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VOLVO TRANSITION TO FOSSIL FREE HEAVY DUTY TRANSPORT SOLUTIONS

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Volvo GTT Powertrain Strategic Development | Staffan Lundgren

2022-11-18



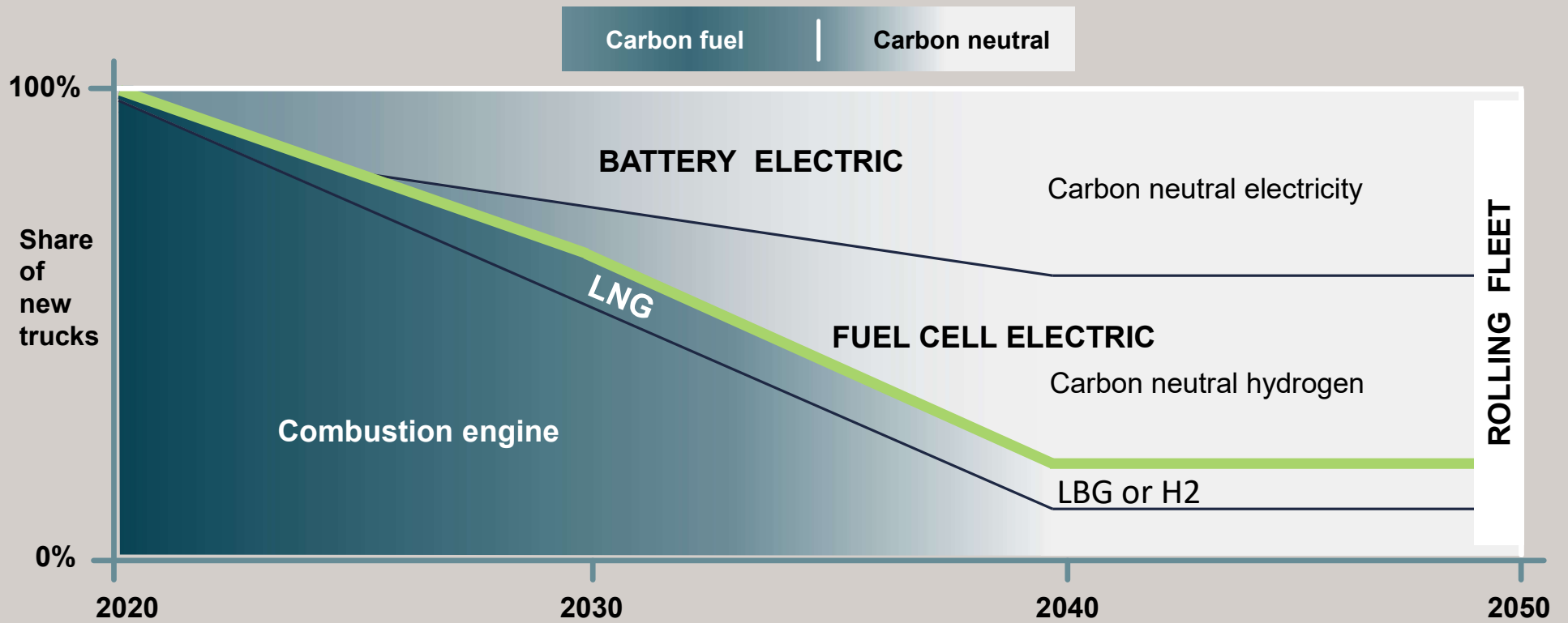
Long-term ambition:

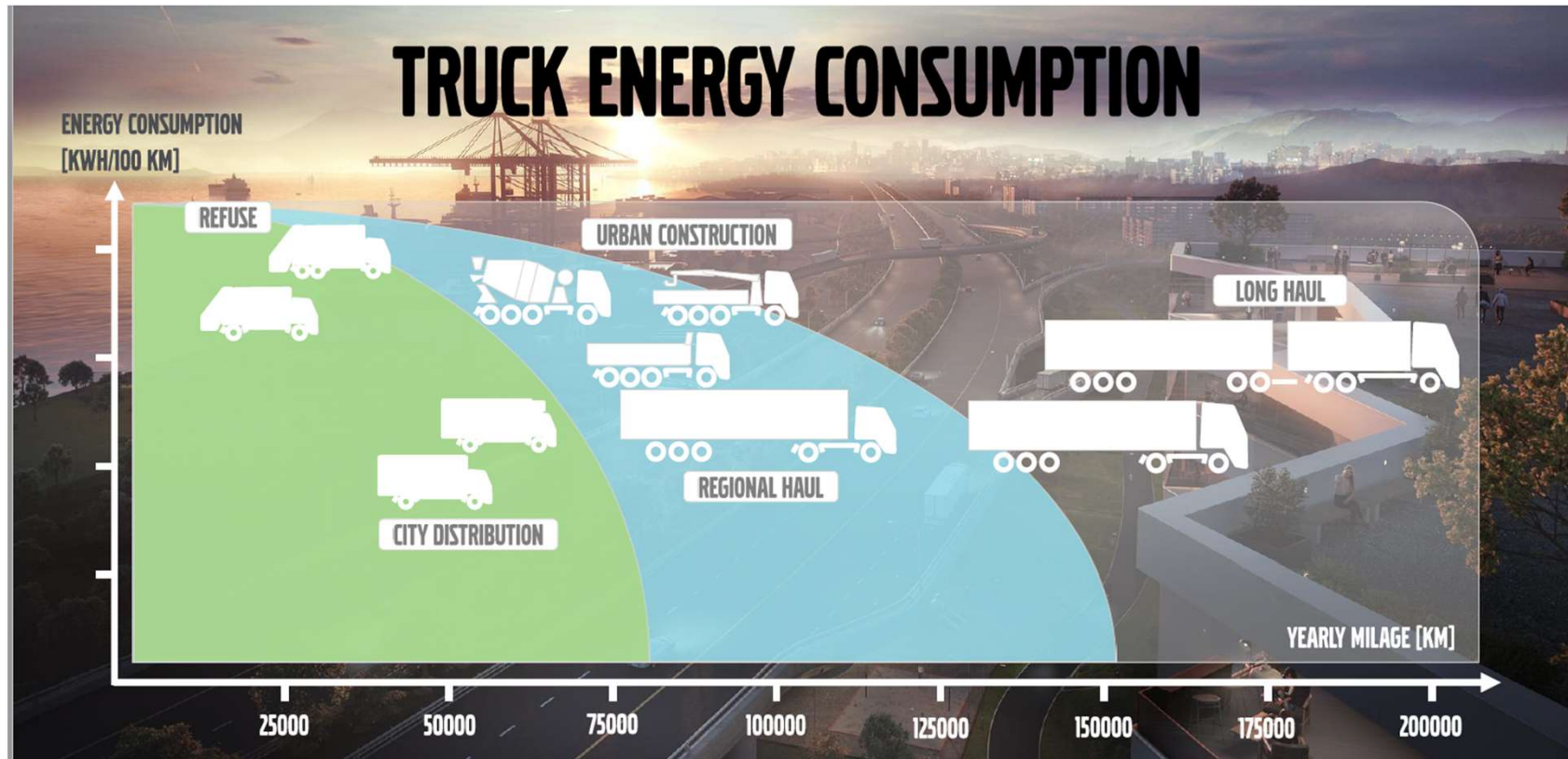
100%

Safe
Net Zero
More productive



100% fossil free Volvo Group vehicles from 2040

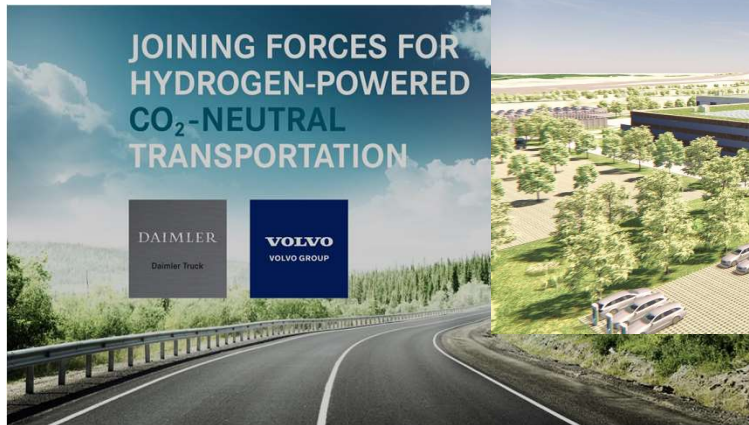




The best solution differs depending on regions and type of transports.

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cellcentric



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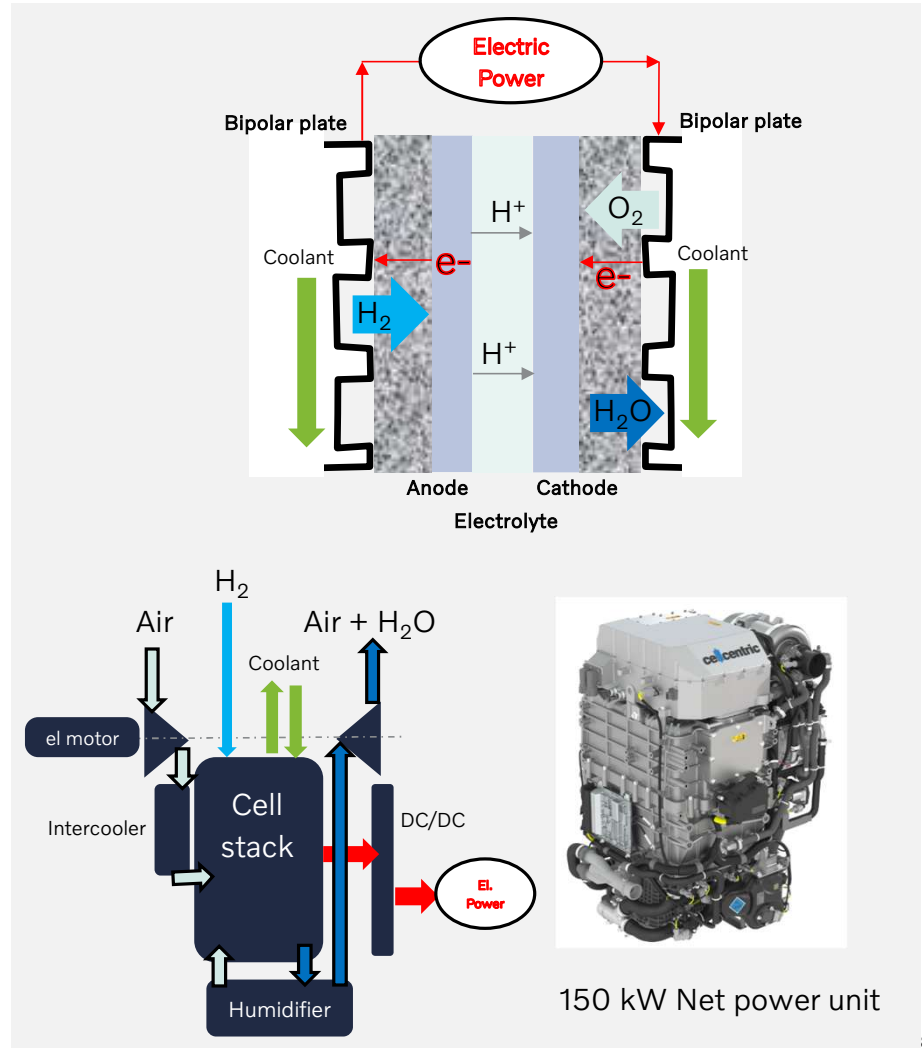
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Fuel cell technology overview

- Key areas to master in the fuel cell technology

- Primary Heavy Duty fuel cell technology
 - High durability
 - High efficiency
 - Full load capability
 - Mass production possible component design



VOLVO

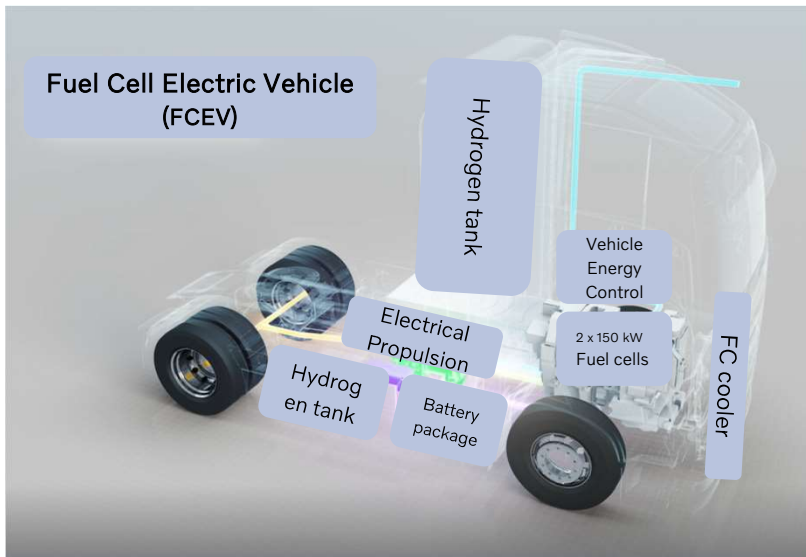
FUEL CELL HEAVY DUTY SYSTEMS DEVELOPMENT VEHICLE COMBINATIONS UP TO 65 TON FOR GLOBAL USE



Fuel cell Electric Vehicle System

Energy & Efficiency Control System:

Braking new ground in Power Technology Integration



Fuel cell

Power capability depending on degradation and cooling capability

Battery system

Power and energy capability depending on degradation and cooling capability

Electric Motor

Power capability depending on cooling capability

Transmission

Torque demand depending on propulsion need

Propulsion Cooling

Power capability depending on degradation and ambient temperature

Brake & brake recovery

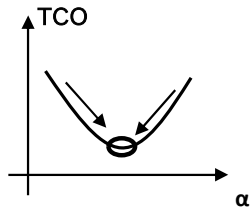
Power capability depending on battery state of charge and cooling capability

Transport mission

Power and energy requirements depending on transport application (GCW, air drag etc.) and local topography and speed limits

TCO optimization

Energy & Efficiency Control & mission management



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FCEV ON- AND OFF-ROAD MULE VEHICLE TESTING





Internal testing in several locations



The Hydrogen Filling Options – Current Status

2025

2030 ?

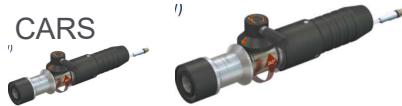
350 BAR



- Early Busses
- Early Trains
- Early Hyundai Trucks
- Need higher filling speed

~0.5 kWh / liter

700 BAR



- Cars, with small nozzle
- Standard for buses under development
- Main track with high filling speed
- ~10% compression loss

~1 kWh / liter

CRYO-COMPRESSED



- High-pressure and cryogenic storage vessels to increase gravimetric and volumetric capacities
- **Potentially lower cooling and compression losses** then liquefaction

~2 kWh / liter

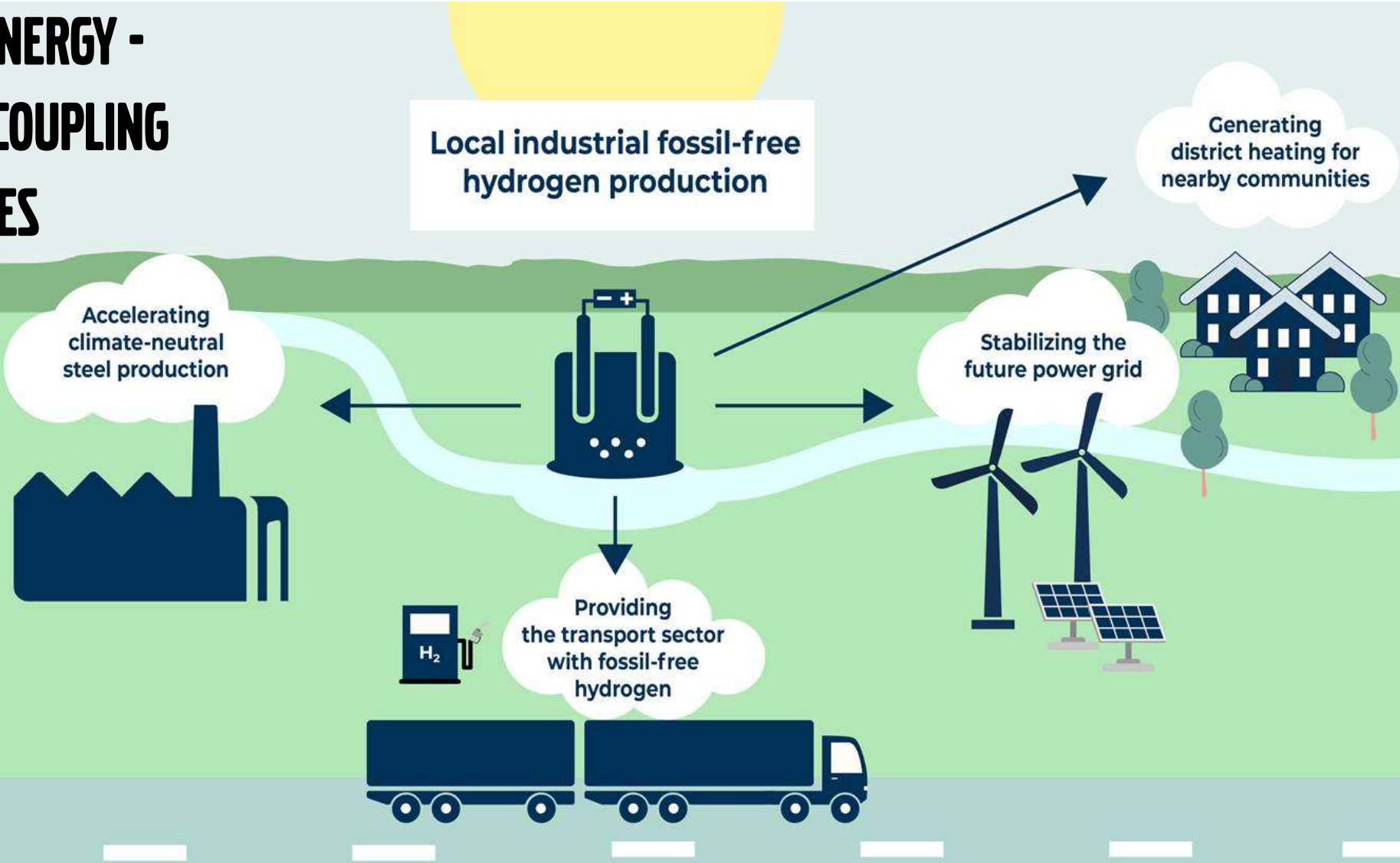
Liquid



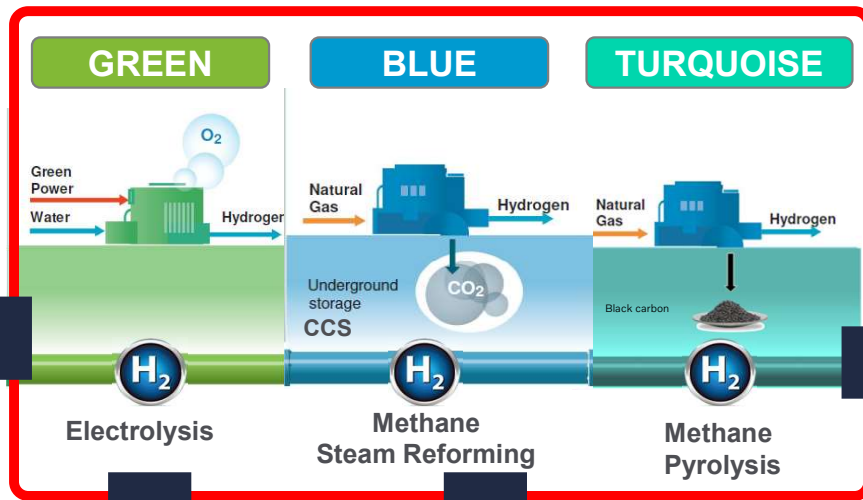
- For long distance aircrafts 2035
Usage for land transports?
If so, when and how? Cost?
- Not widely available until 2030+
- Germany promote
- Safety issues not fully explored
- **Currently 30% energy loss for liquefaction**

~2 kWh / liter

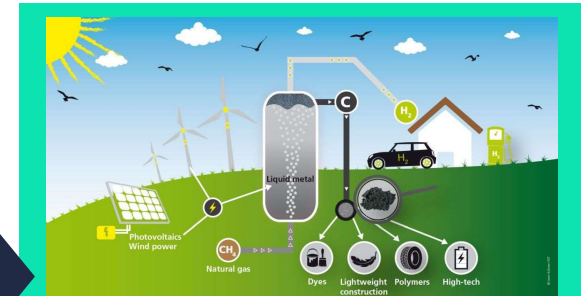
GREEN ENERGY - SECTOR COUPLING SYNERGIES



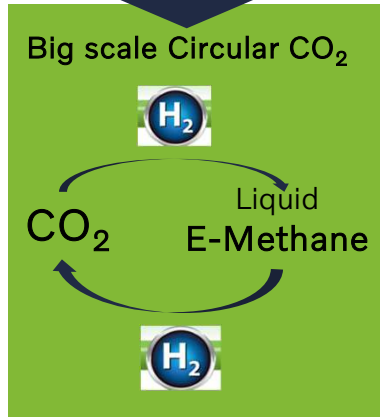
Key Hydrogen paths that can Heavily Reduce HD System CO2 Emissions



- Small & Large scale
- High synergy in H₂ storage, use and in electric grid feed



- Small scale
- Pure carbon extraction
- Carbon Second product use or storage



Steam Reforming, Methane Pyrolysis and Gasification must be purified before usage to be pure enough to use in a Fuel Cell

THREE TOPICS THAT MUST BE IN PLACE TO BUILD A MARKET

- Active support for infrastructure roll out and early vehicles (valid for all new energies)
- Need for new and different vehicle and energy taxation principles

Policies

Taxes

Subsidies

City Zones

Working Market

Revenue ability

Product / operational cost

Energy availability

Energy fill / charge speed

Energy cost

Energy filling density

Product offering

Infrastructure

In summary:

ENERGY DEMANDING ASSIGNMENTS



Three technological paths needed:

- To decarbonize heavy transportation;
 - battery electric,
 - fuel cell electric
 - combustion engine, (that run on biofuels Hydrogen and e-fuels)
- The best solution depending on regions / type of transports.

Fuel cell electric trucks:

- Volvo Trucks has started testing its first trucks using fuel cell technology.
- Commercial pilots limited number 2025, with plans to further expand during 2026.
- Commercially available in the second half of this decade.
- Suitable for long distances and heavy, energy-demanding assignments, (complementing battery electric trucks (BEV).)
- The fuel cell electric trucks will have an operational range comparable to many diesel trucks – up to 1000 km – and a refueling time of less than 15 minutes.

Infrastructure:

- Hydrogen technology is still in an early phase of development
- One of them is large-scale supply of green hydrogen.
- Refueling infrastructure for heavy vehicles is still to be developed.
 - We expect the supply of green hydrogen to increase significantly during the next couple of years, since many industries will depend on it to reduce CO2.

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