Transportation fuels from biomass via gasification route

From R&D to demonstration and flag ship plant

BTL2030 project
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Huge EU market after 2030 - How Can Be Satisfied – 5 %?

What would mean e.g. 5 % of EU market?
- 15 Mtoe/a in road transport
- 300 gasification-synthesis plants of 150 MW feed
- e.g. 25 plants/year after 2030 => 5 B€/year investment

Aviation fuels: 4 % target
- 2 Mtoe/a
- 40 gasification-synthesis plants

Sustainability and ILUC
- GHG reduction > 60 % (Gasification-BTL > 80 %)
- Residues are the main feedstocks of gasification BTL

Source: European Biofuels Technology Platform, SRA Jan. 2008
Solutions for biofuel production from domestic feedstocks in Finland
Target for renewable energy use of 40% by 2030

Government's policy: the share of renewable fuels to 40% by 2030

International influencing, EU 2030 policy, EU SET-Plan, new exports

Gasification

Ethanol
HVO
Biogas (not SNG)

Regulation, sustainability, cascade-use etc.

Several small plants
Kajaani 10,000 m³/a
Myllysuo 90,000 m³/a
Other
Skövde ap. 400 ktoe
Näantali ap. 40 ktoe
Lappeenranta 100 ktoe

Liquefaction

HVO
Kajaani 10,000 m³/a

Pyrolysis

Fuel gas for furnaces and boilers

Suitable for wide range of domestic woody raw material,
Additional production capacity of 600-900 ktoe/a by 2030

Limited raw-material basis - not very suitable for forest residues, black liquor or bark

VTT-pilot + Industrial Demo
City-Refinery
Forestindustry cases
CHP-integrates

Suitable for wide range of domestic woody raw material,
Additional production capacity of 600-900 ktoe/a by 2030

VTT
Key steps in gasification based synfuels process

- **Gasification**
- **Filtration**
- **Reforming**
- **Ultra-cleaning**

**Syngas toolbox**

- Biomass and wastes: 100 MW
- Renewable heat: 30 MW
- Renewable fuel/chemicals: 55 MW
- Input/output: 5-20 €/MWh
- Price: 30-50 €/MWh
- 80-130 €/MWh
Biomass gasification for biofuels and bio-chemicals
- Long experience of medium-to-large scale synthesis gas technologies

- Coal gasifier applied for peat and wood
- Large-scale gasification specially developed for wood feedstocks
- New process for smaller scale and with lower CAPEX
Why commercial gasification and synthesis plants are not yet under construction?

**Economic challenges of first-of-a-kind (FOAK) plants**
- Investment typically 50% higher than for mature plants
- Large > 100 ktoe/a plants require 500 - 1000 M€ investment
- Financing of FOAK carries significant risk component

**Significant political uncertainties**
- Binding targets for renewable fuels missing
- Long-term support for large-scale flag ship projects too expensive
- Complex sustainability issues

HVO and first generation biofuels have so far satisfied the market

**Smaller plant size and simplified processes needed!**
- Reducing CapEx and introducing smaller first-of-a-kind plants
- Maximise integration benefits – biomass logistics, heat integration
- Use local residues and wastes to ensure sustainability
Integrating production of fuels and chemicals from biomass and residues to existing industries to improve competitiveness

Several local sites with CHP integration
- Forest and agricultural residues
- Industrial and municipal wastes
- Integration to district heating, forest, chemical or metal industries

Transport of intermediate products
- Methanol
- Synthetic hydrocarbons (FT)
- Synthetic methane (SNG)

Large-scale refineries or chemical industries
- Co-refining
- Drop-in transportation fuels
- Olefins for renewable packaging materials
- Basic chemicals, fertilisers
- Aromatics
City Refinery Concept: “Vuosaari Gas Hub”
An example of integration alternatives studies in the BTL2030 project

INNOVATIVE SOURCING OF URBAN RESIDUES AND WASTES

- Residues from parks and horticulture, used wood
- Used packaging materials
- By-products from local industries
- Source-separated household wastes
- Sludges from waste water treatment

CONVERSION UNIT INTEGRATED TO CHP PLANT

GASIFICATION & SYNTHESIS

STEAM TO GASIFIER & HEAT FOR BIOMASS DRYING

BIOMASS

FUEL

CHP PLANT

STEAM & OFF-GASES

NATURAL GAS

HEAT

ELECTRICITY

FINAL REFINING TO VALUE-ADDED PRODUCTS

- Sustainable fuels for air, maritime and heavy duty road transport
- Renewable plastics: ABS for boats, lego etc. and olefins for packaging materials
- High-value products: biopanadol, aromatics
- Biofertilizers
- Recovered metals
Production cost estimate for FT liquids: Sensitivity to feedstock price

ASSUMPTIONS
- First-of-a-kind plant or nth plant
- Scale: 1000 bpd (150 MWBIOMASS)
- Availability: 8000 h/yr
- WACC: 8%
- Plant economic life: 20a
- Fixed O&M: 4% of TCI/a
- Electricity: 60 €/MWh
- Heat: 40 €/MWh

CAPEX, M€

CAPEX, M€

https://www.vtt.fi/sites/BTL2030/en
Heat-integrated medium-scale BTL process via piloting and demonstration to industrial use

**P0:** Concept development – PRECHEM-Kokkolan Biorefinery project (2015)

**P1:** Piloting at VTT Bioruukki and system studies 2016-18, 2.7 M€

**P2:** Demonstration at power plant site or at VTT Bioruukki, 2019-22, 20-50 M€

**P3:** First production plant, 200 M€
  Capacity 30 ktoe/a, Investment decision 2022, construction 2022-24
  operational 2025 =>

**P4:** Several plants in operation after 2030, investments 250 M€/plant
  2030: 5 plants, total 250 ktoe/a
  2040: 10 plants, total 600 ktoe/a

Phase 1: Piloting and evaluation project, on-going as national project and two EU H2020 projects
Phase 2: Demonstration project, will be planned together with industrial partners – possible realization 2019-2022
Phase 3: Industrial Flagship project
Alternatives of the intermediate demonstration before entering into Flag ship project

Objectives
- To lower the technical risks related to key enabling technologies
- To gain long-term experience on process performance with different feedstock
- To test effects of new process developments and to define an optimal process concept

Rationale
- To test the processes at as small-scale as technically possible in order to minimize costs
- To involve a group of companies representing the whole value chain which could later on make profit from industrial follow-on projects
- To carry out this critical and not economically profitable stage with strong public support

Main alternatives
A. Slip-stream gas cleaning and fuel synthesis demonstration connected to an industrial gasification plant (similar idea to the NSE demo plant as operated in Varkaus in 2009-11)
B. To build and operate a small pilot-scale (1-3 MW input) demonstration plant at VTT Bioruukki demonstrating the whole chain from biomass gasification to fuel synthesis
BTL2030-project – Case A: Industrial slip stream demo
(required budget 50-60 M€ - part of which would be commercial fuel gas investment)

"Critical demonstrator" in an industrial environment

- DRYING & GASIFICATION
- HOT FILTRATION
- REFORMING AND FINAL GAS CLEANING
- BOILER OR INDUSTRIAL KILN

10 – 30 MW

1 – 3 MW slip stream

- Energy production covers costs after public support for the investment
- Low risks: CFB/air-blown gasifier modified to a DFB process

Slip stream demonstration of alternative final products:
- EU H2020 demo project(s)
- Further R&D & piloting projects
- Partnering with leading synthesis technology suppliers

https://www.vtt.fi/sites/BTL2030/en
How to realize alternative A: industrial slip stream demo

- Main principles of this alternative
  - Industrial fuel gas production pays back part of the investment and enables continuous operation
  - The costs of slip-stream testing of gas cleaning and synthesis technology are reasonable to reduce the risks before entering into flag ship project
  - Different public financing instruments and sources can be applied simultaneously

- Requirements
  - The investor of the primary fuel gas plant exists and has interests also on BTL
  - Other parts of the BTL value chain are also represented by companies who are willing to invest on the project and can foresee profitable business from BTL

- This is most suitable for a large national effort realized by a group of Finland-based companies – on the road in fulfilling national strategy
  - 10-15 M€ investment support (TEM) + 10-15 € from Business Finland or H2020

- Main challenges
  - The interests of the fuel gas investment and BTL demonstration may be controversial thus limiting the scope of demonstration
  - The main investor should also be and important part of the future value chain of BTL
BTL2030-project – CASE B: Pilot-scale demonstration of the complete production chain at VTT (~ 15-25 M€)

- Gasification at 2 MW scale
- Hot filtration & reforming
- Simplified final gas cleaning
- Synthesis demo
  - 1 t/day production
  - 150-200 tons to be produced
- 1 MW district heat boiler at VTT Bioruukki

Most critical novel technologies to be verified in long-term semi-industrial operation

- Final product upgrading
- Product characterization
- Engine testing

https://www.vtt.fi/sites/BTL2030/en
How to realize alternative B: Pilot-scale demo at VTT

- Main ground-braking ideas of this alternative
  - The whole production chain is demonstrated at the smallest realistic scale, which enables continuous operation
  - Small-scale results in reasonable costs (15-25 M€) and enables process optimization and modifications without major economic risks
  - Various feedstock can be tested and a total of 200 tons of products would be produced for final refining tests

- Requirements
  - A suitable group of industrial companies are committed to the project and can foresee profitable business from follow-on industrial BTL projects
  - National funding for a 15 M€ project can be found with 50% industrial share (in this case the consortium could consist mainly of Finnish companies)
  - EU-IA financing is an alternative way for realizing this alternative with 20 M€ (in this case and European consortium with a max- of 3-5 Finnish partners is needed)

- Main challenges
  - Long continuous operation at VTT Bioruukki would require also external personnel
  - After this project there would still be some risks related to scaling up the processes