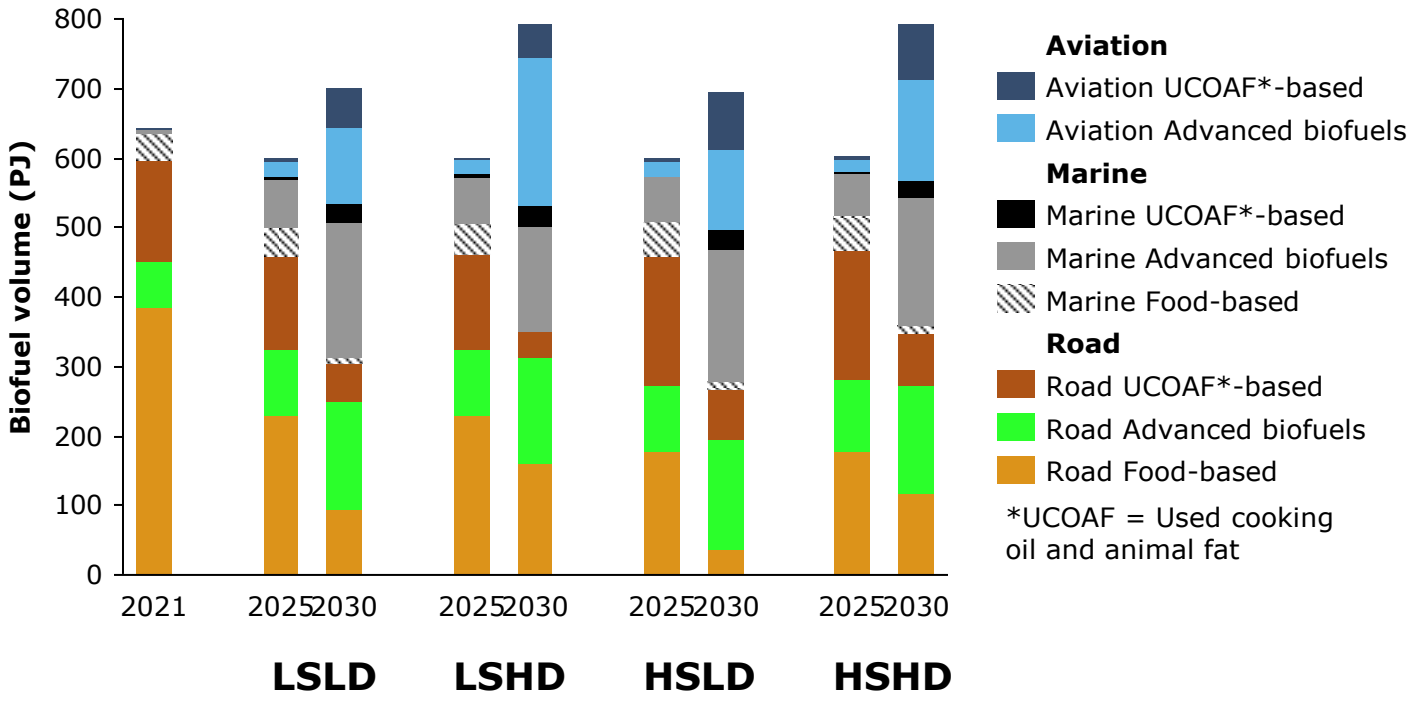
Total additional cost for RJF relative to fossil jet fuel





Forthcoming publication: De Jong et al. (2018), please do not cite, as preliminary

EU: Biofuel mix by end use sector



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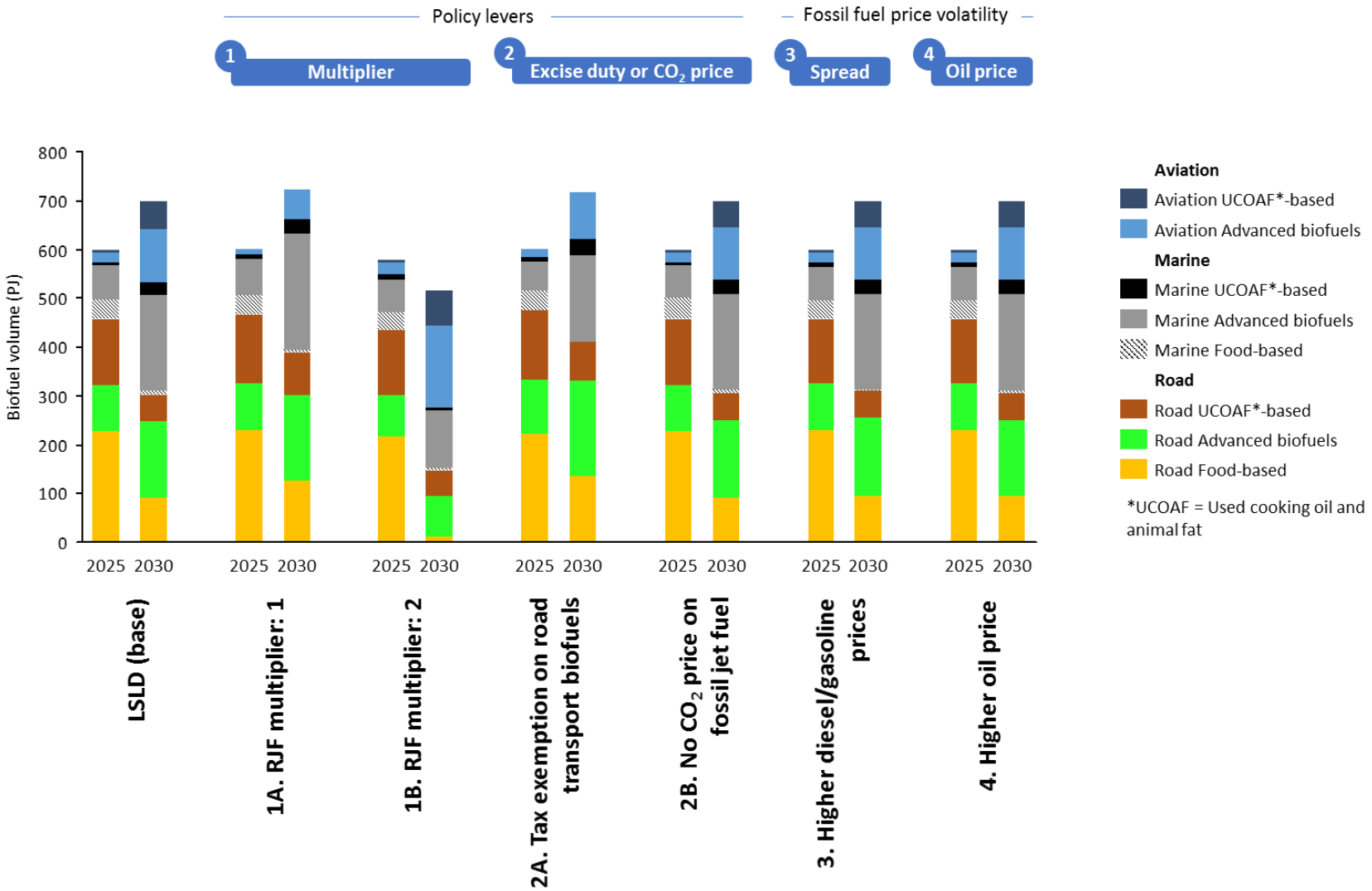
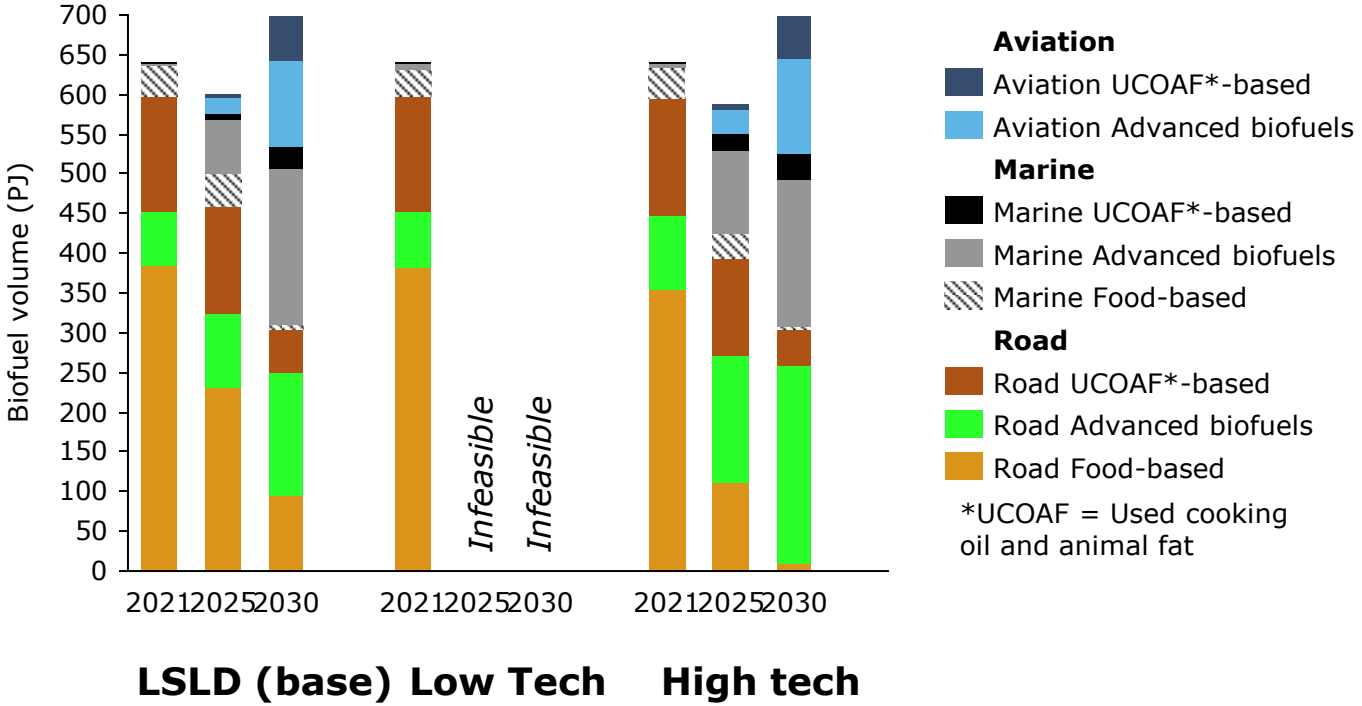
Biofuel mix by end use sector



Biofuel mix by end use sector

Sensitivity scenarios: technology development



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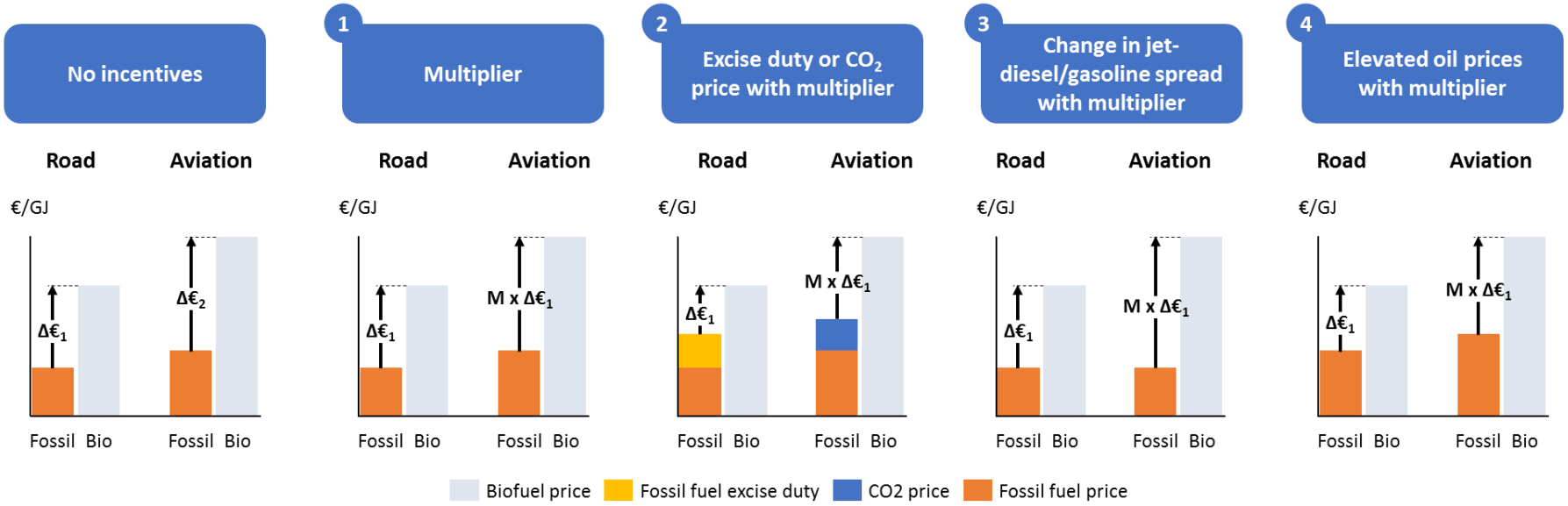
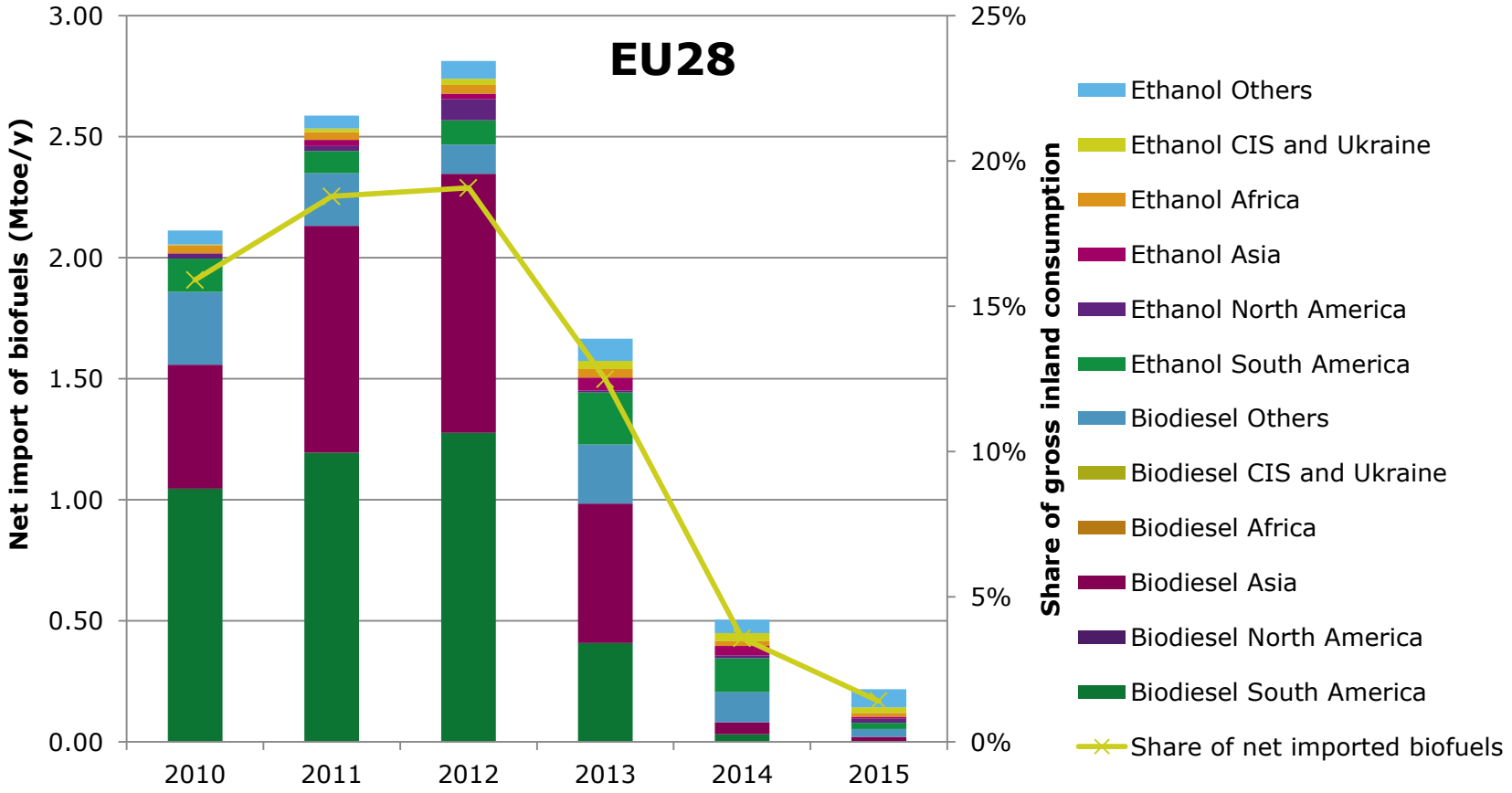

No incentives
1
Multiplier
2
Excise duty or CO_2 price with multiplier
3
Change in jet-diesel/gasoline spread with multiplier
4
Elevated oil prices with multiplier
Road
Aviation
€/GJ
$\Delta€_1$
$\Delta€_2$
M x $\Delta€_1$
Fossil
Bio
Biofuel price
Fossil fuel excise duty
CO2 price
Fossil fuel price

Development of net imports of biofuel to the EU



Data: EUROSTAT (2017), F.O. Lichts World Ethanol & Biofuels Report (2016)

Excluding imports of vegetable oils

5 strategies to reduce the cost of biofuel production

1. Smart site selection
2. Upscaling!
3. Intermodal transport
4. Pre-treatment: distributed supply chains
5. Integration with existing industries

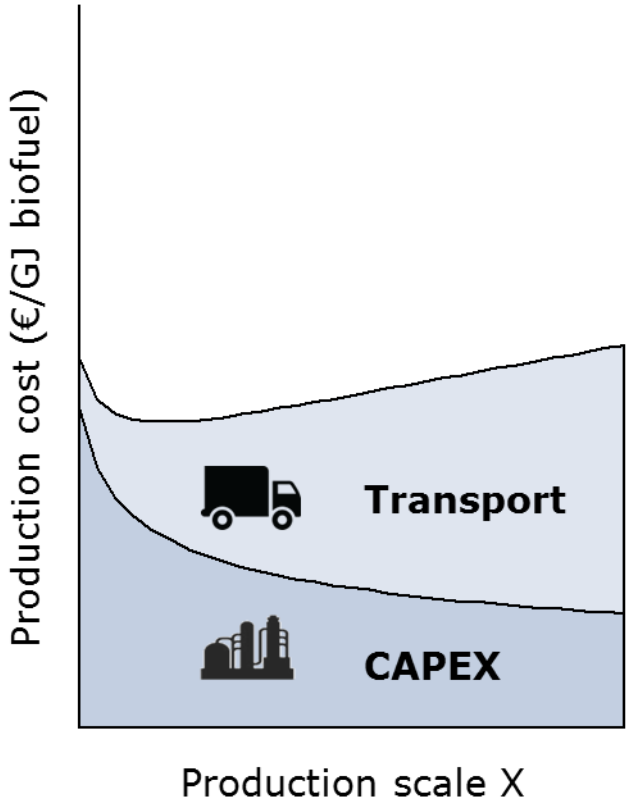
2 Upscaling!

Oil industry

odz. Bigger is better

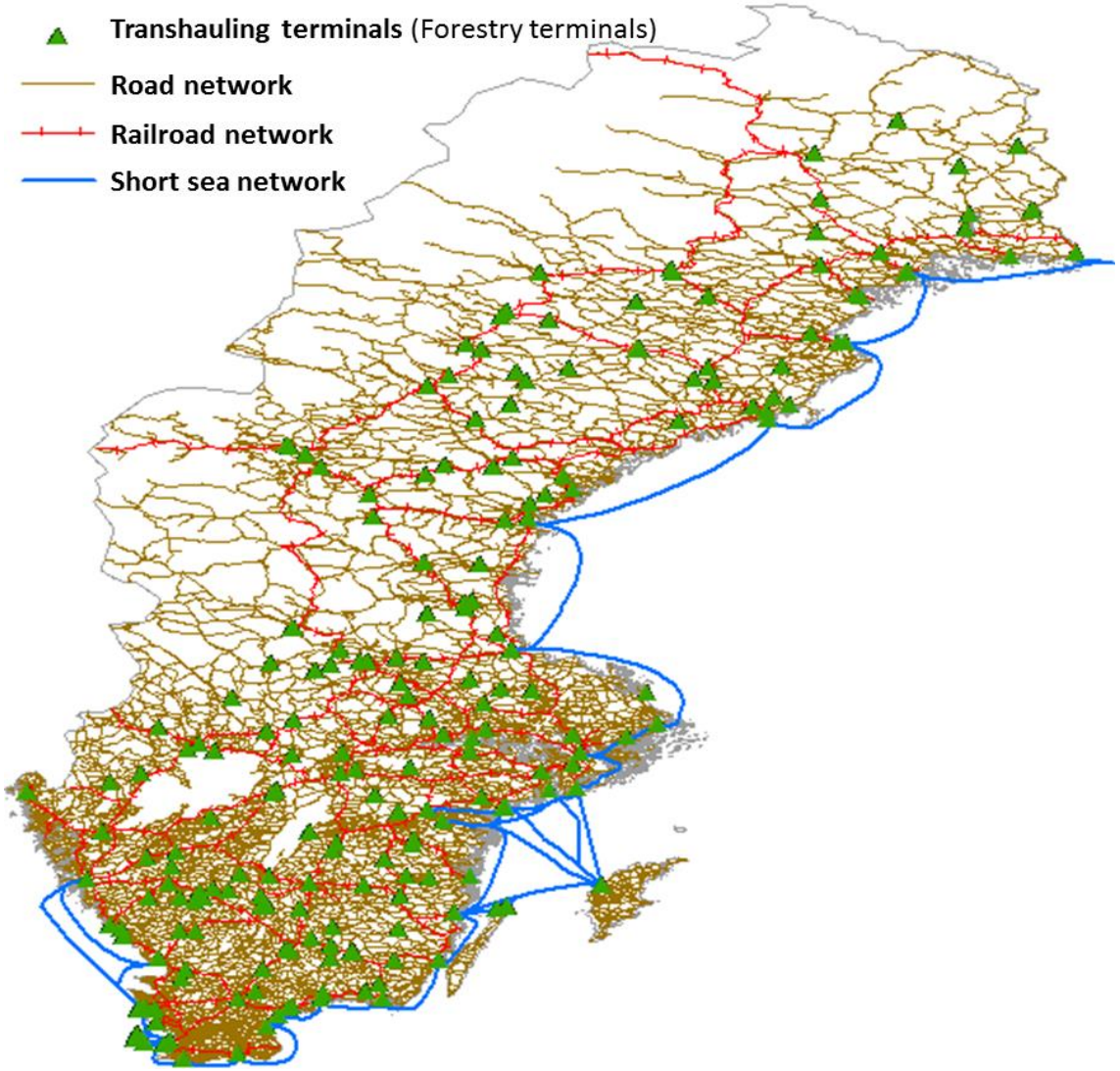
Biofuel

There's a trade-off



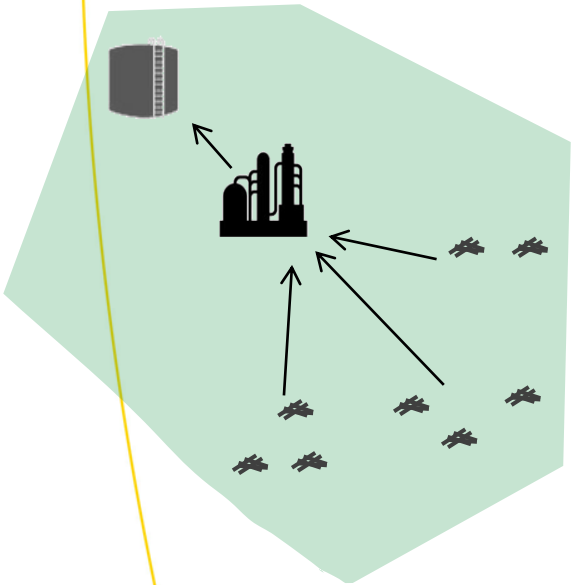
Trade-off: scale vs transport cost

3 Intermodal transport



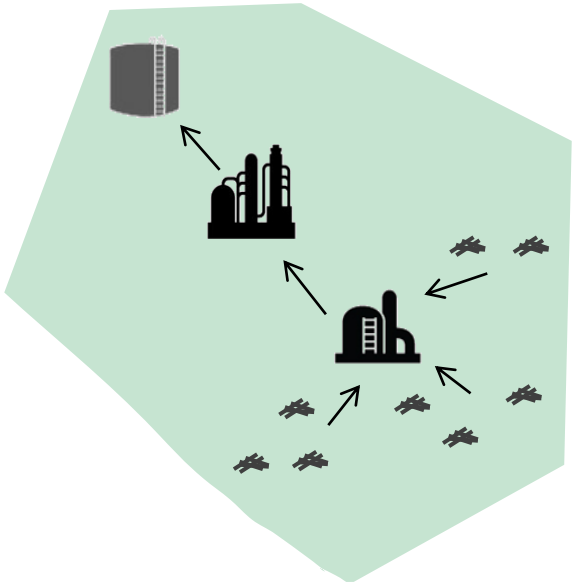
4 Distributed supply chains

Centralized supply chain



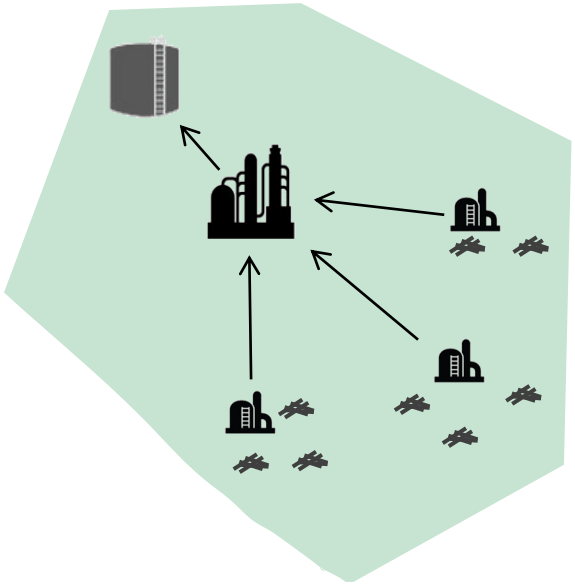
Lower CAPEX/OPEX, higher upstream transportation cost

Distributed supply chain (Linear type)



Higher CAPEX/OPEX, lower upstream transportation cost

Distributed supply chain (Hub-and-spoke type)



Higher CAPEX/OPEX, lower upstream transportation cost

Feedstock | Pre-treatment unit | Upgrading unit | Storage terminal

Trade-off: conversion cost vs transport cost

5 strategies to reduce the cost of biofuel production

Which one dominates?

1. Smart site selection
2. Upscaling!
3. Intermodal transport
4. Pre-treatment: distributed supply chains
5. Integration with existing industries

5 strategies to reduce the cost of biofuel production

Which one dominates?

1. Smart site selection – very important

2. Upscaling! – cost reduction of 0-12% (increasing with biofuel production level)

\+

3. Intermodal transport – cost reduction of 0-6% (increasing with biofuel production level)

4. Pre-treatment: distributed supply chains – cost reduction of <1%

\+

5. Integration with existing industries – cost reduction of 1-10%, decreasing with biofuel production level

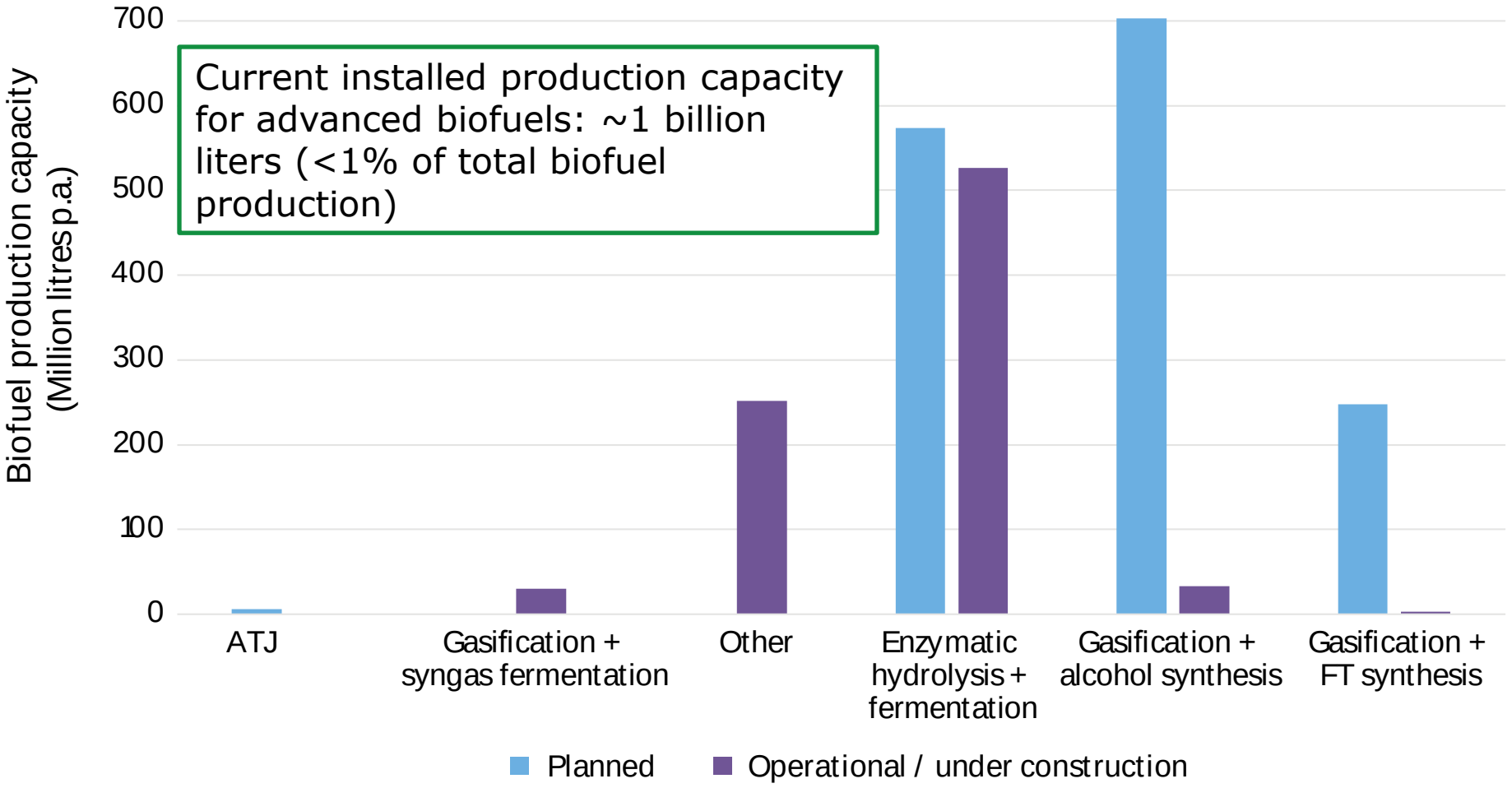
Conclusions Sweden case

1. Even with all 5 cost strategies, biofuel is more expensive than fossil fuel
   (in this spatiotemporal context for this technology)

2. Economies of scale provide the largest cost benefits
   (although upscaling for this technology is yet to be proven)

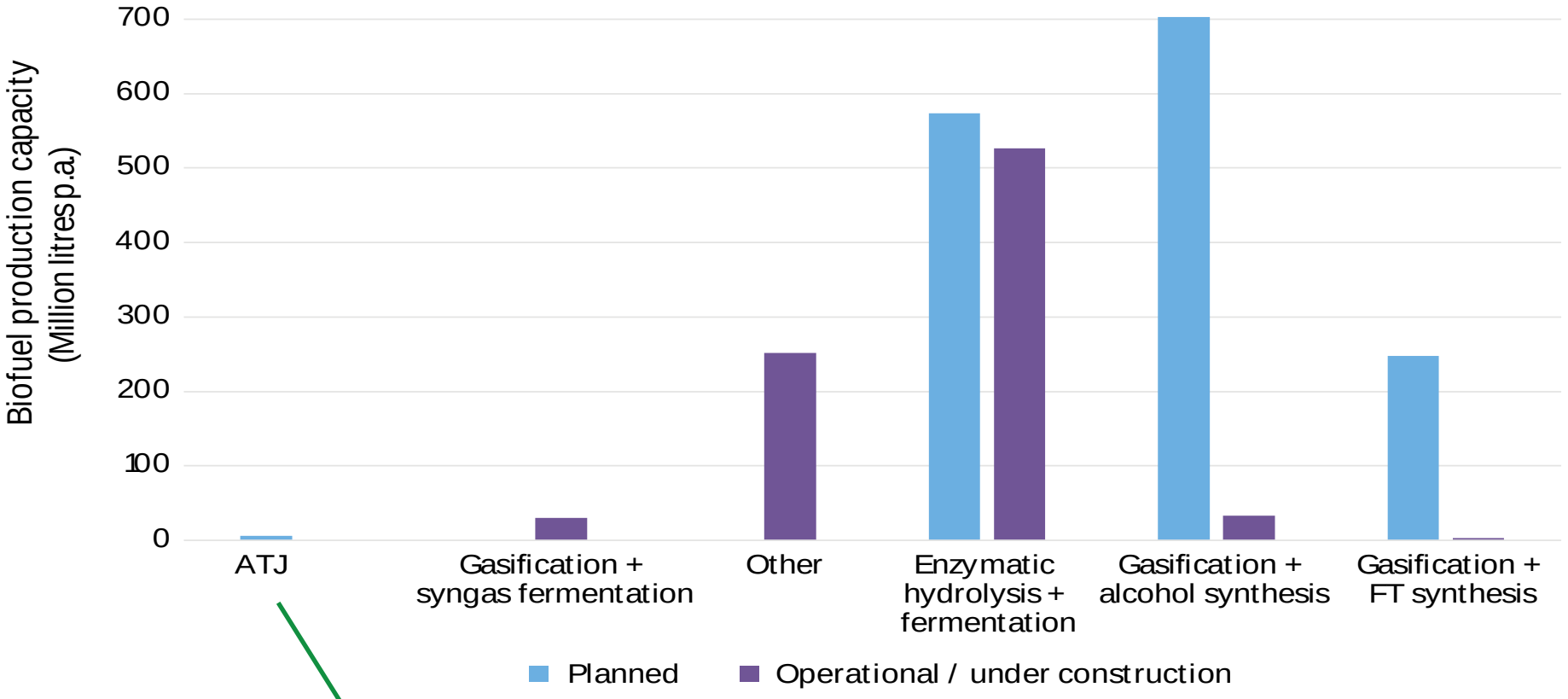
3. Distributed supply chain designs are only preferred when transport distance is high or biomass density is low

Planned and operational capacity of advanced biofuel plants



Source: IRENA (2016) INNOVATION OUTLOOK ADVANCED LIQUID BIOFUELS

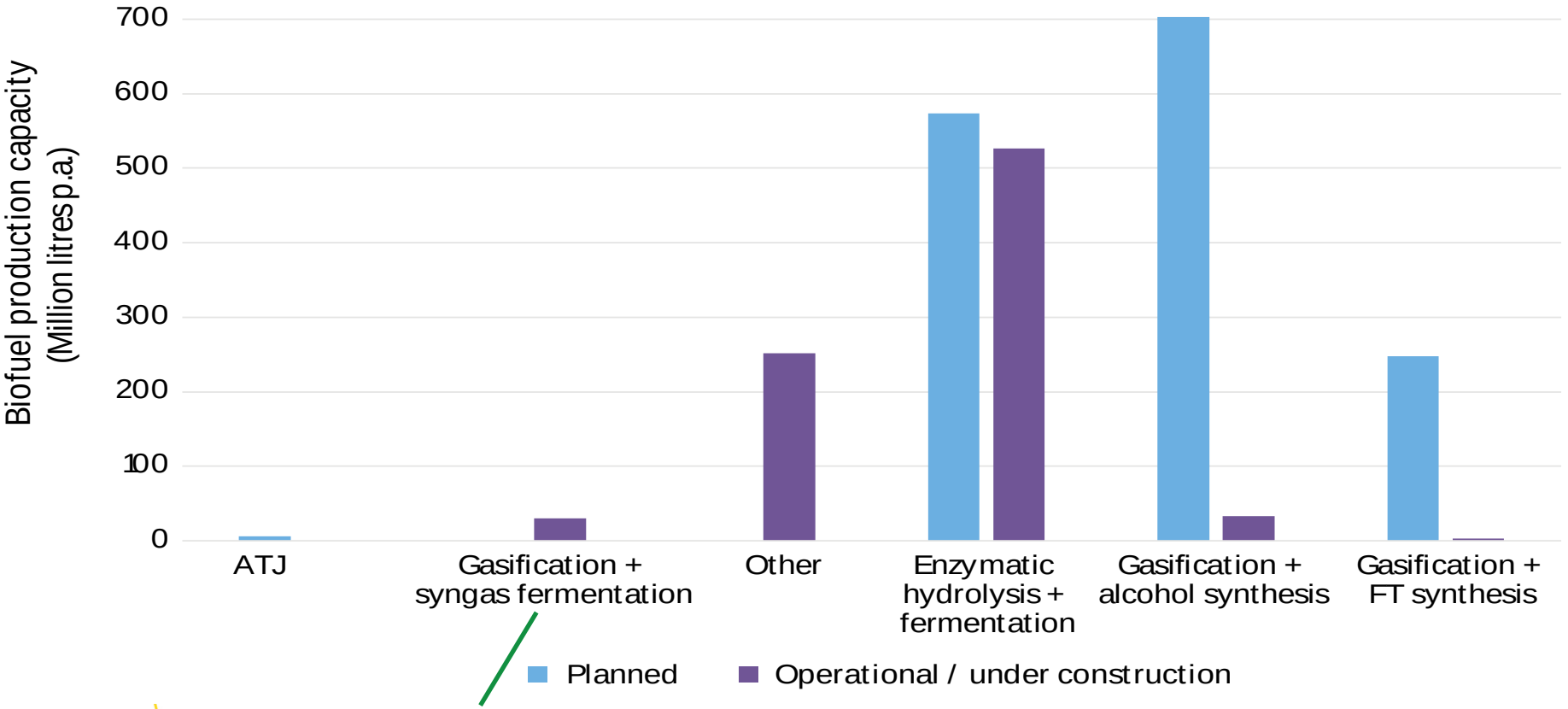
Planned and operational capacity of advanced biofuel plants



- Swedish Biofuels AB, Sweden (Capacity: 6 ML/y), waste gas fermentation (Lanzatech) combined with conversion of alcohols into drop-in jet fuels (Swedish Biofuels)

Source: IRENA (2016)

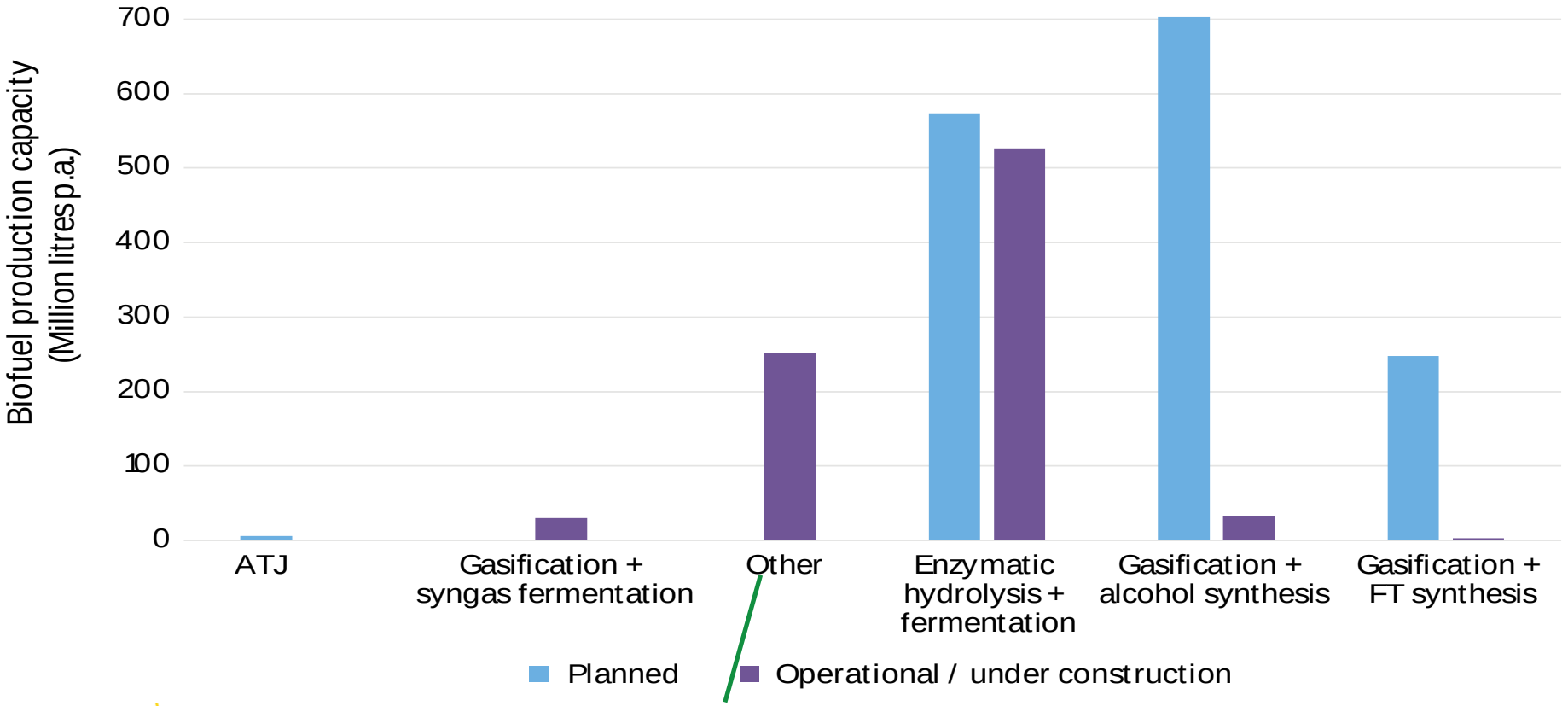
Planned and operational capacity of advanced biofuel plants



- INEOS Bio, US (Capacity: 30 ML/y). Palm fronds and MSW to ethanol.

Source: IRENA (2016)

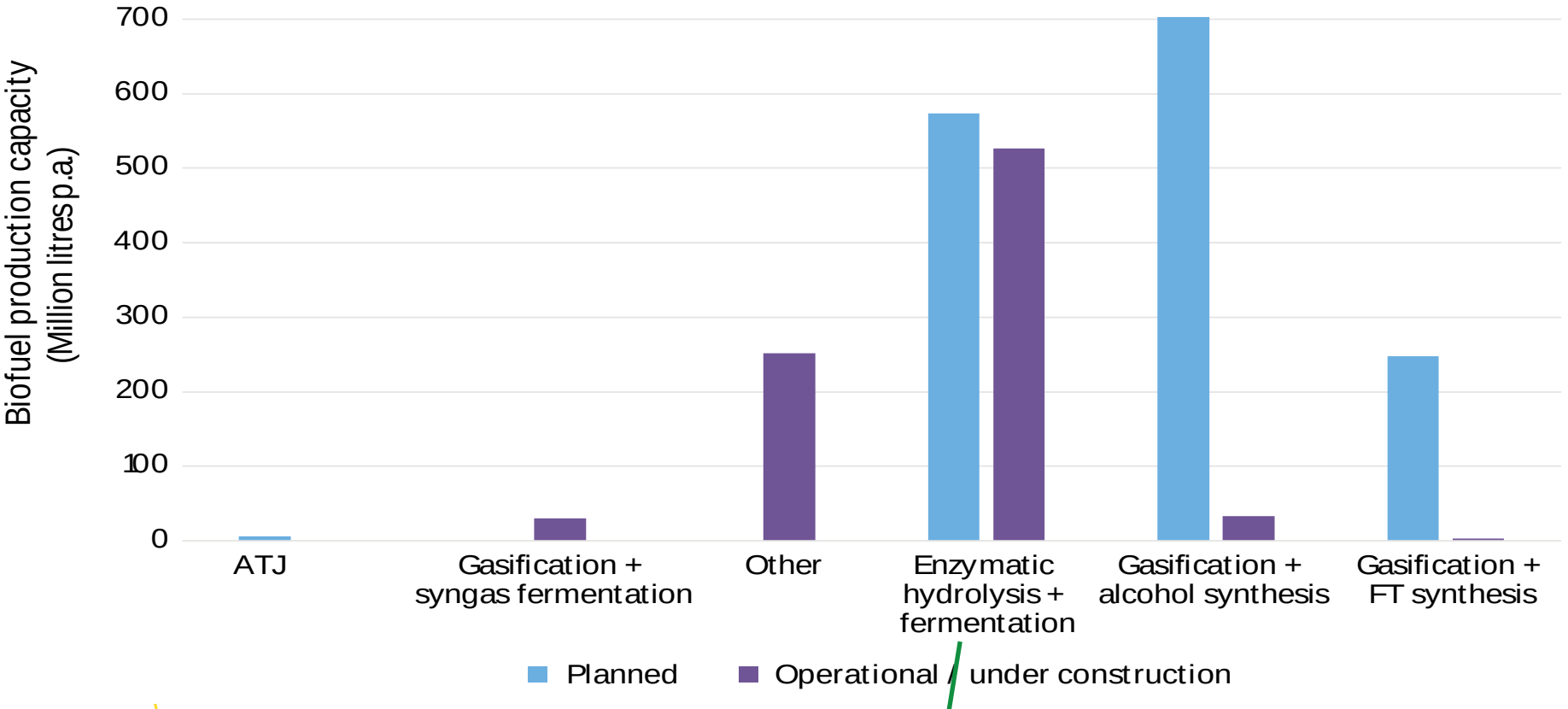
Planned and operational capacity of advanced biofuel plants



- BioMCN, Netherlands (Capacity: 252 ML/y). Crude glycerine, biomethane to methanol

Source: IRENA (2016)

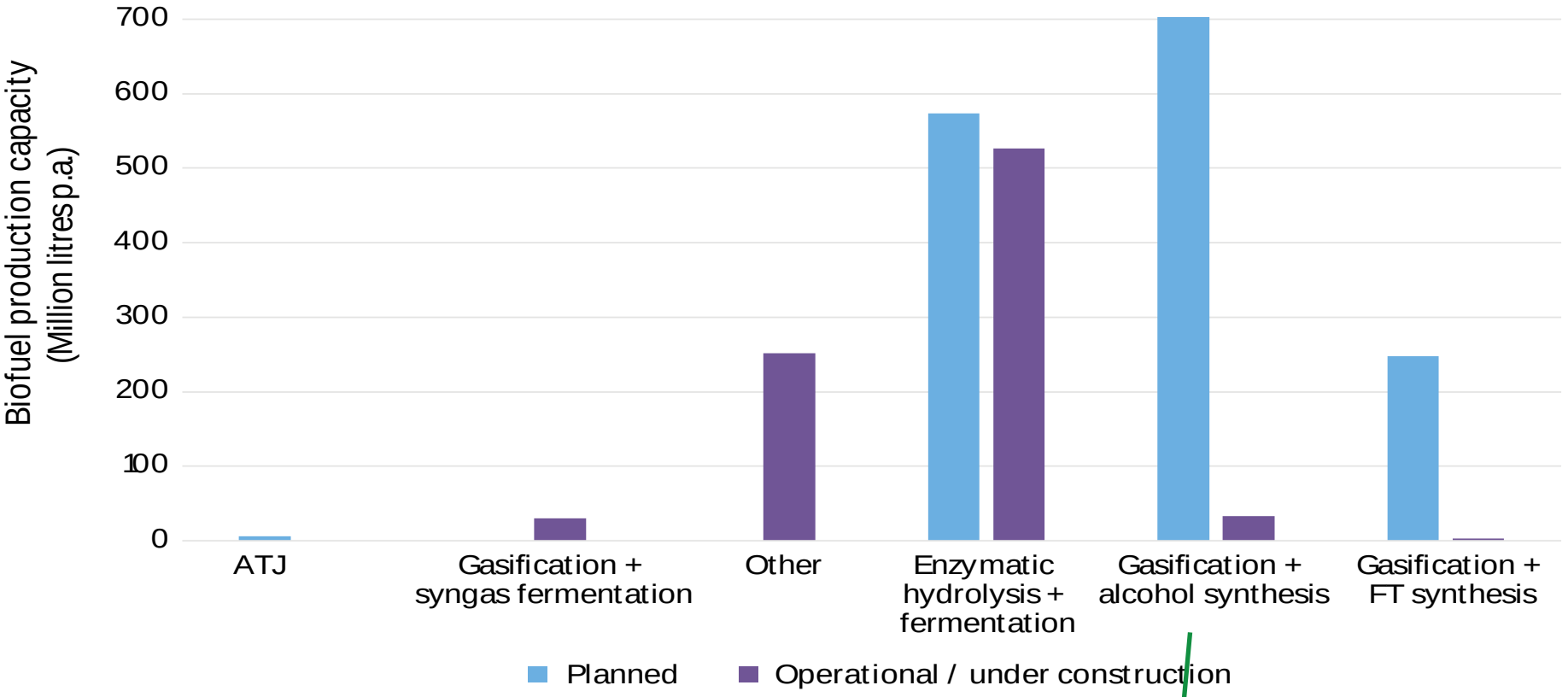
Planned and operational capacity of advanced biofuel plants



- Operational capacity mainly in the US (242 ML/y) including Dupont (114 ML/y) and POET-DSM (76 ML/y)
- Operational capacity in Europe is 95 ML/a including Beta Renewables (Italy, 51 ML/y) and Borregaard (Norway, 20 ML/y)

Source: IRENA (2016)

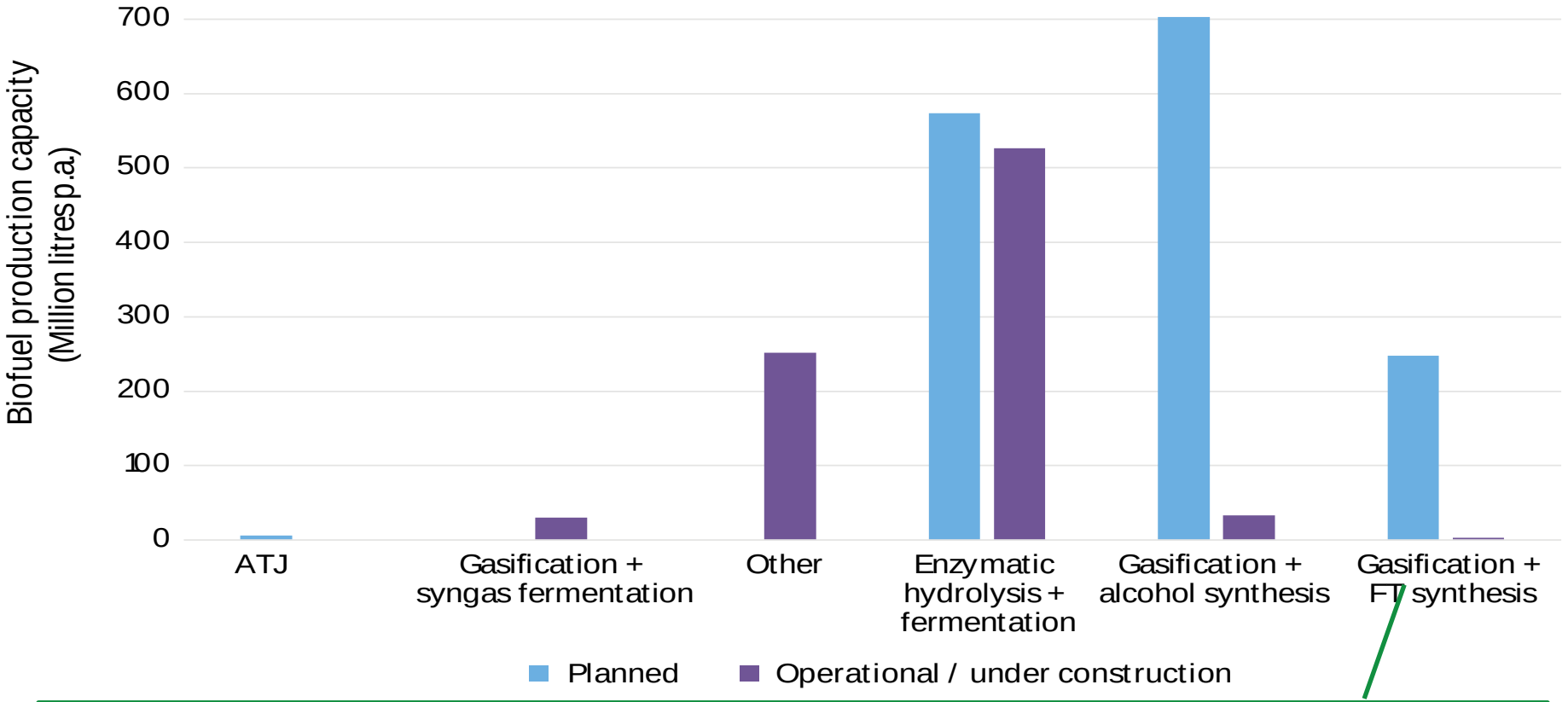
Planned and operational capacity of advanced biofuel plants



- Operational capacity: mainly Enerkem (Canada, 34 ML/y)
- Planned capacity: half of capacity is Woodspirit (Netherlands, 464 ML/a), by BioMCN. The project is officially cancelled.

Source: IRENA (2016)

Planned and operational capacity of advanced biofuel plants



- Planned capacity in the US is in advanced stage: Fulcrum Biofuels (33 ML/a), Red Rock Biofuels (61 ML/a)
- Planned capacity in Europe is more uncertain: UPM Stracel BTL (France, 108 ML/y)

Source: IRENA (2016)