

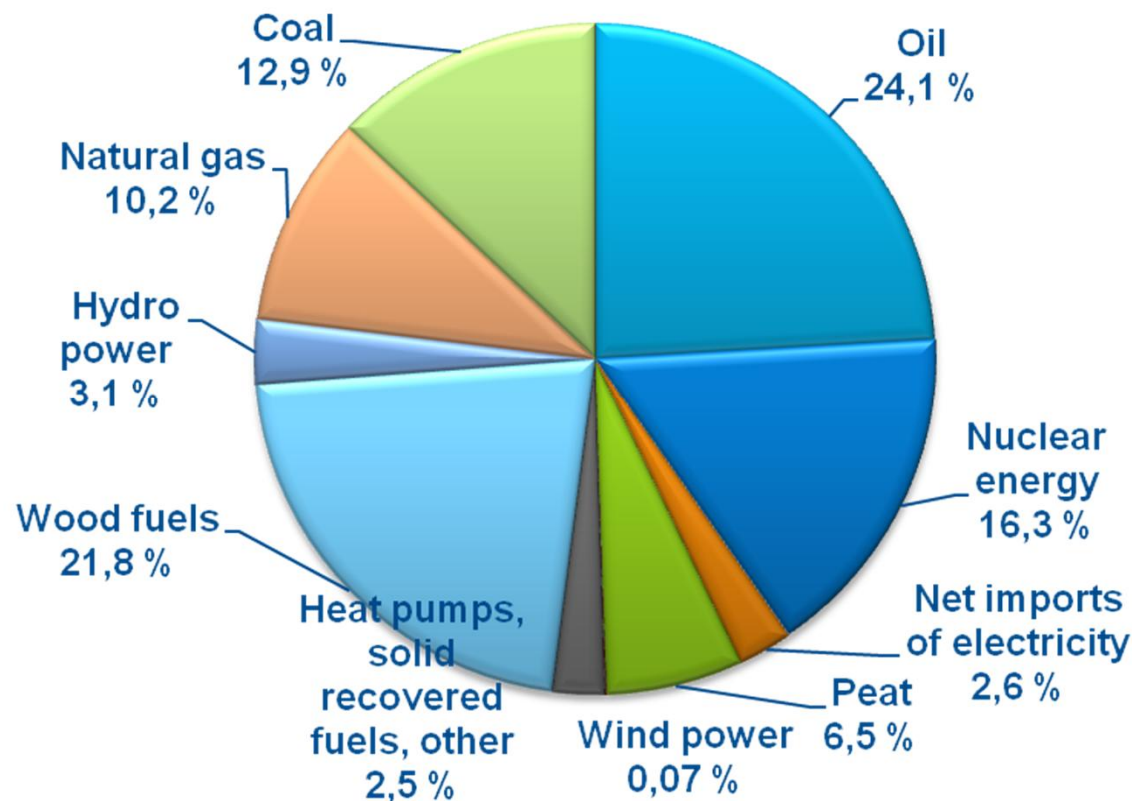
Challenges and opportunities of biofuel production in Finland

Esa Kurkela

VTT Technical Research Centre of Finland Ltd
COMSYN workshop on 2nd generation biofuels
Stuttgart 18.4.2018

Characteristics of the energy sector in Finland

- § Versatile structure of energy production with high efficiency (30 % of electricity by CHP)
- § Indigenous energy sources cover only 1/3 of the energy demand
- § High share of RES 25 %
- § Energy intensive industry covers 50 % of the energy demand
- § CO₂ tax on fuels introduced already in 1990's
- § EU-Targets to reduce CO₂ emissions -40% by 2030



Special targets set by the Finnish Government

- ” To increase the share of renewable transport fuels to 40 % by 2030”
- ”To stop using coal in energy production and to halve the use of imported oil for domestic use”

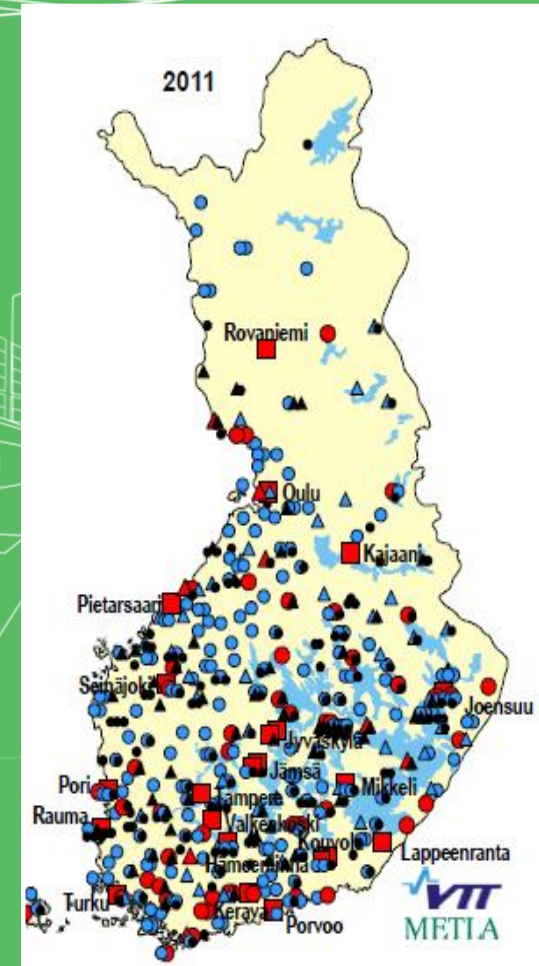
FOREST ENERGY

– ONE BACKBONE OF BIOECONOMY



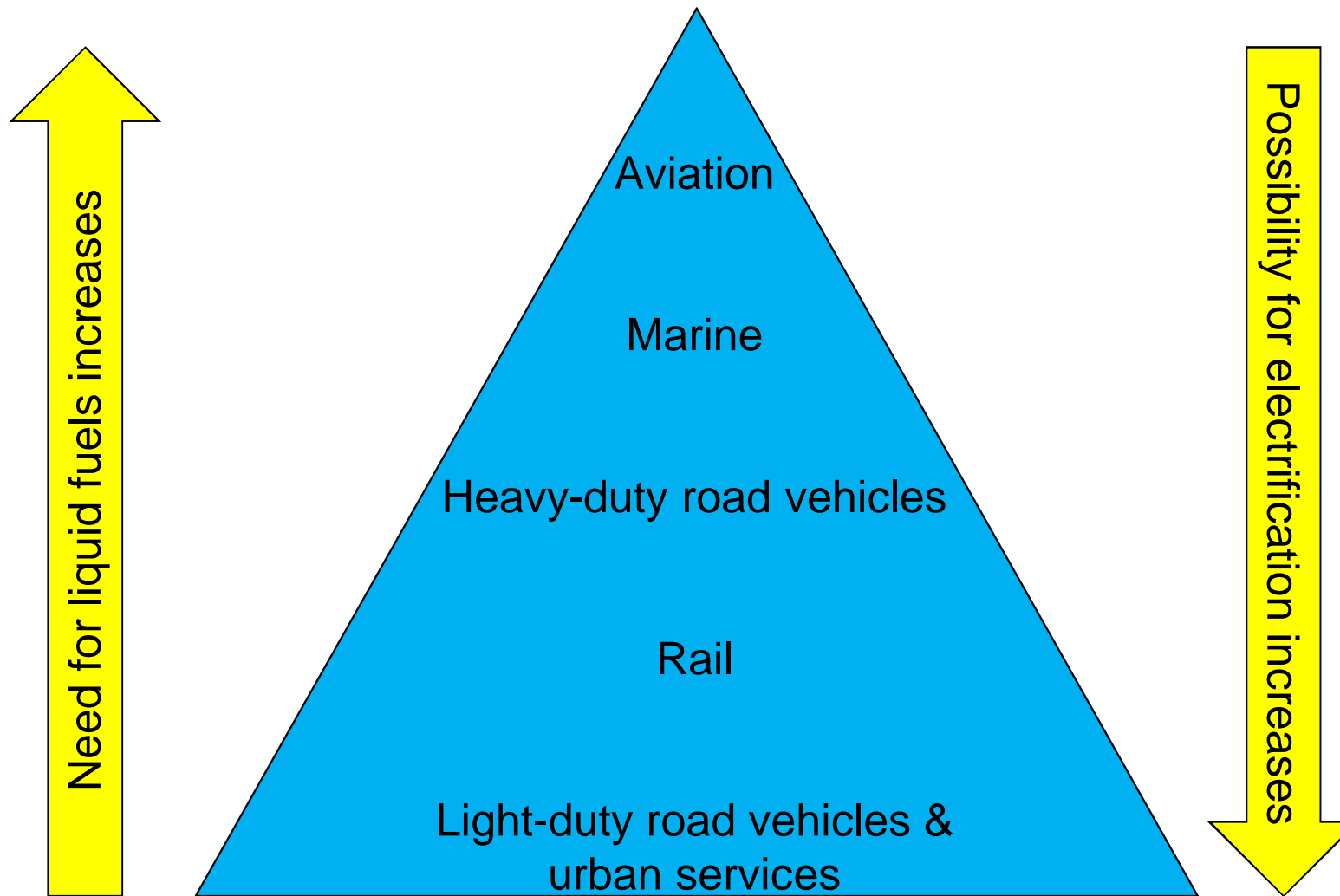
Finnish Expertise in Bioenergy
= Heat, power, fuels

Finnish companies handle the whole chain
Strong R&D support from VTT, LUKE and Universities



Use of forest residues:
8 Mm³ (2012) at > 500 sites

Hierarchy of fuels



NESTE

- § Leading producer of renewable diesel in the world
- § Annual production capacity of 2.6 million tons
- § Production in Porvoo/Finland, Rotterdam and Singapore



NEXBTL technology allows flexible use of different vegetable oils and waste animal fat as raw material

NESTE to boost biofuel production by 1m tonnes with opening of Singapore refinery.

Posted on Dec 14, 2017 3:55:59 PM

"We investigated the strengths of both potential operating environments, and also revisited our outlooks for raw materials and demand."

Neste, the Finnish company well-known for its work with fossil fuels is to continue its push to establish itself as a major player in biofuels, after it chose Singapore as the planned site for its next bio-refinery that will boost production by around one million tonnes.

Neste elected to locate its next bio-refinery in Singapore, seven years after opening its first biofuel site in the country, to increase its capacity for renewable diesel, aviation fuel and raw materials for various biochemical uses. The latest production facility, which Neste says will begin operations in 2022, will include an improved pre-treatment unit that will be used to make use of waste materials that are of poor quality.



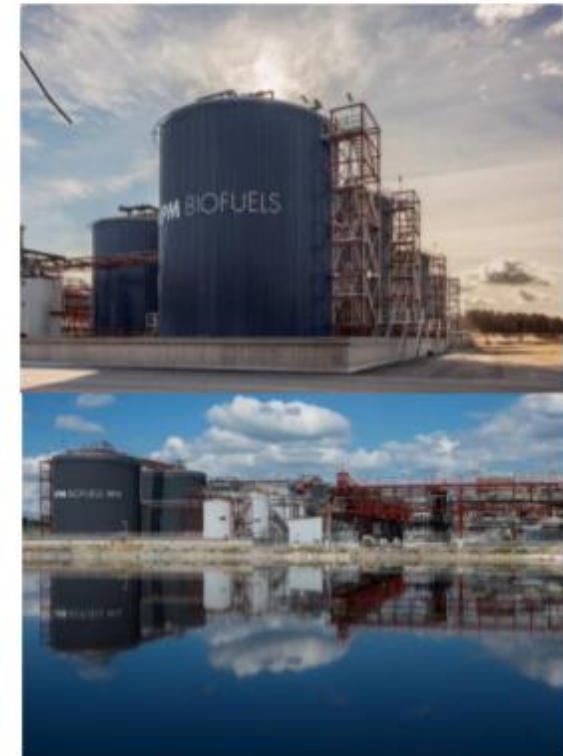
<https://www.biobasedworldnews.com/neste-boost-production-biofuel-singapore-refinery>

Renewable diesel UPM BioVerno wins EU Sustainable Energy Europe Award



The UPM Biofuels has received the European Union's Sustainable Energy Europe Award 2014 in the "Travelling" category for its renewable crude tall oil based UPM BioVerno diesel in Brussels, Belgium. The Sustainable Energy Europe Awards reward and promote Europe's best sustainable energy projects in the fields of energy efficiency, renewables and clean transport.

<http://www.upmbiofuels.com/whats-new/biofuels-stories/renewable-diesel-bioverno-wins-eu-sustainable-energy-europe-award/Pages/Default.aspx>



- § Lappeenranta, Finland
- § HVO-like renewable diesel from tall oil (wood-based residues from pulping)
- § Capacity: 100 ktoe/a

http://www.etipbioenergy.eu/images/Factsheet_UPM_final.pdf



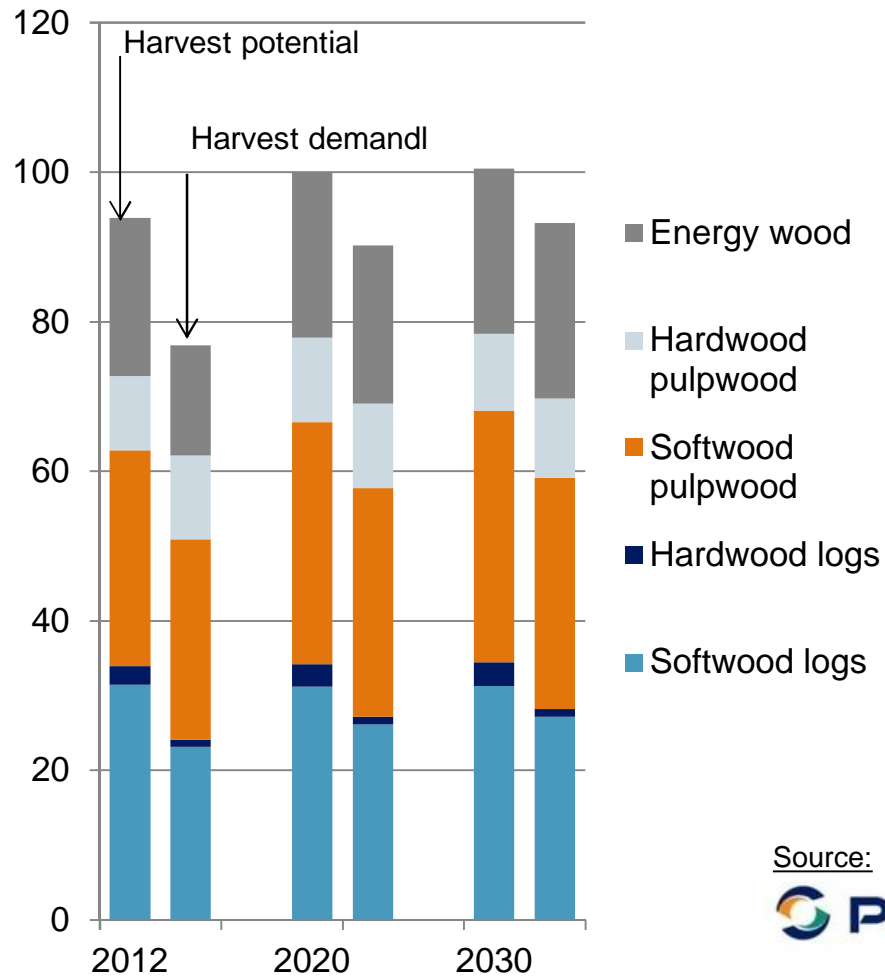
**THE MORE YOU UTILIZE YOUR FOREST,
THE BIGGER FOREST RESOURCE YOU WILL HAVE**

**76 % of land area in Finland is
covered by forests**

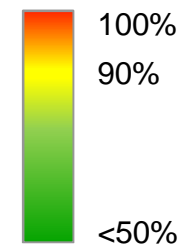
FINNISH WOOD BALANCE – MAXIMIZING CASCADING

Annual
growth
million
m3/a

CrossCluster 2030 scenario

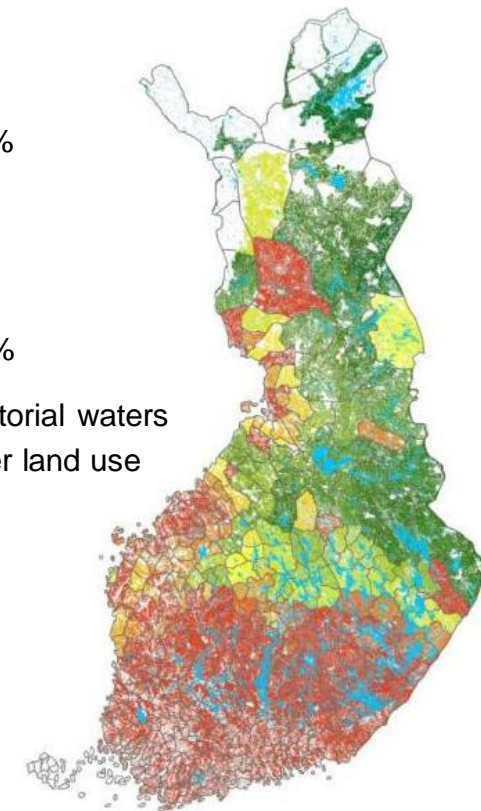


Forest chips potential
utilization rate (%) 2020



■ Territorial waters

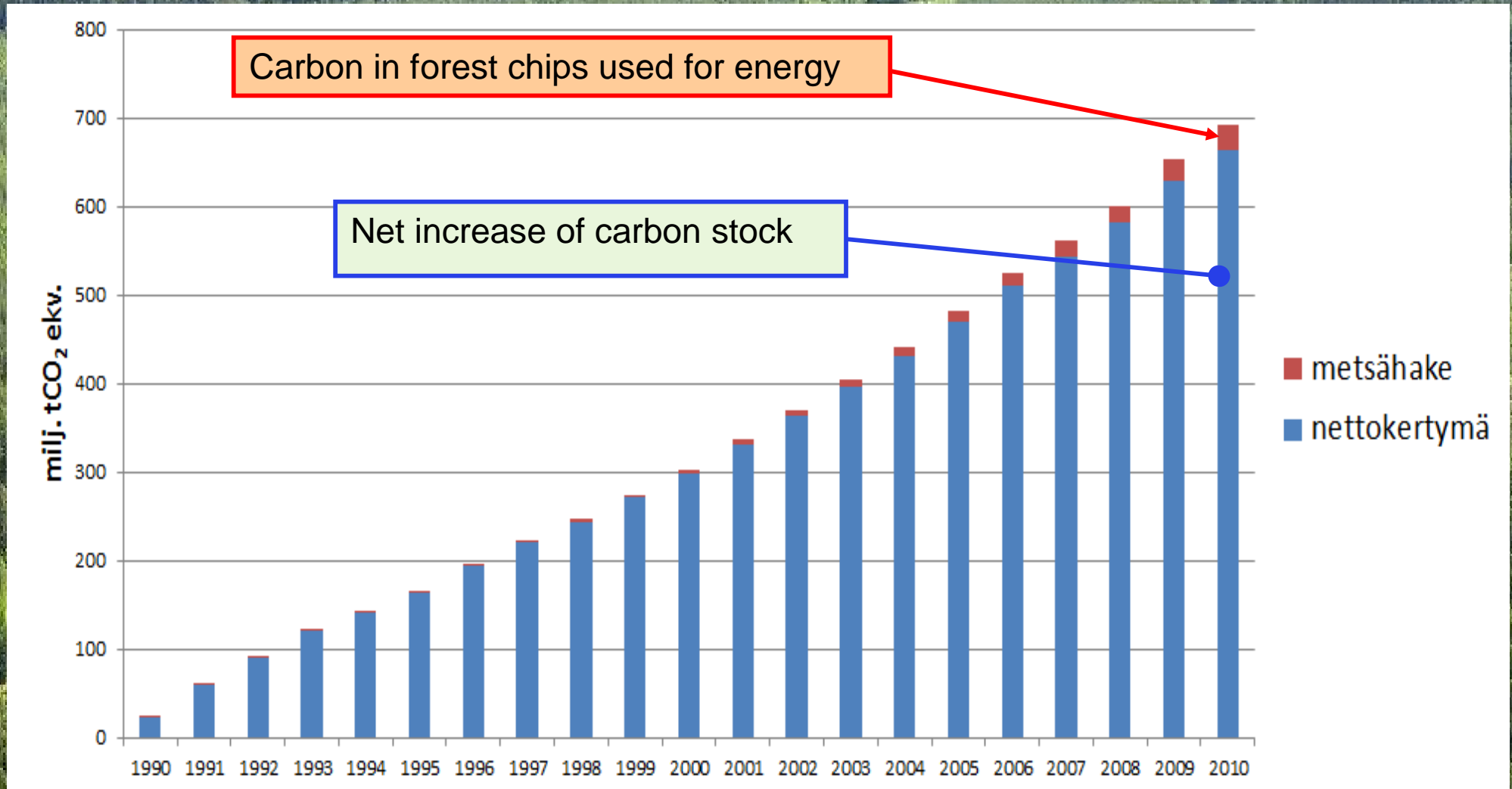
■ Other land use



Source:

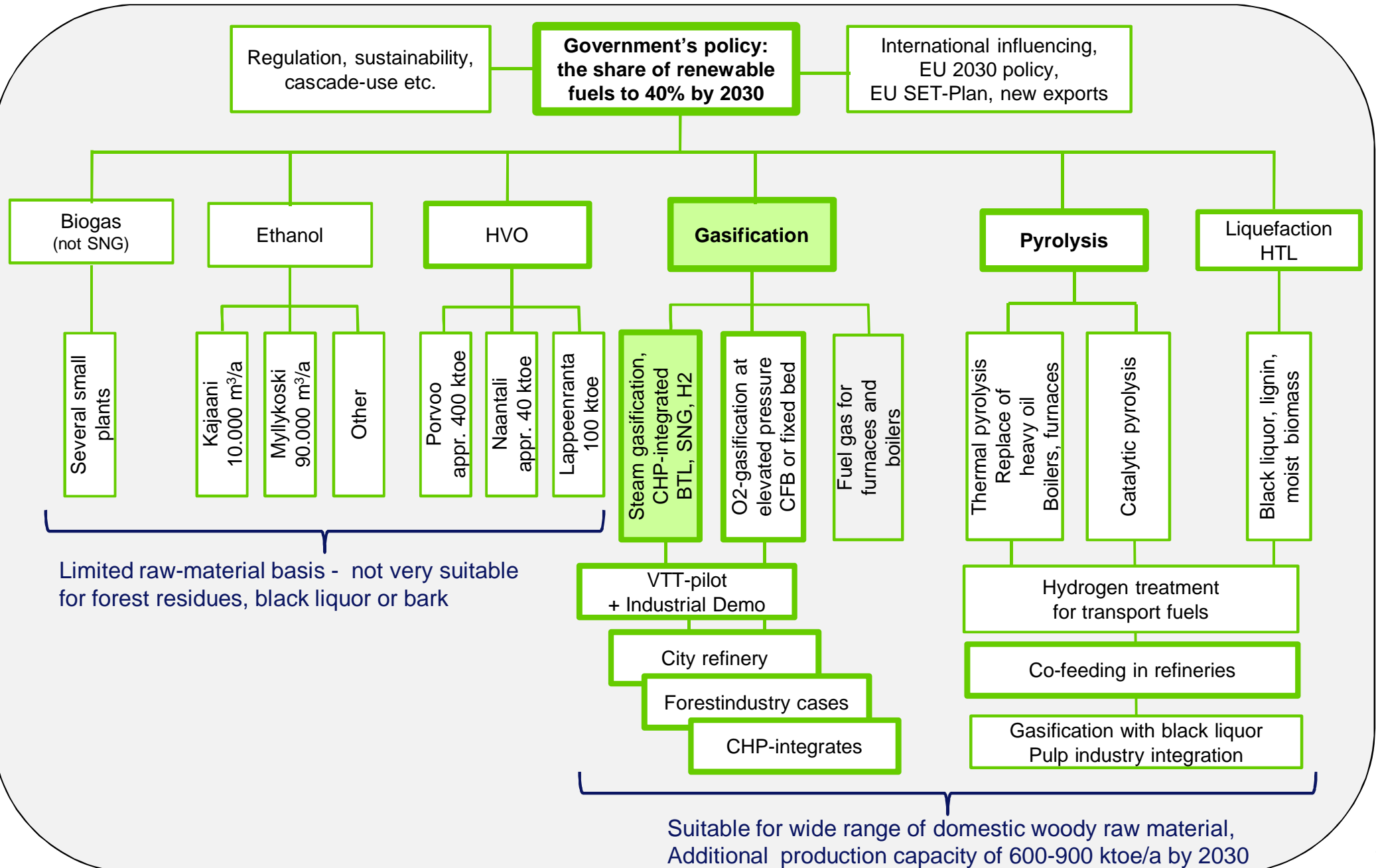


Net increase of carbon stock in the Finnish forests in 1990 - 2010



Solutions for biofuel production from domestic feedstocks in Finland

Target for renewable energy use of 40 % by 2030



Integrating production of fuels and chemicals from biomass and residues to existing industries to improve competitiveness

Several forest industry sites with local CHP integration



- Forest residues and agricultural residues
- Industrial and municipal wastes
- Integration to food, forest, chemical or metal industries

Transport of intermediate products



- Pyrolysis oil
- Methanol
- Synthetic hydrocarbons
- Synthetic methane

Large-scale refineries or chemical industries



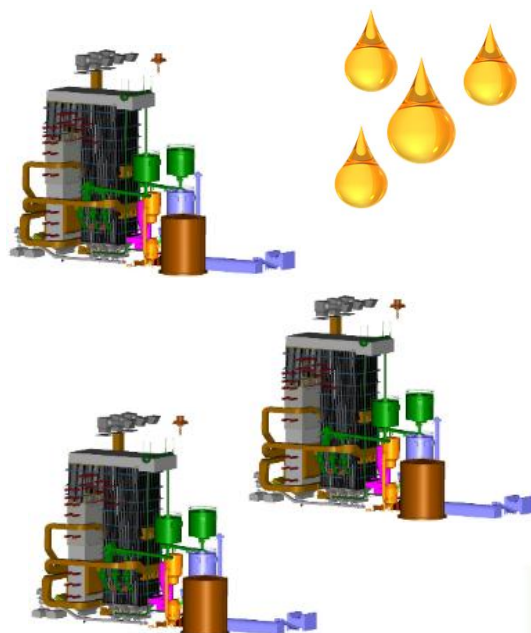
- Co-refining
- Drop-in transportation fuels
- Olefins for renewable packaging materials
- Basic chemicals, fertilisers
- Aromatics

Derisking capacity building via phased implementation of biofuels, power and biochemicals co-production

BIOMASS



Forest residues



**Pyrolysis and
fractionation**

**BIO-
BASED
FUEL
OIL**

**REFINERY
BIO OIL**

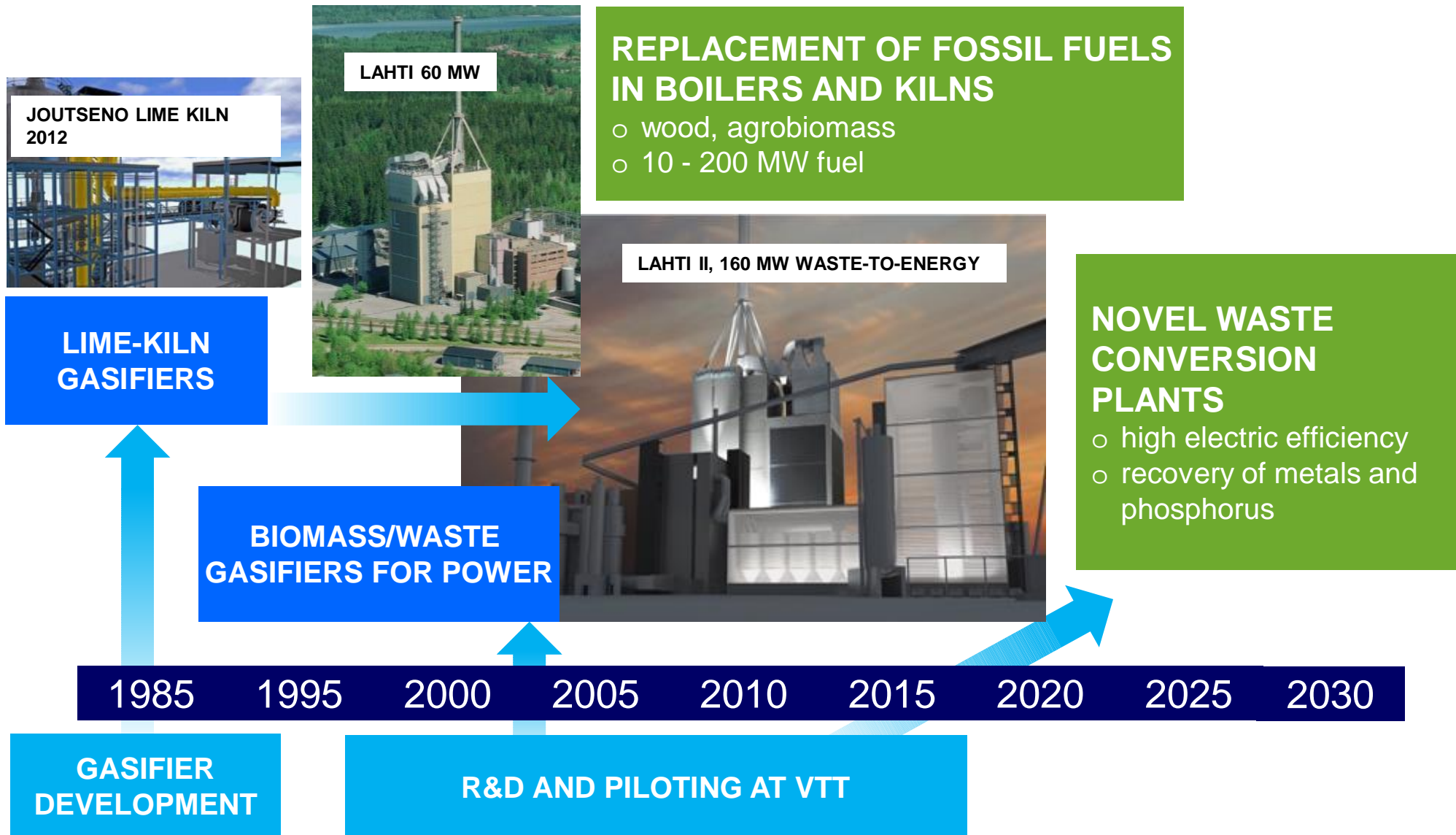


**Co-refining with mineral oil
By-production of chemicals
Power and heat production**



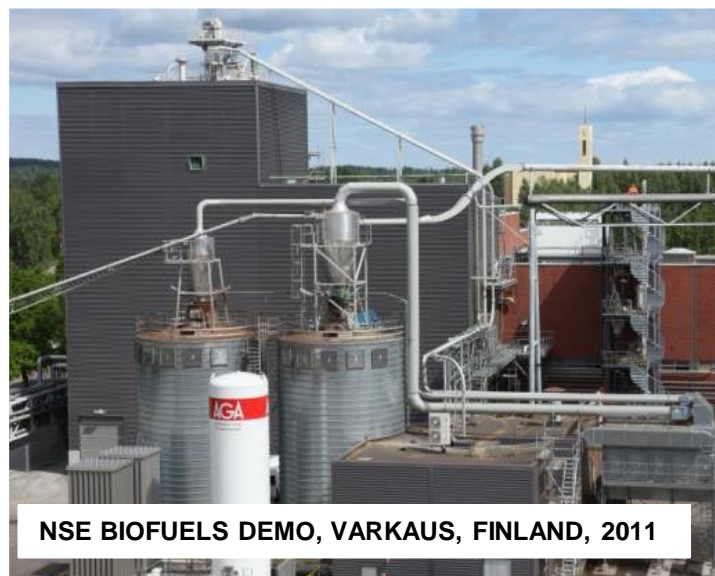
Biomass and waste gasification for boilers and kilns

- Industrial experience in Finland since 1980's



Biomass gasification for biofuels and bio-chemicals

- Long experience of medium-to-large scale thermochemical biorefineries



COAL GASIFIER
APPLIED FOR
PEAT AND WOOD

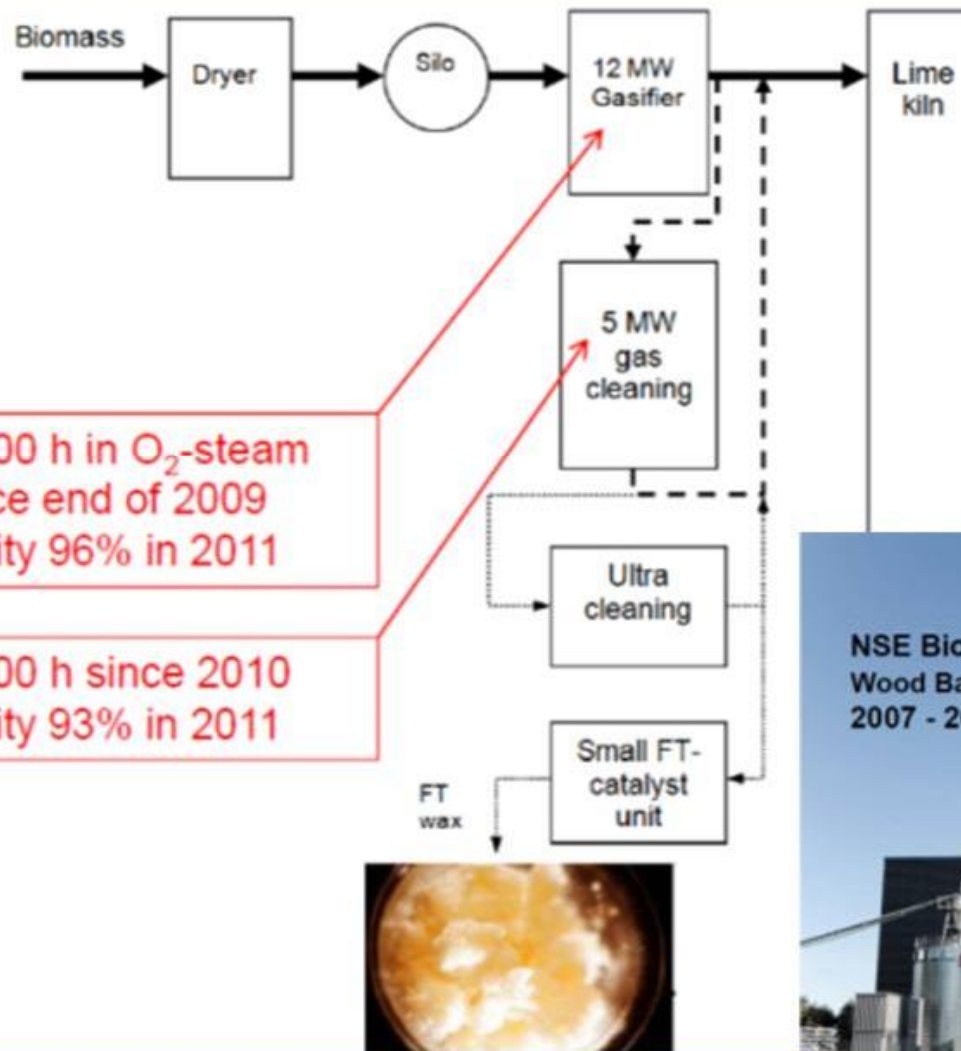
LARGE-SCALE GASIFICATION
SPECIALLY DEVELOPED
FOR WOOD FEEDSTOCKS

NEW PROCESS FOR SMALLER
SCALE AND WITH LOWER CAPEX

O₂-Blown CFB Gasification

Demonstration plant of NSE Biofuels at Varkaus, Finland

Nordic Bioenergy 2011, Jyväskylä, 6.9.2011



- Over 9000 h in O₂-steam mode since end of 2009
- Availability 96% in 2011

- Over 5500 h since 2010
- Availability 93% in 2011

FT wax



NSE Biofuels Oy
Wood Based BTL Diesel Development
2007 - 2011



From: Sami Kokki,
Foster Wheeler, 2011

FOSTER WHEELER

STORAENSO

From: V. Jokela,
Stora Enso

NESTE OIL

Ilkka Hannula | Esa Kurkela

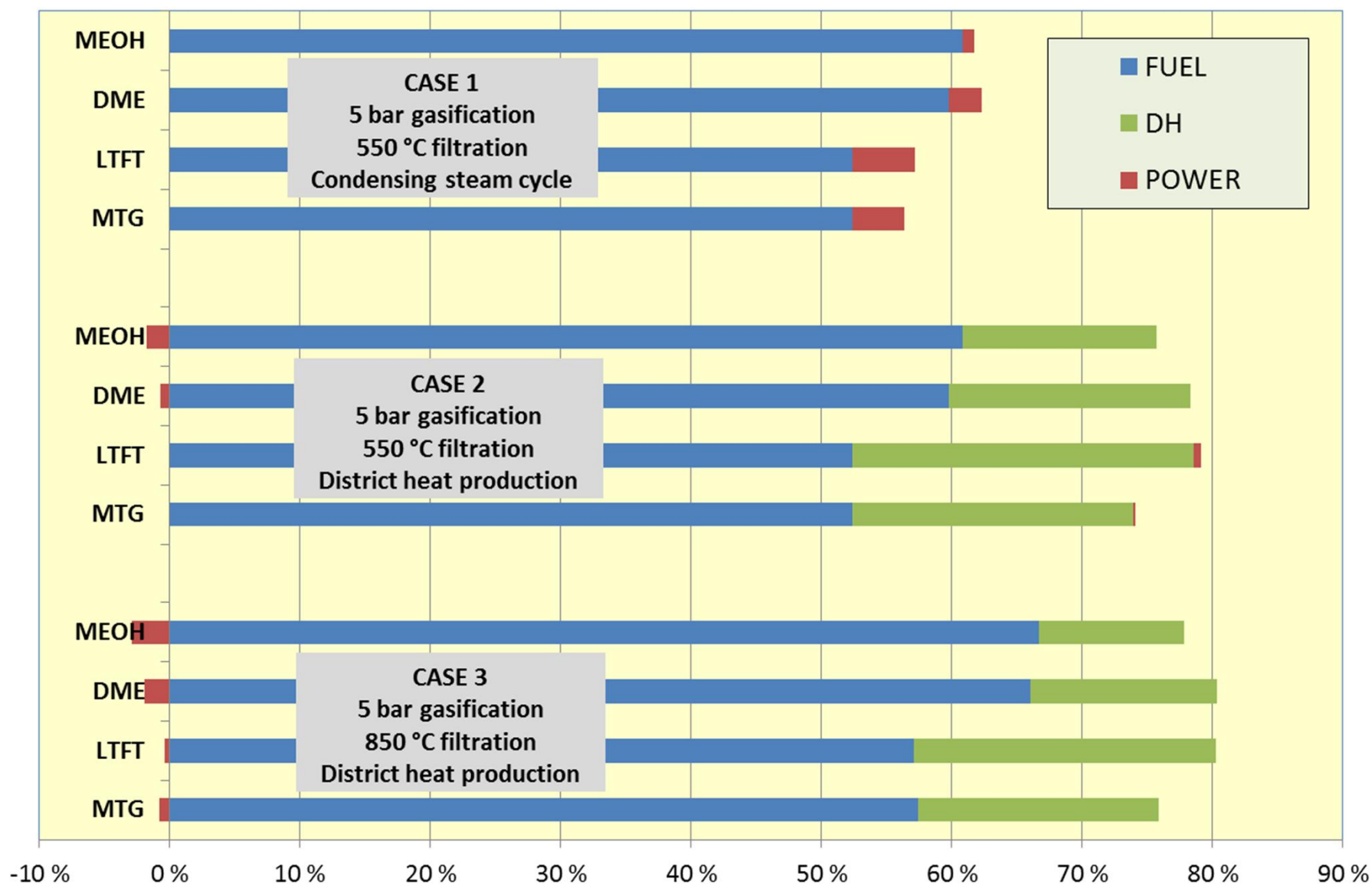
Ilkka Hannula | Esa Kurkela

- § Detailed evaluation of 20 individual plant concepts
- § Large scale: 300 MWth of biomass
- § O₂ gasification at 5 bar (and 22 bar)
- § MeOH, DME, FTL & MTG
- § Based on technically proven process
- § Estimated impact of further R&D to the overall economics
- § Nth plant economics
- § Available for download:
<http://bit.ly/192VI3G>

Estimated overall biomass conversion efficiencies

300 MW of biomass to dryer (AR 50 wt%, LHV)

5 bar CHP gasification, hot filtration, reforming of tars and hydrocarbons



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

Smaller plant size and simplified processes needed!

- Reducing CapEx a key
- Maximise integration benefits – biomass logistics, heat integration
- Use local residues and wastes to ensure sustainability

Biomass gasification for synthesis applications

MATURITY



NSE Demo plant
Varkaus, 2009-11

Ready for
commercialisation
> 150 MWth

**PRESSURISED
CFB OXYGEN-
BLOWN
GASIFICATION**



DFB pilot
VTT Bioruukki

**LOW-PRESSURE
DUAL FLUID-BED
STEAM
GASIFICATION**

Currently under development
> 100 – 150 MWth
TEKES-project BTL2030
H2020-project COMSYN



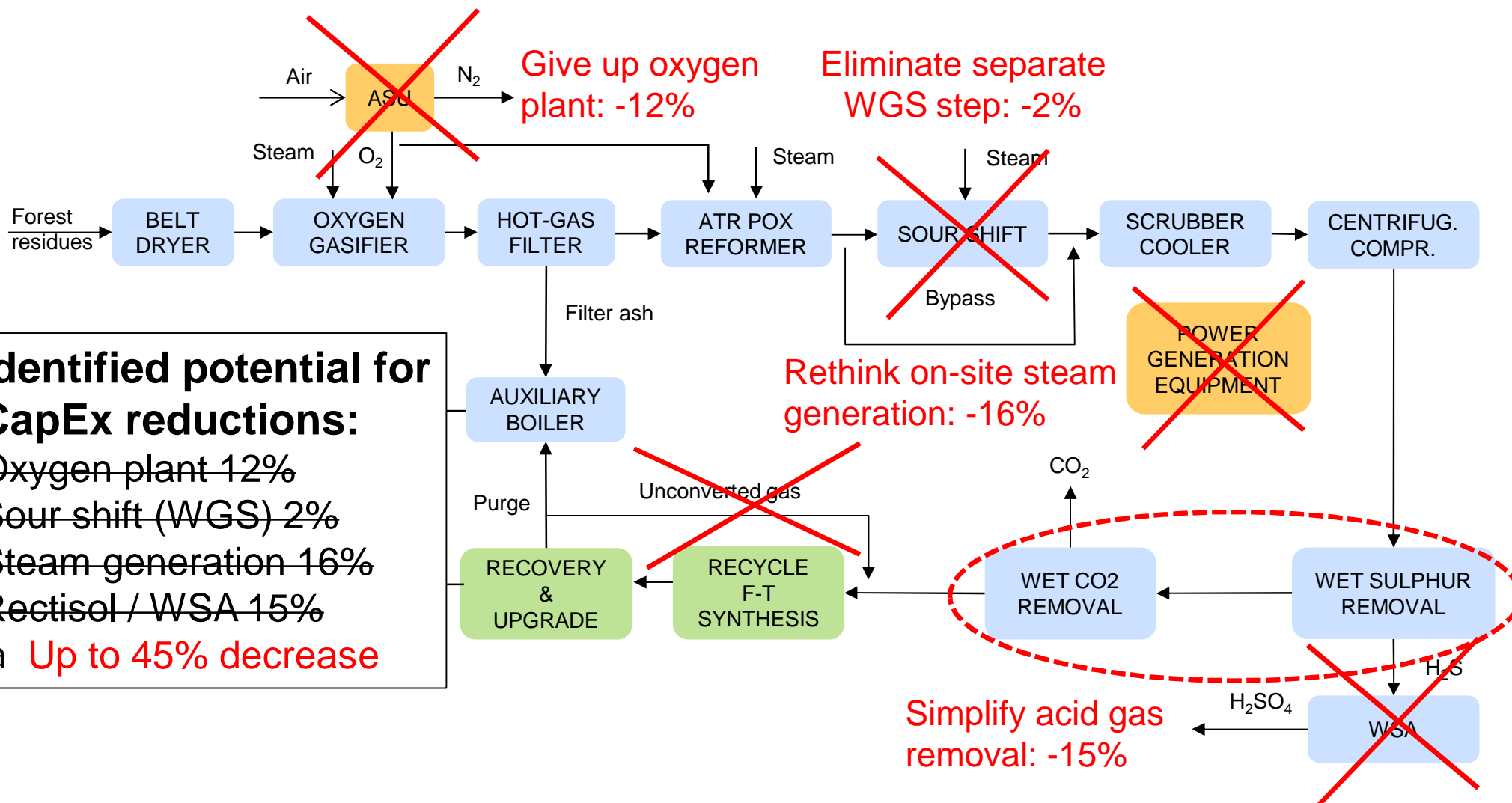
SXB pilot
VTT Bioruukki

**PRESSURISED
FIXED-BED
OXYGEN-BLOWN
GASIFICATION**

Development started 2016
< 50 MWth
EAKR-project GASGEN
H2020-project FLEXCHX

SCALE

Block diagram for a stand-alone large-scale biomass-to-liquids plant



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

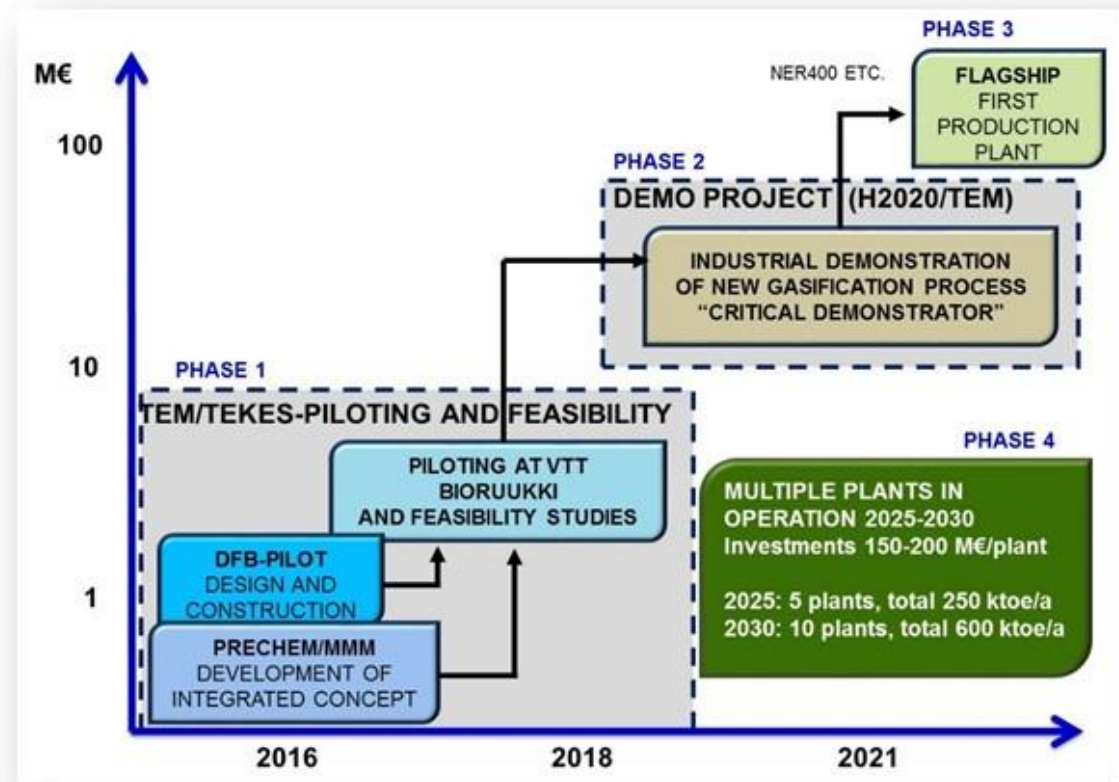
Capacity of industrial plants: FT-products 30-70 ktoe/a; 90-200 MW biomass feed

Phase 1: Piloting at Bioruukki & system studies 2016-18, 3 M€

Phase 2: Demonstration at an industrial site 2019-21, 50 M€

Phase 3: First production plant, 220 M€; investment decision 2022

Phase 4: Duplication at global markets; 150-200 M€/plant
2026: 5 plants, total 250 ktoe/a
2032: 10-20 plants, total 1 Mtoe/a
2035 > full market penetration



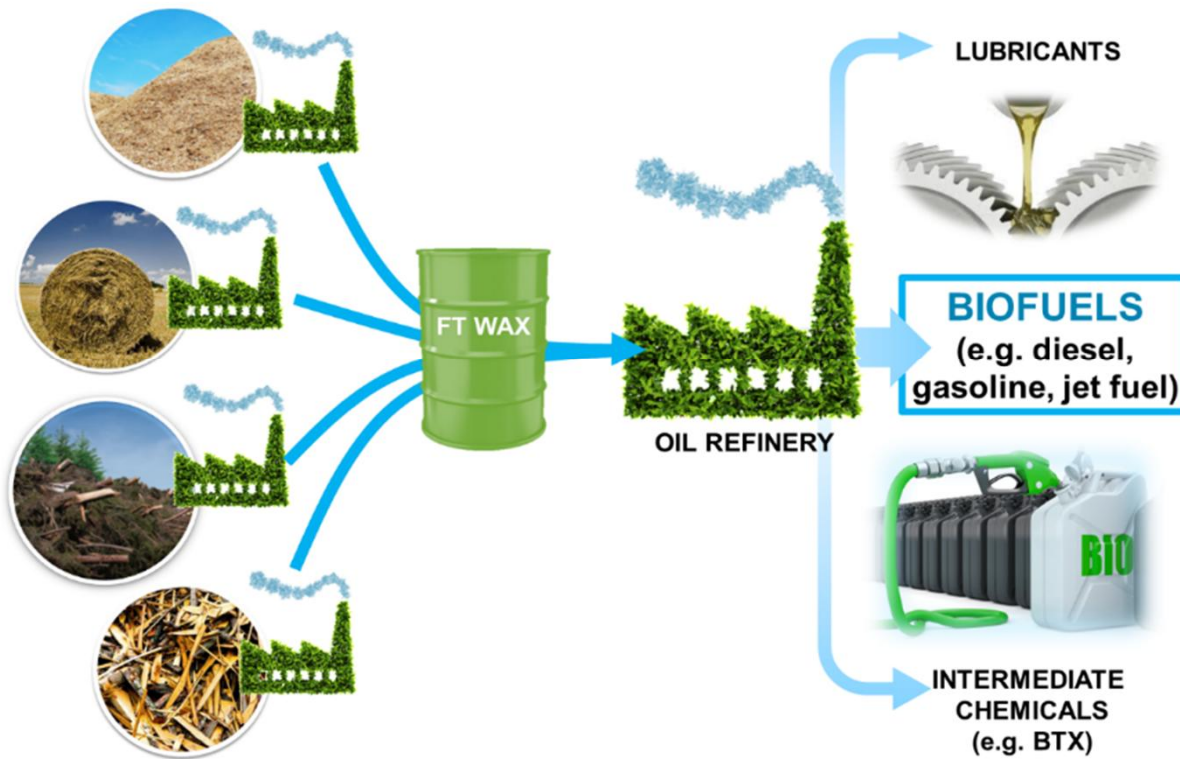
Plans created in the BTL2030 project

<http://www.vtt.fi/sites/BTL2030/en>

COMSYN

Compact Gasification and Synthesis process for Transport Fuels

Project duration: 1.5.2017-30.4.2021; Budget: 5.1 million €



- § Decentralized primary conversion of biomass at 30 – 150 MW
- § Central refining of FT products at large refineries

GASIFICATION & GAS CLEAN-UP



FILTRATION



FT SYNTHESIS



REFINING



TECHNO-ECONOMIC ASSESSMENTS & CASE STUDIES



Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center
Institute of Engineering Thermodynamics



MARKET STUDIES



Making Future.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727476

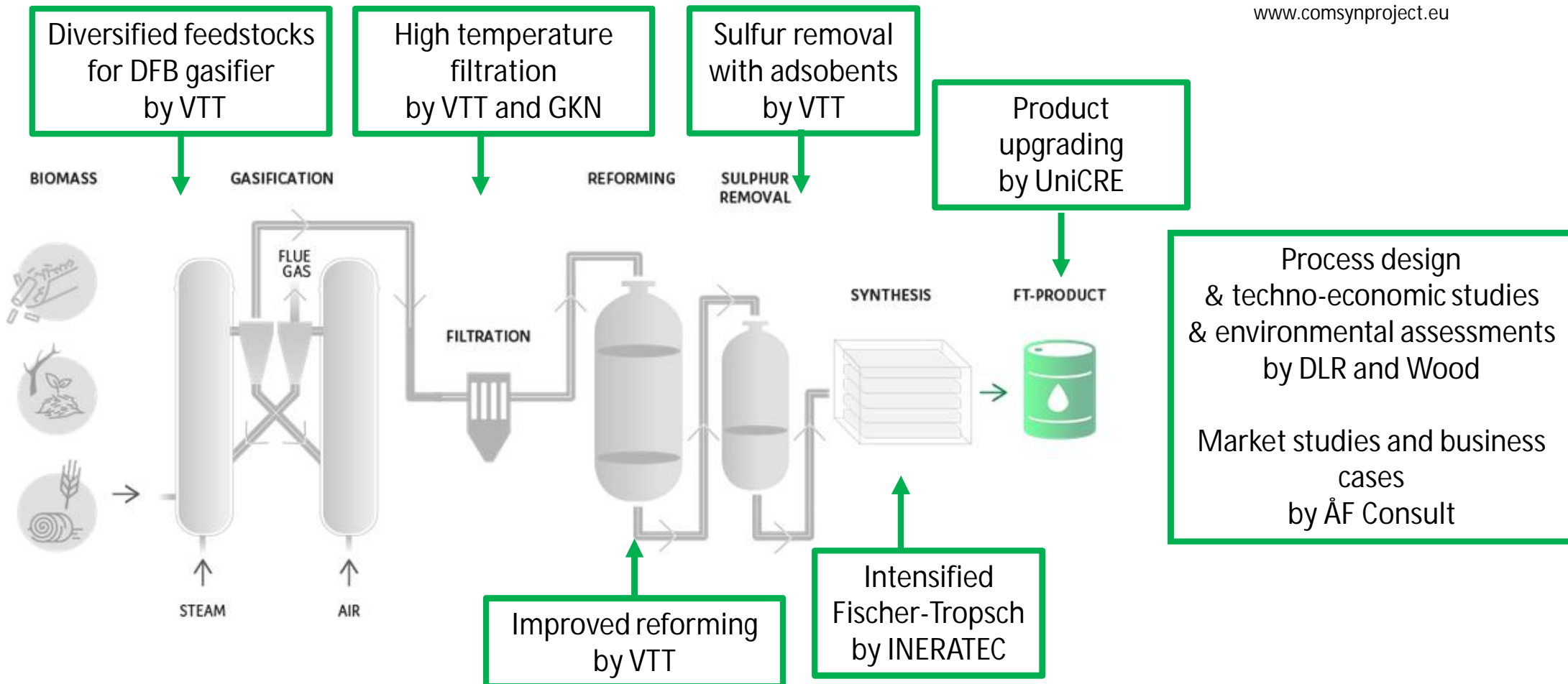


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727476

Technology development

COMSYN

www.comsynproject.eu



VTT Technical Research Centre of Finland Ltd



- VTT is one of the leading R&D&I organisations in Northern Europe.
- We provide expert services for our domestic and international customers and partners, both in private and public sectors.



* Loikkanen, T. et al. Roles, effectiveness, and impact of VTT. Towards broad-based impact monitoring of a research and technology organisation. 2013. VTT, Espoo. VTT Technology 113. 106 p. + app. 5 p.



Net turnover and other operating income
 269 M€ (VTT Group 2016)



Unique research and testing infrastructure



Personnel 2,414
 (VTT Group 2016)



Wide national and international cooperation network