Biofuels – Future Opportunities for Refiners

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Preem's vision:
Preem leads the transition
towards a sustainable society
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Preem's refineries

Efficient refining

- 21% less CO2
- 59% less NOx
- 93% less SOx

per produced unit compared to average refinery in western Europe.

700 employees

11,4 million ton crude oil per year
(220 000 bpd)

280 employees

6 million ton crude oil per year
(125 000 bpd)

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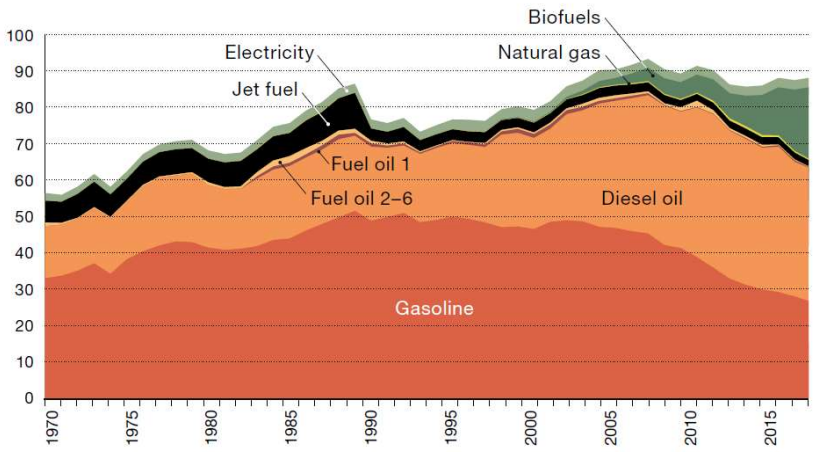
Situation in Sweden for the transport sector (Swedish Energy Agency)

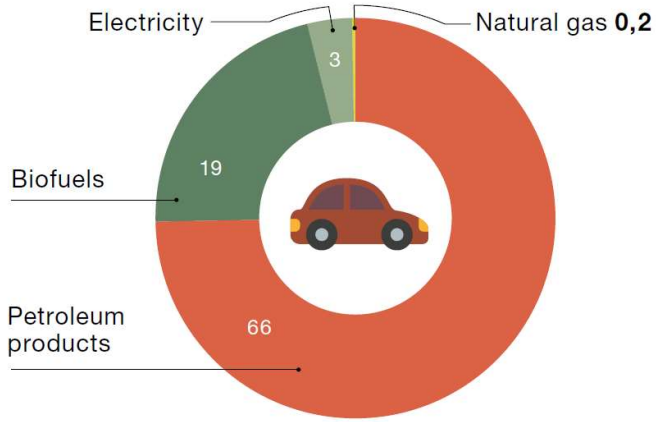
Final energy use in the transport sector, domestic, 1970–2017, TWh



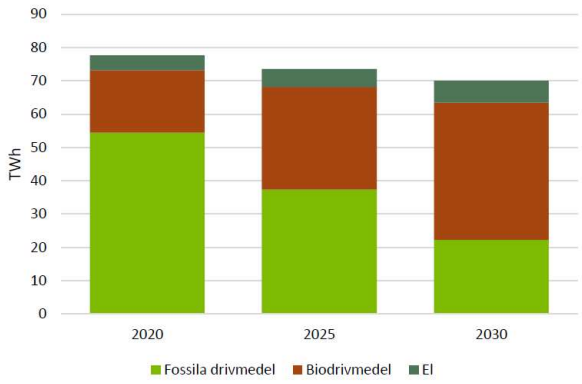
Sources: The Swedish Energy Agency, SCB (Statistics Sweden), Swedish Transport Agency.
Remark: Until 1989 all jet fuel was included in domestic aviation, however from 1990 and onwards the jet fuel was divided into domestic- and foreign energy use.

Final energy use in the transport sector, TWh, 2017

- Petroleum products, mainly gasoline and diesel, accounted for 75 per cent of the energy use in the transport sector in 2017.
- During the last few years, the amount of biofuels has increased significantly.
- Road transport accounted for 94 per cent of the final domestic transport sector energy use followed by rail transport (3 per cent), aviation (2.5 per cent) and shipping (0.4 per cent).



Source: The Swedish Energy Agency



Figur 2. Energianvändning inrikes transporter, TWh, reduktionspliktsscenario.
Anm: Inkluderar energianvändningen från flyg, bantrafik och inrikes sjöfart

Increase share of biofuels and improved energy efficiency is expected towards 2030 for Sweden

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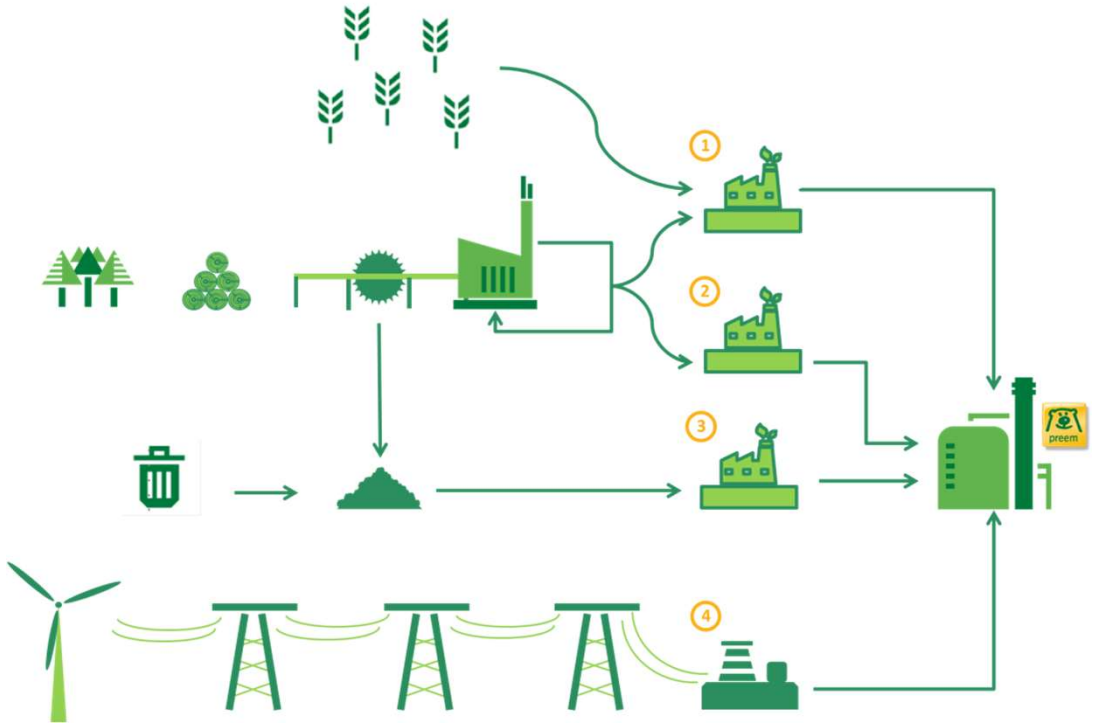
Preem's strategic renewable programs



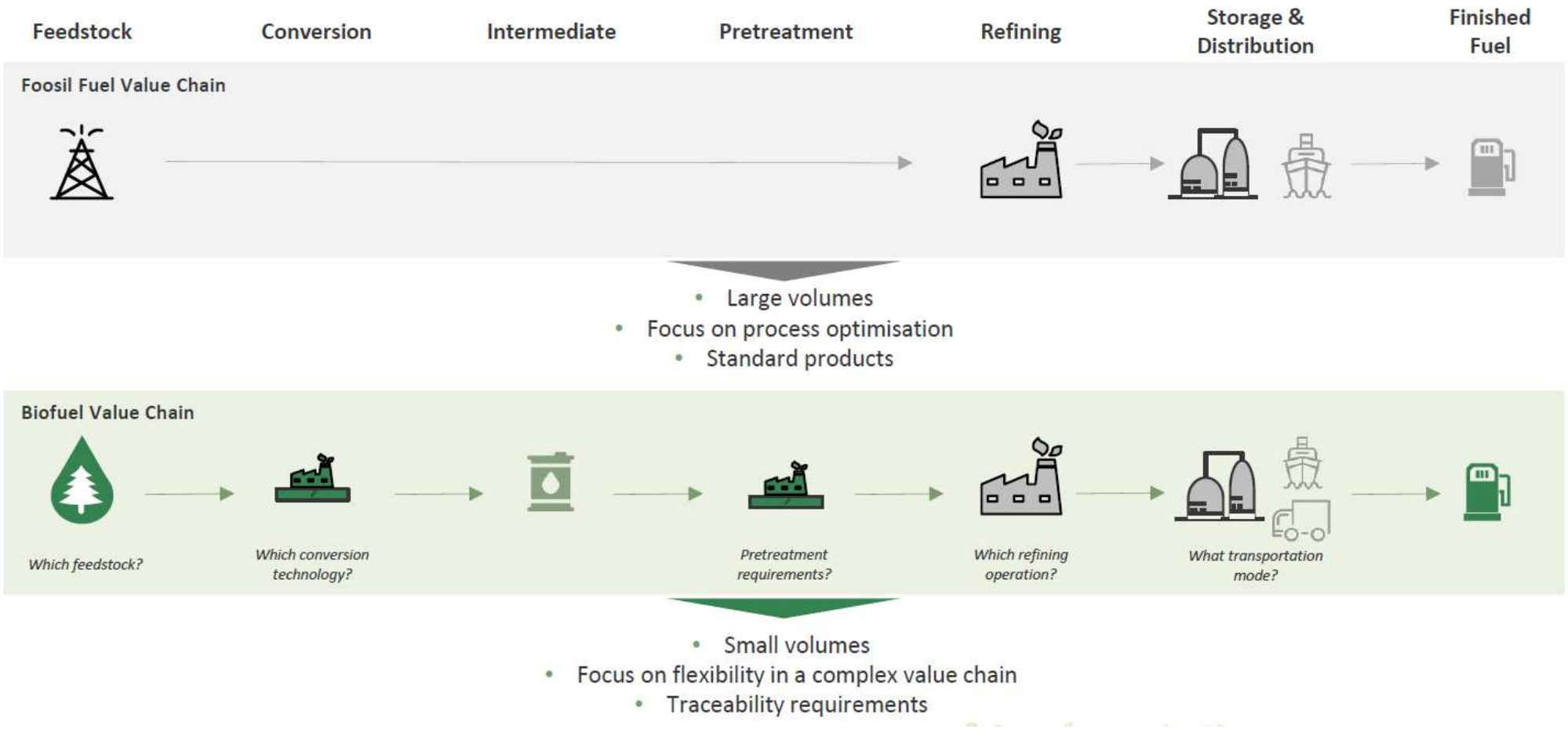
1. Increase HVO production
   - Increase from 250 00 to 1 300 000 m3/h

2. Extraction and liquefaction of lignin for upgrading in refinery
   - Cooperation with Renfuel AB
   - Cooperation with SunCarbon

3. Fast pyrolysis of solid biomass for upgrading at refinery
   - Cooperation with Biozin AS in Norway and Setra Group in Sweden

4. Electro fuels/CCS
   - Cooperation with Vattenfall for electrolyzer installation.
   - Demonstrate CCS at Lysekil refinery

Opportunities with renewable fuel production in an oil refinery - new value chains and business players/constellations



Challenges with co-processing of renewables from lignocellusic biomass

- Technical challenges
  - Miscibility with conventional refinery feed and stability during storage
  - Chemical composition and impurities that causes catalyst deactivation
  - Presence of hetero atoms (S, O, N…)
  - Effect on the refinery overall operations

- Other challenges
  - Sustainability determination and real emission reductions in overall value chain, not only by verification of renewable content in liquid product
  - Availability of feedstock for large scale production
  - Each feed needs to be validated in long term testing at industrially relevant scale

Opportunities for several insertion points in the refinery

- Crude oil distillation unit
- Fixed bed hydrotreater/cracker
- FCC
- Slurry hydrocracking

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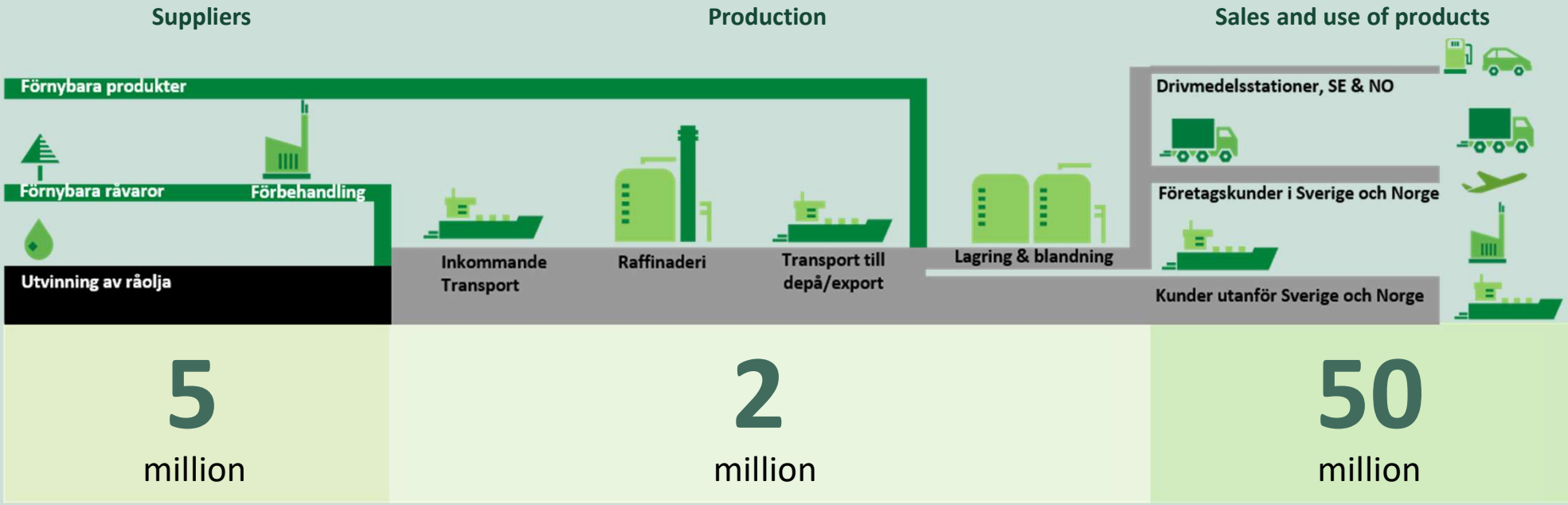
The hydrogen demand for HDO, HDS, HDN is a potential source for CO2 emissions

Source: Basu, P. Biomass Gasification, Pyrolysis and Torrefaction.
* Preem.

	Gasoline	Diesel	Vacuum resid*	VGO*	FPBO*	Lignin*
C (%)	84.9	87.4	85.0	85.3	49.2	63
H (%)	14.8	12.1	10.5	12.1	7.3	6
N (%)	0.08	0.04	0.8	0.2	0.3	0.2
S (%)			3.3	1.2	0.0	3
O (%)			0.7	0.4	43.2	27

Emissions throughout value chain: 57 million tonnes CO_2e



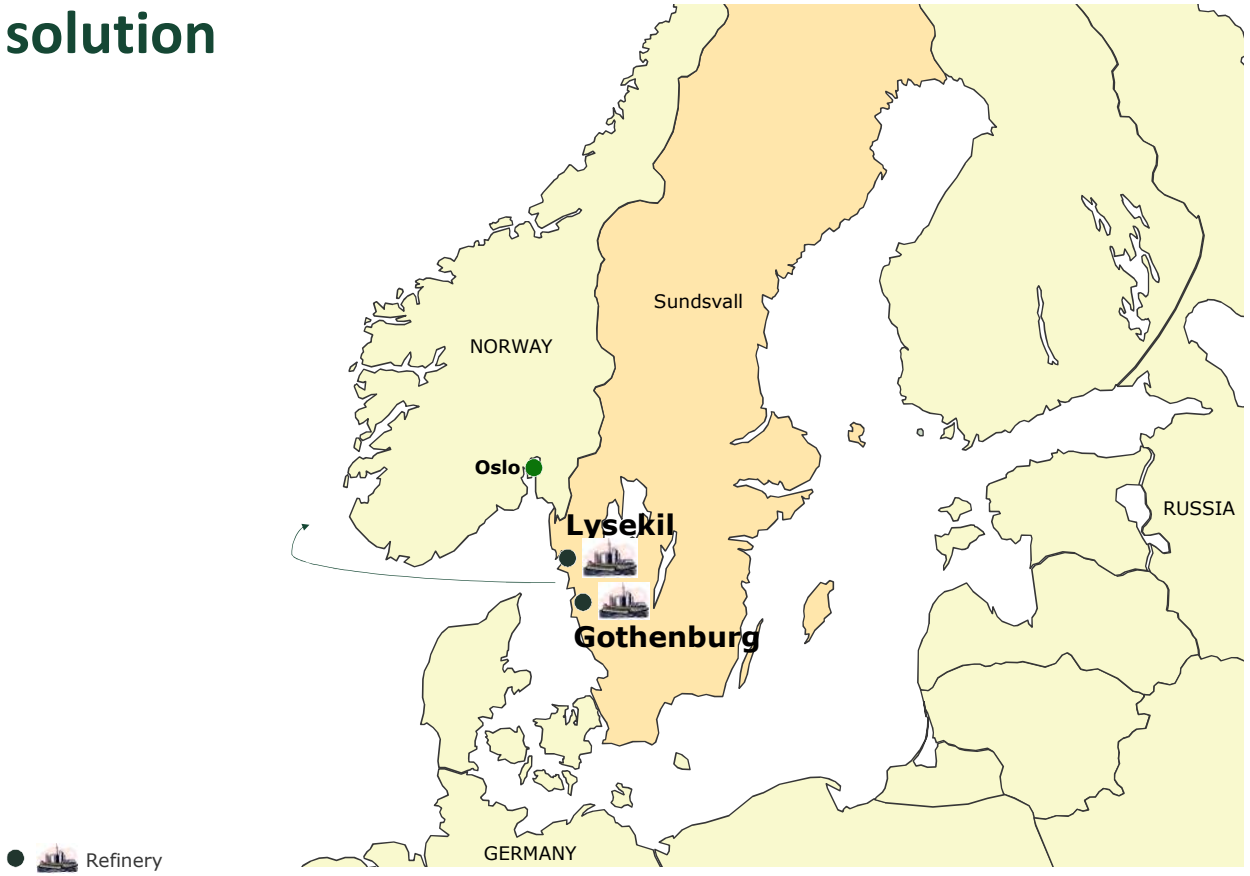
Ideal Refinery Locations with Direct Deep Sea Access makes Preem a good candidate for a North Sea CCS solution

Location

- Both Lysekil and Gothenburg Refineries have deep water access
- Both refineries could be a part of a Skagerrak cluster where CO_2 could be transported to a centralized hub for storage

Infrastructure

- Preem has two large Hydrogen plants where CO_2 concentration is high
- Excess heat, available at both refineries could potentially be utilized as energy source for capturing CO_2
- Three more SMRs are being planned



Conclusions

- Biocrudes and bio-oils have potential to be co-processed in Preem's refineries thus producing large volumes of liquid drop in transport fuels in mid to long term.
- The bio-fuel value chain is in itself challenging with respect to feedstock volumes, pre-treatment methods under development and business constellations.
- Policies that rewards biofuels with high emission reduction potential is supportive in order to develop highly sustainable conversion technologies.
- Cost effective and renewable source of hydrogen will be crucial for the future hydrotreatment of renewable feedstocks.
- Renewable carbon molecules in the co-processed liquid products can have a large impact of overall CO2 emissions.
- CCS is also relevant for Preem to become climate neutral by 2045.

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