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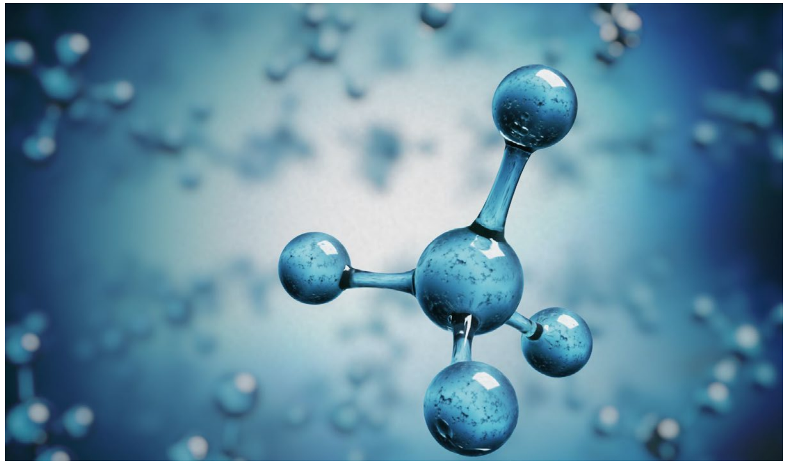

Synergies of green hydrogen and bio-based value chains deployment

IEA Bioenergy Intertask project 2022-2024

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Fossil-free hydrogen is a key energy carrier

- Fossil-free hydrogen is a **key energy carrier** in a net-zero society – foremost in **hard-to-abate sectors**

- Biomass-based H_2 has great potential to accelerate the realization of the hydrogen economy – **currently overlooked**

- Brings **important benefits**
    - Non-weather dependent, fossil-free hydrogen production
    - Negative emissions
    - Process integration opportunities

Figure 4. An Illustrative Hydrogen Colour Spectrum

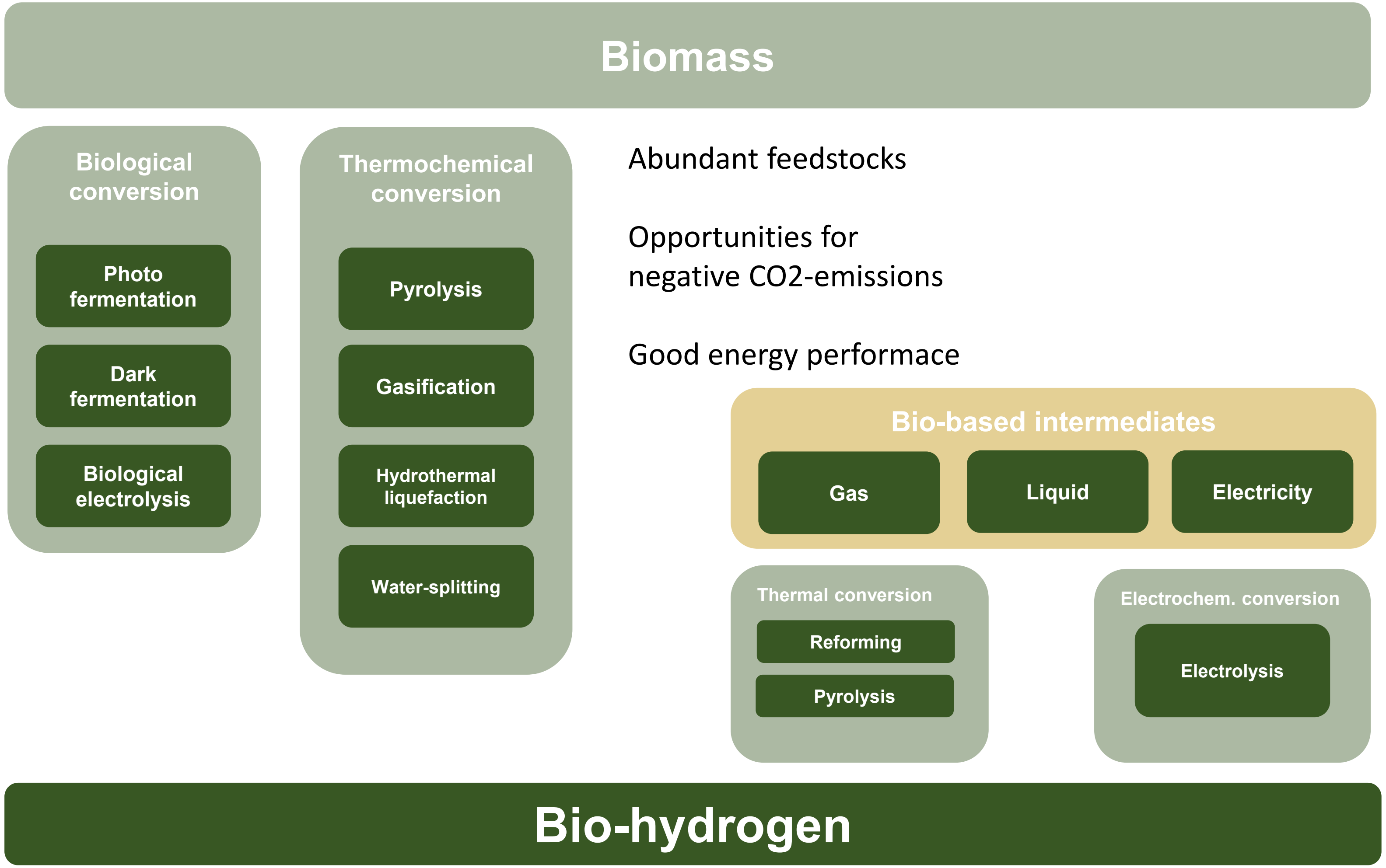
	Terminology	Technology
PRODUCTION VIA ELECTRICITY	Green Hydrogen	Electrolysis
	Purple/Pink Hydrogen	
	Yellow Hydrogen	
PRODUCTION VIA FOSSIL FUELS	Blue Hydrogen	Natural gas reforming + CCUS gasification + CCUS
	Turquoise Hydrogen	Pyrolysis
	Grey Hydrogen	Natural gas reforming
	Brown Hydrogen	Gasification
	Black Hydrogen	

**GCG footprint given as a general guide but it is accepted that each cate*

Source: Global Energy Infrastructure (GEI), 2021

Many pathways to produce bio-hydrogen

H2-production from a wide range of substrates, incl. waste streams



Abundant feedstocks

Opportunities for negative CO2-emissions

Good energy performace

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Many options for integrating hydrogen in bio-conversion

Gasification based processes

- Carbon dioxide capture and reverse-water-gas-shift reaction
- Addition of hydrogen to gasification of biomass
- Addition of hydrogen to fuel synthesis

Pyrolysis/HTL based processes

- Addition of hydrogen in-situ during (catalytic) hydro-pyrolysis/solvolysis
- Hydro-treatment of pyrolysis vapors
- Hydro-treatment of bio-oils/-crude
- Carbon dioxide capture and reverse-water-gas-shift reaction

Microbial processes

- Carbon dioxide capture and reverse-water-gas-shift reaction

From N. Dahmen, Case studies on green hydrogen in bio-based processes
Berlin, IEA Expert workshop, March 29, 2023

Biomass conversion technologies have limited carbon efficiencies

Limitations posed by the differing elemental composition of feedstock and product

Biomass feed is used both as carbon source and as energy source, parts of the feedstock is combusted in the process

By-products and side reactions lead to formation of C-containing streams other than the main desired product

Ref: Furusjö, E., et. al., (2022) Bio-electro fuels – hybrid technology for improved resource efficiency. Publ. No FDOS 45:2022. Available at https://f3centre.se/

Hydrogen addition to the biomass conversion process improves the carbon efficiency

- Gasification-based biofuel production has great potential for integration - Doubled (or even tripled) yield from the same amount of biomass.

- The carbon efficiency can increase to over 90 percent if the energy and hydrogen for the process are taken from electricity instead of from the biomass raw material.

- The GHG-performance of bio-electro-fuels is good if the GHG footprint of the electricity used in the process is low

PUBLICATION FDOS 45:2022

Final report

BIO-ELECTROFUELS

– hybrid fuels for improved resource efficiency

April 2022

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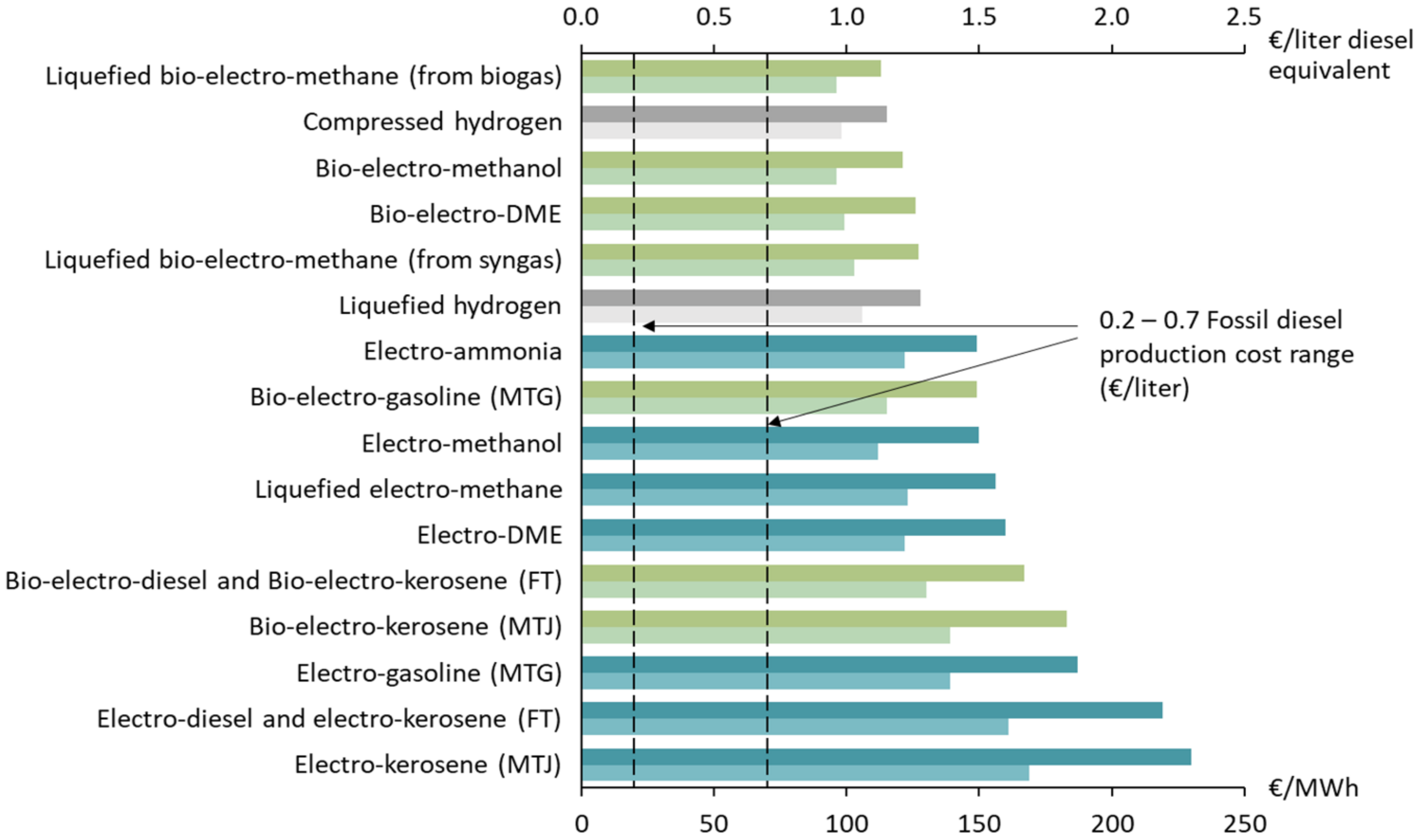
A collaborative research program between the Swedish Energy Agency and f3 The Swedish Knowledge Centre for Renewable Transportation Fuels

Swedish Energy Agency www.energimyndigheten.se

THE SWEDISH KNOWLEDGE CENTRE FOR RENEWABLE TRANSPORTATION FUELS www.f3centre.se

Ref: Furusjö, E., et. al., (2022) Bio-electro fuels – hybrid technology for improved resource efficiency. Publ. No FDOS 45:2022. Available at https://f3centre.se/

Indirect electrification is cost-efficient



Ref: Grahn et.al, Prog. Energy 4 (2022) 032010

Aim & Objectives of the ITP-project

- Illustrate how green hydrogen and bio-based value chains can support each other

- Identify and assess the synergies in between green hydrogen and bio-based value chains in different sectors and at different timeframes
  - Technology maturities, economics, sustainability performances, and infrastructural topics are addressed through Case Studies.

- What is needed to realize the potential of these synergies?

- The project will provide science-based views on several value chains, the drivers and barriers for the deployment, and measures to overcome barriers.

Pre-framing / WP1 | Status quo of synergy value chains

T40, *T32, T33, T34, T36, T37, T39, T42, T44, T45, Hydrogen TCP*

- Possible combinations of green hydrogen and bio-based value chains (feedstocks, technologies, products); drivers, barriers, lessons learned, key process and performance data (expert WS)
- Definition of Case Studies for WP2 and WP3
- Definition of framework and criteria for Case Study assessments

Hydrogen TCP ⇔

WP2 | Case Studies on hydrogen from biomass

T33, *T36, T39, T44, Hydrogen TCP*

- Techno-economic assessment
- Comparison to hydrogen from green electricity

WP3 | Case Studies on hydrogen use in bio-based processes

T34, *T32, T33, T37, T39, T40, T42, T44, Hydrogen TCP (tbc), AMF TCP (tbc)*

- Techno-economic assessment
- Specific applications: heavy transport, jet fuels, seasonal storage/back-up

ETSAP TCP ⇔

WP4 | Synergies and services from hydrogen and bio-based value chains deployment

T44, *T37, T40, ETSAP TCP (tbc), Hydrogen TCP (tbc)*

- Definition and evaluation of system level synergies and energy system services (expert WS)
- Overview of synergies and services in energy system models and roadmaps
- Evaluation of synergy value chains under different frame conditions

BECCUS ITP ⇔

WP5 | Assessment and synthesis

T45, *T32, T33, T34, T36, T37, T39, T40, T42, T44*

- Potential of green hydrogen with respect to the anticipated role of biofuels and e-fuels
- Reduction of the carbon footprint of PtX products through biogenic CO2
- An outline of promising value chains under different framework conditions and timeframes
- Assessment of climate and other sustainability effects of Case Studies
- Key benefits and constraints of different value chains, needs for policies

WP6 | Project management and dissemination

T44

WP2 and WP3 Implementation

- Describe case studies with different bio-H2 technology pathways:
  - Biomass gasification for hydrogen production (T33)
  - Biological production of hydrogen from wet streams (e.g., from waste-water) (T36)
  - Conversion of bio-based building blocks, such as methanol, ethanol and/or biomethane, to hydrogen (T39, T44, T33)
- Process description (including a block process scheme)
- Development status, applications, and production scale
- Assessment of the technology readiness
- SWOT-analysis
- A number of different KPI’s

Thanks!

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