

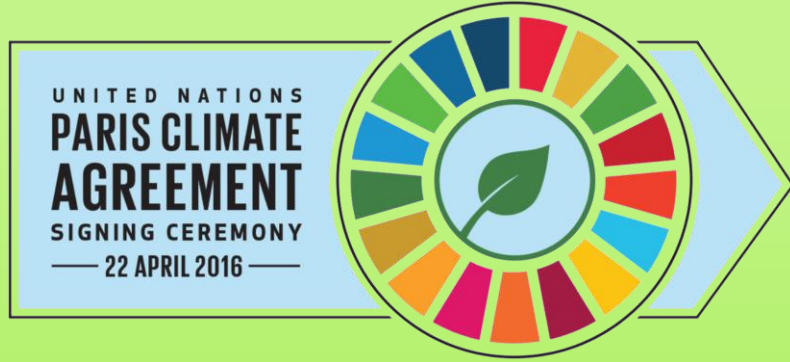
Smart Energy Systems & Zero-Emission Mobility

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Urgency to reduce the impact of climate change

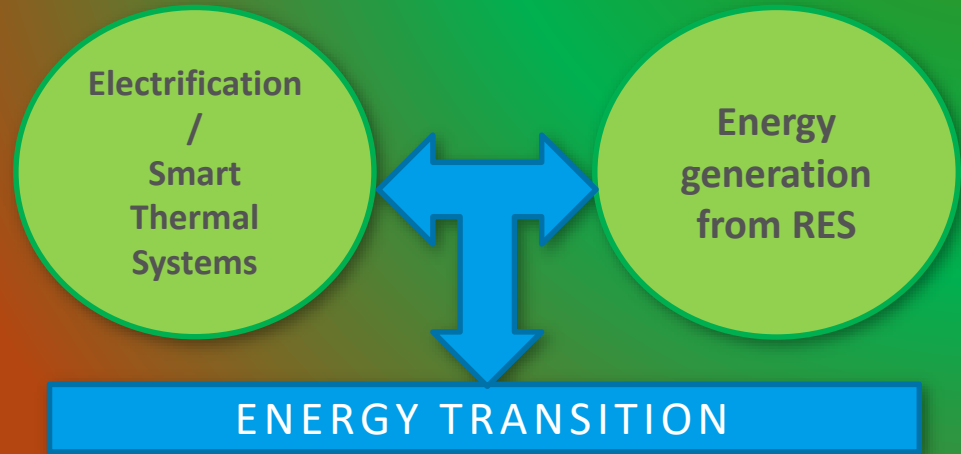
Limiting global warming to 2°C (1,5°C)



The **2021 United Nations Climate Change Conference, (COP26)** 26th United Nations Climate Change conference, Glasgow, Scotland, 1-12 November 2021

Energy transition

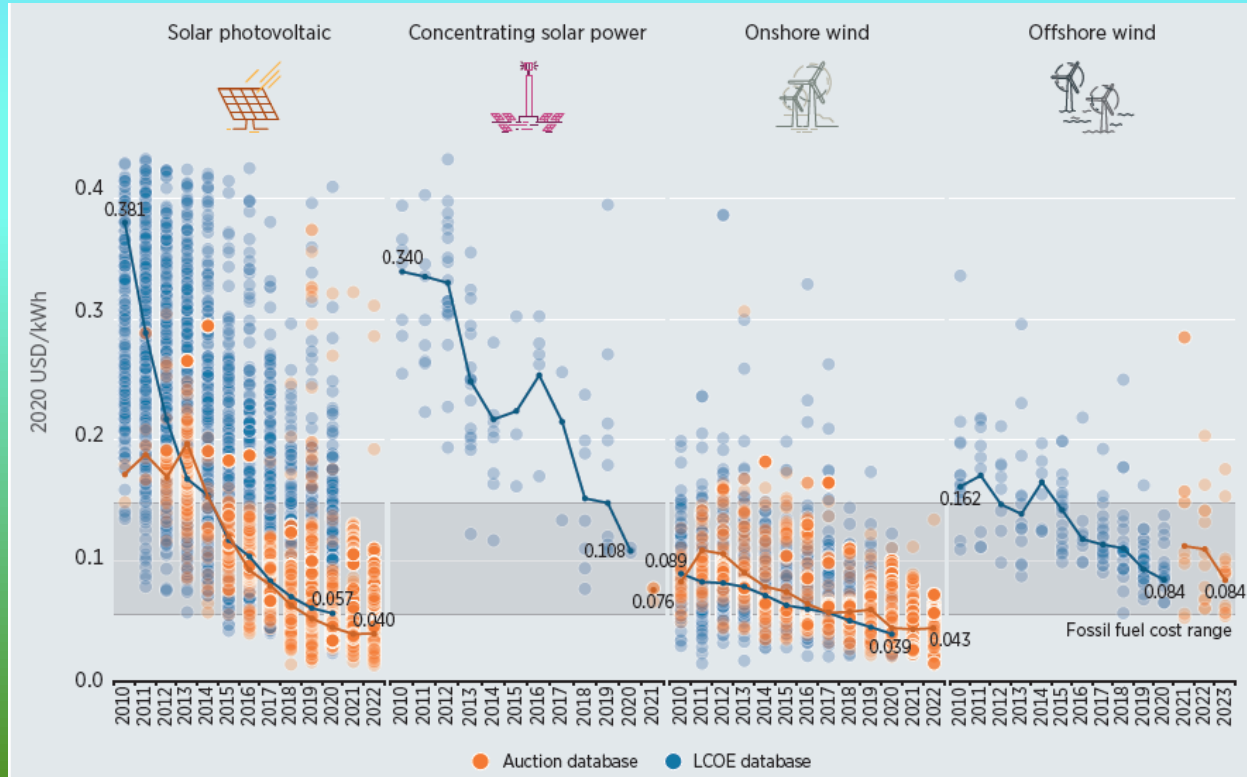
- Energy generation from renewables (up to 100% as a final goal)
- Possible path:
electrification of all end users and smart thermal systems without gas connection



Good news!

Electrification both in supply and demand I

Important key driver is low cost renewable electricity

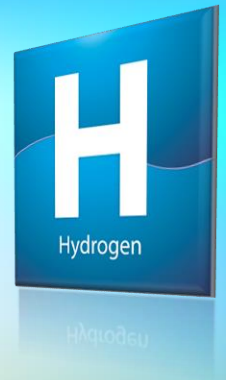


Source: IRENA Renewable Cost and Auction and PPA Databases

Sector coupling

- Mobility
- Power
- Built Environment
- Industry





In the **global transition toward a sustainable future**, solar (or green) hydrogen can play many important roles.

Hydrogen is clean and safe energy carrier that can be used as a fuel in transportation, to supply energy to households, as well as a feedstock for industry.



World's first hydrogen-powered train

A white rectangular sign with a black border and a black arrow pointing to the right. The text "Green Hydrogen" is written in black on the sign.

Green Hydrogen

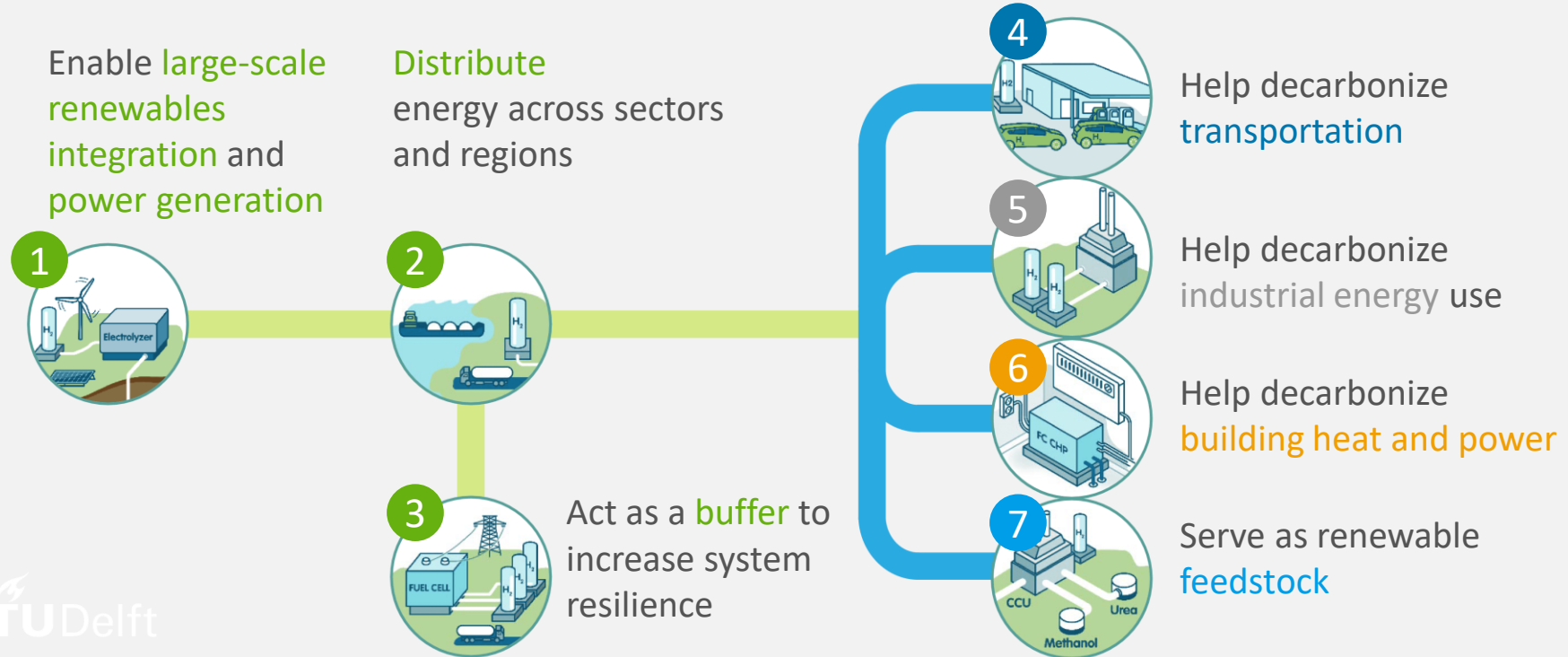
Hydrogen-based electricity system

- decoupling of electricity usage and production in place and time
- cost effective storage of energy on the short and long term
- useful deployment of temporal surplus of wind and solar power that otherwise would have to be curtailed
- stabilization of electricity prices with variable production of wind and solar energy
- energy-efficient transport, in bulk, over long distances, via pipelines, ships and trucks.

Hydrogen Council:

Hydrogen can play 7 roles in the energy transition

Enable the renewable energy system → Decarbonize end uses



Green Hydrogen

Fit for 55

The EU aims to achieve a 55% net reduction in greenhouse gas emissions by 2030 compared to 1990 levels and to be climate neutral by 2050.

Fit for 55 package contains proposals to achieve the CO2 reduction target for 2030 and also to pave the way to becoming the first climate-neutral continent in the world by 2050.

European Commission

July 2021

THE ROLE OF **HYDROGEN** IN MEETING OUR 2030 CLIMATE AND ENERGY TARGETS

The use of innovative energy carriers such as **hydrogen**, particularly coming from **renewable electricity**, will play a **key role in the European Green Deal**. Hydrogen can be used as a fuel, an energy carrier or a feedstock, and could reduce emissions in hard-to-abate sectors, **particularly in industry and transport**.

The EU Hydrogen Strategy looks to harness the **tremendous business opportunities** associated with the production of decarbonised hydrogen. Global interest will mean new opportunities for EU companies, which are being **stimulated with the proposals adopted by the Commission today**.

2030 TARGETS

- 40GW** of renewable hydrogen electrolyzers in the EU
- 10 million tonnes** of renewable hydrogen produced in the EU

The policy framework for hydrogen will be completed in December 2021.

https://ec.europa.eu/commission/presscorner/detail/en/fs_21_3676

Green Hydrogen

Fit for 55

Fit for 55:

All new cars on the European market must be zero-emission vehicles from 2035.

REVISED RENEWABLE ENERGY DIRECTIVE

The revised Renewable Energy Directive promotes the use of renewable hydrogen:

- Extending the **EU-wide certification system** for renewable fuels to include hydrogen
- Decarbonising industry and heavy-duty and long-distance transport, with concrete targets

TRANSPORT



2.6%

for renewable fuels of non-biological origin

INDUSTRY



50%

renewable share in hydrogen consumption

CO₂ STANDARDS FOR CARS AND VANS

The CO₂ standards for cars and vans set technology neutral targets to reduce emissions by 2030 and by 2035. Hydrogen can be part of the solution, **in particular for heavy-duty vehicles**, if the industry chooses to invest in this technology.



ALTERNATIVE FUEL INFRASTRUCTURE REGULATION

The Alternative Fuel Infrastructure regulation will also support the deployment of alternative fuels infrastructure, including refuelling points for hydrogen.

One refuelling station will be available every 150 km along the TEN-T core network and in every urban node.

FUELEU MARITIME PROPOSAL

The FuelEU Maritime proposal covers all renewable and low-carbon fuels in maritime transport, including decarbonised hydrogen and decarbonised hydrogen-derived fuels (including methanol and ammonia).



The Future is electric



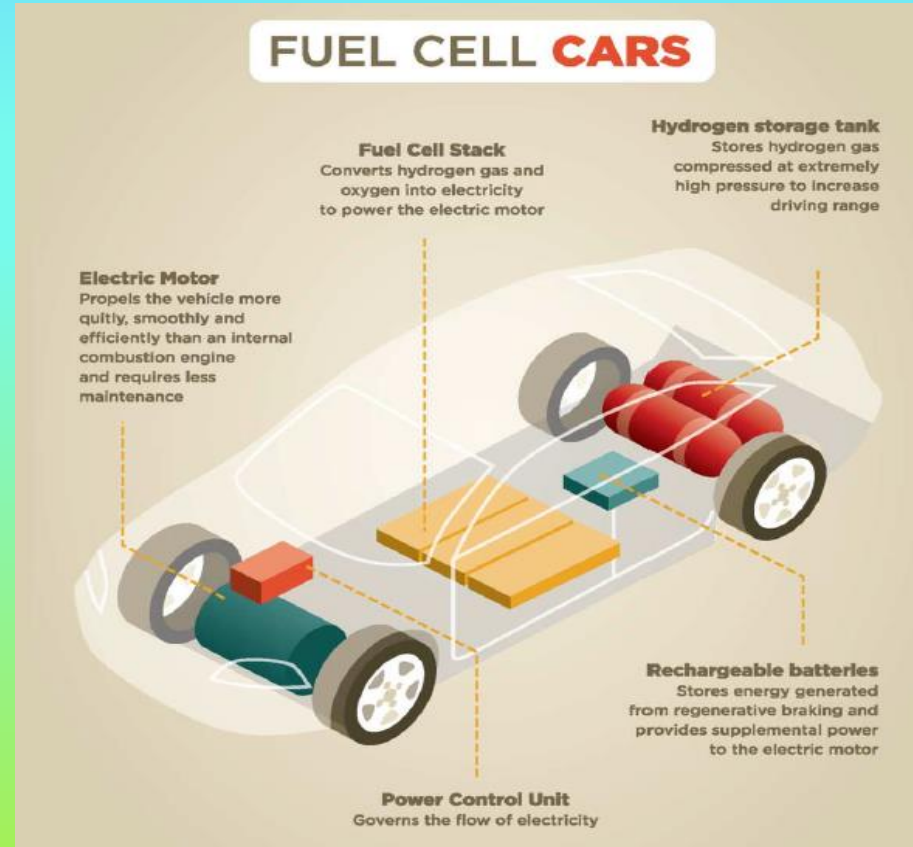
Tesla Model 3



Toyota Mirai

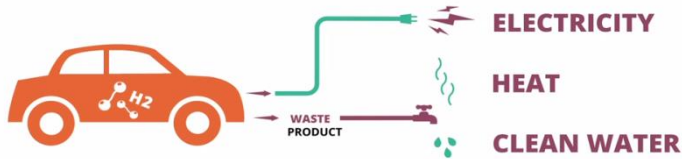
Fuel cell car

converts the chemical energy of a fuel (hydrogen) directly to electricity



Hydrogen car

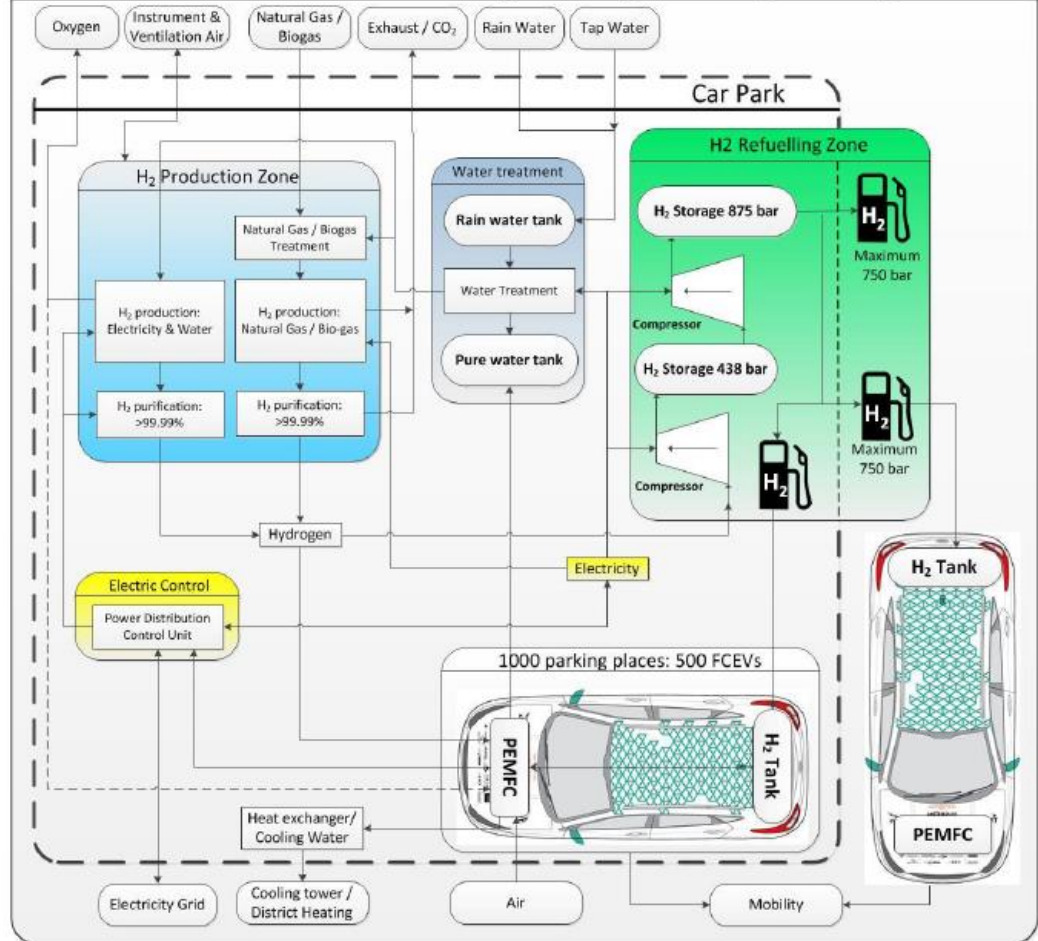
THESE TYPE OF CARS PRODUCE...



...WHICH WE CAN USE IN...



Car Park Power Plant: Balancing Power grids & H₂ Fuelling station



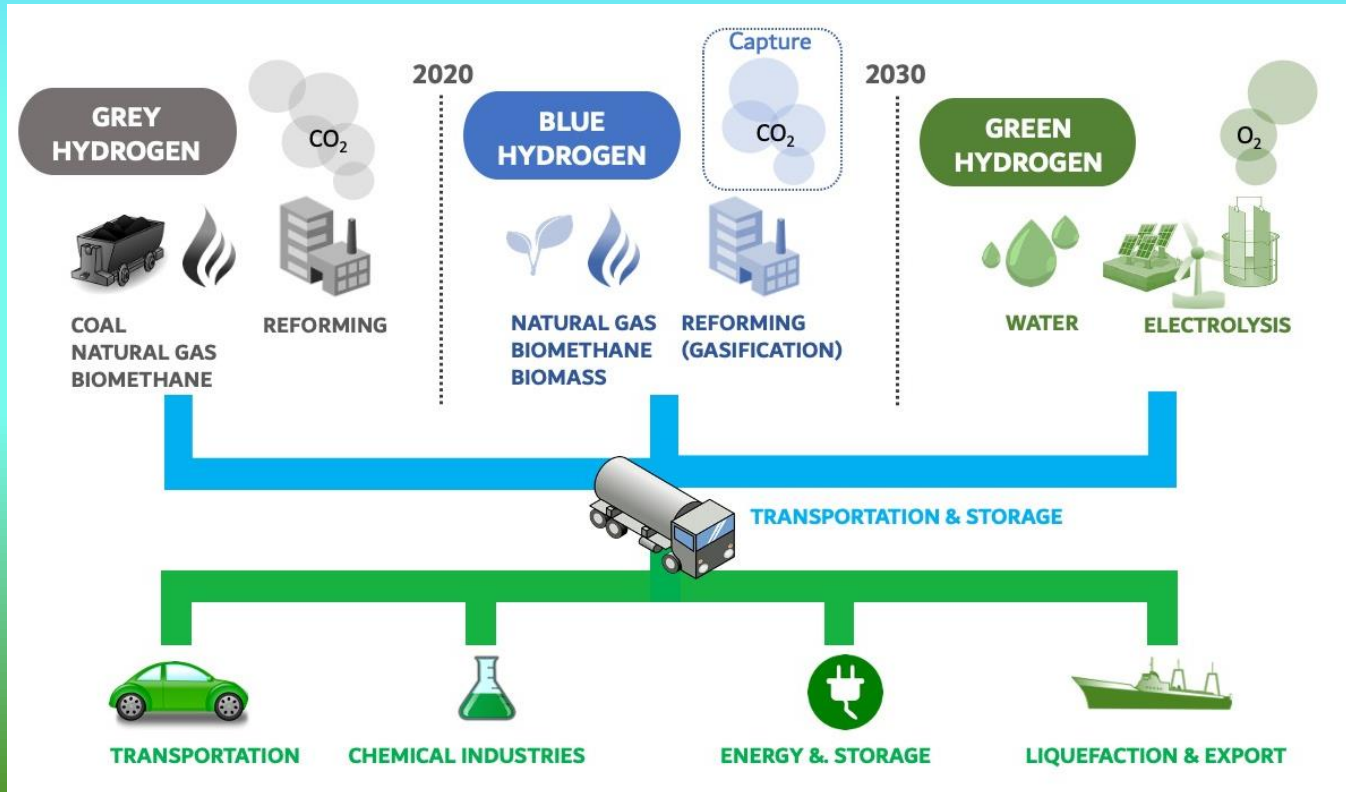
Car as a Power Plant

Vehicle-to-grid demonstration & testing

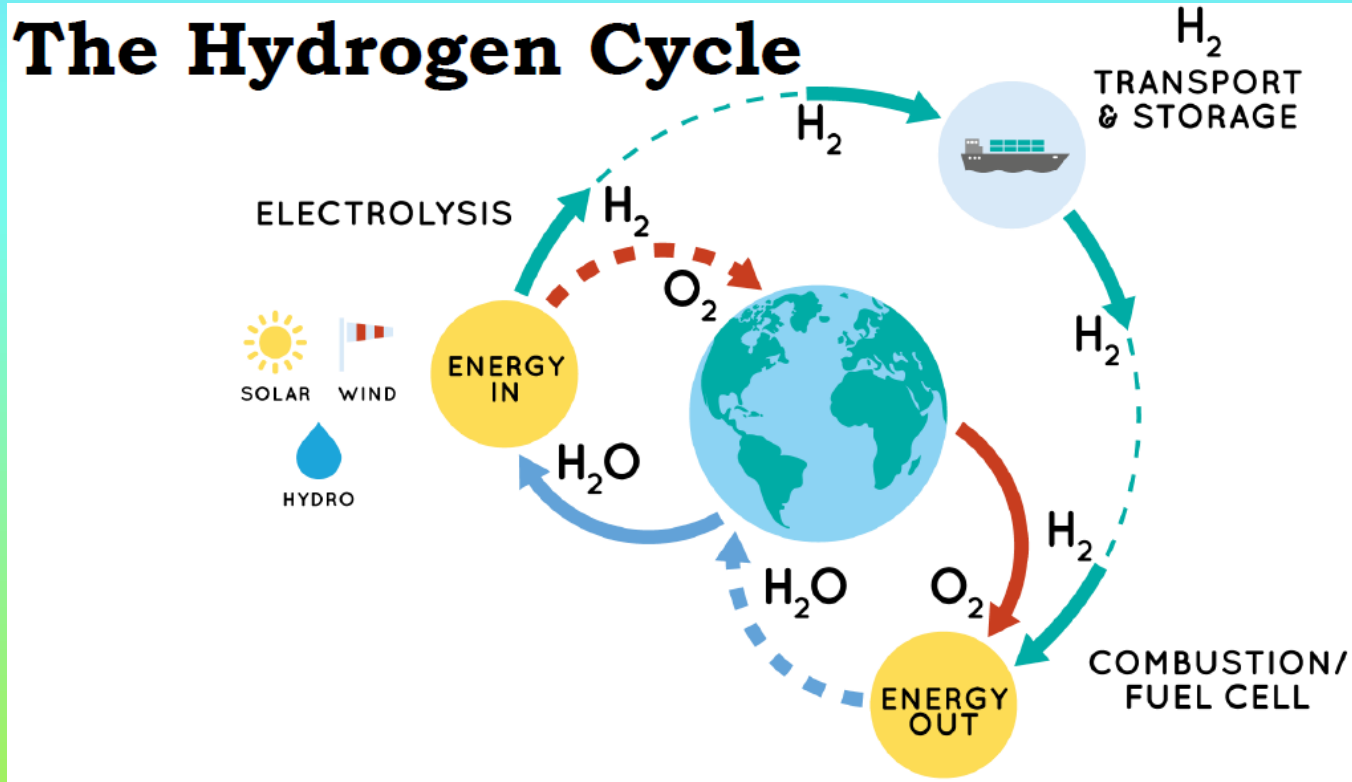


Europe's first connection between a fuel cell vehicle and the local electricity grid at **The Green Village**, TU Delft

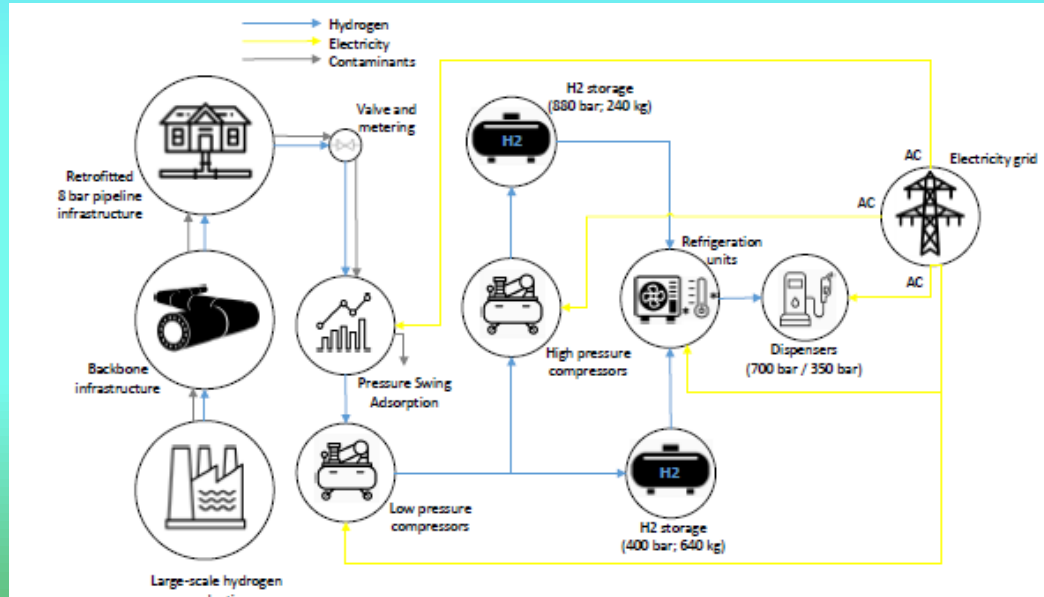
Hydrogen production



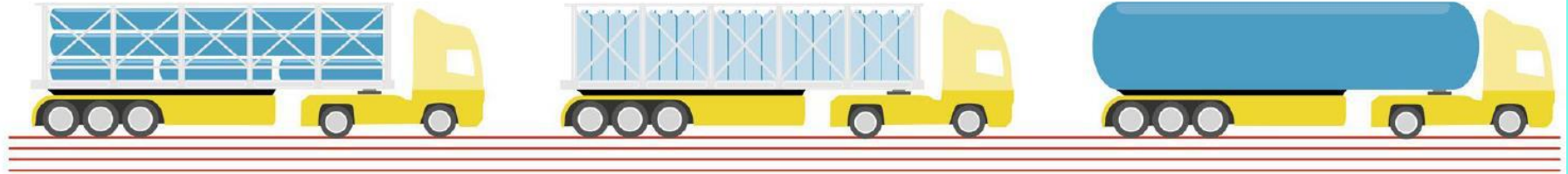
The Hydrogen cycle - Electrolysis



Hydrogen transport - backbone infrastructure



Hydrogen transport by trailers



TUBE TRAILER

200 – 250 bar, $\approx$ 500 kg, ambient temperature

CONTAINER TRAILER

500 bar, $\approx$ 1,000 kg, ambient temperature

LIQUID TRAILER

1 – 4 bar, $\approx$ 4,000 kg, cryogenic temperature



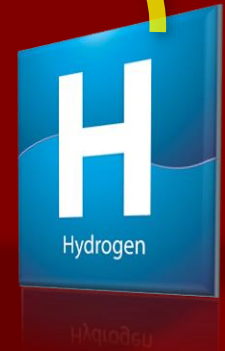
How to analyse and steer this
complex transition
of energy system, mobility and
other sectors?

System solutions

Do not think
in efficiency

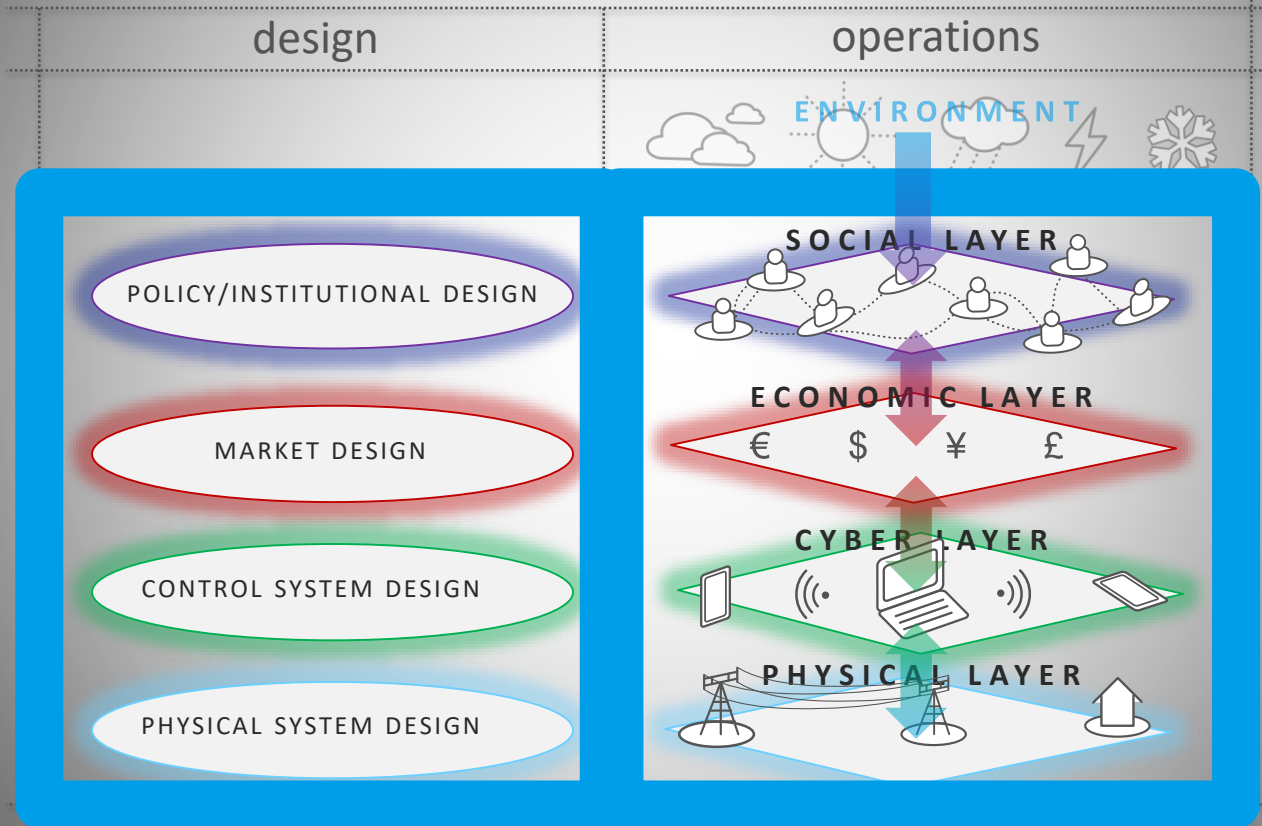
but in

system cost!



Energy transition

– complex socio-technical challenge

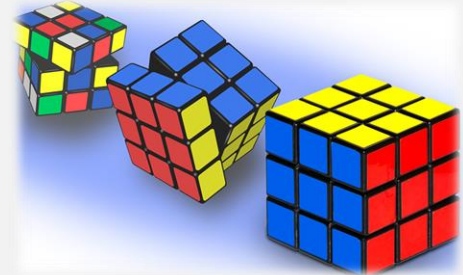
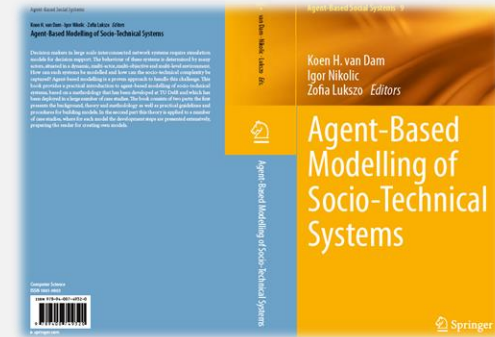


There are so many tools...

- mainly specialistic tools, designed to address a very specific problem

What we need is...

- an integrated “modelling laboratory” beyond the capacities of each single research unit
- Integrated approach for **multi-models and co-simulation** with a (real-time) interconnection to the available facilities of the research and modelling units from different sectors



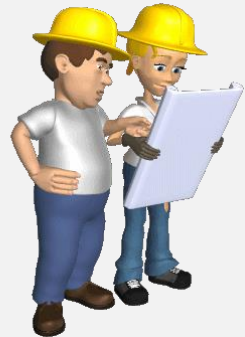
There are so many tools...

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What we need is...

Complex Socio-Technical Systems Engineering



Thank you for your attention!



Jan Giesen, Huizen achter de duinen, 1924