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Hydrogen: a European Approach

November 4th 2020

Europe: green hydrogen as a the vector to replace fossil fuels

Oil & gas majors	Share performance since 1/1/2020
Total	-28.5%
BP	-47.4%
Shell	-56.9%

Green hydrogen is the centerpiece of the EU Green Deal as a key enabler to Net-Zero by 2050 and green industry. The EU has announced a **Hydrogen Strategic Roadmap on July 8th featuring 10 million-ton green hydrogen (390 TWh) by 2030.** The Clean Hydrogen Alliance bringing together industry**. Support schemes** with CCfD mechanism, IPCEI, Innovation Fund and EIB funding.

Germany introduces National Hydrogen strategy with 37 measures (covering production, usage (mobility, industry, heat, infrastructure, R&D, European market, international trading) and 9 bn€ funding by 2030 aiming at **14 TWh** green hydrogen by 2030 aiming at making Germany #1 with focus across the value chain and global partnerships.

Electrolysis OEMs	Share performance since 1/1/2020
Nel	+114.7%
ITM	+314.2%
McPhy	+559.1%

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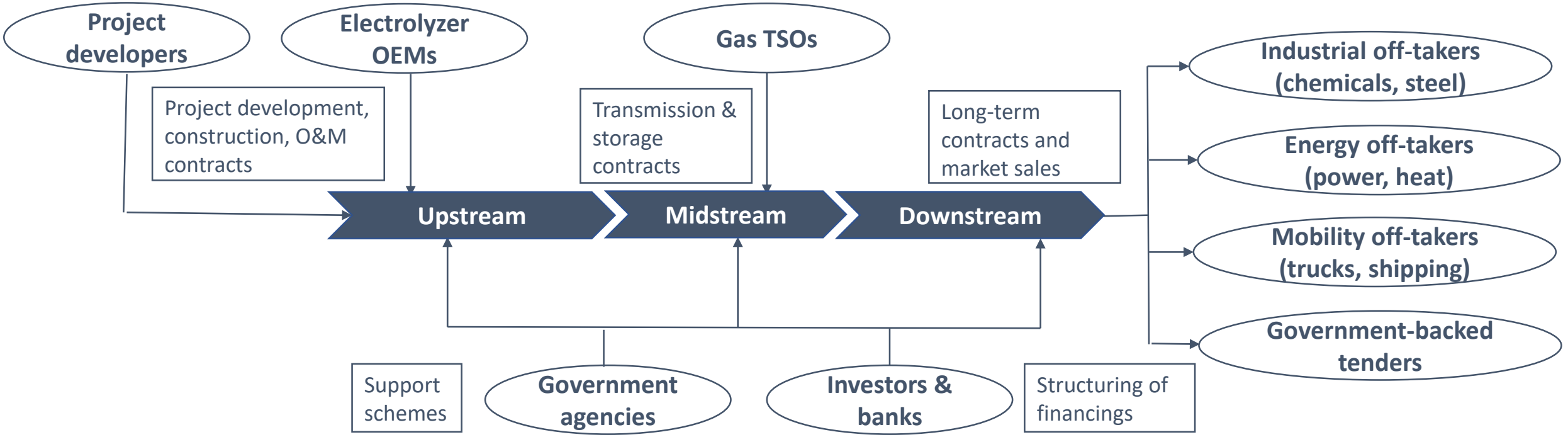
The HyDeal project: a systemic approach



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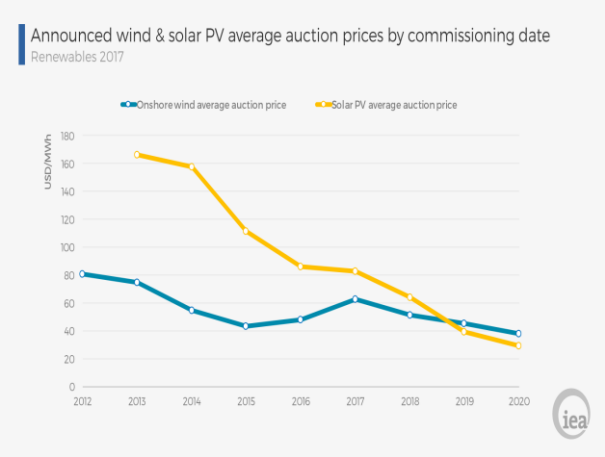
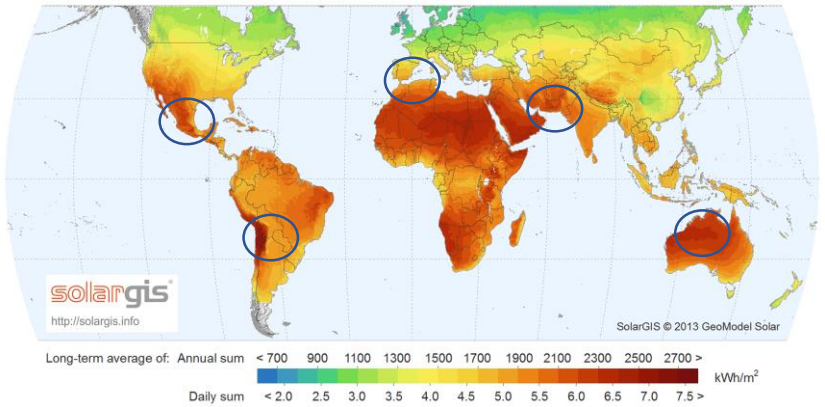
Solar: an overwhelming resource both in cost and volume





Solar power prices have fallen to levels around 15 $/MWh in auctions in Latin America, Southern Europe and the Middle East. Cell efficiencies (heterojunction and tandem cells) are expected leap from 20% to 30% in the next decade, **and 10 $/MWh by 2025 is likely to be achieved,** 80% cheaper than most conventional generation.

The global solar PV market reached 116 GW in 2019 (x 2.5 in 5 years) representing **48% of net global power capacity additions**. Estimated **500 GW of annual production capacity** across the value chain (polysilicon, ingots/wafers, cells, modules…) is planned for the next 3-5 years.

The capacity to export massive volumes of solar under the form of hydrogen through gas pipelines and shipping opens the door for **TW-scale power producing hubs** (and water desalination) in the Mediterranean, Latin America, the Middle East, South Asia and Australia.

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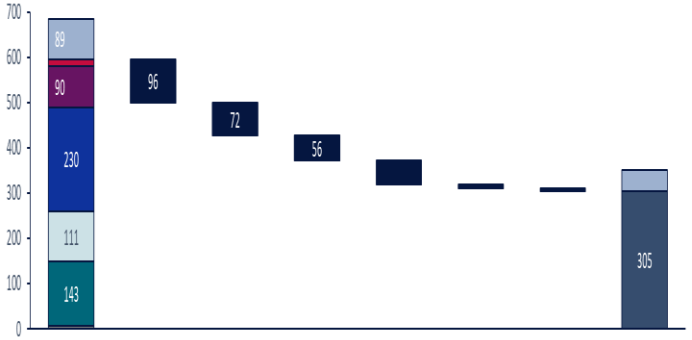
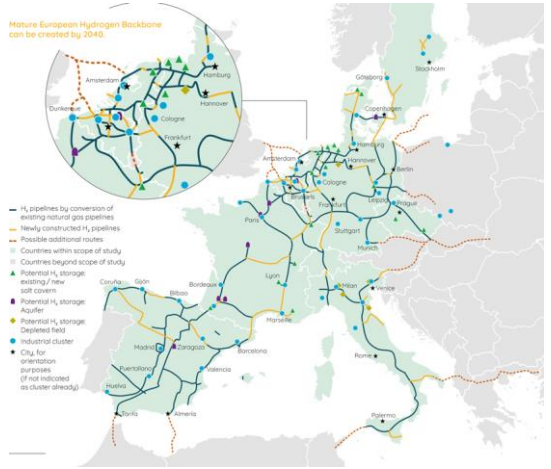
A clear roadmap to fossil fuel parity: 1.5 $/kg hydrogen delivered





Electrolysis Gigafactories are being planned by several key OEMs (Nel, McPhy, ITM, Thyssenkrupp…) targeting larger stacks (from 1 MW to 5 MW) and higher efficiencies, following the model of the wind turbine industry.

Higher efficiencies, effects of scale, plant automation, Balance-of-plant optimization, plant load maximization through vertical integration with downstream value chain help **target electrolysis plants costs (including installation) reduced by 60% to 300 $/kW by 2025**, and 200 $/kW in 2030.

The combination of **super low solar and electrolysis costs** and the ramp up of midstream infrastructure (transmission and underground storage) should allow **delivered costs of green hydrogen to end consumers below 1.5 $/kg by 2025 and 1 $/kg by 2030**, matching the cost of delivered natural gas in Europe.

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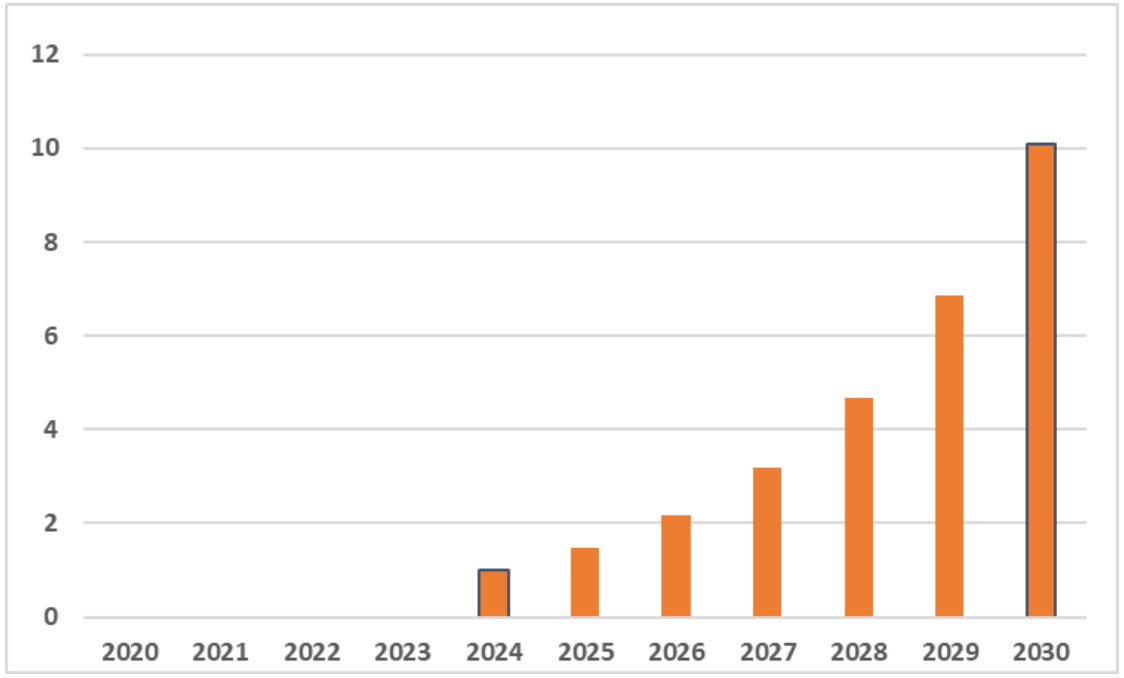
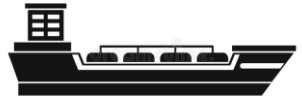
A booming market driven by the race to global green leadership

European green hydrogen market
(in millions of tons)



Source: European Commission



Hydrogen-fired power generation

- Business model Convert gas and coal-fired plants, contract 24/7 PPAs with RE100 users, trade on seasonal power grid volatility
- Financial characteristics Opportunity to acquire stranded fossil assets with subsidized retrofit, reliable cash flows
- Equity story USP Turning lead (stranded fossil assets) into gold (dispatchable RE)

Green ammonia production

- Business model Build green ammonia plants to capture the zero-carbon chemicals and shipping fuel markets at fossil parity
- Financial characteristics High capital intensity, fair return on capital employed, high growth (in shipping)
- Equity story USP Market leadership and dash to scale allow to aim at "winner takes all"

Green steel production

- Business model Convert existing steel plants with DRI from coking coal to hydrogen to capture the green steel market
- Financial characteristics Opportunity to acquire stranded steel assets with subsidized retrofit, reliable cash flows
- Equity story USP Market leadership and dash to scale allow to aim at "winner takes all"

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