Greening of industry with biomass steam gasification and carbon capture

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How to reach Carbon Neutrality/Climate Neutrality?

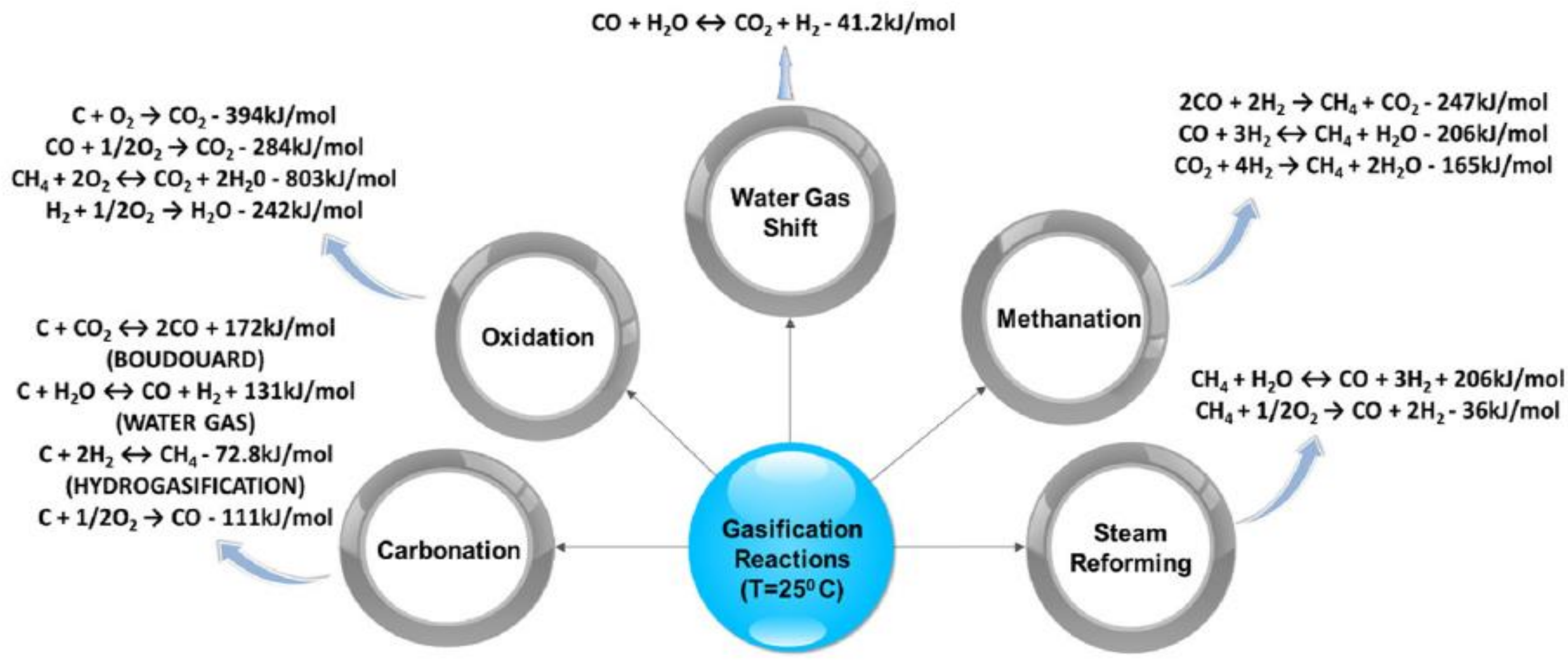
PRESENTATION CONTENT

1. Research agenda for waste and circular economy, University of Latvia
2. Biomass/waste gasification – bottlenecks and opportunities
3. Green gas – SNG, bioLNG, bioMeOH, green H_2
4. Pilot project Latvia/Netherlands – industrial greening
5. Circularity and carbon neutrality – green and blue route
6. Conclusions and main takeways

UNIVERSITY OF LATVIA GASIFICATION RESEARCH LAB

GASIFICATION CHALLENGES

Gasification is a process that converts organic or fossil-based carbonaceous materials at high temperatures (>700°C), without combustion, with a controlled amount of oxygen and/or steam into carbon monoxide, hydrogen, and carbon dioxide.



Source: Biomas gasificiation, 2017 Elsevier

One of the major issues in **biomass gasification** is to deal with the **tar** formed during the process. **Tar** is a complex mixture of condensable hydrocarbons, which includes single ring to 5-ring aromatic compounds along with other oxygen-containing hydrocarbons and complex PAH.

CONVERSION TEMPERATURE DIAGRAMME OF IMPORTANT TAR COMPOUNDS

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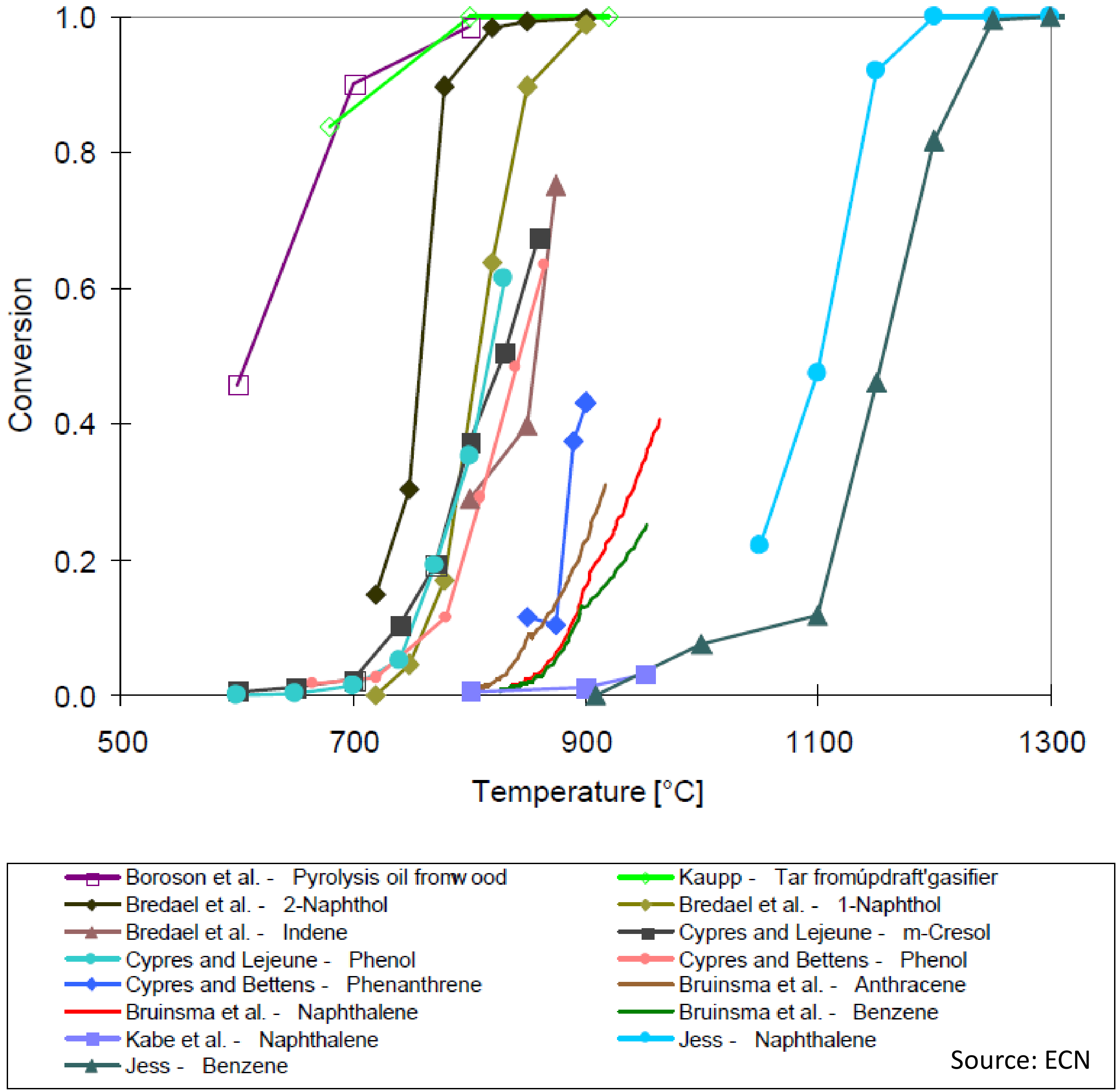


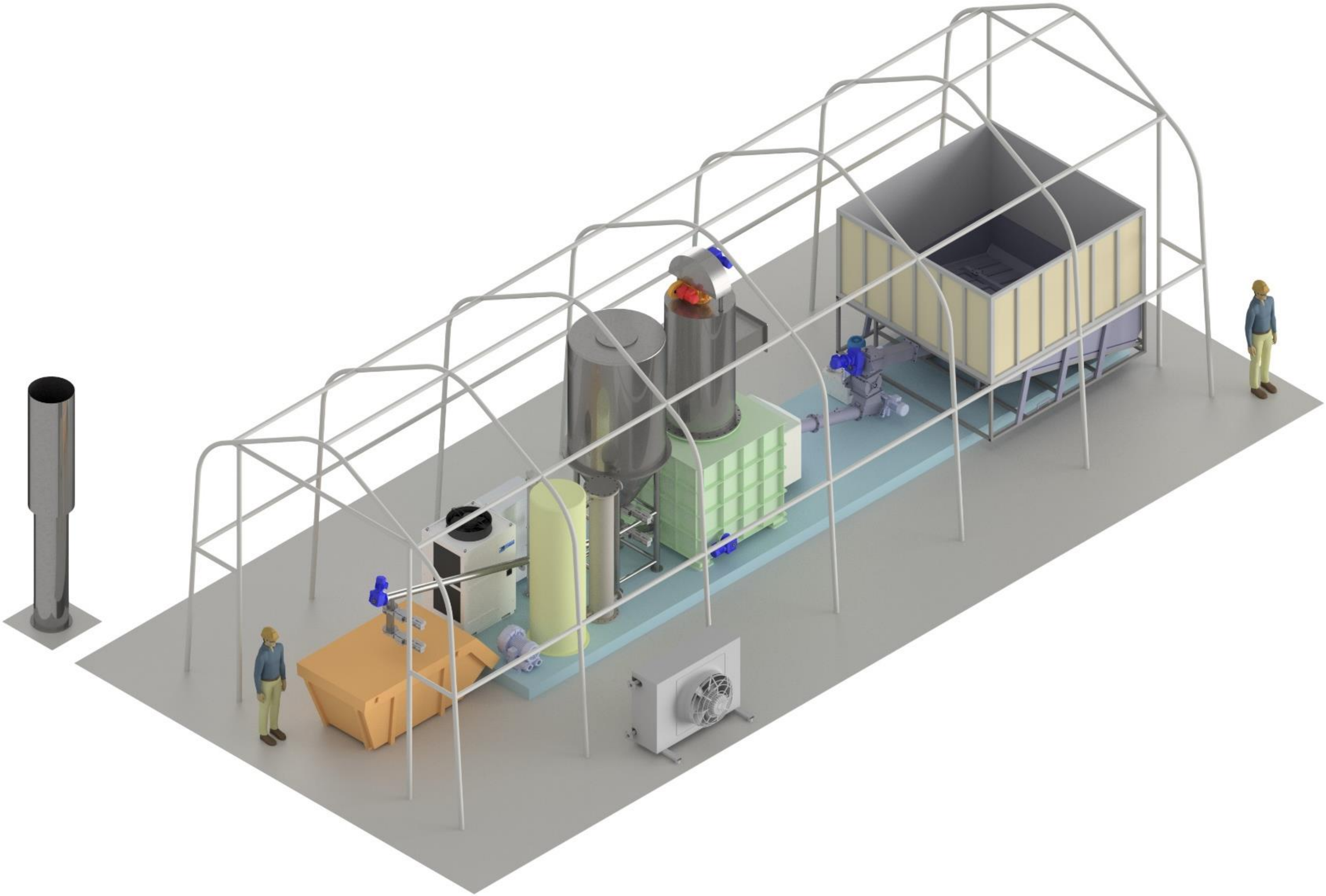
Source: ECN

TECHNOLOGY UNDER DEVELOPMENT AND COMMERCIALIZATION

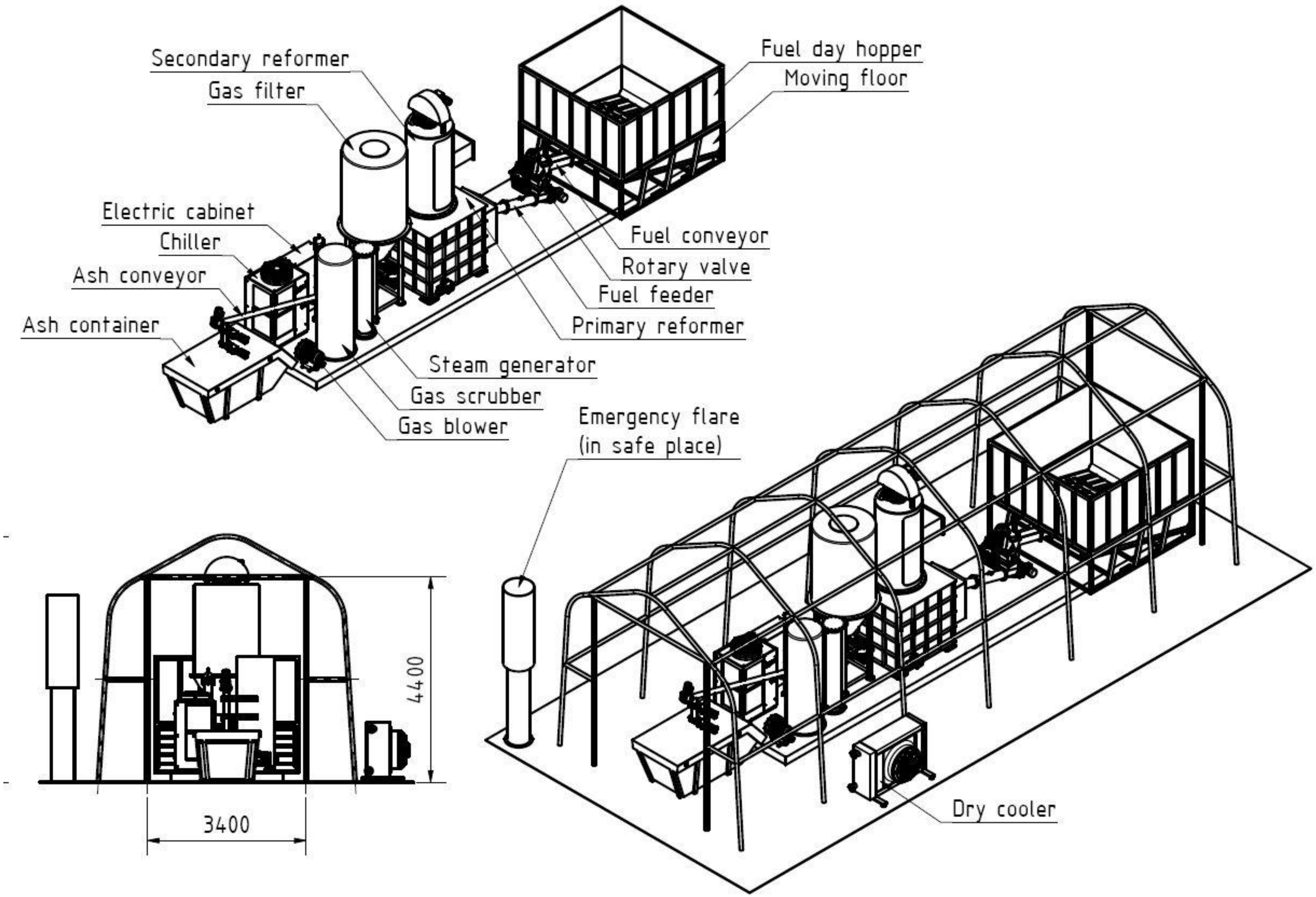
Complex thermochemical biomass or waste regeneration system based on proprietary **Atmospheric Steam Auto Thermal Reformer (A-SATR)** – fuel flexible modular gasification system with plug-in ready downstream applications.

- The system is based on **step grate** auto thermal reformer (gasifier) with **high temperature cracking to eliminate tars**, high efficiency heat exchanger, hot gas filters and gas cooling.
- In carbon capture mode, **wet oxygen as gasification agent** and steam is applied at high temperatures to eliminate the presence of nitrogen. In combination with highly efficient heat recovery of gas chemical energy A-SATR delivers truly adiabatic process.
- A-SATR is based on **modular pre-fab principle** allowing for short reaction time and mobility of the system.
- Installation **does not have chimney**, only an emergency flare.
- The system can be designed and manufactured for **0.1 to 2.5 t/h** throughput per unit with rated thermal input of **0.5 to 12.5 MW**, reducing the specific CAPEX for modular and pre-fab options.
- In contrast to downdraft/cross draft type or fluidized bed gasifiers (commonly considered as more efficient type, but feedstock and process sensitive), **A-SATR reformer provides high fuel flexibility for carbon-based materials**. The drawbacks of updraft gasification (e.g. high tar concentrations) are dealt with downstream using tar cracking and heat recovery processes.

DEMO PLANT 500 KW_{TH} OUTPUT 3D VISUALIZATION



A-SATR 500 DEMO LAYOUT



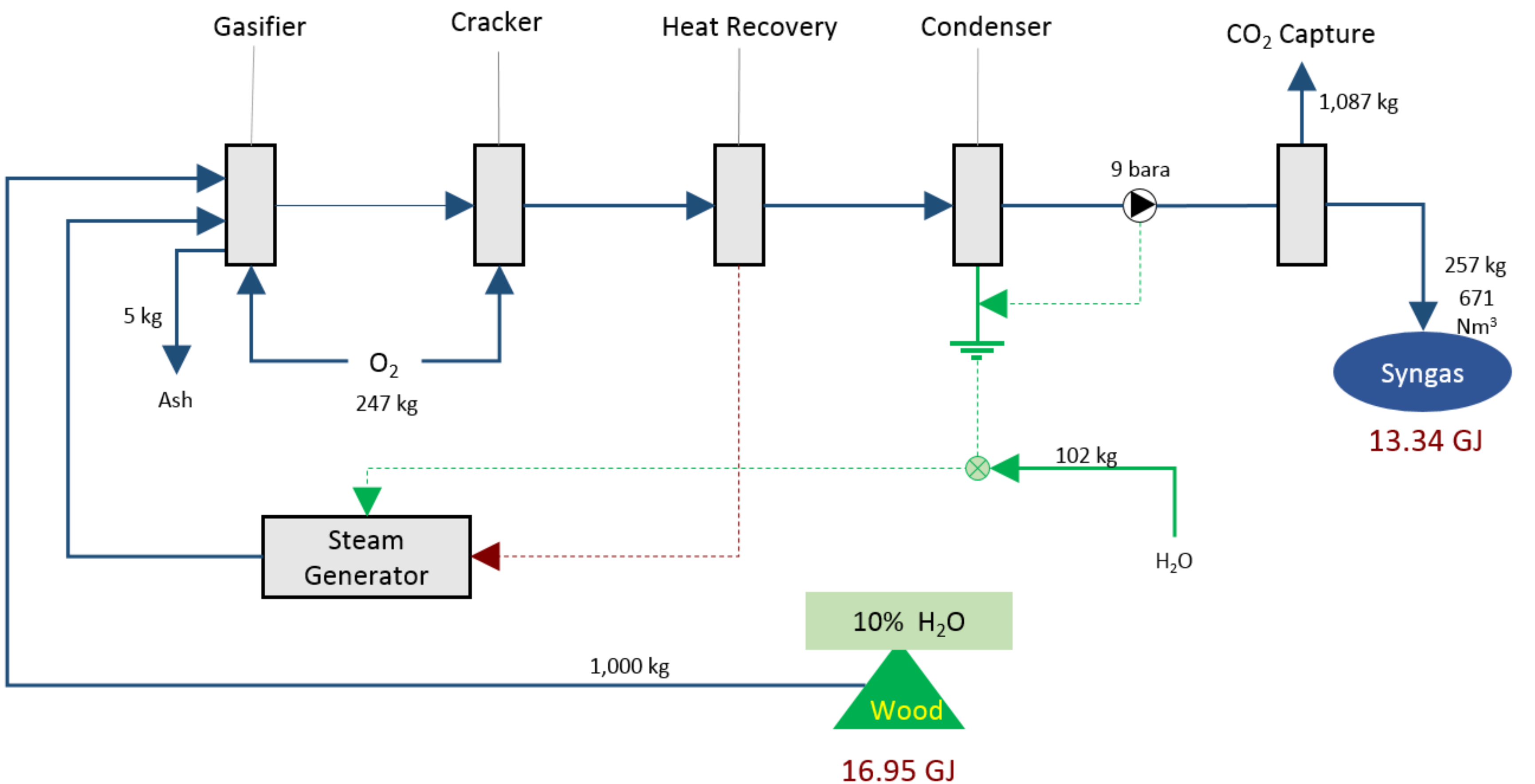
DEMO PLANT OVERALL TECHNICAL DATA

Plant Model	Atmospheric Steam Auto Thermal Reformer with vertical high temperature heat exchanger
Transportability	mobile/modular installation for light permitting and re-allocation
Fuel	biomass, straw, grass, RDF/SRF
Rated power	500 kW_{th}
Reformer Type	non pressurized step grate adiabatic superheated steam
Plant Size	3400x15000x4400 (tent size 5500x15000x5267)
Day hopper	18.4 m3 volume for 24h operation (3000x3000x2100)
Filtering system	dry scrubber and bag house hot gas filter
Ash	5% of original fuel
Water consumption	de-mineralized water for steam production start up 1 – 2m^3. No intake when running
Discharge water	15 L/h clean condensed water (in case moisture content higher >15%)
Power	max 20 kW
Oxygen requirement	0 (in the system without CO_2 separation)
Hydrated lime $Ca(OH)_2$	0 (in the system with biomass as feedstock)

<u>Auxiliary Equipment</u>

Fuel feeders	max 200 kg/h
Emergency flaring	max 500 Nm^3/h
Control System	Integrated PLC & SCADA

A-SATR GEEN GAS PRODUCTION PROCESS SCHEME

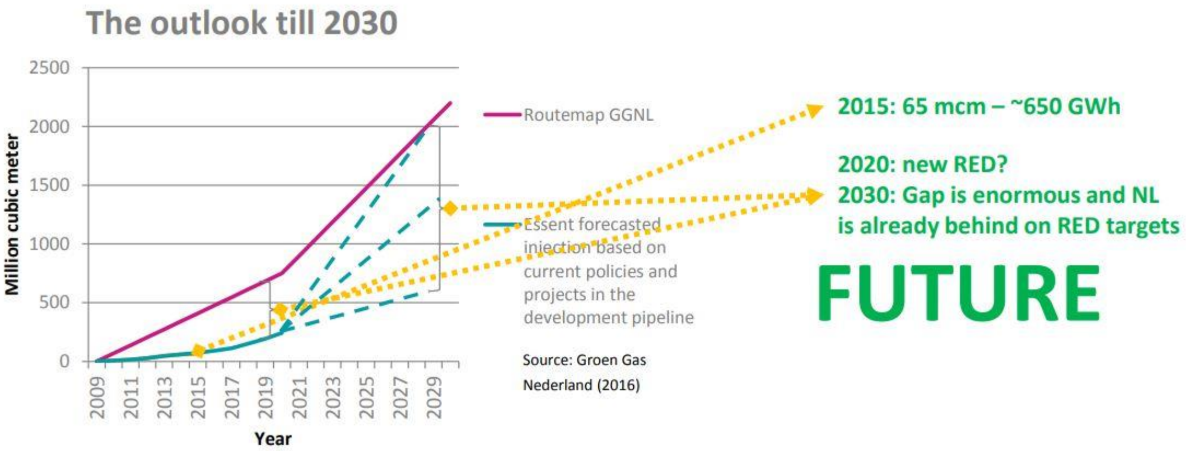


MARKET OVERVIEW FOR GREENING INDUSTRY POTENTIAL

Ambitions of the Netherlands
The ambitions of the Netherlands are expressed in the National Renewable Energy Action Plan, in the area of renewable energy. In this action plan, calculations are based on a gross final energy demand for renewable energy, amounting to 51 Mtoe (2.1 EJ) in 2020, of which renewable heat will contribute a total of 2.2 Mtoe (91 PJ). For this purpose, it is expected that bioenergy will make the largest contribution. To achieve this, the Netherlands expects a significant contribution from the direct feed-in of biomethane into the natural gas grid ('green gas'), of 0.58 Mtoe (24 PJ) in 2020. *Today around 40 bcm gas in the Netherlands each year. Biomethane covers less than 0,25%.* Other feasible option for greening the gas market is direct use of green gas in industrial heat/steam generation process by co-mixing of the green gas with natural gas in dual burners at existing gas boilers and have side stream of hydrogen generation

Resource availability
In 2020, approx. 13.4 to 16.4 million tonnes of dry biomass material would be available within the Netherlands for the generation of energy. This is 30 to 40% of the biomass used within the Netherlands on an estimated annual base. This can ensure the generation of 53 to 94 PJ of final energy, with which 101 to 157 PJ in fossil energy can be avoided.
Two different techniques can be employed for the production of green gas, namely - digestion based on 'wet biomass and energy crops' and gasification of dry biomass The digestion technique is presently well-developed and available. The gasification technique has not yet been developed to feasible commercial scale yet.

Stimulation framework
Upcoming green heat incentives and CO_2 capture and storage SDE++ schemes are well in line to demonstrate and scale up green gas production technologies particularly efficient gasification having much smaller footprint then anaerobic biogas production and sound environmental impacts to allow industrial applications in urban areas. Green hydrogen production is another added value of the integrated gasification systems feasible in current market conditions without governmental subsidies.



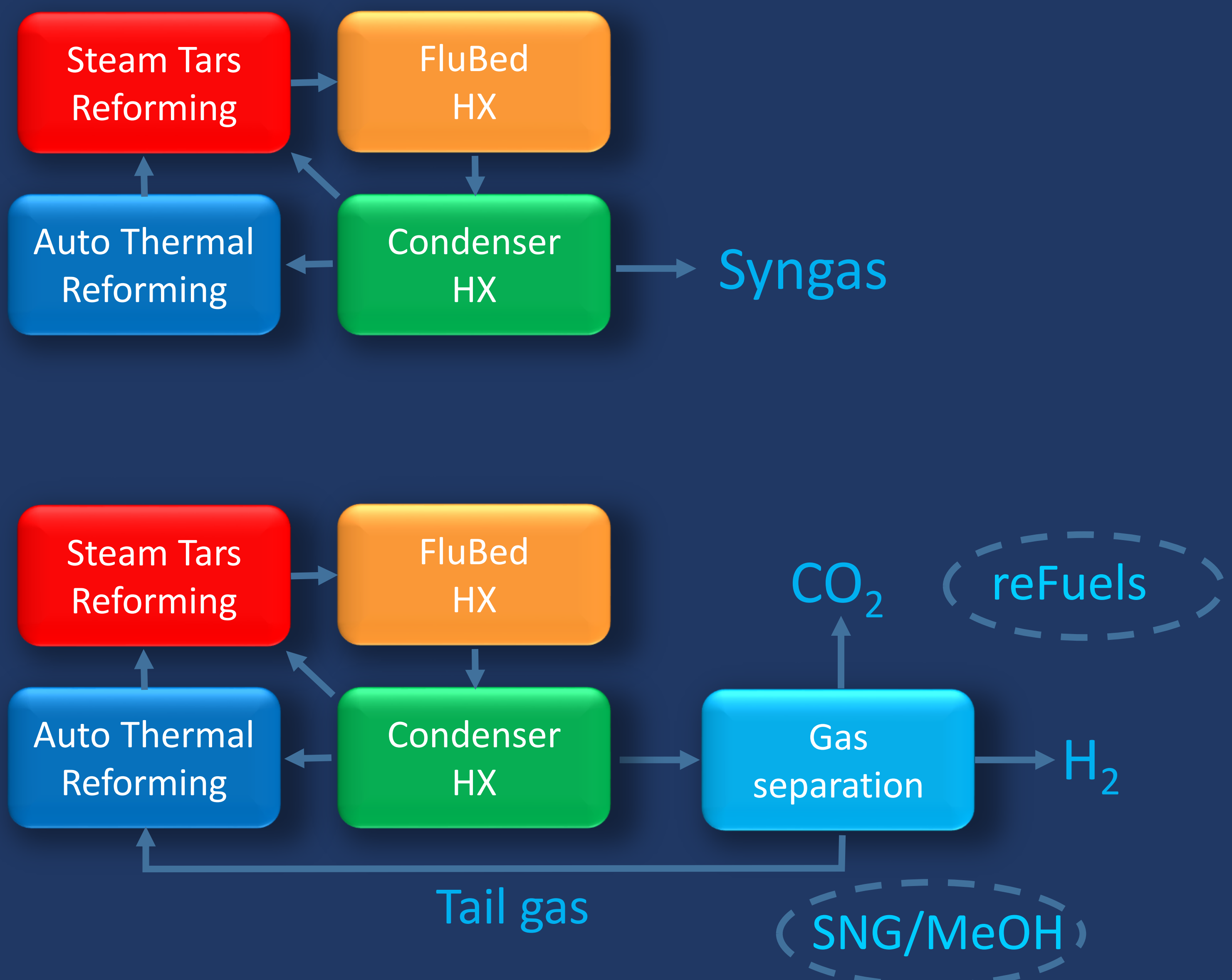
Although the Dutch biomethane market is operational since 1998, the real start was in 2008.

In 2015, 650 GWh was injected which primarily comes from anaerobic biogas installations.

No feasible solid biomass facilities have been operational so far.

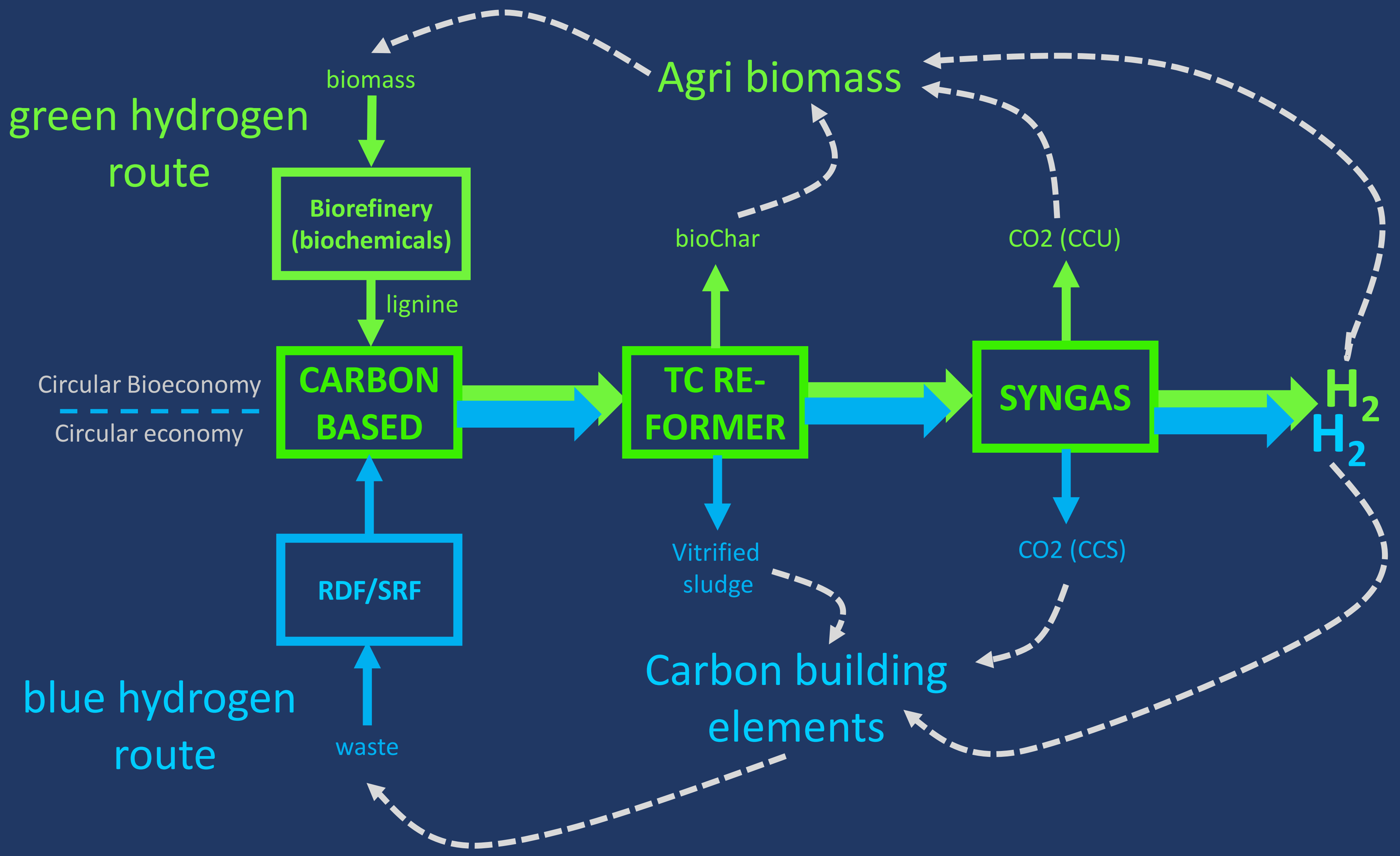
Source: Essent and green-gas.eu

Industrial greening via biomass gasification road map



Industrial partner HyroGas (Latvia)

Start-up Modus Operandi



CONSCLUSION AND MAIN TAKE AWAYS

1. Gasification and distributed generation (electrons and molecules).
2. End of waste syngas.
3. Atmospheric Steam Auto Thermal Reformer can integrate green and blue platforms under one technological process.
4. Modularity and standartization of solutions can speed up technology deployment time.
5. Combination of upstream and downstream technology choices allows addressing industrial greening needs and carbon neutral mobility needs.
6. Timely response to COVID-19 circumstances for localizing economies increasing flexiblity of waste management and circular bioeconomy.
7. Affordable and efficient response to circularity challenge and carbon neutrality.

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