

Finnish Country Summary – Biomass Gasification in 2013

IEA Task 33 meeting, Göteborg Nov2013

Ilkka Hannula

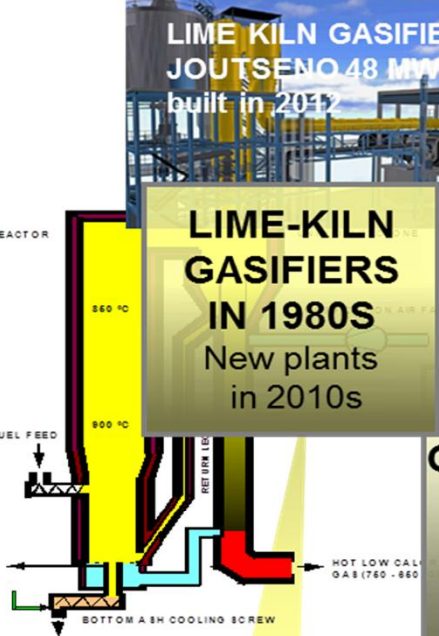
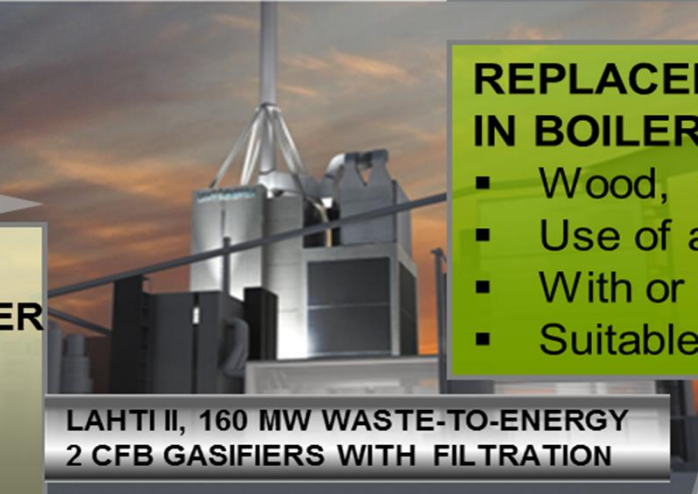
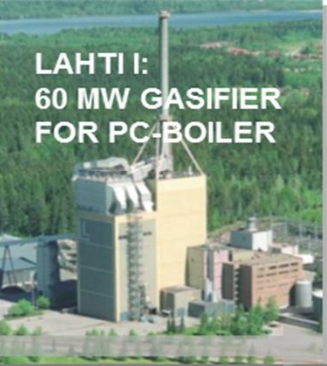
BIOMASS AND WASTE GASIFICATION FOR BOILERS AND KILNS

WASTE-TO-ENERGY PLANTS WITH MATERIAL RECOVERY

- High electric efficiency
- Recovery of valuable metals
- Use of ash for construction materials

REPLACEMENT OF FOSSIL FUELS IN BOILERS AND KILNS

- Wood, straw & other agrobiomass
- Use of ash for fertilising purposes
- With or without gas filtration
- Suitable size range 10-200 MW fuel



LIME-KILN GASIFIERS IN 1980S
New plants in 2010s

BIOMASS/WASTE GASIFIERS FOR POWER
FIRST DEMO PLANTS
LAHTI I, CORENSO
2 new plants in 2012-13



Initial CFB/BFB Gasification R&D and Piloting

CFB-boiler development

R&D on
Hot Gas Filtration
Waste gasification
Straw gasification

R&D NEEDS 2014 - 17

- Filter ash treatment and utilisation
- Novel gasification and gas cleaning systems aiming to recovery of metals in waste gasification and recycling of nutrients in biomass gasification
- Improved gas cleaning methods



Vaskiluodon Voima – Substituting Coal for Biomass in a PC boiler

- 140 MW_{th} gasifier adjoined to the existing 560 MW coal-fired power plant
- PC boiler in operation since 1982
- Coal consumption 400,000 – 500,000 t/a
- Enables to replace up to 40 percent of coal
- Production capacity
 - electricity 230 MW
 - district heating 170 MW
- Vaskiluodon Voima's total investment ~40 MEUR



CARBONA

AND © Metso

metso

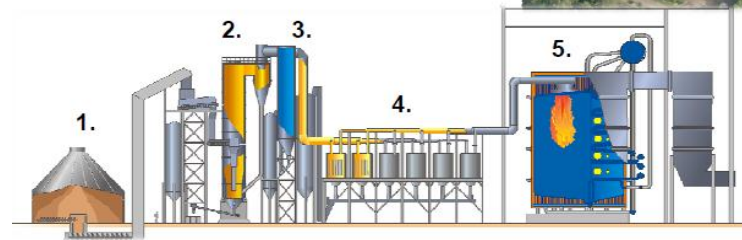
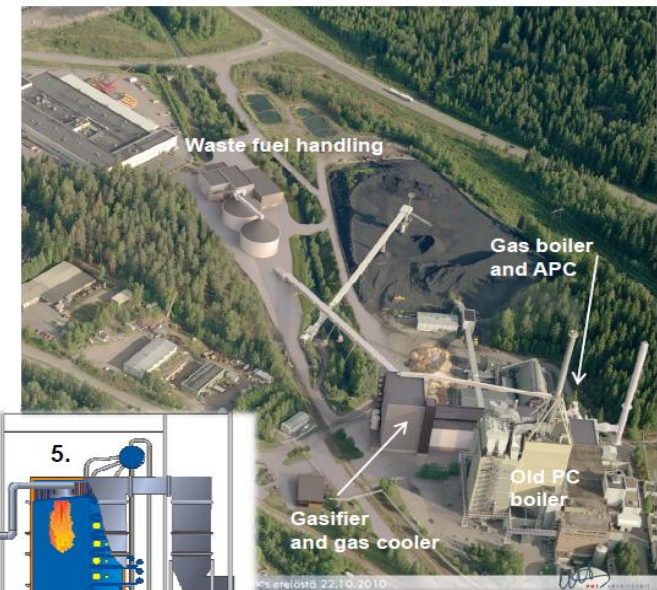
RECENT PROJECTS:
Biomass and waste
gasification for
boilers and kilns

Lahti Energia – Gasification Power Plant

2 x 80 MW_{th} gasifiers
Waste-derived fuel
50 MW_e & 90 MW_{heat}

1. Fuel handling
2. Gasifier
3. Gas cooling
4. Gas filter
5. Gas boiler and flue gas cleaning

Start-up April 2012
Total investment 157 M€



Architecture study of the plant

BIOMASS GASIFICATION FOR FUELS AND CHEMICALS



PEAT AMMONIA PLANT OULU/FINLAND



Gussing Dual Bed Gasifier & Testing Platform



GTI Pilot



NSE Biofuels Demo at Varkaus

BIOMASS/WASTE GASIFICATION FOR POWER
Industrial experience on Large FB gasifiers

BIOREFINERIES FOR INTEGRATED PRODUCTION OF BIO-FUELS

- FT-Diesel, MeOH, DME, SNG, H₂, renewable chemicals
- Integration to forest and agro-industries
- Combined Fuel, Heat & Power with maximal overall efficiency
- Size range 50-300 MW biomass input
- Biomass utilisation efficiency > 70 %
- Bio-CCS easy to add – if needed?

1985	1995	2000	2005	2010	2015	2020	2025	2030
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Initial Gasification R&D and piloting In USA, Germany, Sweden, etc. (coal, brown coal, biomass)

SYNGAS R&D for BIOFUELS

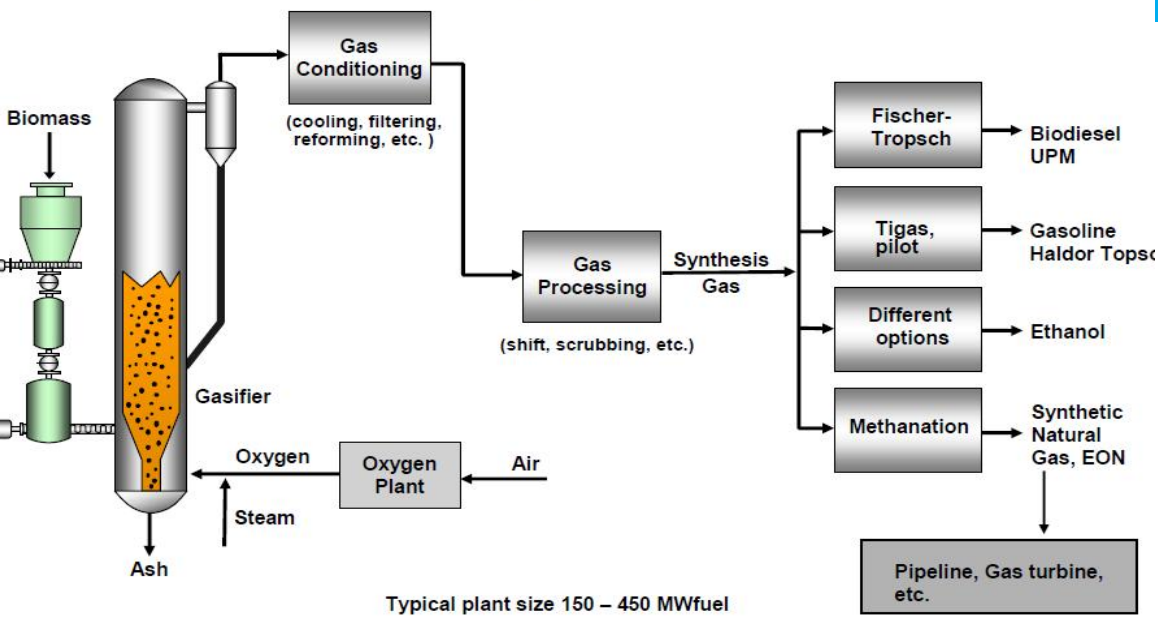
- Concept development for biofuels
- Gasification process development (Dual-Bed, O₂-blown CFB and BFB)
- Catalytic reforming and tar scrubbing
- Final gas cleaning and synthesis
- Small-scale testing of synthesis catalysts

R&D NEEDS 2013 - 2020

- Improved O₂ gasifier for large scale (> 150 MW feed)
- Improved Dual-Bed gasifier for medium size range (20-150 MW)
- Better and cheaper gas cleaning
- Synthesis and concept R&D for reduced capex and high overall efficiency

Synthesis gas for transportation fuels and SNG

ANDRITZ Carbona active projects



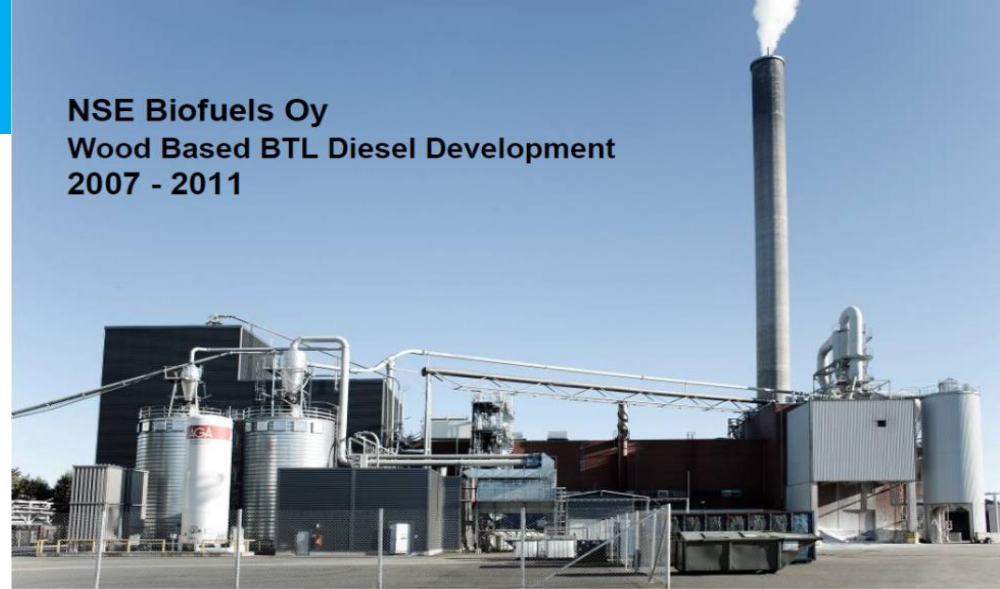
Typical plant size 150 – 450 MW_{fuel}

CARBONA

Carbona Gasifier for Syngas Production

ANDRITZ

NSE Biofuels Oy Wood Based BTL Diesel Development 2007 - 2011



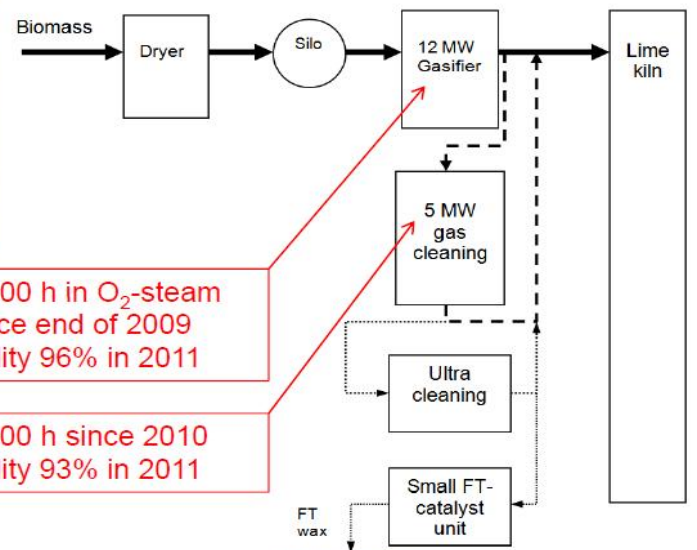
STORAENSO

NSE

NESTE OIL

PROCESSES CHAIN OF THE VARKAUS TEST PLANT

ic 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



**RECENT PROJECTS:
Biomass gasification for
synthetic fuels and chemicals**

[▶ Stock exchange releases](#)[▶ Investor news](#)[▶ Press releases](#)[▶ Product news](#)[▶ Archive](#)

UPM TO BUILD THE WORLDS FIRST BIOREFINERY PRODUCING WOOD-BASED BIODIESEL

(UPM, Helsinki, 1 February 2012 at 10.00 EET) – UPM is to invest in a biorefinery producing biofuels from crude tall oil in Lappeenranta, Finland. The industrial scale investment is the first of its kind globally. The biorefinery will produce annually approximately 100,000 tonnes of advanced second generation biodiesel for transport. Construction of the biorefinery will begin in the summer of 2012 at UPM's Kaukas mill site and be completed in 2014. UPM's total investment will amount to approximately EUR 150 million.

"The biofuels business has excellent growth potential. The quality of our end product and its environmental characteristics has gained significant interest among a wide range of customers, and the investment is profitable. Lappeenranta is the first step on UPM's way in becoming a significant producer of advanced second generation biofuels. This is also a focal part in the realisation of our Biofore strategy", says UPM President and CEO **Jussi Pesonen**.

UPM's advanced biodiesel, UPM BioVerno, is an innovation which will decrease greenhouse gas emissions of transport up to 80% in comparison to fossil fuels. The product's characteristics correspond to those of the traditional oil-based fuels and highly complement today's vehicles and fuel distribution systems.

Nämä hankkeet kilpailevat rahoista

Sievin Teollisuuspuisto

Bioetanolijalostamo Sieviin.
Investointi arviolta

100 miljoonaa euroa,
kapasiteetti **50 000** tonnia
bioetanolia vuodessa.

Raaka-aineina olki, ruokohelpi ja lehtipuubiomassat Pohjanmaalta. Prosessissa syntyy myös biohiiltä, furfuraalia, etikkahappoa ja poltettavaa rankkia.

STI Biofuels

Sehanpurusta bioetanolia tuottava jalostamo Kajaaniin.

Investointi **40** miljoonaa euroa, suunniteltu kapasiteetti **10 000** tonnia etanolia vuodessa.

Sivutuotteena syntyy merkittävä määrä ligniiniä, joka käy polttoaineeksi sähkön ja höyryn tuotantoon.

Neste Oil

Neste Oil on kevästä asti käyttänyt ajoittain mäntyöljypikeä Naantalın bensini- ja dieseljalostamolla.

Nyt yhtiö tähtää jatkuvaan tuotantoon.

Raaka-aineena käytettävää mäntyöljytähdettä syntyy sellunkeiton sivutuotteena.

Neste Oil

Uuslutuvan lentopolttoaineen jatkuva tuotanto Porvoossa.

Raaka-aineena kasviöljyt ja jättepohjaiset raaka-aineet.



UPM-Kymmene

Puupohjaisen liikennepolttoaineen valmistus. UPM kieltäytyi kertomasta tarkempia yksityiskohtia hankkeestaan.

Feedstock Optimum

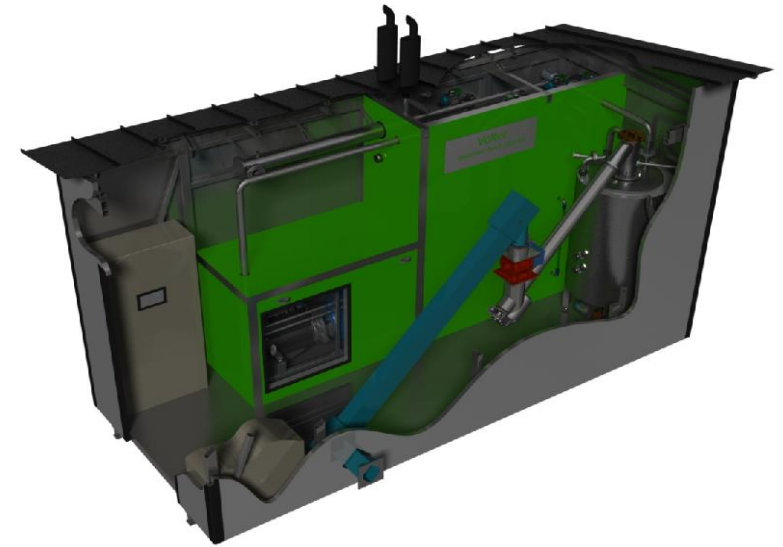
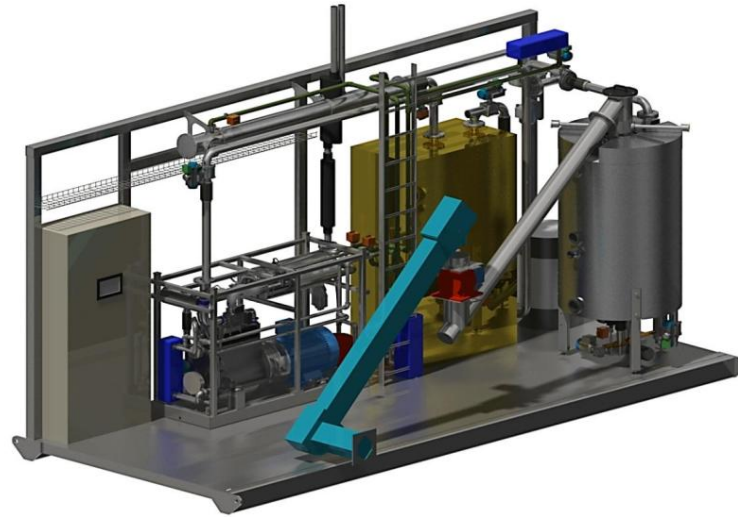
Biohiilen ja puuöljyn tuotantolaitos Nurmekseen. Raaka-aineena Pohjois-Karjalan ja Kainuun puu. Biohiilellä voi korvata kivihiiltä, puuöljyä voi jalostaa liikennepolttoaineeksi.

Suomen Bioetanoli

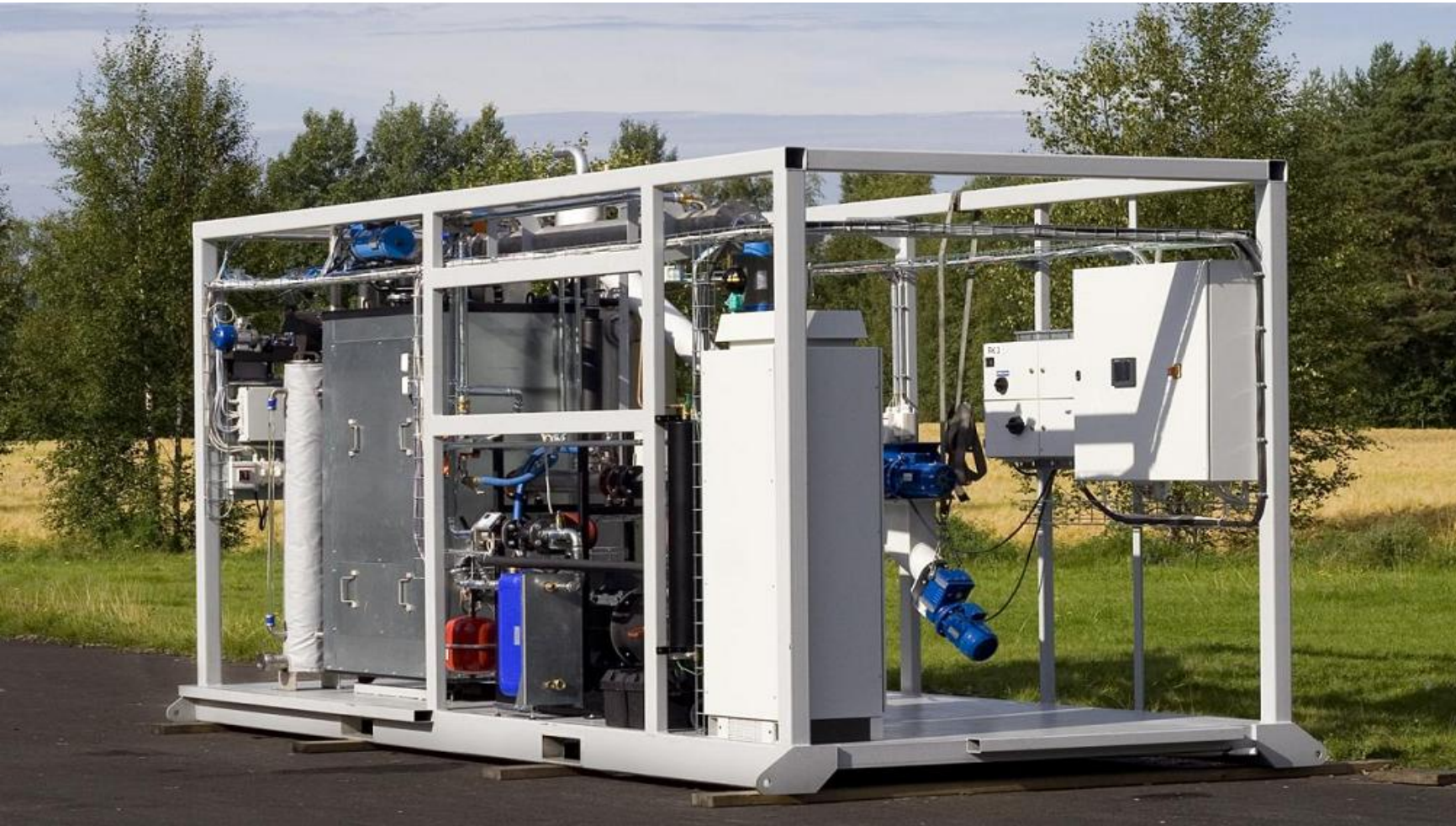
Olkipohjaista etanolia tuottava biojalostamo. Suunniteltuna sijoituspaikkana Kaakkois-Suomi.

Mia Ylisuutar/Aamulehti

Combined Heat and Power

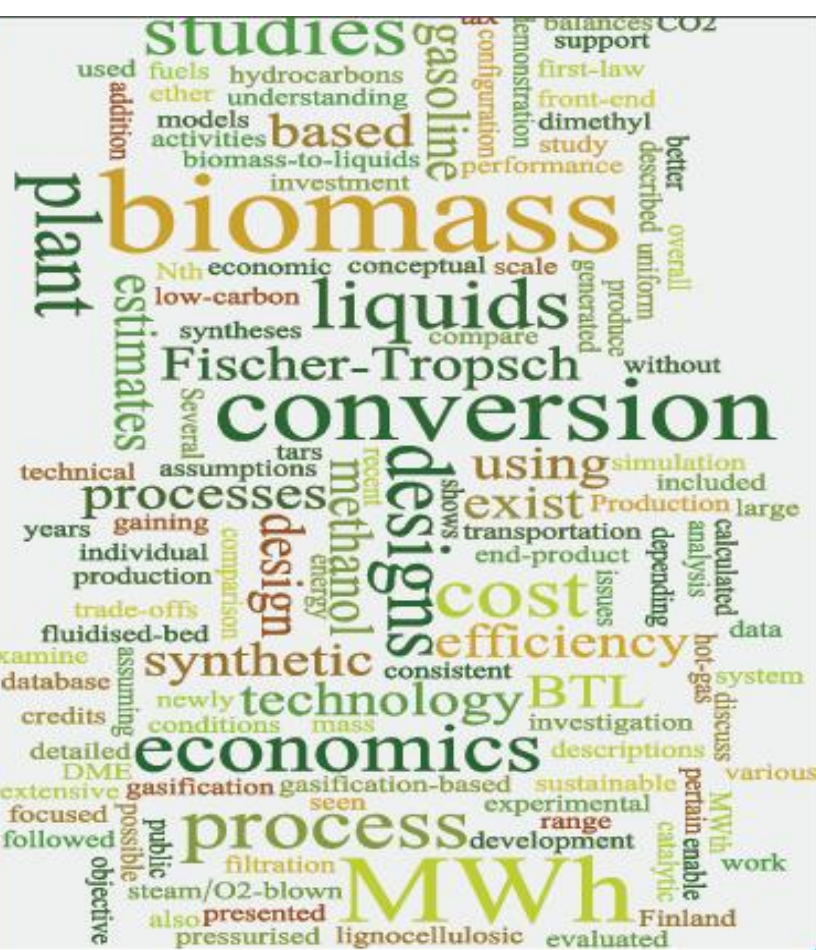


Model:	Volter 30 (40)
Fuel:	Wood chips (birch, spruce, pine, aspen)
Fuel moisture:	<18%
Particle size:	8mm ≤ P ≤ 50mm, fine particles (<3,15mm) <1%, all <63mm
Plant structure:	Steel frame, Insulated with paroc (or similar) panels
Color:	As per agreement
Fuel supply:	Spring agitator, auger, rotating feeder
Generator:	Agco Sisu Power 4,9L, 4-cyl. (8,4L, 6-cyl.)
Output:	Generator output 30kW (40kW), thermal 80kW (100kW)
Plant usage (e):	ca. 1,5-2,5kW
Fuel consumption:	ca. 3,5 m3 (4,5 m3) of chips/24h at 100% power level
Automation:	Schneider electric PLC, GSM –alarms, remote internet control
Connections:	Electricity cable, Heat channel, water line, broadband, GSM-connection
Installation:	Asphalt or concrete base
Ash removal:	Automatic ash removal
Max. o.t./a:	7000h
Maint. interval:	once a week
Other:	



- Volter 30
- Installed inside an existing building





Liquid transportation fuels via large-scale fluidised-bed gasification of lignocellulosic biomass

Ilkka Hannula | Esa Kurkela

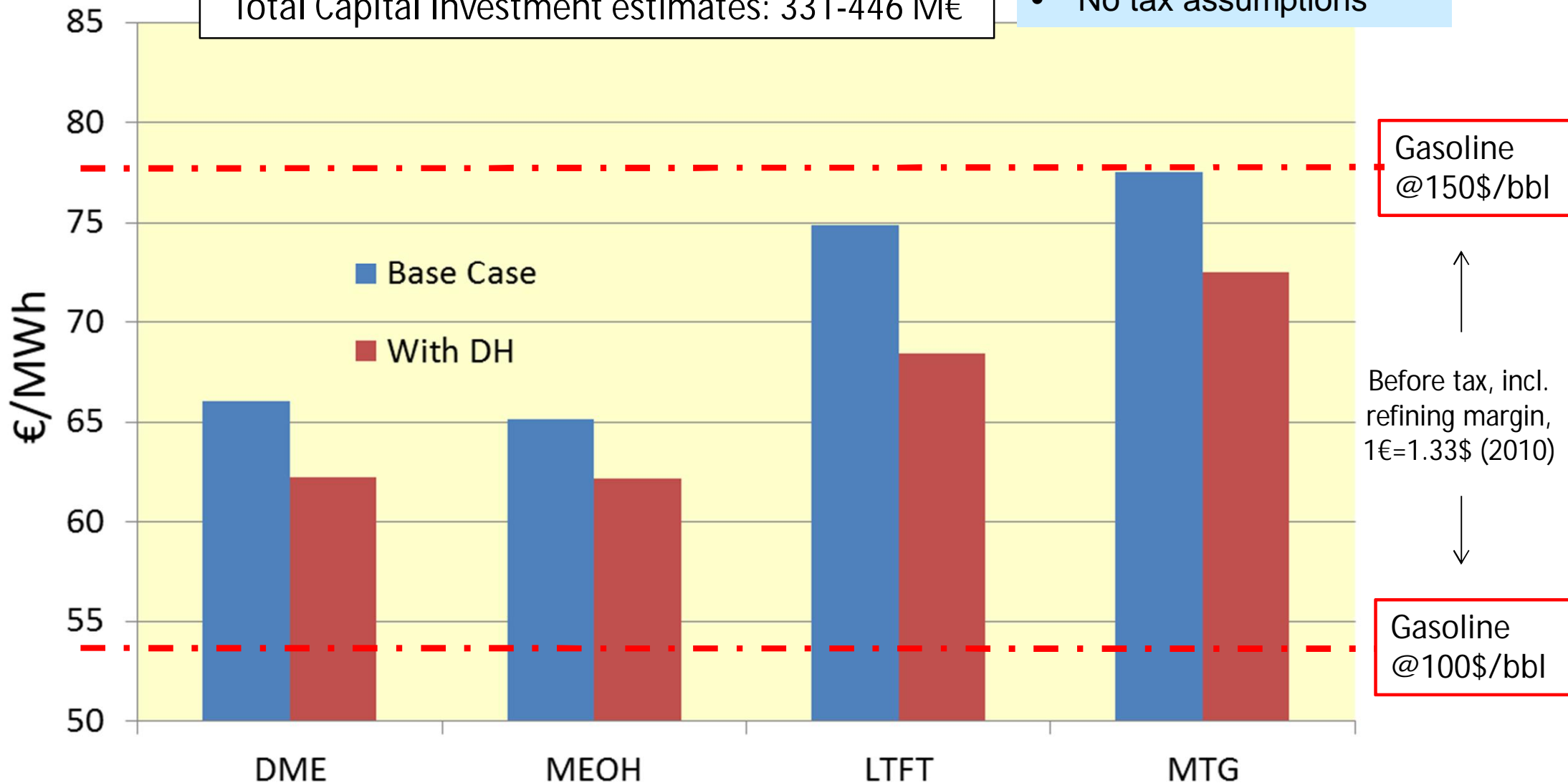
Updated Techno-Economic Assessment

- Detailed evaluation of 20 individual plant designs
- MeOH, DME, FTL & MTG
- Based on technically proven process
- Estimated impact of further R&D to the overall economics
- Large scale: 300 MWh of biomass (~1300 mtpd, dry)
- Nth plant economics
- Available for download: <http://bit.ly/192VI3G>

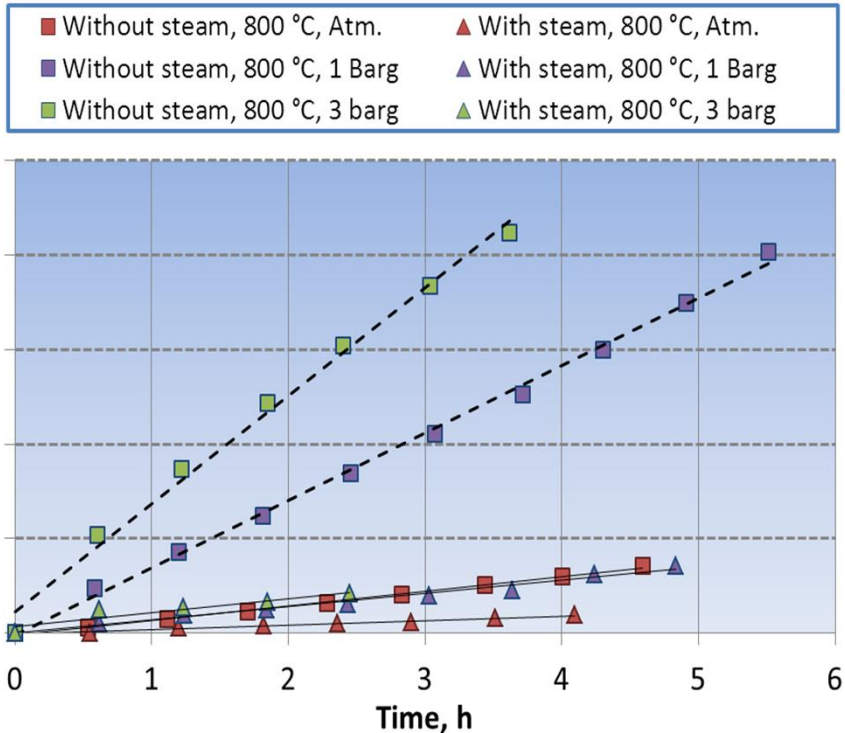
Levelised production cost estimates*

300 MW biomass @ 17 €/MWh, 0.12 ann. factor
 Electricity 50 €/MWh, DH 30 €/MWh@5500 h/a
 Total Capital Investment estimates: 331-446 M€

- Mature technology
- No investment support
- No CO₂ credits
- No tax assumptions

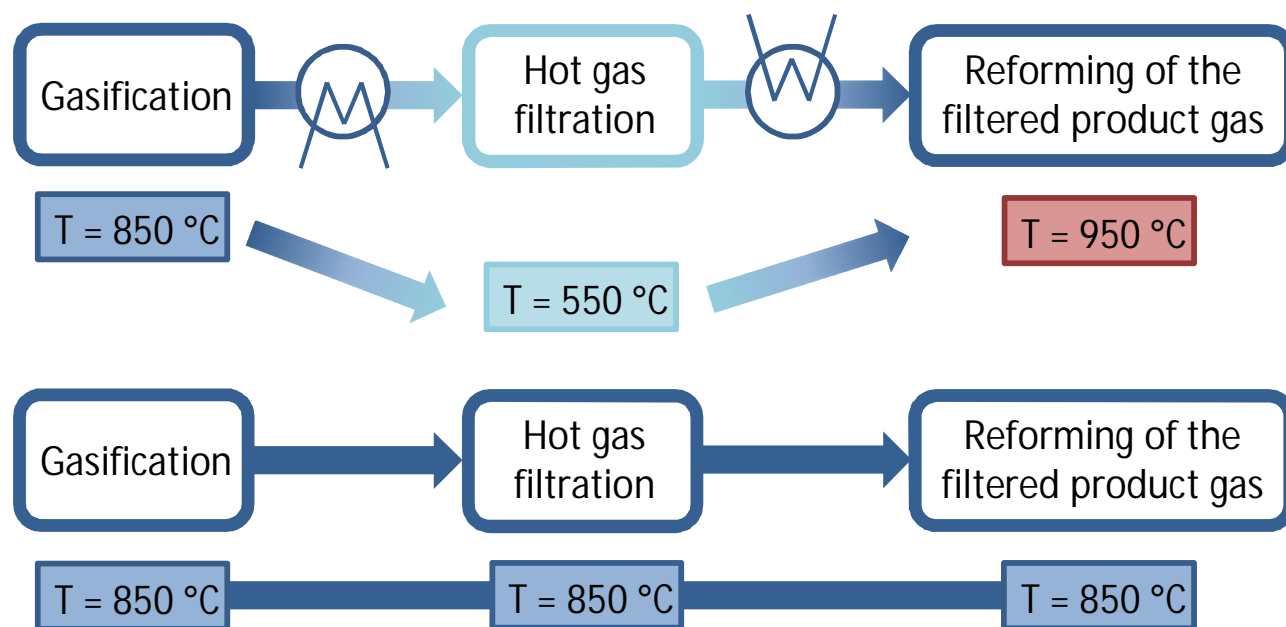


Baseline pressure difference over filter, mbar



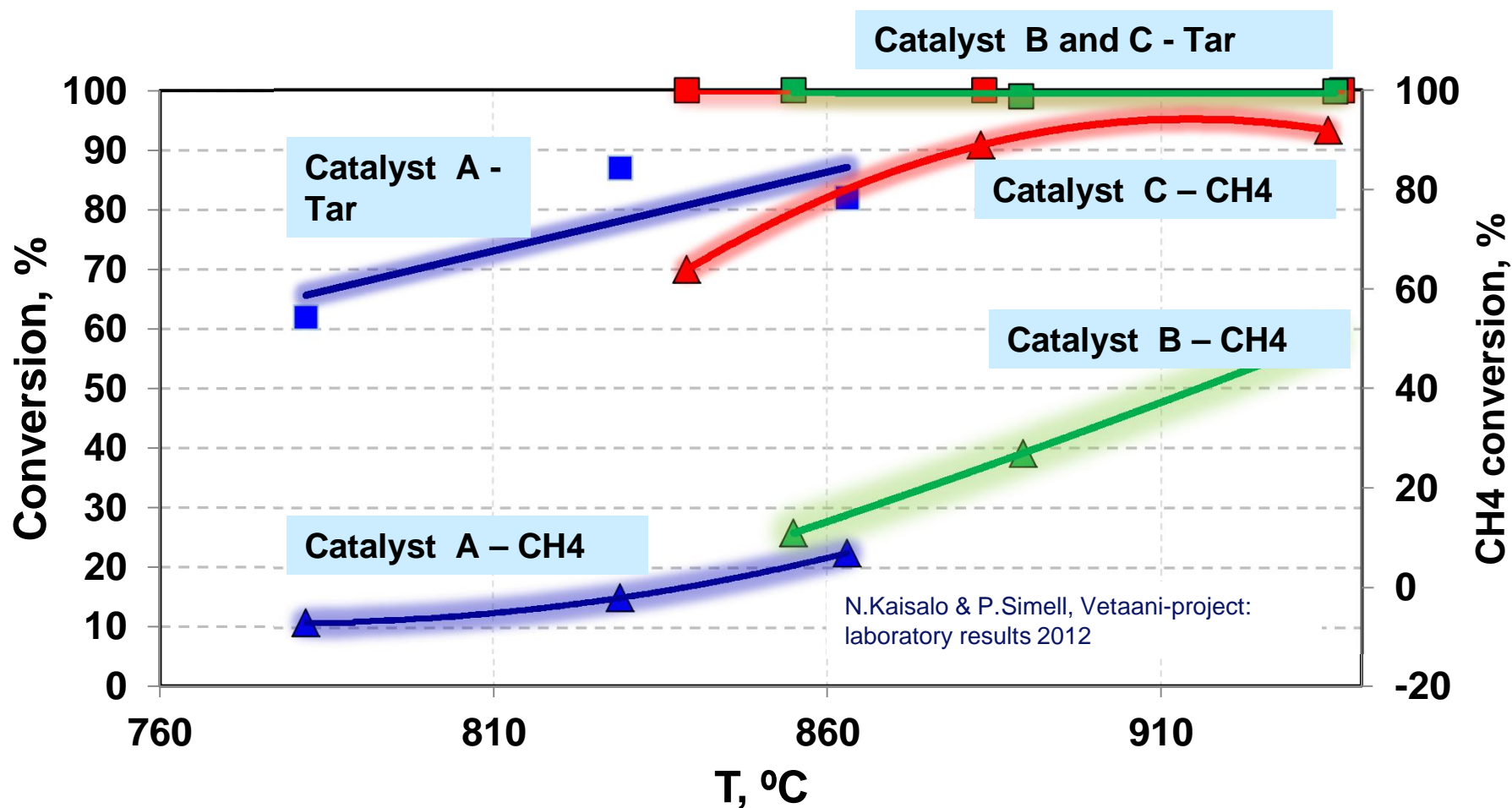
HOT GAS FILTRATION

- Hot gas filtration R&D focused on filter blinding phenomenon.
- Experimental work with a bench-scale pressurised hot gas filtration unit ALMA.
- The main variables to be studied:
 - Filtration temperature and pressure
 - Particulate and tar concentrations
 - Use of different sorbents and additives



Reforming of tars and light hydrocarbon gases

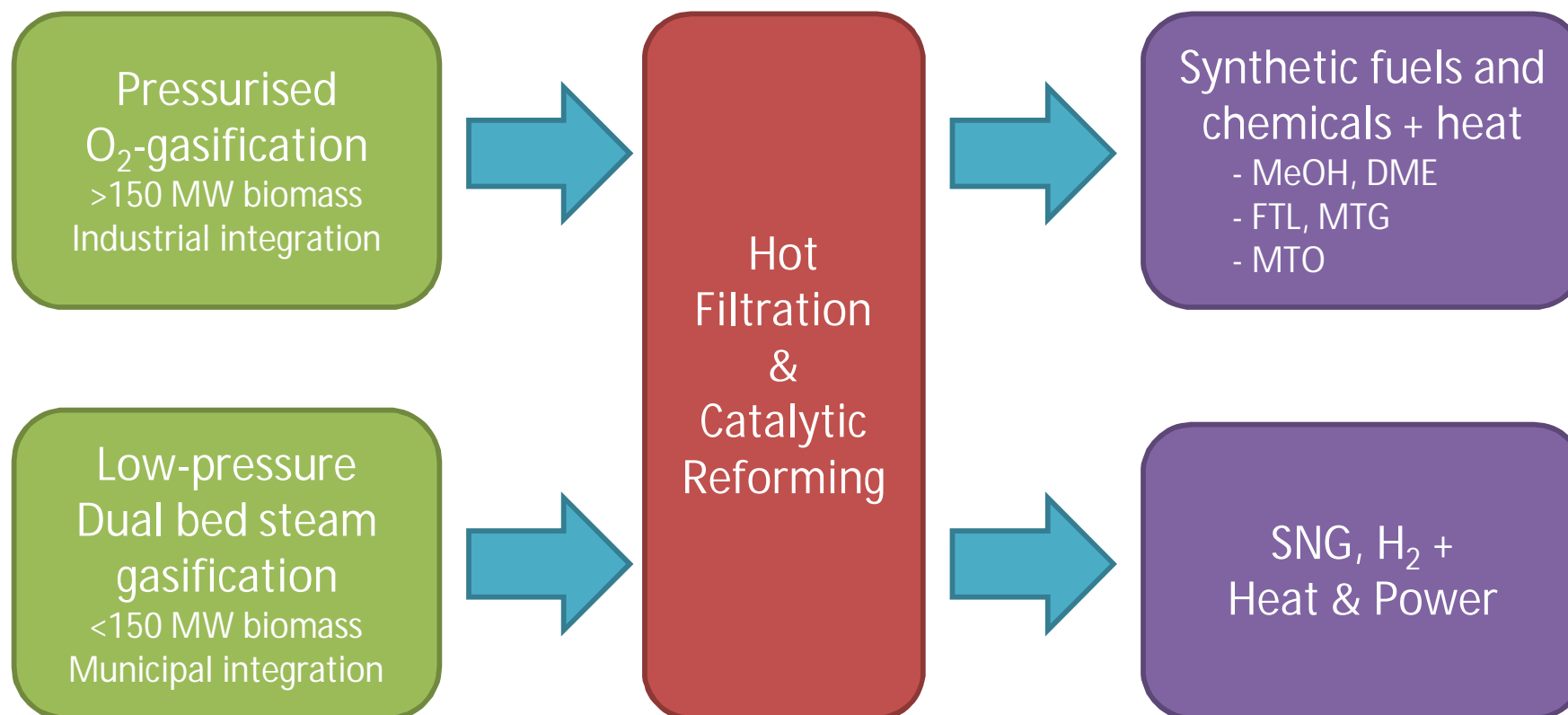
- VTT's reformer is based on staged reforming without soot formation
- Different catalysts from alternative suppliers can be used
- Complete tar and C₂-hydrocarbon conversion
- CH₄ conversion depends on temperature, catalyst type and reactor volume



2G-Biofuels 2020 Project

budget 7.3 M€ in 2012–14; second piloting phase in 2015–17

Gasification task – 4.2 M€



Industrial partners: Andritz-Carbona, Foster Wheeler, Metso, UPM-Kymmene, NSE Biofuels, Fortum. Main financier: Tekes



Biomass-to-Syngas R&D at VTT

▪ 2G 2020 BIOFUELS 2012 – 2014

- **Pilot-scale R&D** on improved steam/O₂ gasification and indirectly heated gasification alternatives
- **Simplified final gas** cleaning for once-through-type synthesis
- Heat integration alternatives
- Industrial support from Andritz-Carbona, Foster Wheeler, Fortum, NSE Biofuels and UPM – further R&D for the industrial D&D projects

▪ PRODUCTION OF SNG OR H₂ FROM BIOMASS 2011-14

- Evaluation of process alternatives – less capital intensive and suitable to smaller size than BtL plants
- **Pre-competitive R&D on gasification and gas cleaning**
- Wide industrial support in the Vetaani-project

▪ NORDSYNGAS: 2010-14

- **Nordic University co-operation:** Luleå, Piteå, Sinteff, VTT
- Fundamental aspects of pressurised gasification
- System studies related to integrated plants to pulp and paper industries

▪ GASIFICATION REACTIVITY 2011 – 2014

- **Fundamental research** with Åbo Akademi and Jyväskylä University
- Funded by Finnish Academy

2G Biofuels and RES-Infra of VTT

- VTT will move and reconstruct its pyrolysis and gasification test facilities to a new industrial site at Espoo
 - Design and construction in 2012 – 13
 - Commissioning in 2013-14
 - Testing activities continue at present site in Otaniemi until end 2013
- Main test facilities:
 - Flash pyrolysis pilot plant and bench-scale pyrolysis facilities
 - Dual fluidized-bed steam gasification pilot plant
 - High-pressure O₂-blown/air-blown gasification PDU plant
 - Atmospheric-pressure CFB gasification pilot plant for waste fuels
 - Bench-scale gasification and gas cleaning equipment
 - Synthesis testing in slip streams and with simulated gases

2G Biofuels R&D project

7.2 M€ - 3 a, incl. ca 1 M€ for test facilities

VTT RES-Infra

5.5 M€

investment