The Energy System Integration and Sector Coupling:

Technology Approach

IAEE Webinar Series

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Biogas

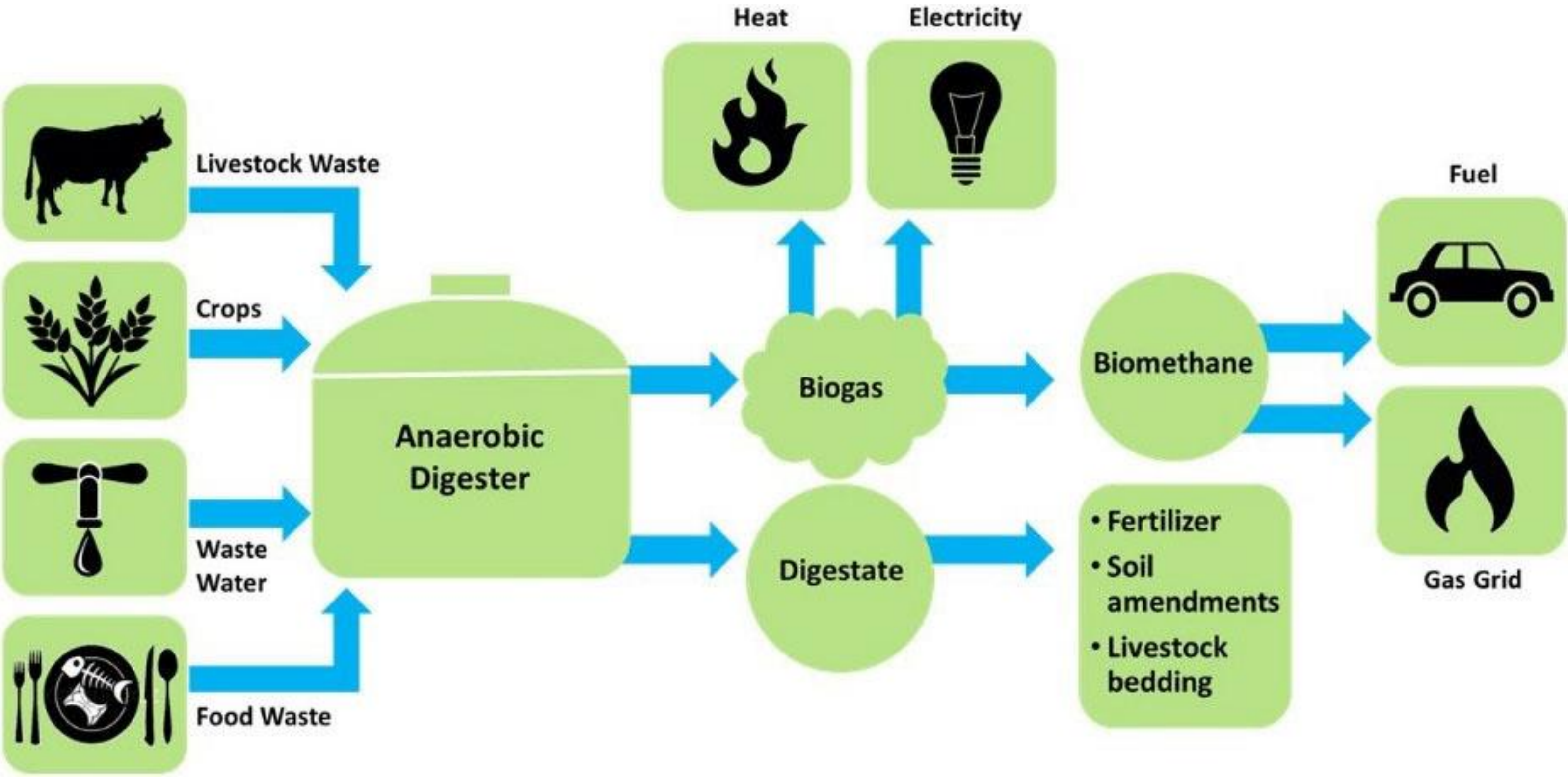
Biomethane and Synthetic Natural Gas (SNG)

Hydrogen

Biogas

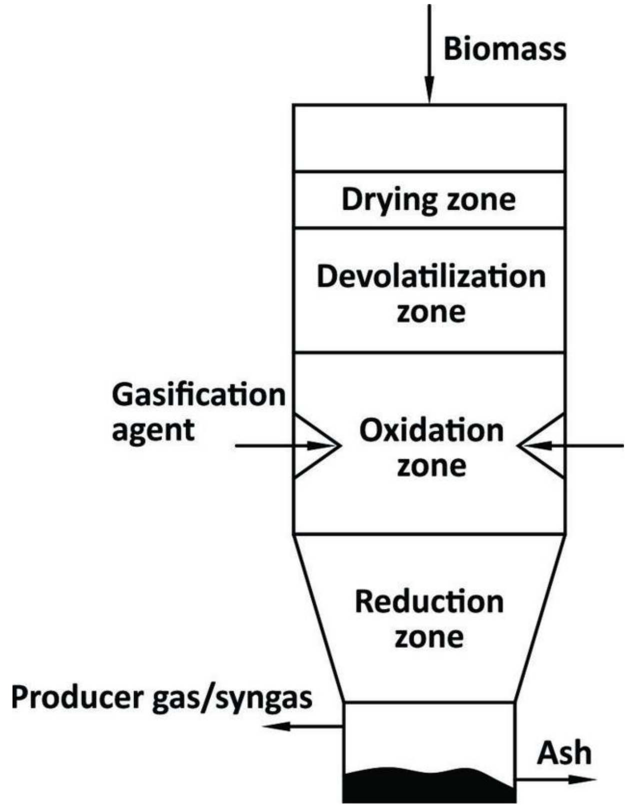
- A gaseous biofuel composed principally of methane (CH_4) and carbon dioxide (CO_2)
- Produced from biomass/biowaste by:
  - Anaerobic digestion
  - Thermal processes (pyrolysis or gasification)
- In practice:
  - Landfill gas
  - Sewage sludge gas
  - Other gases from anaerobic fermentation
  - Biogasses from thermal processes

- Anaerobic digestion – microorganisms break down biodegradable material in the absence of oxygen



Anaerobic digestion process (Graphic by Sara Tanigawa, EESI, Source)

- Gasification is a highly efficient way of thermochemical conversion, in a gasifier, in the presence of an oxidizing agent, in which a mixture of different products is obtained

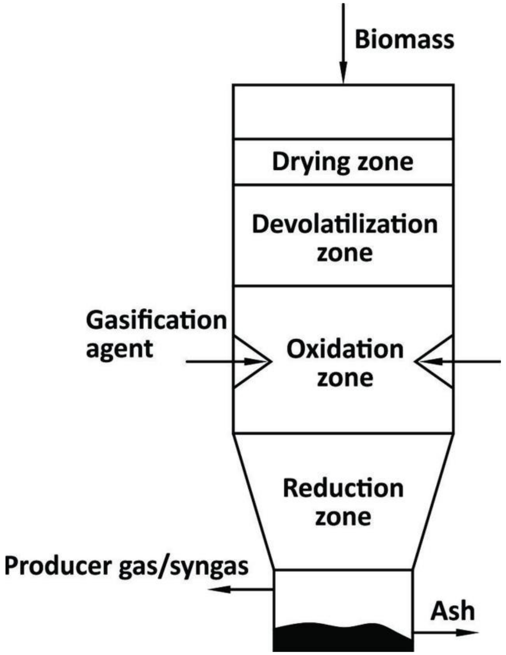


Biomass – wood chips gasification process in CHP system (Source)

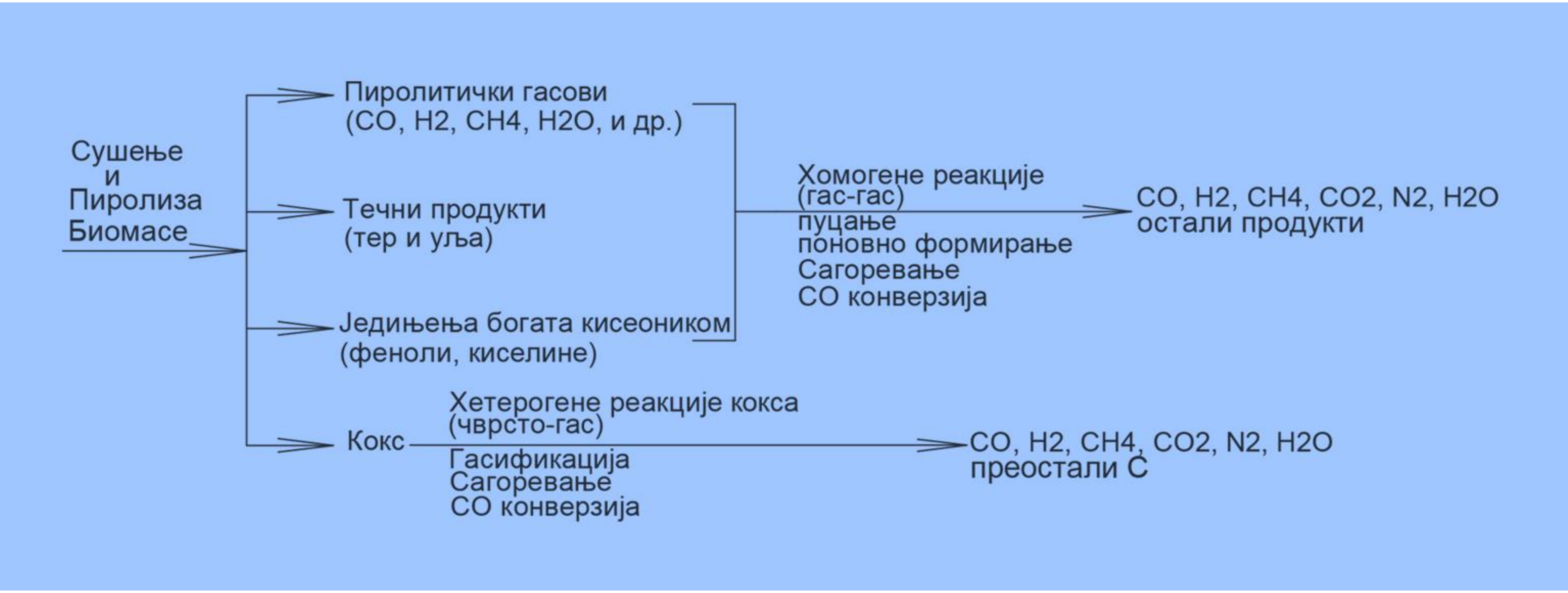
- Volatiles (gaseous phase):
  - water vapour
  - combustible (CO, H_2, and CH_4)
  - non-combustible (CO_2 and N_2)
  - gaseous hydrocarbons
- Condensing compounds such as tars and oils (liquid products)
- Oxygen-rich compounds: phenols and acids
- Ash/small amounts of char

- Less significant products, present in smaller quantities or traces

- Pyrolysis or devolatilization is the thermal decomposition of materials (biomass) at elevated temperatures in the absence of an oxidizing agent.
- After drying, it is the first phase gasification

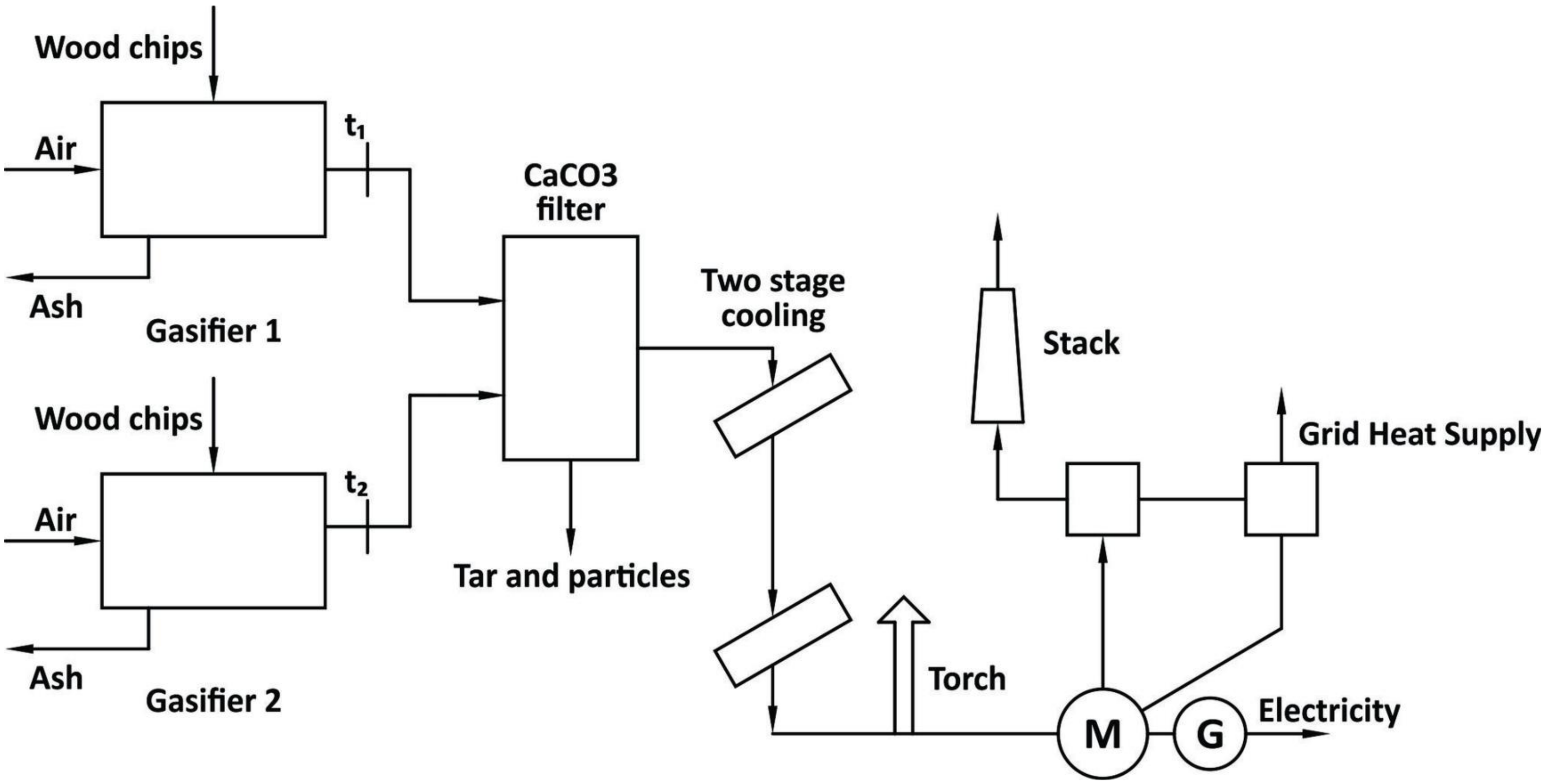


Biomass – wood chips gasification process in CHP system (Source)



Scheme of the biomass gasification process (Source)

- Product of gasification, as a key precursor for biofuel products, has a variety of applications, according to the tailoring of the yield and ratio of gasification products:
  - on-site
  - to generate heat and electricity (CHP)
  - synthetic fuel production and their deployment as transportation fuels, is considered very attractive lately.
  - upgraded and injected into the natural gas pipeline system and then transported to more remote customers



Scheme of the biomass gasification process (Source)

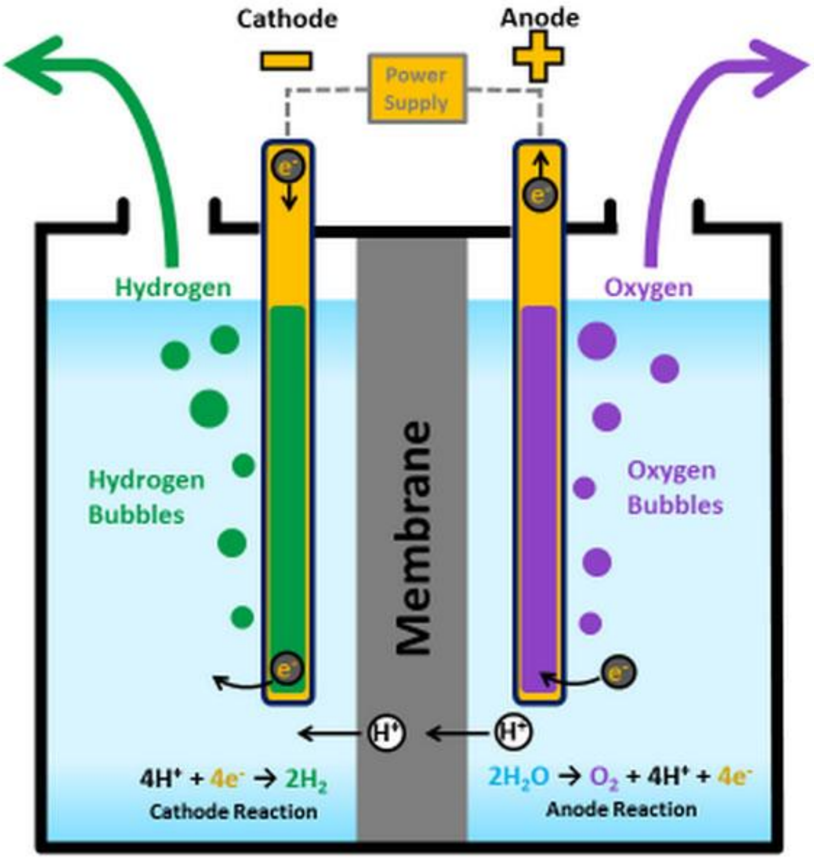
Biomethane and Synthetic natural gas (SNG)

- Biogas purification → upgraded to biomethane
- Its quality is smilar to natural gas
- Natural gas blending/injection into a natural gas grid for the same application
- Biomethane can be used as a transport fuel in vehicles on CNG, as well as LNG, and it is under the Renewable Transport Fuel Obligation.

- SNG describes a variety of natural gas alternatives that are as close as possible in composition and properties to natural gas.

Hydrogen

- Promising technologies to produce low/zero/negative-carbon hydrogen
  - Hydrogen produced from the electrolysis of water using renewable electricity
  - Solar PV/Offshore wind
  - Nuclear
  - Regional decarbonised power mix
  - $H_2O \rightarrow H_2 + \frac{1}{2}O_2$
  - Early commercialisation



- Hydrogen produced from methane pyrolysis with CCU
- CO_2 being rendered into solid carbon
- $2CH_4 \xrightarrow{t} C_2H_6 + H_2 \rightarrow C_2H_4 + 2H_2 \rightarrow C_2H_2 + 3H_2 \rightarrow 2C + 4H_2$
- Demonstration stage

- Hydrogen produced from steam methane reforming (SMR) with CCS
  - $CH_4 + H_2O \rightarrow CO + 3H_2$

    $CO + H_2O \rightarrow CO_2 + H_2$
- Early commercialisation

- The ‘greening’ of the gas network through blending would indeed take advantage of the robustness and extensiveness of an already existing energy infrastructure.
- Benefits for energy storage, resiliency, and emissions reductions – blending hydrogen into the existing natural gas infrastructure
- Several projects worldwide are demonstrating blends with hydrogen concentrations as high as 20 %.
- A long-term impact of hydrogen on materials and equipment is not well understood – challenging for utilities/industry to plan large-scale blending:

- Hydrogen compatibility of piping and pipelines when blends are used.
- Life-cycle analysis – life-cycle emissions of technologies using hydrogen/natural gas blends, as well as alternative pathways such as synthetic natural gas.
- Techno-economic analysis – to quantify the costs and opportunities for hydrogen production and blending within the natural gas network, as well as alternative pathways such as SNG.

- Although the technological solutions exists (TRL) the future of hydrogen depends on whether technologies reach commercial maturity (CRL) driven by:
  - relative performance of competing clean energy sources
  - capital costs
  - consumer preferences
  - policy decisions

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