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Renewable Energy for Industry

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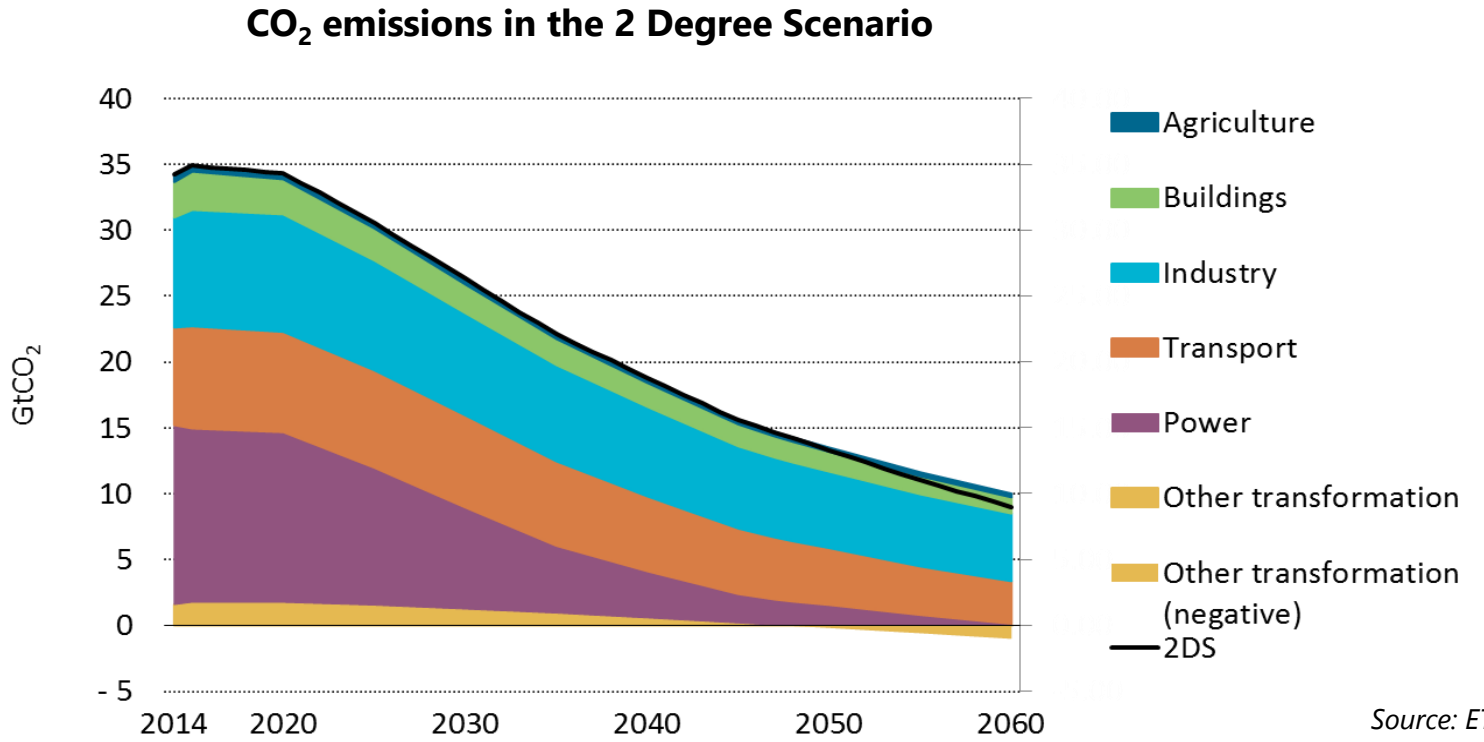
Nordic Pavillion, COP23, Fidji - Bonn, 15 November 2017

IEA

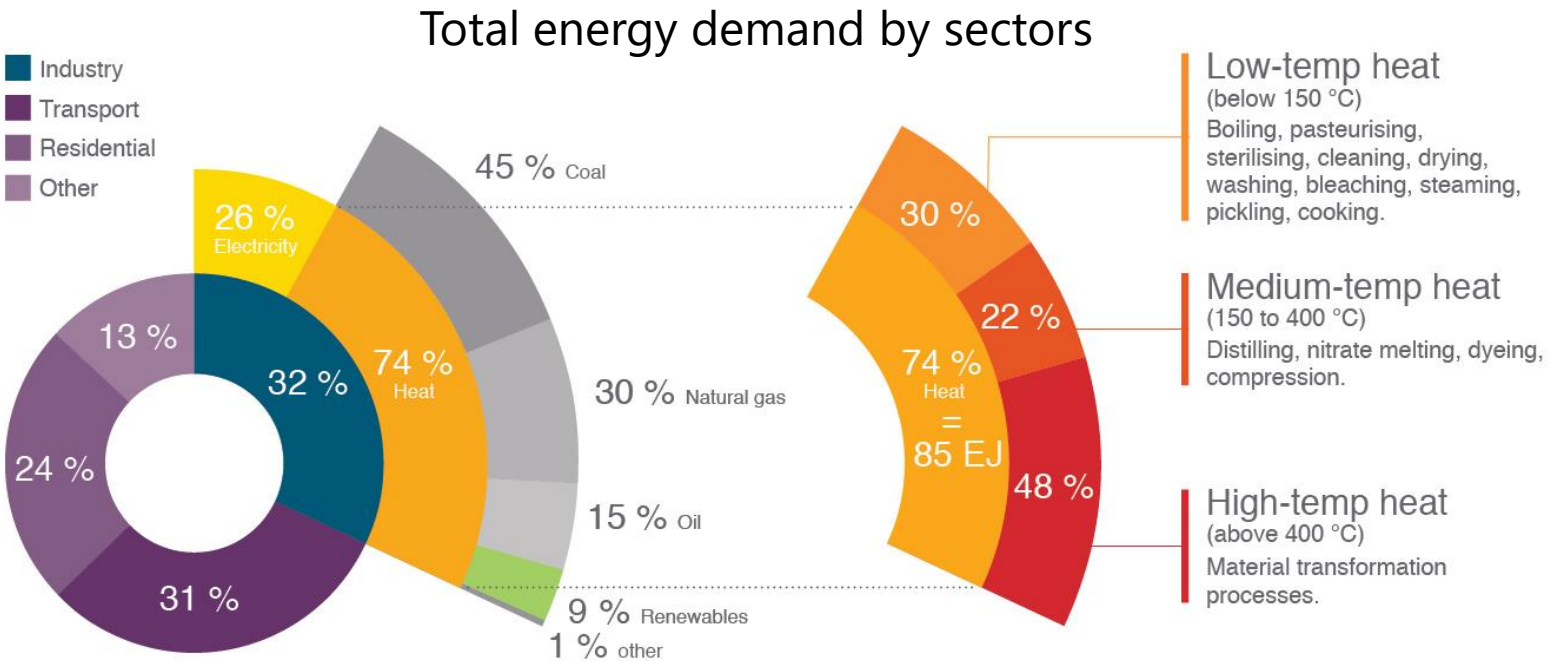
Industry represents a major issue for climate change



Source: ETP 2017

Cement, iron and steel, and chemicals responsible for the bulk of remaining industrial emissions in 2050.

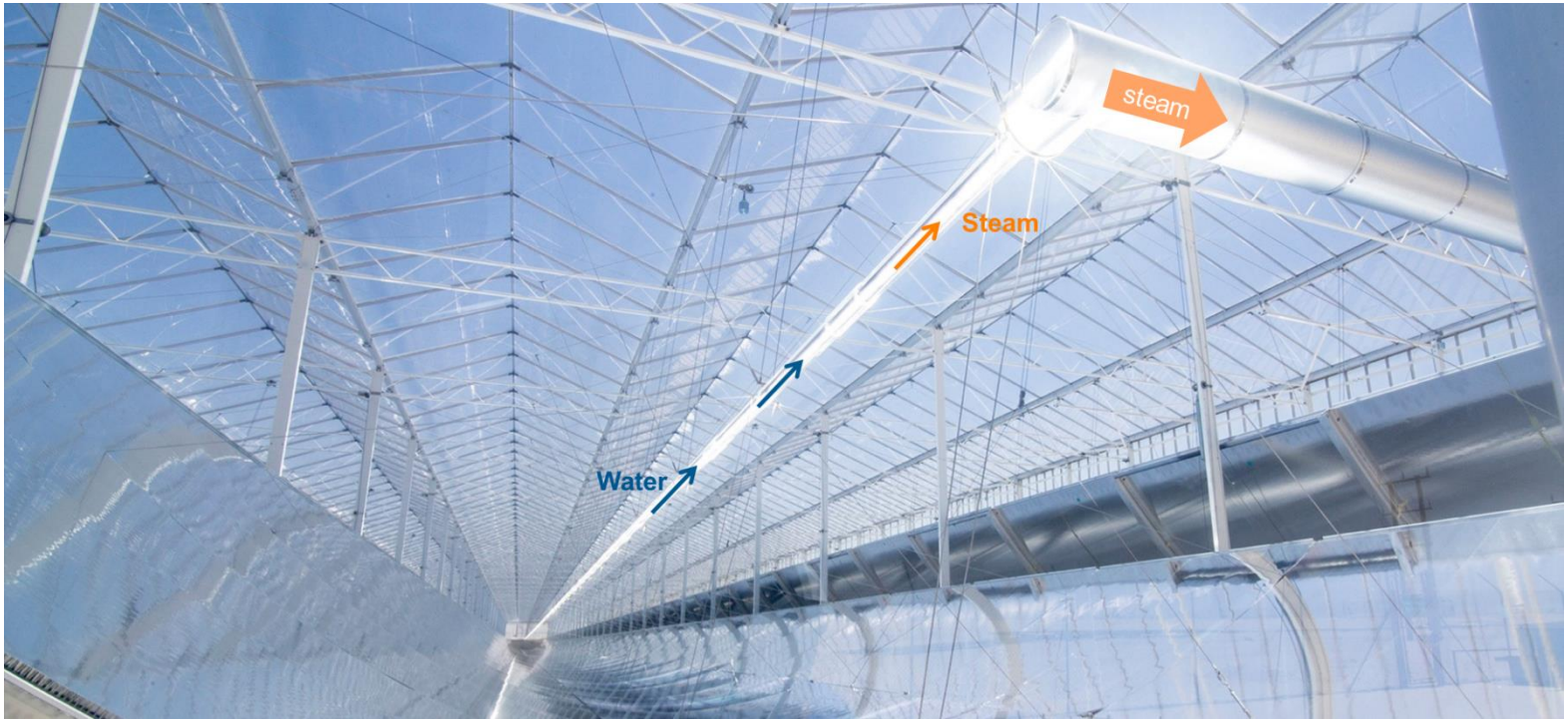
Industry remains dependent on fuel combustion for process heat



Source: Solrico, 2017

Heat represents three quarters of the energy demand of industries world-wide, and half of it is low to medium temperature heat, more easily supplied by direct renewable heat

Direct renewable heat is improving on various fronts



Source: Glasspoint, 2017

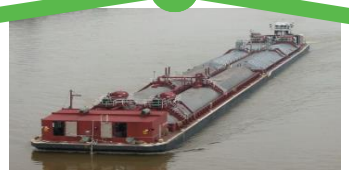
Enclosed troughs technology delivers significant improvements and cost reductions to solar heat, opening new applications such as enhanced oil recovery in Oman

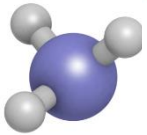
Renewable power can replace fossil fuels in many uses

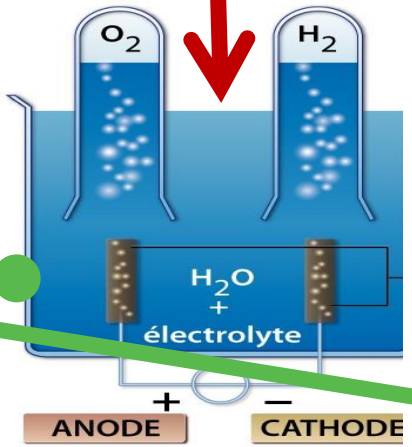
Buildings
Heating
Cooking
Lighting

Industry
Steam
Force
Electrolysis

Transports
EVs
H-rich fuels



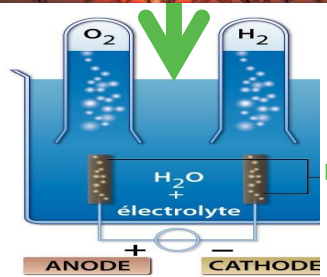




Feedstock, process agents, fuel

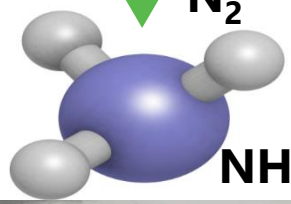
Beyond current uses, renewable electricity can replace fossil fuels in direct uses in buildings, industry and transports, directly or through electrochemistry/electrolysis

Ammonia precursor of fertilisers: a low-hanging fruit



H_2

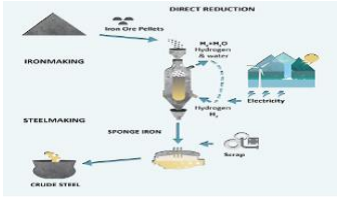
N_2



NH_3

Precursor fertilizers industry

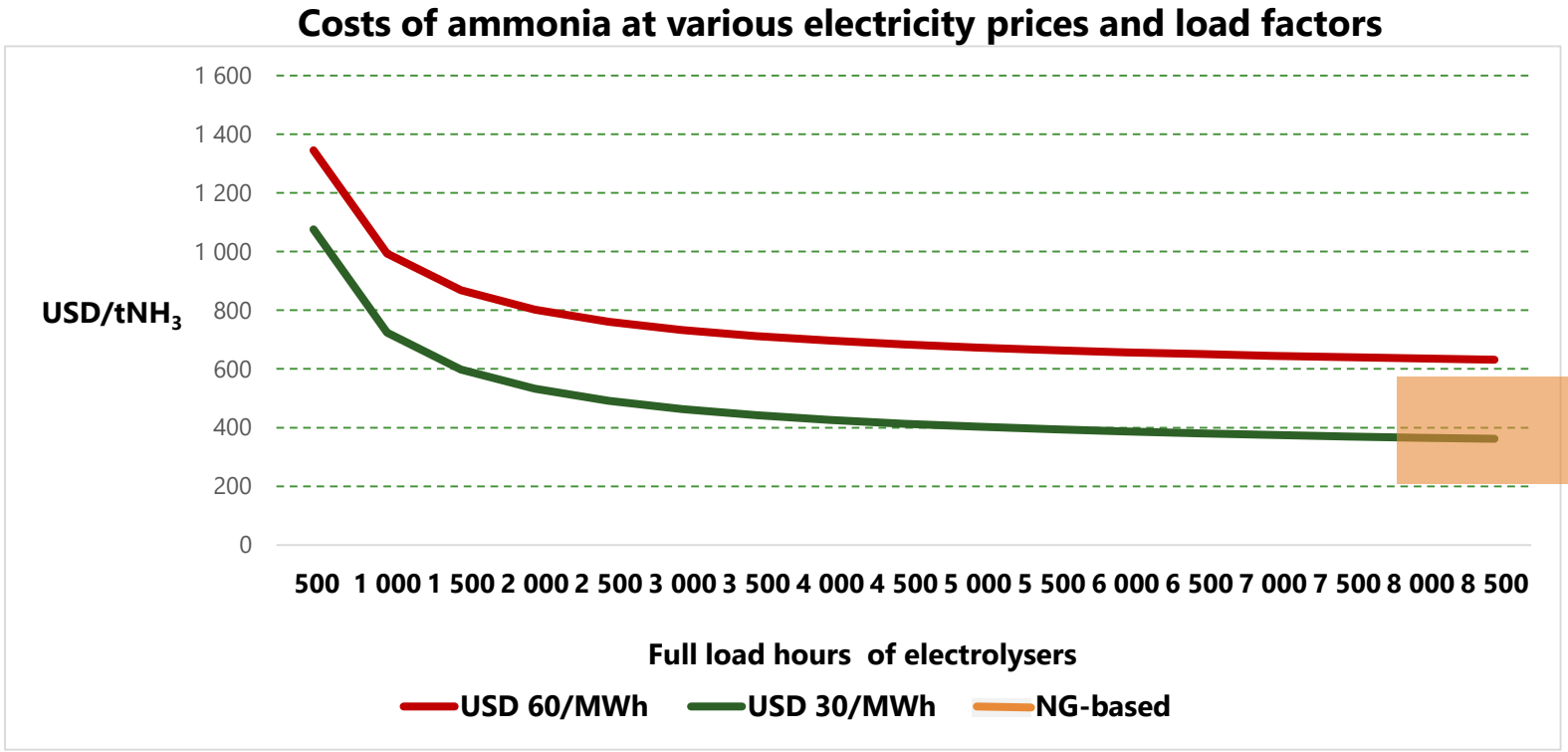
Process agent steel industry



Fuel

Ammonia may have multiple uses in industry as feedstock, process agent and fuel

Producing ammonia from cheap solar and wind

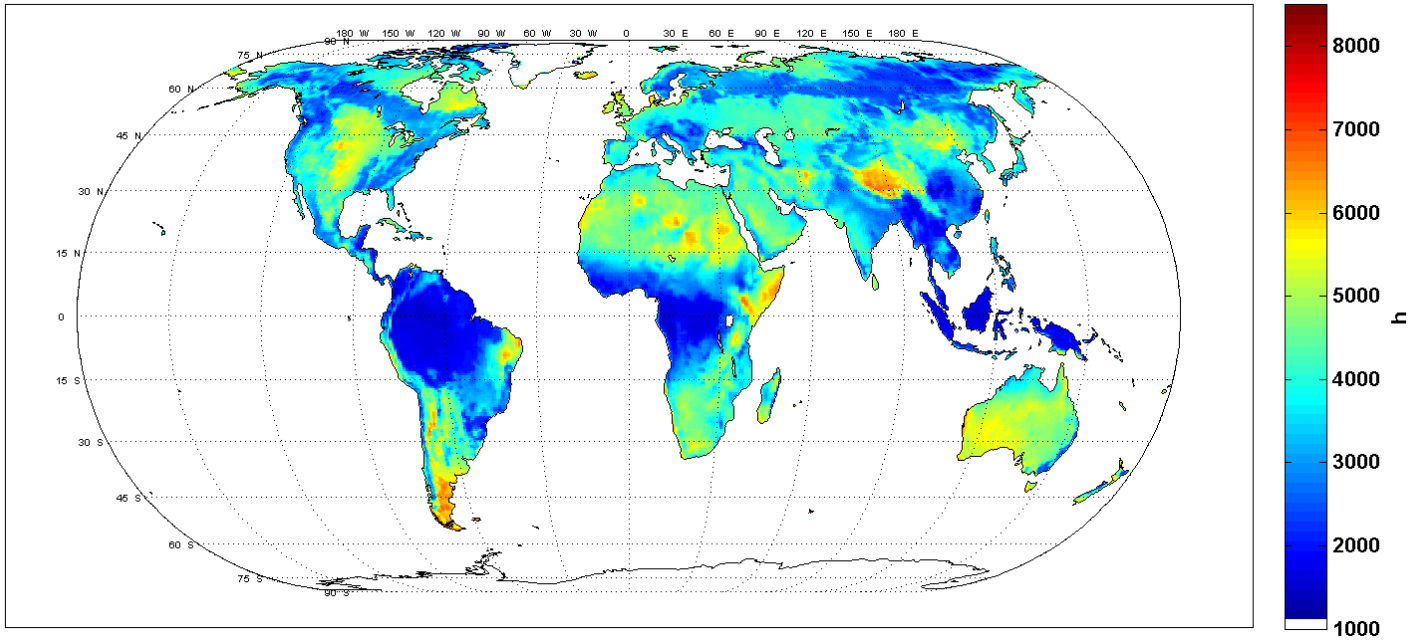


Assumptions: Capex electrolysers USD 450/kW; Capex, NH_3 plant USD 382 million 500,000 t/y; efficiency electrolysers 70%; WACC 7%, lifetime 30 years, Opex USD 14 to 37/tNH_3 (plus electricity).

At USD 30/MWh or less, and with high capacity factors, solar and wind power in best resources areas can now run all-electric ammonia plants at competitive costs.

The emergence of low-cost renewable power is a game-changer

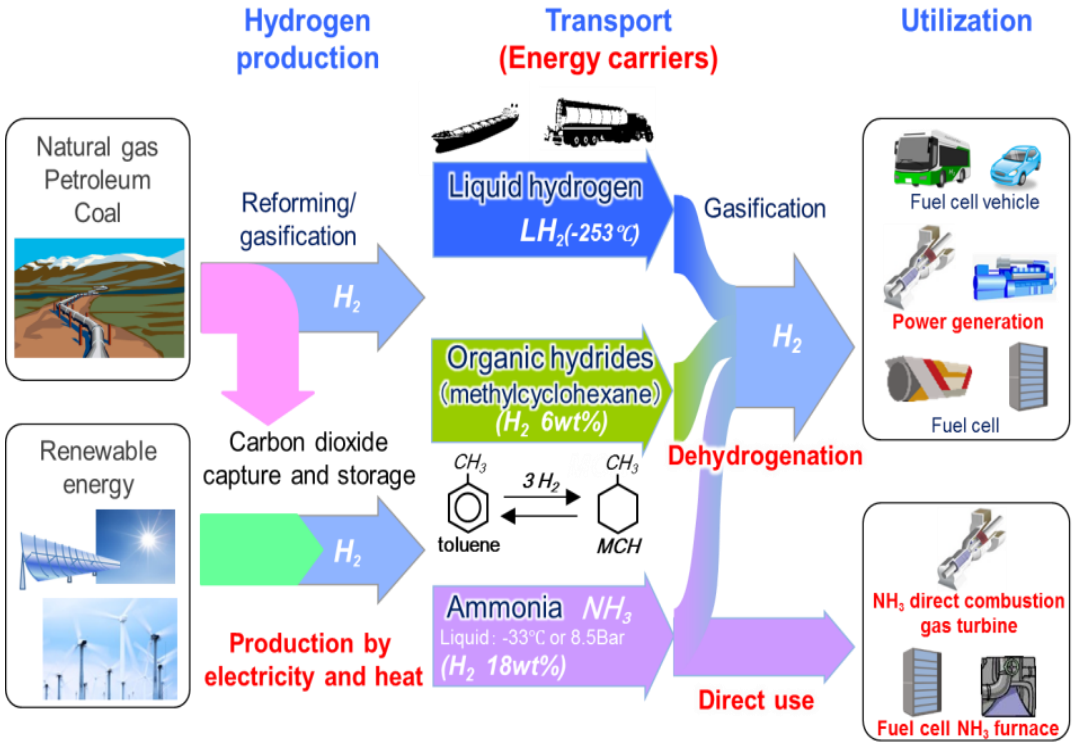
Hybrid solar and wind full load hours adjusted for overlap



Source: Fasihi & Breyer, 2017

Capacity factors of combined wind and solar power exceeds 50% in vast areas, often remote from large consumption centers, potentially delivering huge amounts of power at less than $30/MWh

Exploiting cheap RE will require massive trade



Source: Japan's Energy Carriers Program, 2017

Ammonia is rich in hydrogen, easy to store and ship, and may prove the most versatile carrier of renewable energy

Ammonia is also a fuel

- Works in combustion engines, turbines, fuel cells, directly/cracked
- 100-y safe handling in industry
- Stationary applications in power and industry sectors
- A possible fuel for boats, long-haul trucks, even lighter vehicles
- Power-to-power efficiency better than other fuels for long-term storage
  - Pumped-storage hydropower and batteries more efficient short-term storage options

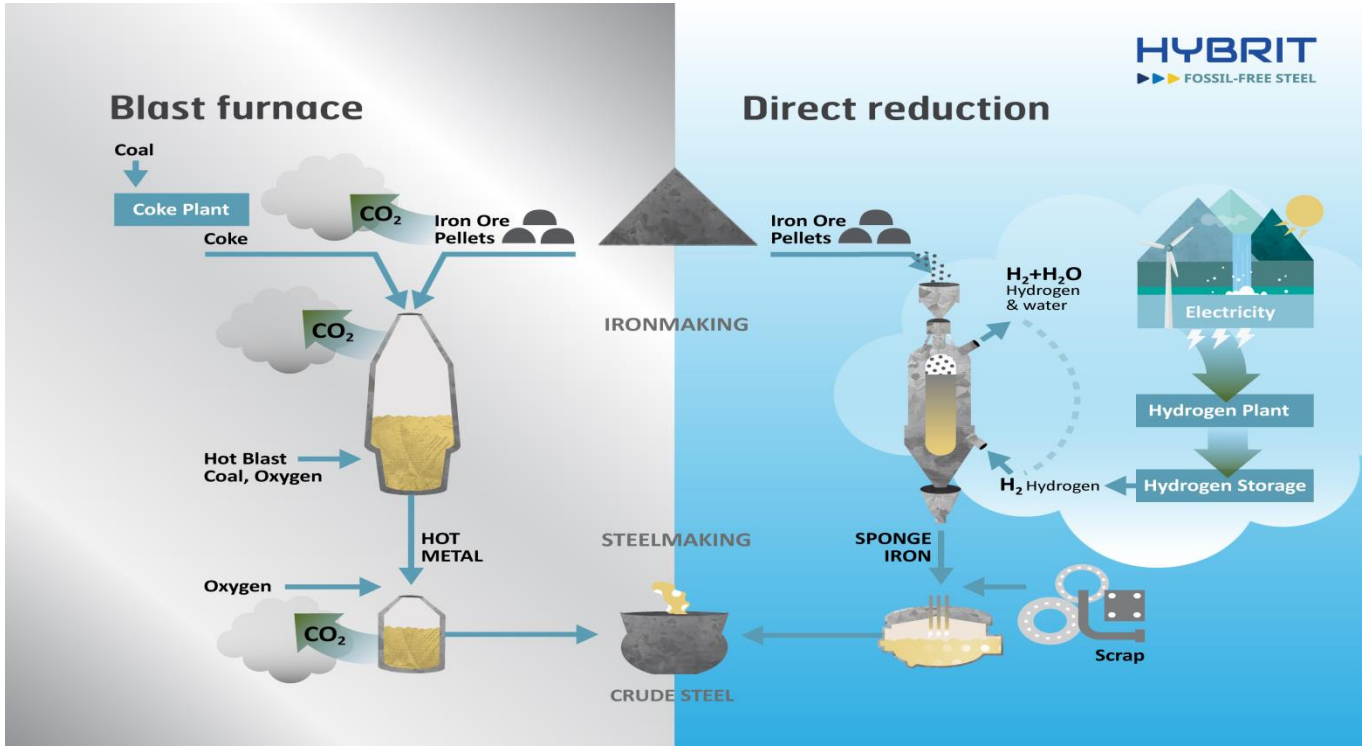
Power to power efficiency

Fuel	PtP efficiency CO_2 from air	PtP efficiency CO_2 from fumes
CH_4	27%	31%
MeOH	27%	32%
DME	23%	28%
NH_3	35%	
NH3 PEM	*29%*	
NH3 SOEC	*39%*	

Sources: Grinberg Dana et al, 2017

Ammonia can be used as a carbon-free fuel in various ways, which must be further developed

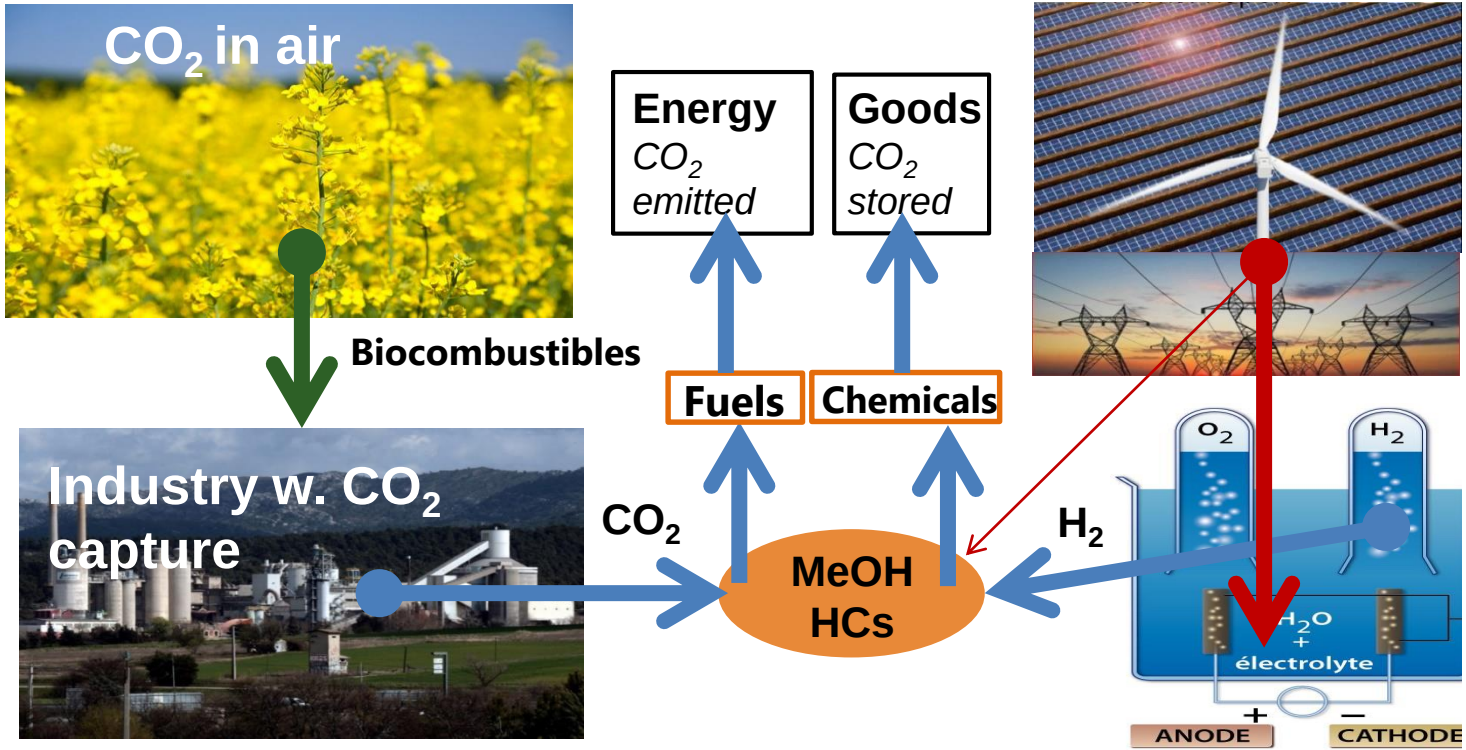
Renewable power can make CO_2-free iron and steel



Sources: Hybrit Projekt, 2017

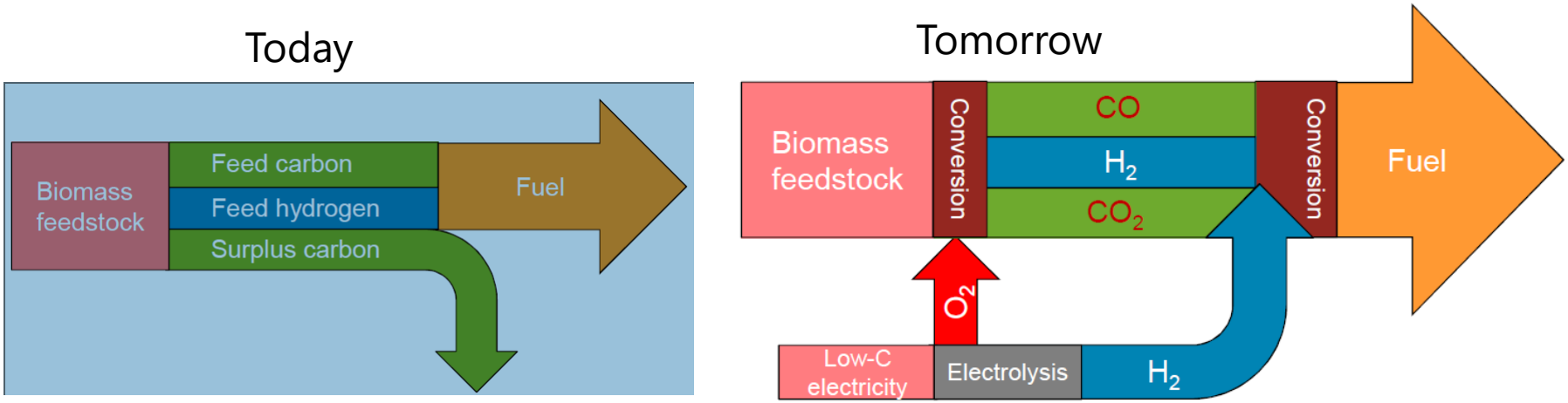
Substituting natural gas with renewable-based hydrogen for direct iron reduction may be phased in gradually and lead ultimately to CO_2-free iron and steelmaking

Renewable hydrogen can be combined with recycled CO_2



Manufacturing methanol from renewables-based water electrolysis and recycled CO_2 would strongly reduce life-cycle CO_2 emissions and could drive negative emissions

Multiplying the use of constrained biomass feedstock

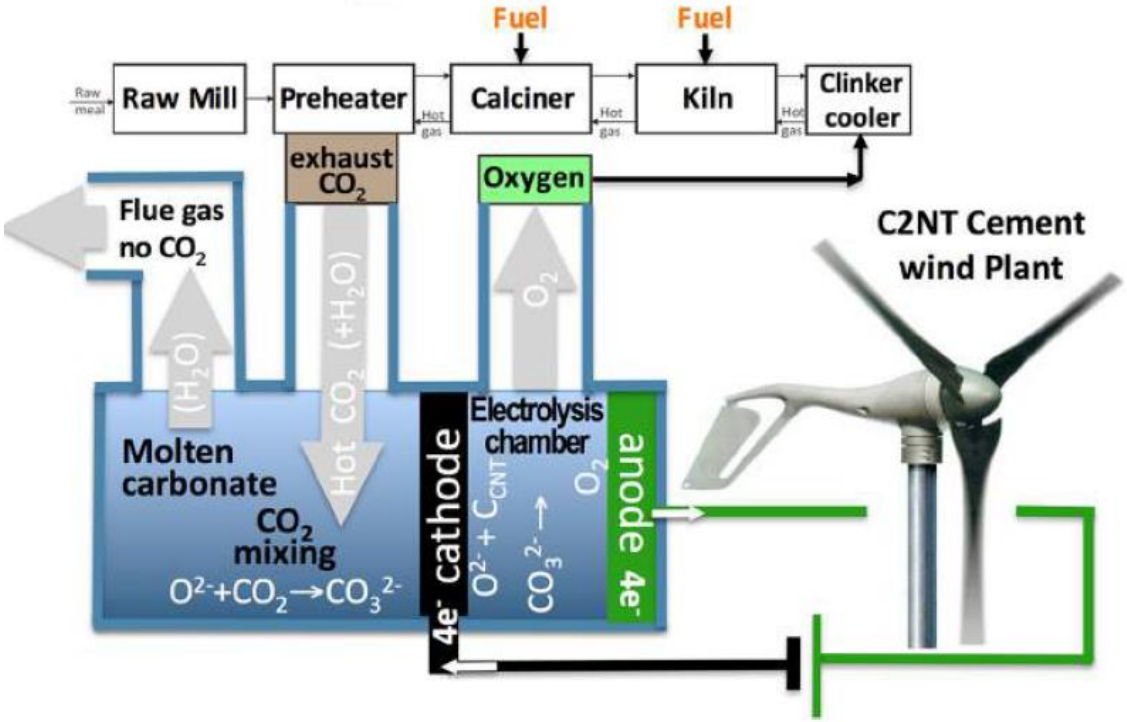


Source: Hannula, 2016

Using hydrogen and oxygen from renewable electricity can augment the potential of biomass in converting CO_2 into fuel

Electrolysis might allow for CO_2-free cement manufacturing

Concept scheme of co-production of cement and carbon nanotubes



Source: Stuart Licht, Journal of CO_2 utilization, 2017

Still at lab-scale, molten carbonate electrolysis run on solar and wind could be coupled with an oxyfuel cement factory and produce high-value carbon nanotubes instead of CO_2

Policy options

- De-risking investment is key – as always
- Carbon pricing would improve competitiveness
- Risks of carbon leakage for heavily-traded commodities
  - Global sectoral agreements?
  - Border carbon adjustments? Standards?
  - Reconsidering the carbon leakage issue and identifying win-win strategies will help fostering RE deployment in most favourable areas - and vice-versa
- Procurement of green materials could help jump-start deployment
  - Private procurement by Business-to-Consumer companies, public procurement for infrastructures

A new era of international collaboration is required to foster global decarbonisation of industry

Concluding remarks

- Industrial air pollutants and CO_2 emissions must be addressed
  - Renewable heat can increase its contribution but faces obstacles
- The recent rapid cost reduction of solar PV and wind power opens new possibilities for greening the industry
  - Directly with electricity
  - With hydrogen-rich chemicals, including ammonia, as feedstocks, process agents and fuels
- Electrification of industry can help integrate variable renewables.
- RE for industry creates new Terawatt-scale market opportunities for PV and wind
  - International collaboration should facilitate new forms of international energy trade

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