Transportation fuels from biomass via gasification route

From R&D to demonstration and flag ship plant

BtL2030
www.vtt.fi/sites/BTL2030/en

COMSYN
www.comsynproject.eu

FLEXCHX
www.flexchx.eu

BTL2030 project

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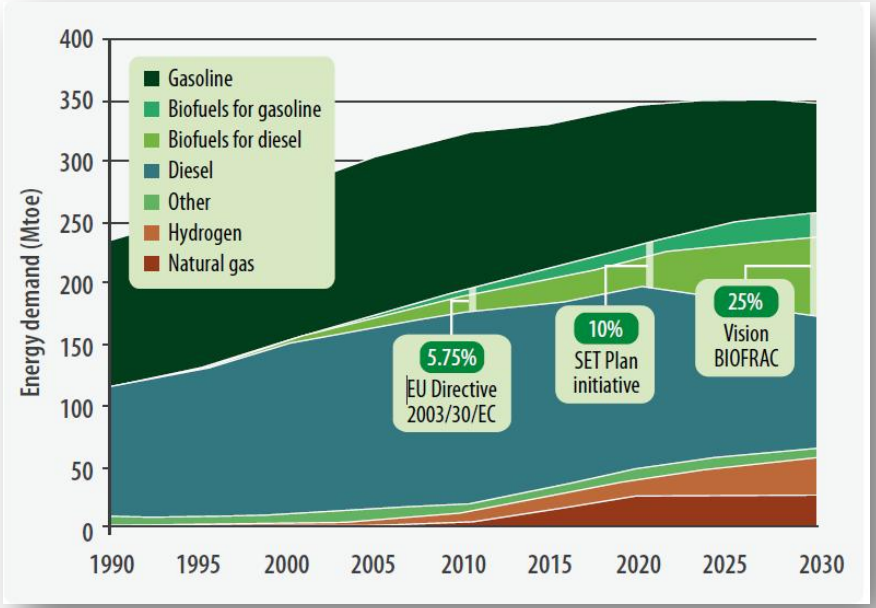
Huge EU market after 2030
- How Can Be Satisfied – 5 %?



Source: European Biofuels Technology Platform, SRA Jan. 2008

Biofuels Technology Platform

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

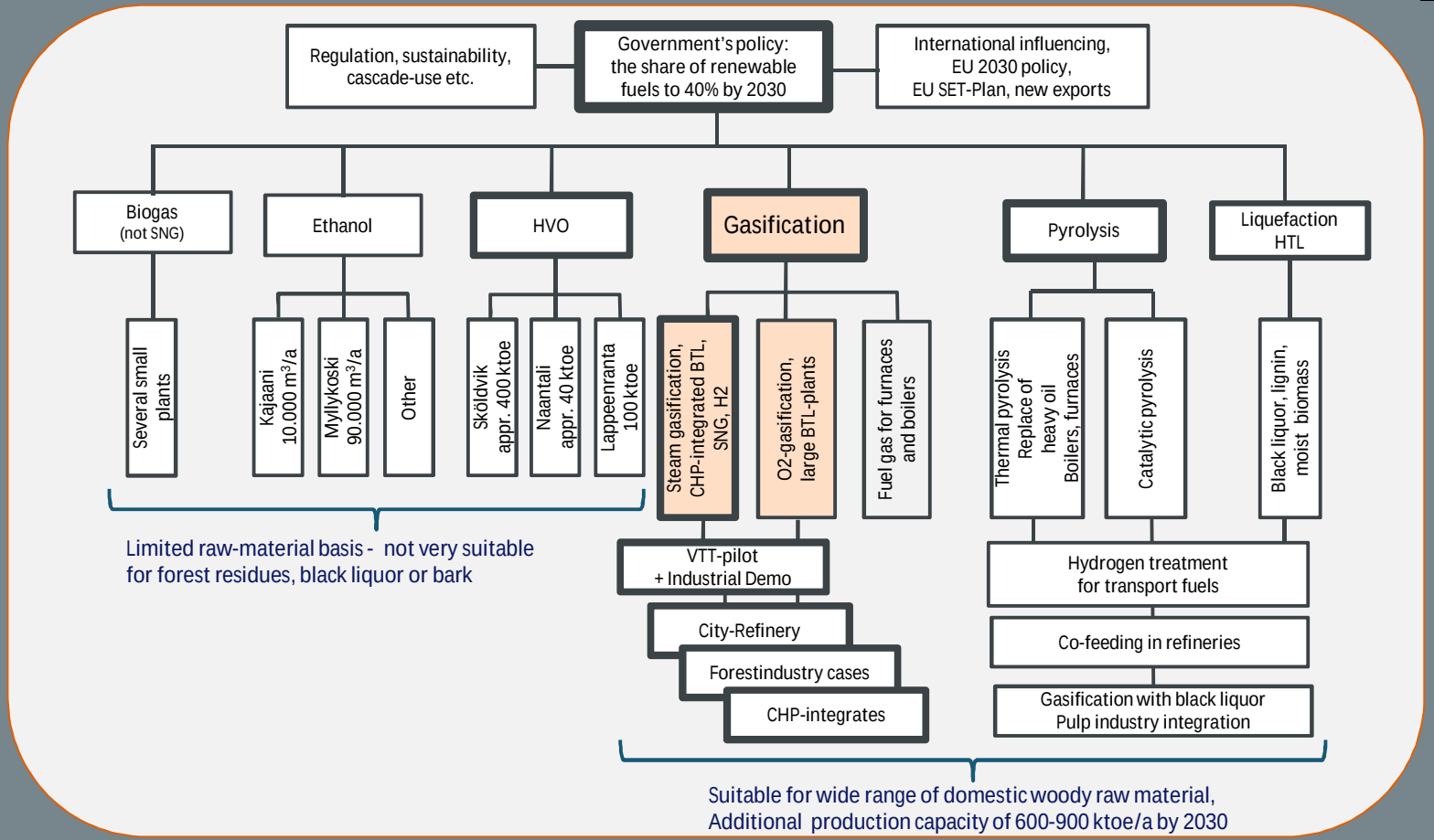
- 2 Mtoe/a
- 40 gasification-synthesis plants

Sustainability and ILUC

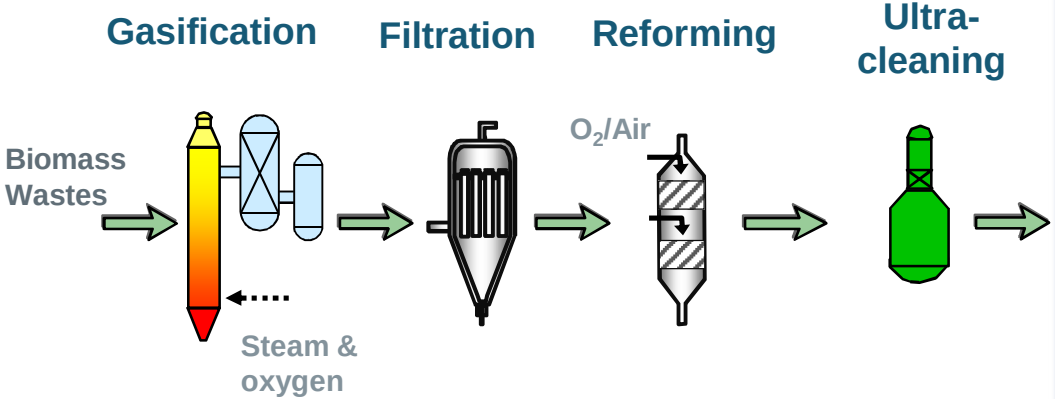
- GHG reduction > 60 % (Gasification-BTL > 80 %)
- Residues are the main feedstocks of gasification BTL

Solutions for biofuel production from domestic feedstocks in Finland

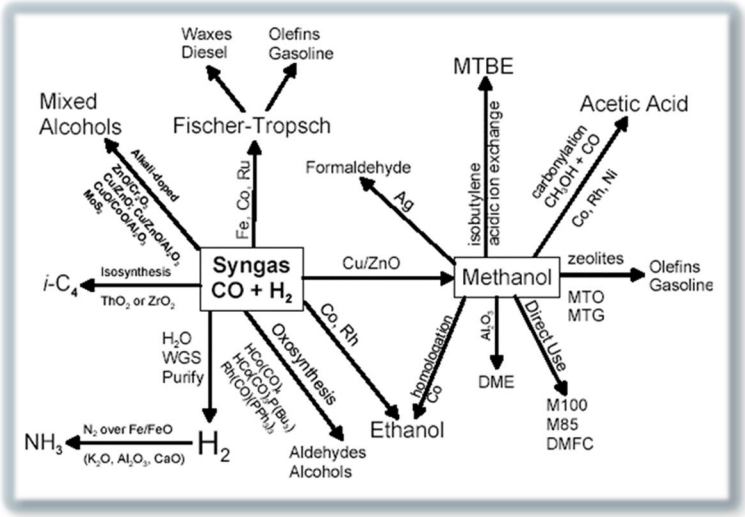
Target for renewable energy use of 40 % by 2030



Key steps in gasification based synfuels process



Syngas toolbox



	Biomass and wastes	Renewable heat	Renewable fuel/chemicals
Input/output	100 MW	30 MW	55 MW
price	5-20 €/MWh	30-50 €/MWh	80-130 €/MWh

Biomass gasification for biofuels and bio-chemicals

- Long experience of medium-to-large scale synthesis gas technologies

PEAT AMMONIA PLANT
OULU, FINLAND, 1991

NSE BIOFUELS DEMO, VARKAUS, FINLAND, 2011

PILOT PLANT AT VTT BIORUUKKI, ESPOO, 2016

1985 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030

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

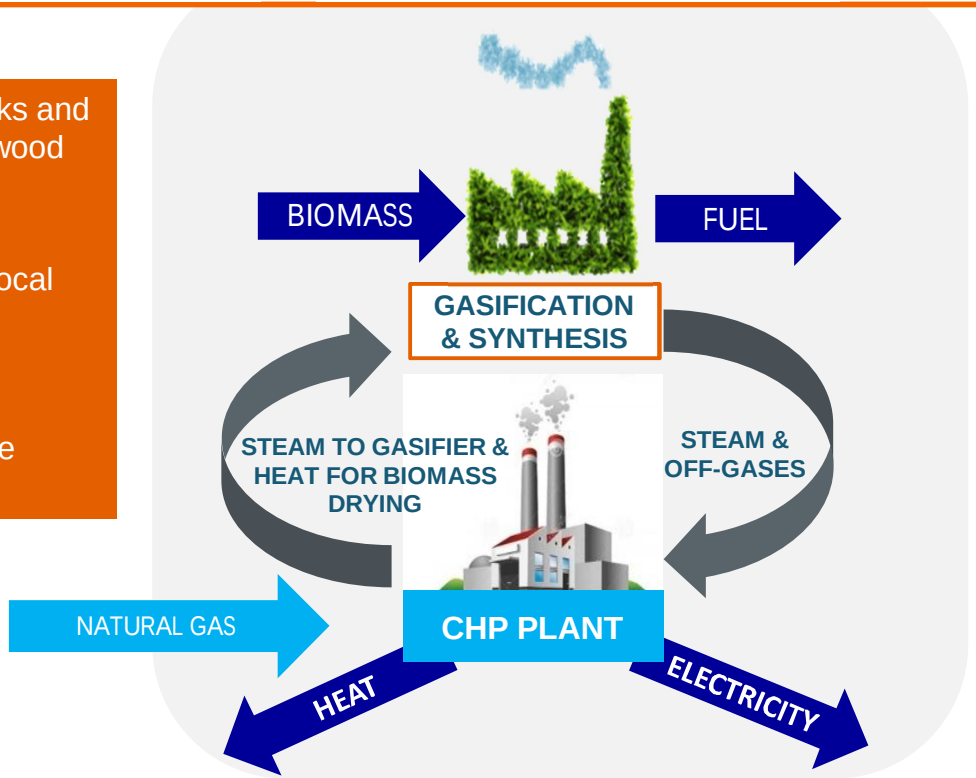
- Co-refining
- Drop-in transportation fuels
- Olefins for renewable packaging materials
- Basic chemicals, fertilisers
- Aromatics

City Refinery Concept: ”Vuosaari Gas Hub”

An example of integration alternatives studies in the BTL2030 project

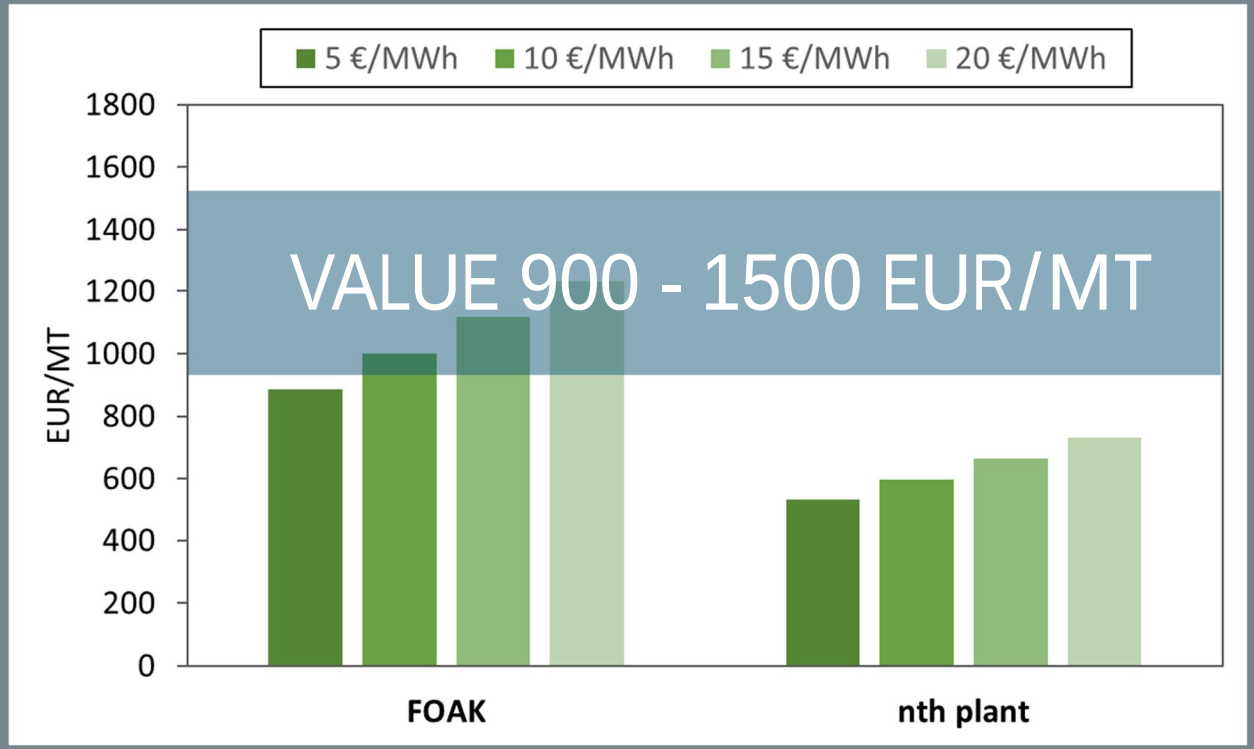
INNOVATIVE SOURCING OF URBAN RESIDUES AND WASTES → **CONVERSION UNIT INTEGRATED TO CHP PLANT** → **FINAL REFINING TO VALUE-ADDED PRODUCTS**

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



- 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 $MW_{BIOMASS}$)
- 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€	300	200

https://www.vtt.fi/sites/BTL2030/en

Heat-integrated medium-scale BTL process via piloting and demonstration to industrial use

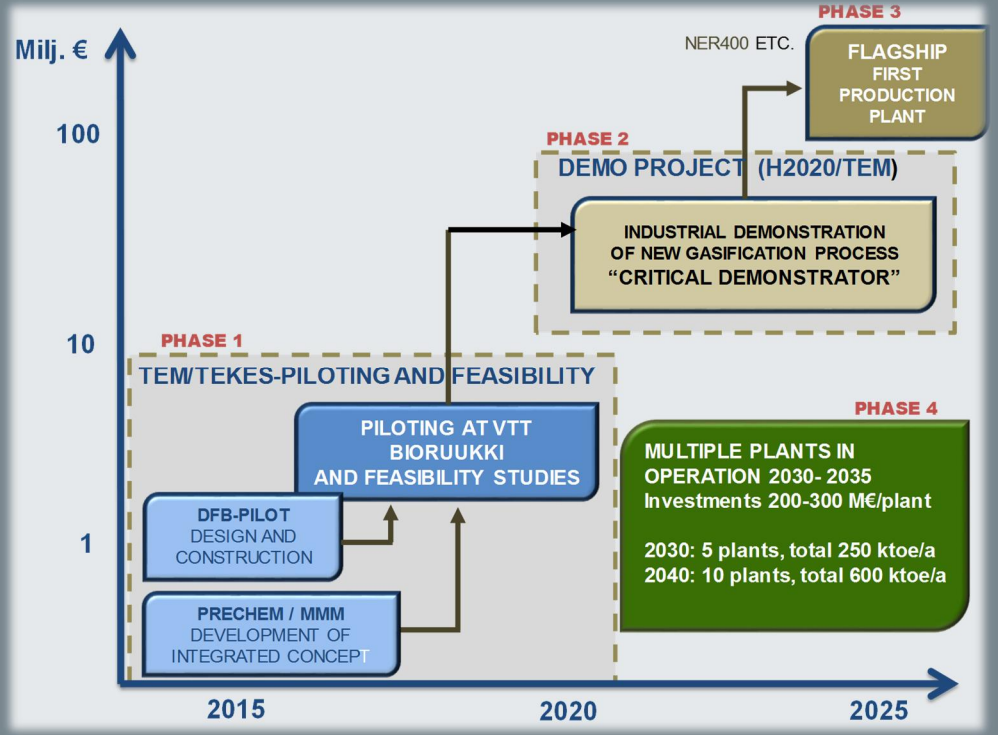
P0: Concept development – PRECHEM-Kokkolan Biorefinery project (2015)

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 operationial 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

Low risks: CFB/air-blown gasifier modified to a DFB process

DRYING & GASIFICATION

HOT FILTRATION

10 – 30 MW

Energy production covers costs after public support for the investment

BOILER OR INDUSTRIAL KILN

1 – 3 MW slip stream

REFORMING AND FINAL GAS CLENING

FT-DEMO or PSA-H2 or SNG

Slip stream demonstration of alternative final products:

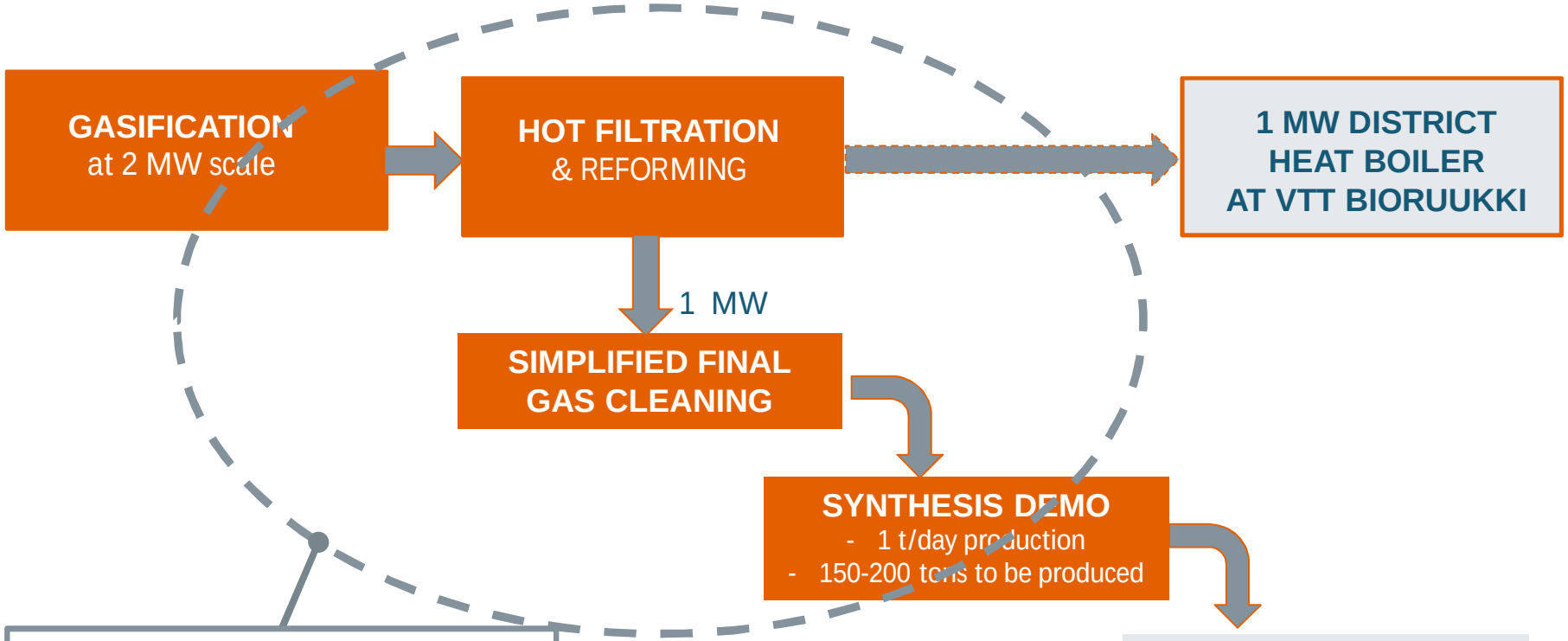
- EU H2020 demo project(s)
- Further R&D & piloting projects
- Partnering with leading synthesis technology suppliers

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€)



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