



IEA Bioenergy
Technology Collaboration Programme



Carbon-negative production of hydrogen through biomass gasification

IEA Bioenergy ExCo-workshop

Joakim Lundgren, Luleå University of Technology

October 19, 2023, Lyon, France

The IEA Bioenergy Technology Collaboration Programme (TCP) is organised under the auspices of the International Energy Agency (IEA) but is functionally and legally autonomous. Views, findings and publications of the IEA Bioenergy TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

Technology Collaboration Programme

by **iea**

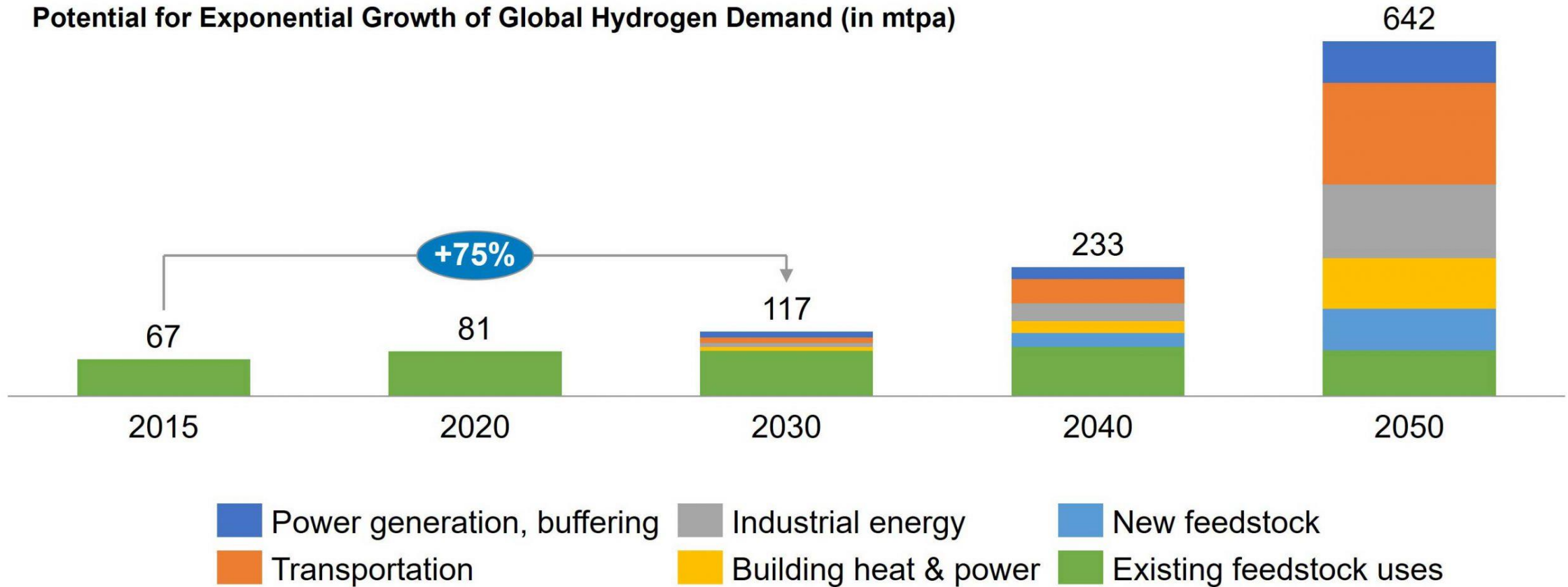
Hydrogen- the hottest thing in green energy?



Sources: Hydrogen Europe, 2023 and Bloomberg, 2023

The demand for green hydrogen is expected to skyrocket

Potential for Exponential Growth of Global Hydrogen Demand (in mtpa)



Source: Hydrogen Council

Hydrogen demand directly converted to power demand

- Other production pathways than electrolysis seems overlooked
- Hydrogen via biomass gasification deserves more attention
 - Non-weather dependent, fossil-free, large-scale hydrogen production
 - Mitigate the power demand
 - Process integration opportunities
 - Negative CO₂-emissions

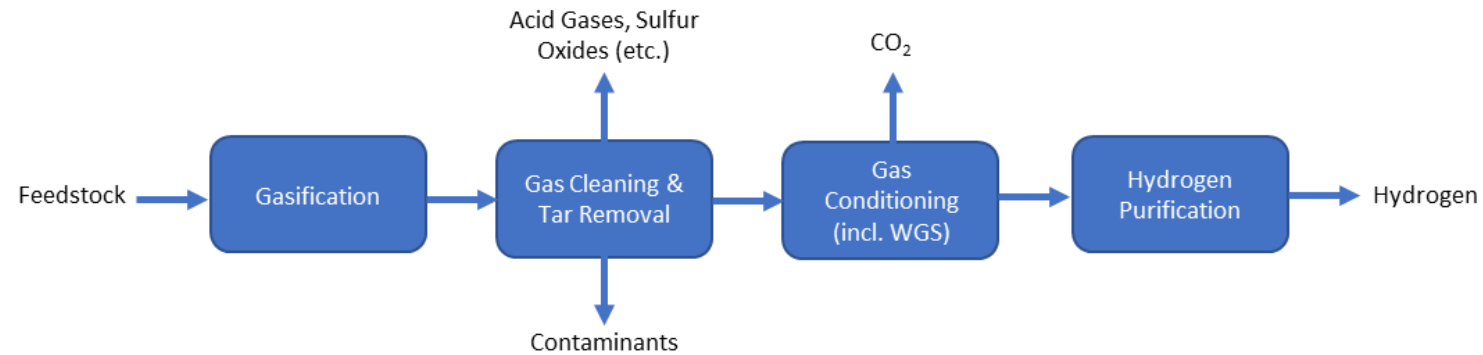
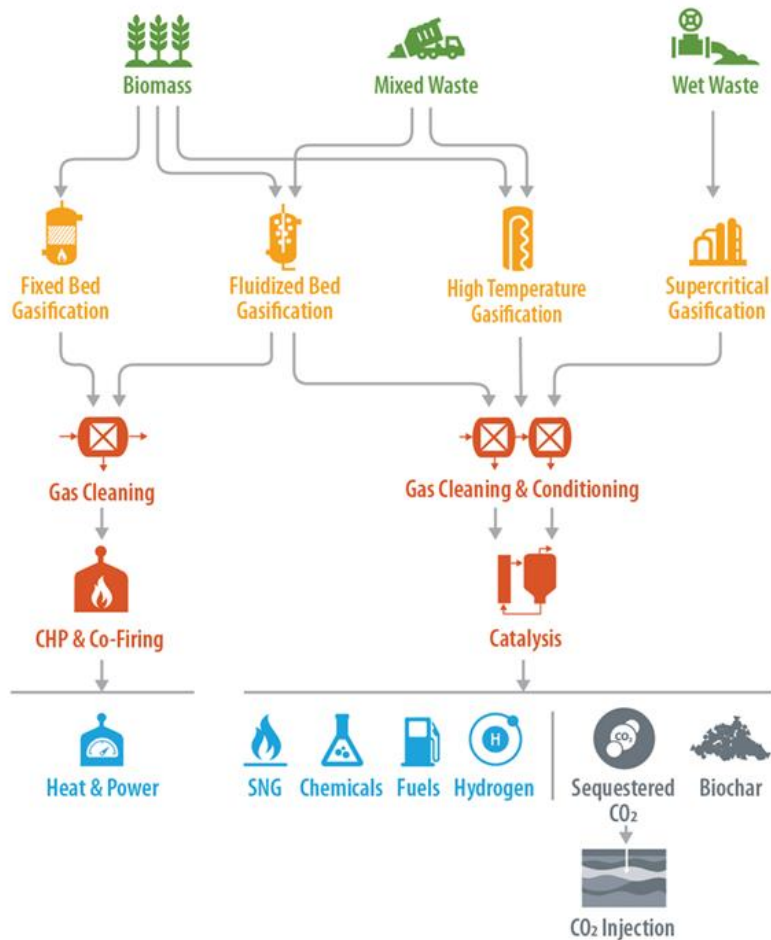
Figure 4. An Illustrative Hydrogen Colour Spectrum

	Terminology	Technology	Feedstock/ Electricity source
PRODUCTION VIA ELECTRICITY	Green Hydrogen	Electrolysis	Wind, Solar, Hydro, Geothermal, Tidal
	Purple/Pink Hydrogen		Nuclear
	Yellow Hydrogen		Mixed-origin grid ener
PRODUCTION VIA FOSSIL FUELS	Blue Hydrogen	Natural gas reforming + CCUS gasification + CCUS	Natural gas, coal
	Turquoise Hydrogen	Pyrolysis	Natural gas
	Grey Hydrogen	Natural gas reforming	
	Brown Hydrogen	Gasification	Brown coal (lignite)
	Black Hydrogen		Black coal

*GCG footprint given as a general guide but it is accepted that each category can be higher in some cases

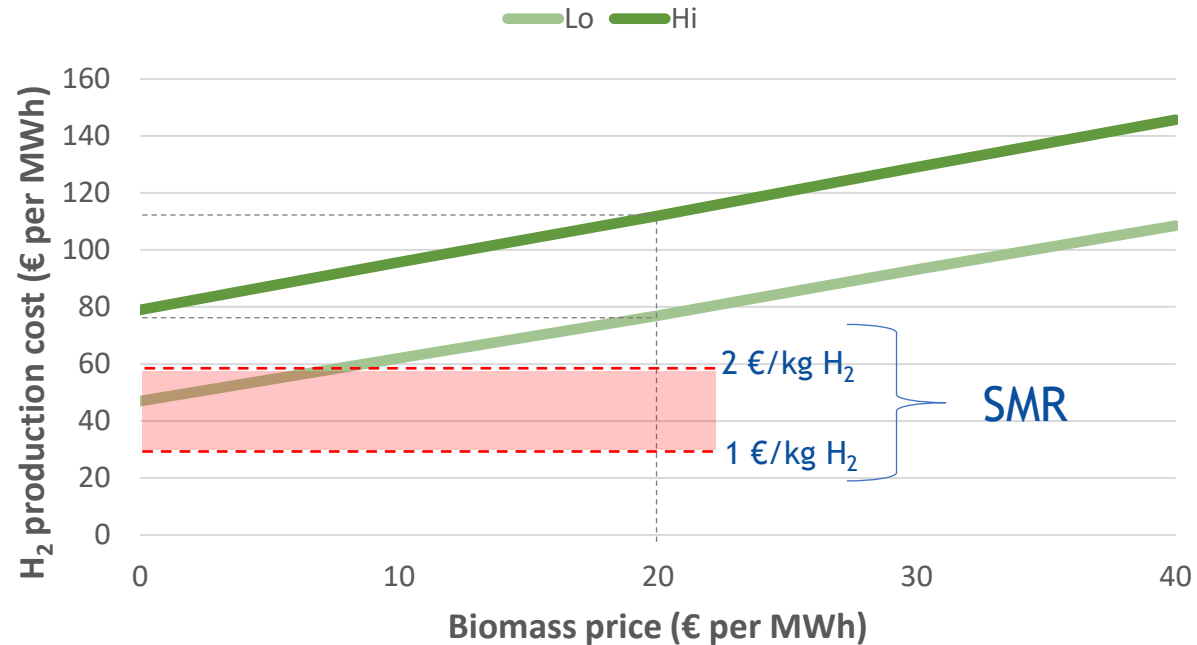
Source: Global Energy Infrastructure (GEI), 2021

Gasification - flexible in feedstock & broad product portfolio



- For every ton of dry biomass gasified, about 0.1 ton of H₂ can be produced together with 1.5-2 ton of CO₂, i.e., 15-20 kg CO₂ per kg H₂

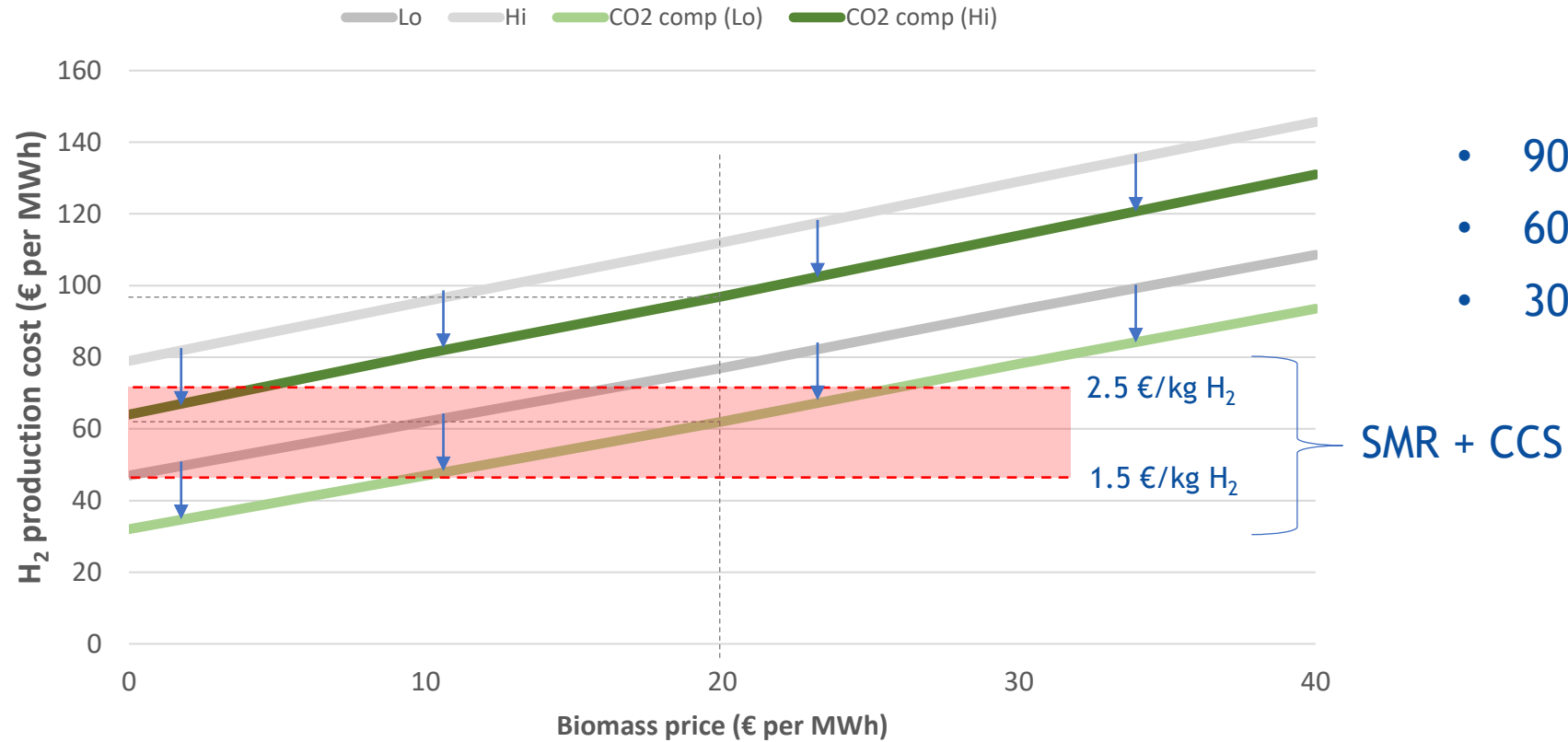
Cost for producing bio-hydrogen via gasification



- Production costs methanol/methane ≈ hydrogen
- CO₂ captured and stored = Negative emissions
- Price negative emissions = 100 € per ton CO₂
- Cost for CO₂ transport and storage = 50 € per ton CO₂
- Net credit = 50 € per ton CO₂

Ref: Advanced Biofuels – Potential for Cost Reduction, IEA Bioenergy, 2020

Cost for producing bio-hydrogen via gasification



- 90 €/MWh H₂ = 3 €/kg H₂
- 60 €/MWh H₂ = 2 €/kg H₂
- 30 €/MWh H₂ = 1 €/kg H₂

SMR + CCS



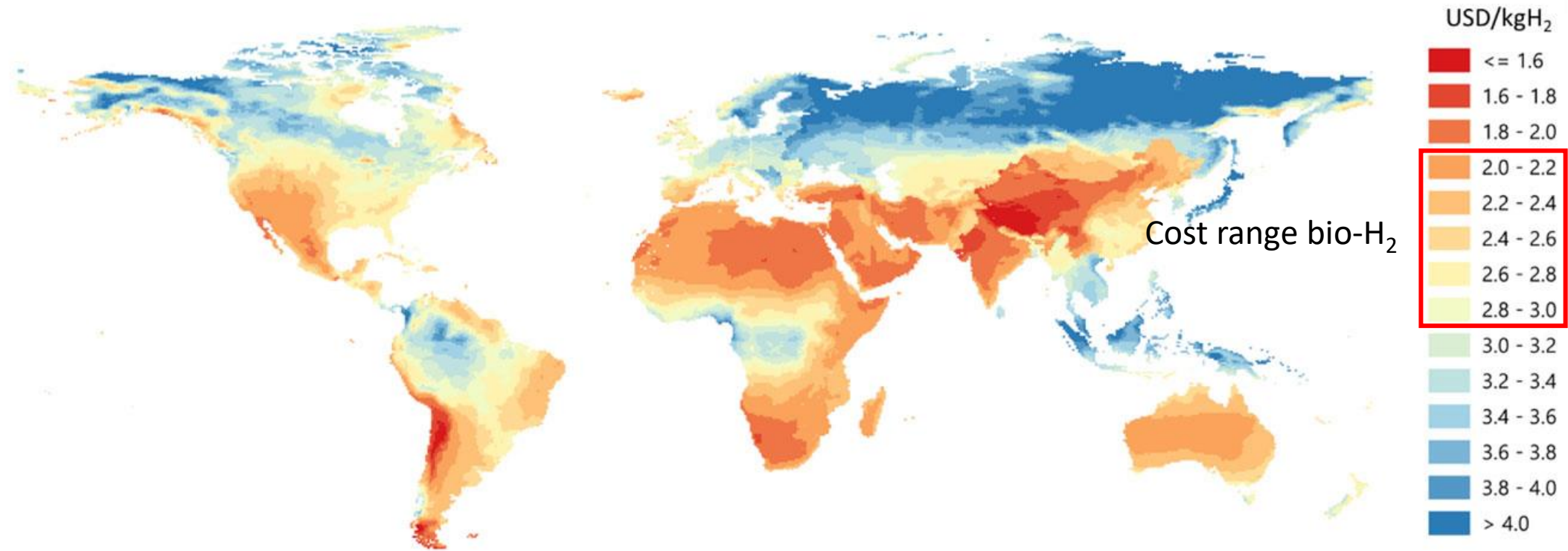
Zlatan Ibrahimovic



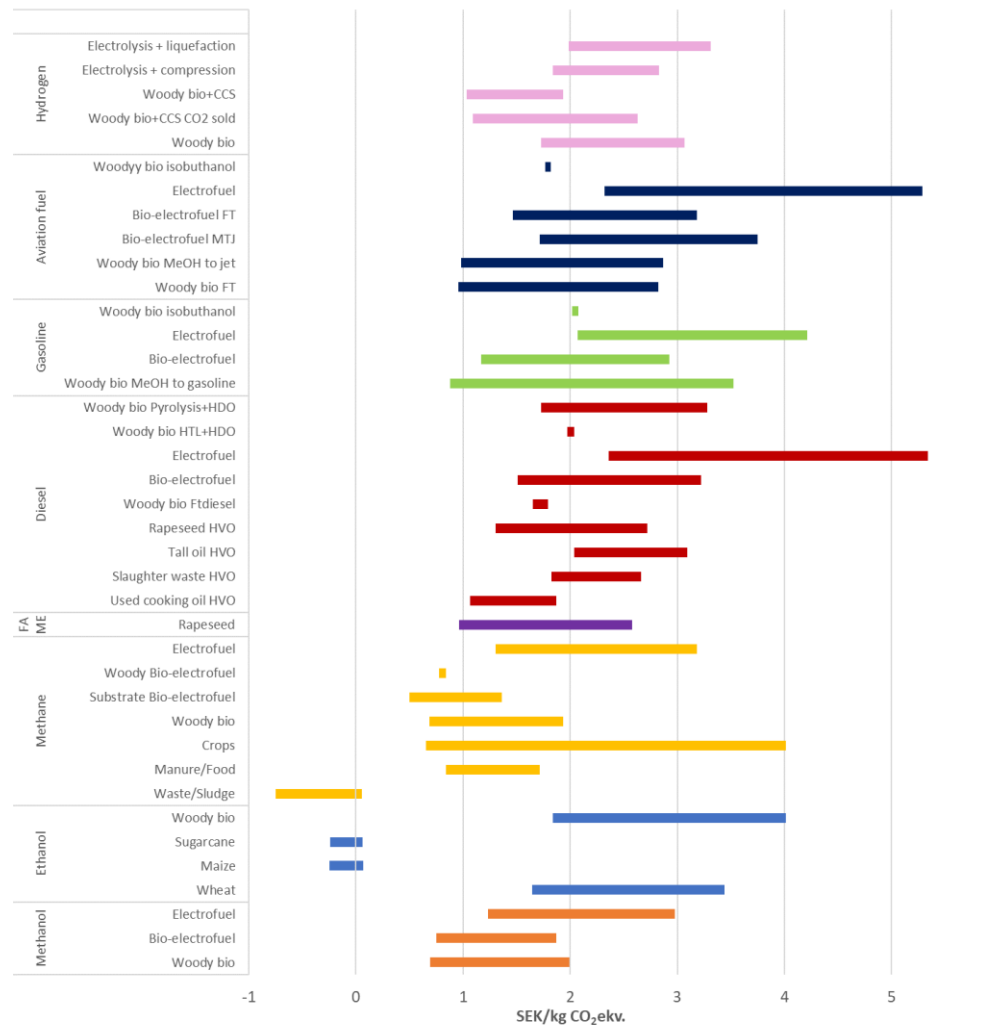
New green technologies are immature and must be supported before they can compete with fossil alternatives!

Photos: <http://hdcoolwallpapers.com/wp-content/uploads/2015/02/HD-Zlatan-Ibrahimović-Wallpapers-10.jpg> and <http://hdcoolwallpapers.com/wp-content/uploads/2015/02/HD-Zlatan-Ibrahimović-Wallpapers-10.jpg>

Estimated cost of hydrogen based on solar cells and onshore wind power beyond 2040-2050

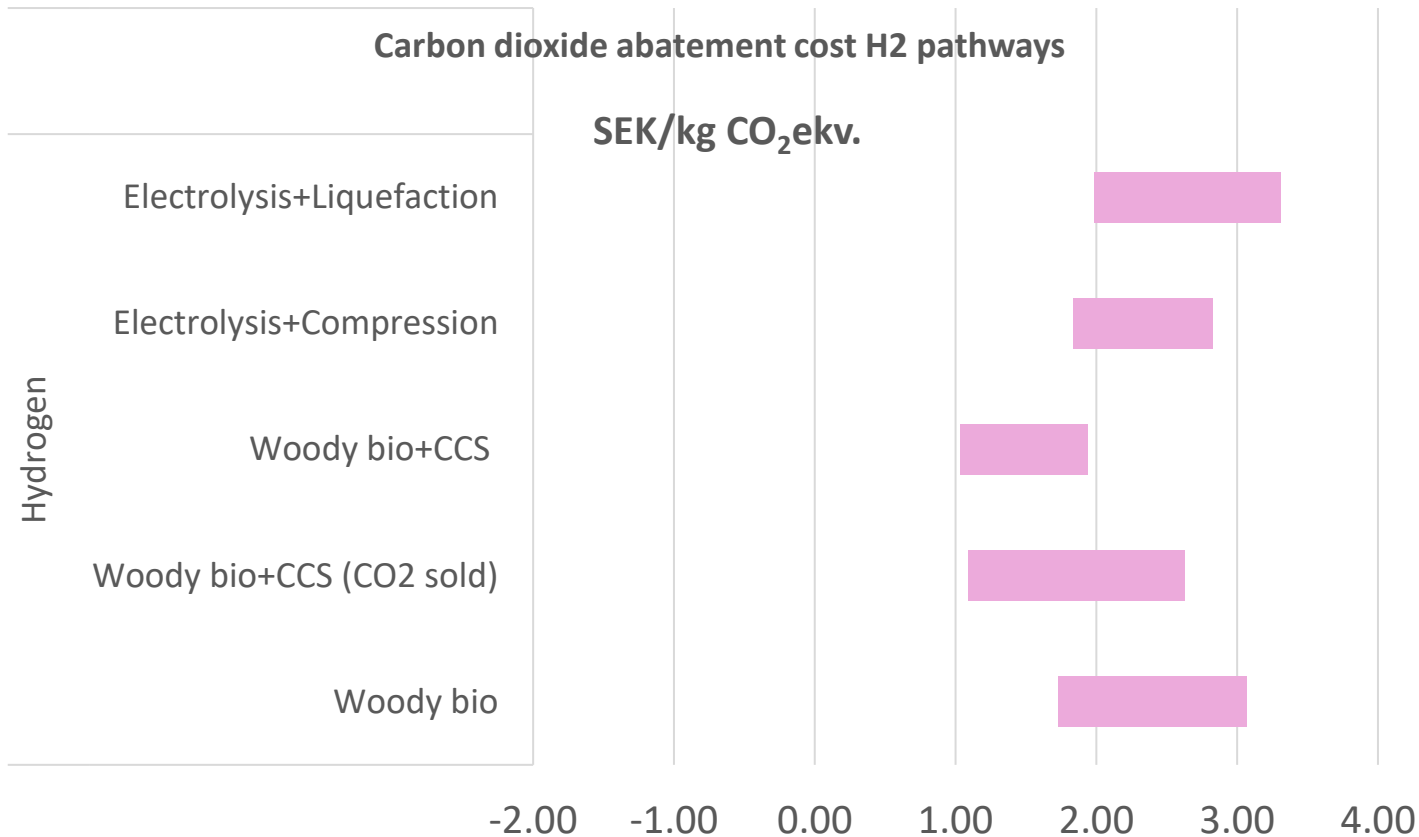


What about the CO₂-abatement cost for hydrogen?



Ref: Hansson et.al (2023). Costs for reducing GHG emissions from road and air transport with biofuels and electrofuels, Report to Swedish Energy Agency

What about the CO₂-abatement cost for hydrogen?



- Assumptions:
 - Bio-H₂ replaces H₂ from natural gas
 - CO₂-emission factor of EU electricity mix
 - Electricity price: 50 € per MWh

Summary

- Gasification based bio-H₂ brings many attractive benefits.
- Difficult to compete with fossil-based hydrogen, but...
 - The current developments of CCUS in other applications will lead to lower capital costs.
 - Every progress made within CCUS thus means more competitive gasification systems.
- Bio-H₂ production cost and CO₂-abatement cost likely to be lower than the costs of power based H₂ in many world regions.
- Gasification based bio-H₂ deserves more attention!!

Joakim Lundgren
joakim@ltu.se



**Centre for
Hydrogen
Energy Systems
Sweden**

AT LULEÅ UNIVERSITY OF TECHNOLOGY



Aurora

Sustainable Hydrogen



IEA Bioenergy
Technology Collaboration Programme

www.ieabioenergy.com