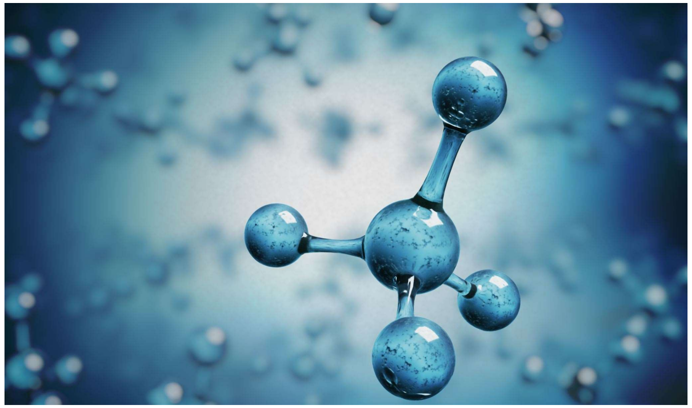


Synergies of green hydrogen and bio-based value chains deployment

ITP

Joakim Lundgren, IEA Bioenergy Task 33

The main objective is to identify and assess synergies in the deployment of green hydrogen and bio-based value chains

- Enhance the deployment of both energy carriers and the energy system under different conditions
- Identify potential synergetic value chains in different sectors and at different timeframes
- **Increase visibility and knowledge of promising solutions through Case Studies covering economics, climate and other sustainability effects, supply chain aspects and infrastructural topics**
- Provide a synthesized view on key barriers and enablers to realize the potential, and on future policy needs

The focus is on **the value chains directly linked to bioenergy**, i.e. biomass as a source of hydrogen and bio-based processes consuming electrolytic hydrogen.

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 Case studies - Bio-H2-production (T33 lead)

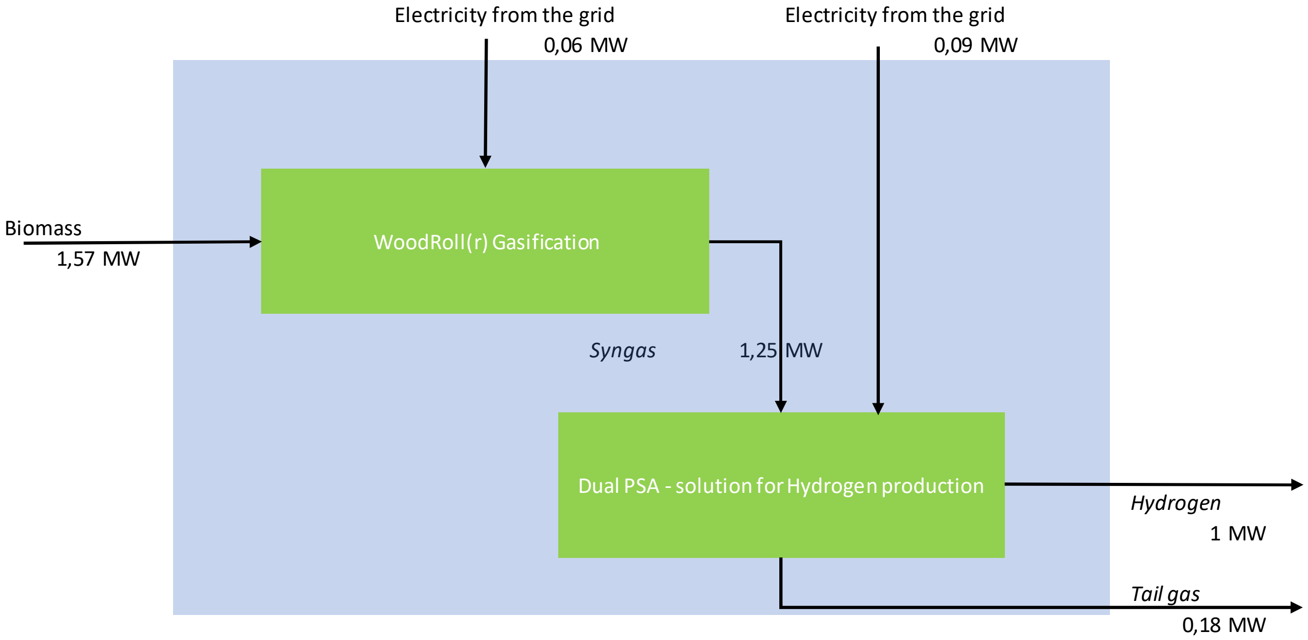
WP2 contact	Project/Company	Country	Technology	
T33/Joakim & Berend	Torrgas	The Netherlands	Large-scale gasification of torrefied biomass	WP5 LCA
T33/Joakim	Cortus	Sweden	Small(-er)-scale gasification of wood-chips	WP5 LCA
T36/Mar Edo	RISE/ Indienz	Sweden	Dark fermentation	
T39/Glaucia	Hytron/Neuman & Esser	Brazil	Ethanol on-site reforming	
T39/Glaucia	Nissan	Brazil	Onboard ethanol reforming - SOFC	
T33/Joakim	Hycamite	Finland	Thermocatalytic decomposition of methane (methane splitting/pyrolysis)	WP5 LCA

WP3 Case studies

WP2 contact	Project/Company	Country	Technology
T32/ Morten	Fünen	Denmark	Biomass combustion with CCU
T33/Joakim	LTU Green Fuels	Sweden	Hybrid biomass gasification and electrolysis process
T34/ Daniele	Silva Green Fuel	Norway	Upgrading of HTL oil
T39/ Franziska	Pilot-SBG (pilot project)	Germany	Hydrogen in HVO/HEFA plants
T39/ Franziska	reFuels	Germany	Green refineries with focus on fuel production
T39/ Glaucia	Omega Green advanced biofuel plant	Paraguay	Hydrogen in HVO plants
T44/ Tilman	HyFuelUp (EU project, just started)	EU	Dual Fluidised Bed – Sorption Enhanced Reforming Gasification + Fluidised bed methanation
T39/ Glaucia	Several commercial actors	Brazil	Biogas reforming to H2 for ammonia production

WP5
LCA

Case study: Biomass gasification by Cortus



- Dual H2 separation is to be used.
  - 1st PSA separates the H2 from the original syngas stream.
  - WGS on tail gas followed by a 2nd PSA.
- The technology is scalable up to 50 MW.
- LCA carried by KTH

Case study: Ethanol on-site reforming by Hytron/NEA

Fuel Reformers

Product to Come – Ethanol

Ethanol

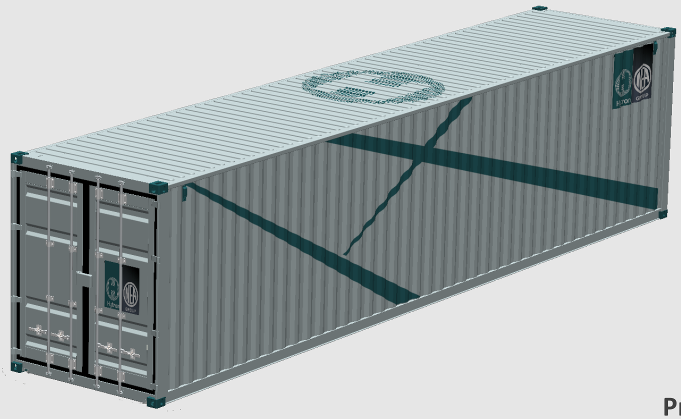
7.65 L / kg H_2

Water

30 L / kg H_2

Electricity

2.35 kWh / kg H_2



Hydrogen

up to 750 kg/day

Process: Steam-Reforming

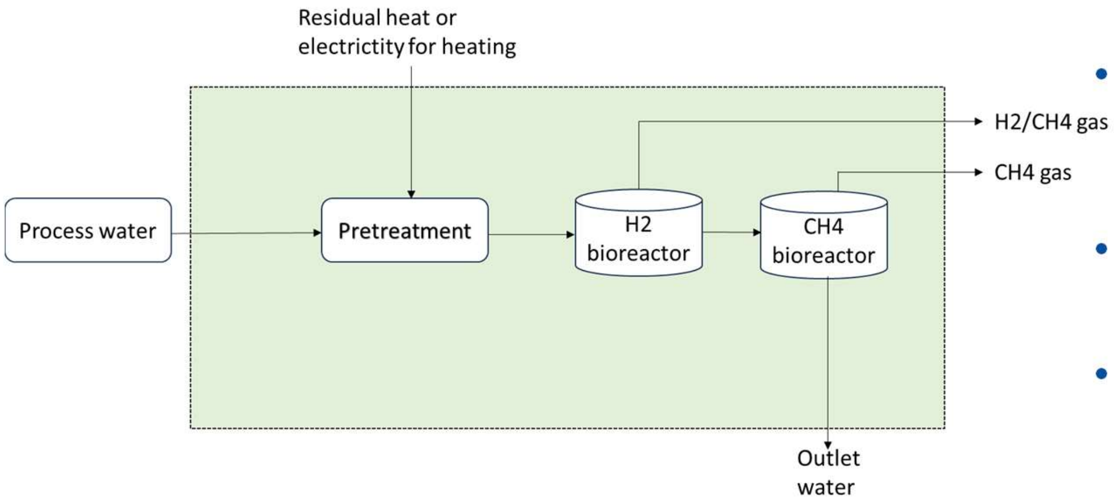
H_2 Purification: PSA (Pressure Swing Adsorption)

H_2 Purity: up to 99.9999% (SAE J2719 / DIN EN 17124 compliant)

H_2 Pressure: 10 bar_g (typical)

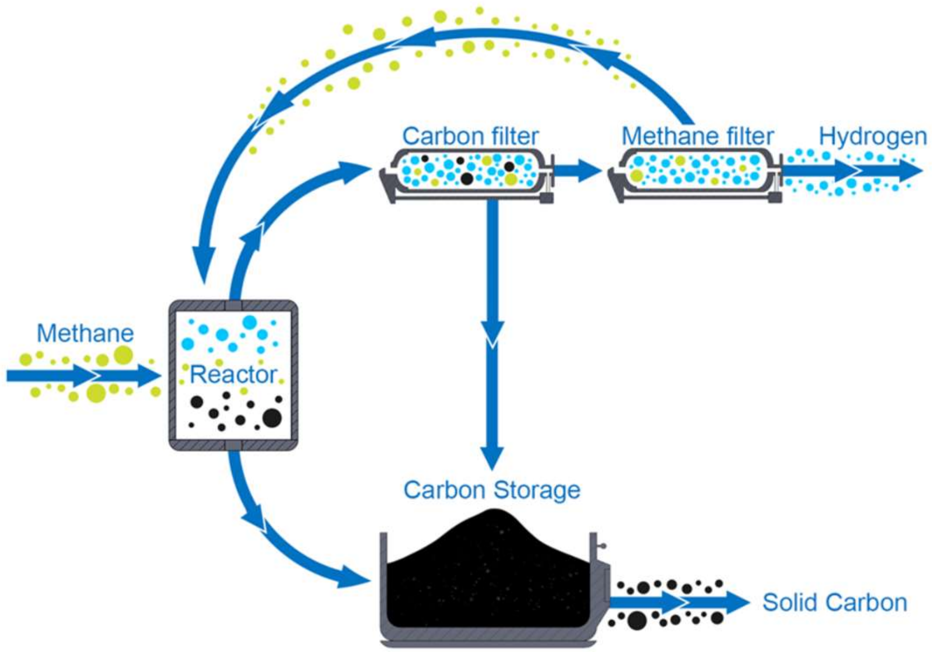
41

Case study: H2-production through dark fermentation by RISE/Indienz



- Microorganisms produce hydrogen in the absence of oxygen.
- Indienz and RISE have developed a pilot scale system for combined biohydrogen and methane production.
- Nordic Sugar provided substrate - wastewater from the sugar processing.
- The concept offers faster degradation of organic compounds and lower hydraulic retention time (HRT) requirements and thus smaller reactor vessels.

Case study: Methane splitting using thermal catalytic process technology by Hycamite TCD Oy



- Energy-efficient production of fossil-free H2 and solid carbon from bio-methane.

  Hycamite builds a demonstration facility (a so-called Customer Sample Facility (CSF) - production capacity 2,000 tons of hydrogen gas and 6,000 tons of high-quality biocarbon per year.

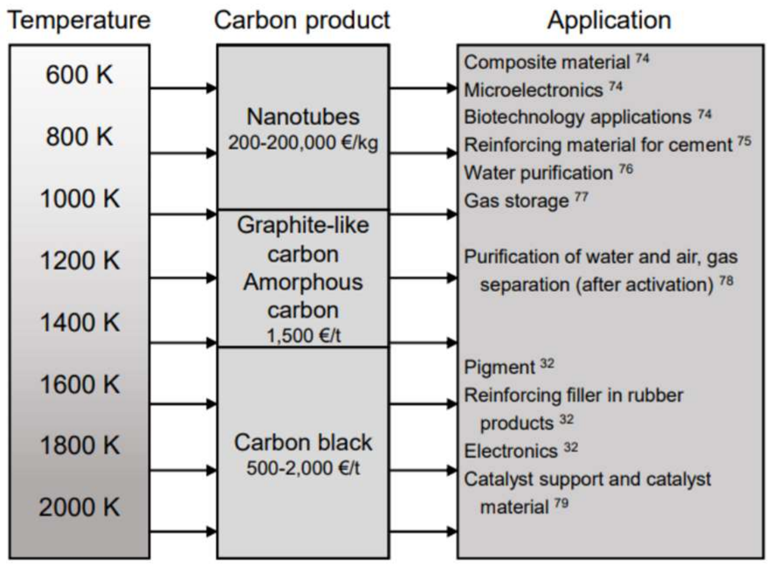
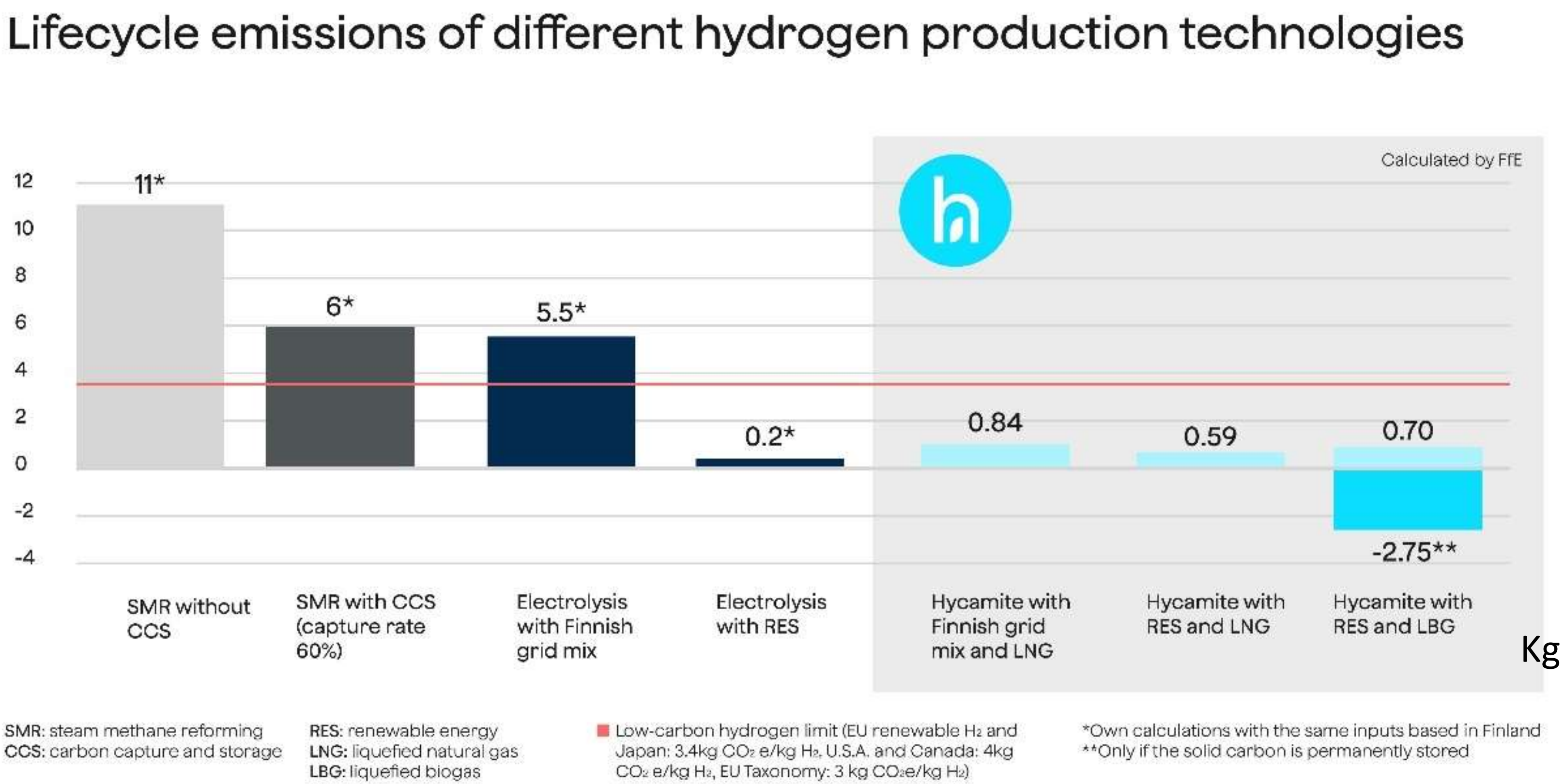


Fig. 2.4: The dependency of the product carbon type on the TDM reaction temperature and application possibilities for the carbon. [32, 74–79]

Case study: Methane splitting using thermal catalytic process technology by Hycamite TCD Oy



Kg CO2/kg H2

TRL assessments

Case	Project/Company	Weighted avg. TRL	Weakest link
Large-scale gasification of torrefied biomass	Torrgas	5.7-6.1	5
Small(-er)-scale gasification of wood-chips	Cortus	5.7-6.1	5
Dark fermentation	RISE/ Indienz	4.1-4.6	4
Ethanol on-site reforming	Hytron/Neuman & Esser	8.1-8.7	6-7
Onboard ethanol reforming - SOFC	Nissan	6.5-7.3	6-7
Thermocatalytic decomposition of methane (methane pyrolysis)	Hycamite	6.4-7.1	5-6

KPI’s for hydrogen production from biological production

o	Parameter	Unit	SoA	Targets	
			2020	2024	2030
1	System carbon yield	kg H_2/kg COD	0.012	0.015	0.021
2	Reactor production rate	kg $H_2/m^3/d$	7.5	15	>15
3	Reactor scale	m^3	3	10	100
4	System capital cost	€/(kg/d)	450	400	350
5	System operational cost	€/kg	3.2	3	2.5

KPI's for hydrogen production from raw biogas

No	Parameter	Unit	SoA	Targets	
			2020	2024	2030
1	System energy use	kWh/kg	64	60	57
2	System capital cost	€/(kg/d)	1,250	1,150	1,000
3	System operational cost	€/kg	1.35	1.32	1.28

KPI’s for hydrogen production via biomass gasification

No	Parameter	Unit	SoA	Targets	
			2020	2024	2030
1	System carbon yield	kg H_2/ kg C	0.15	0.22	0.32
2	System capital cost	€/(kg/d)	1,806	1,514	1,264
3	System operational cost	€/kg	0.013	0.011	0.009

Assessed KPI's

	System carbon yield	Hydrogen yield	Energy Efficiency incl. Side-streams	System capital cost	System operational cost	Reactor production rate	Production cost w/wo carbon credits	Reactor scale/Production capacity
Large-scale gasification of torrefied biomass	To be delivered			To be delivered	To be delivered	N.A		From 30 up to 100 MWth input (LHV basis)
Small(-er)-scale gasification of wood-chips	To be delivered			To be delivered	To be delivered	N.A		Up to 50 MW syngas output
Dark fermentation	78.5 mL H2/g COD			To be delivered	To be delivered	To be delivered		To be delivered
Ethanol on-site reforming	1,2 kg H_2/kg C							Up to 750 kg H2/day
Onboard ethanol reforming - SOFC	0,7 kg H_2/kg C	6.1-9.2 kg H2 per ton sugarcane (fresh weight)						N.A
Thermocatalytic decomposition of methane	60-90% CH4-conversion	0.25 kg H2/kg CH4				N.A		570 kg H2/h (demo scale)

Remaining work

- Summarize and make the mass- and energy balances uniform.
- Calculate the determined KPI’s.
- Editorial work on the WP2-report.
- Webinar September 2024.
- Planning a joint workshop with IEA Hydrogen in Paris May/June 2025.

Thanks!

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IEA Bioenergy
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