EU Strategy on Hydrogen

Jorgo Chatzimarkakis, Secretary General

f-cell – October 2017, Stuttgart

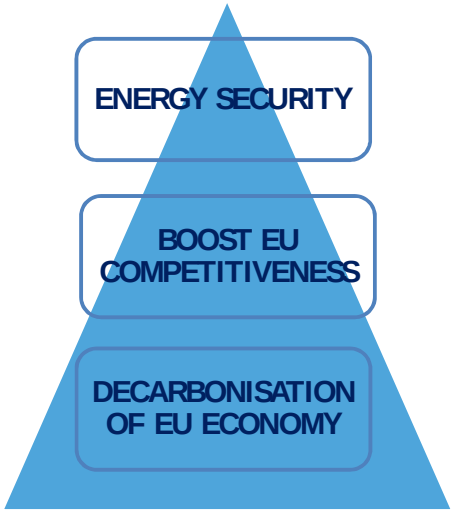
Hydrogen Europe Membership >110 Companies and Associations

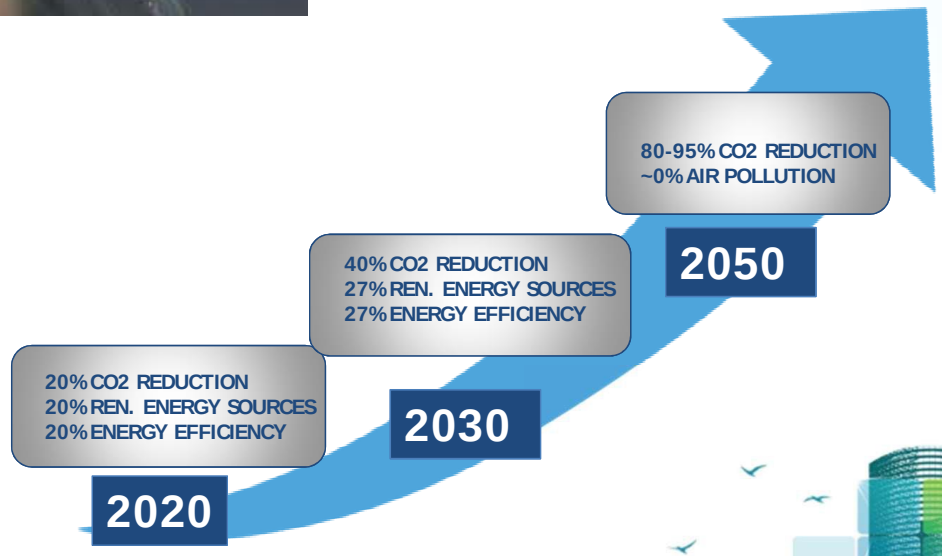
Hydrogen Europe

Top Political Target:
Enabler of a zero-emission society!

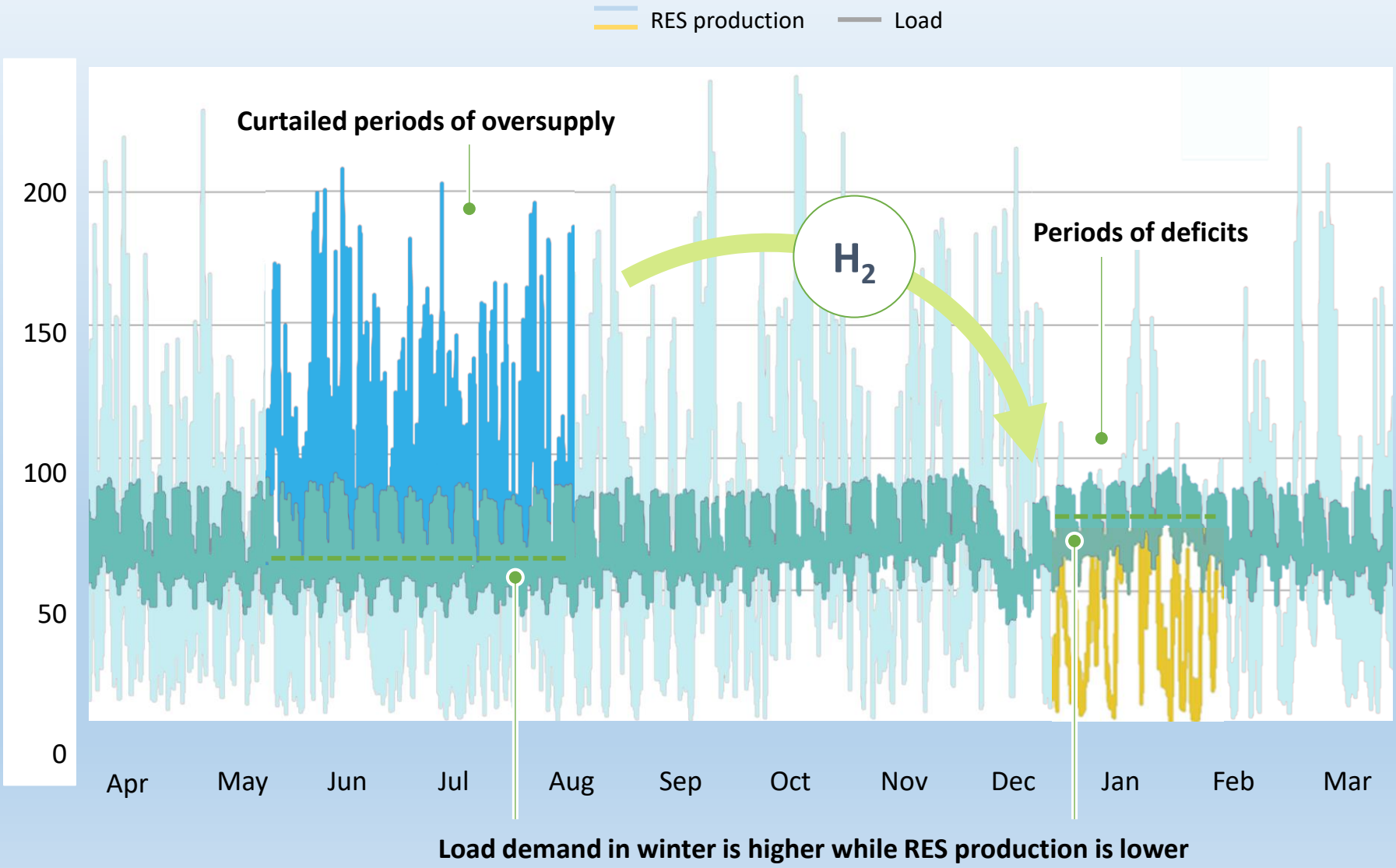
EU CLIMATE AND ENERGY FRAMEWORK

"I want to reform and reorganise Europe's energy policy in a new European Energy Union."



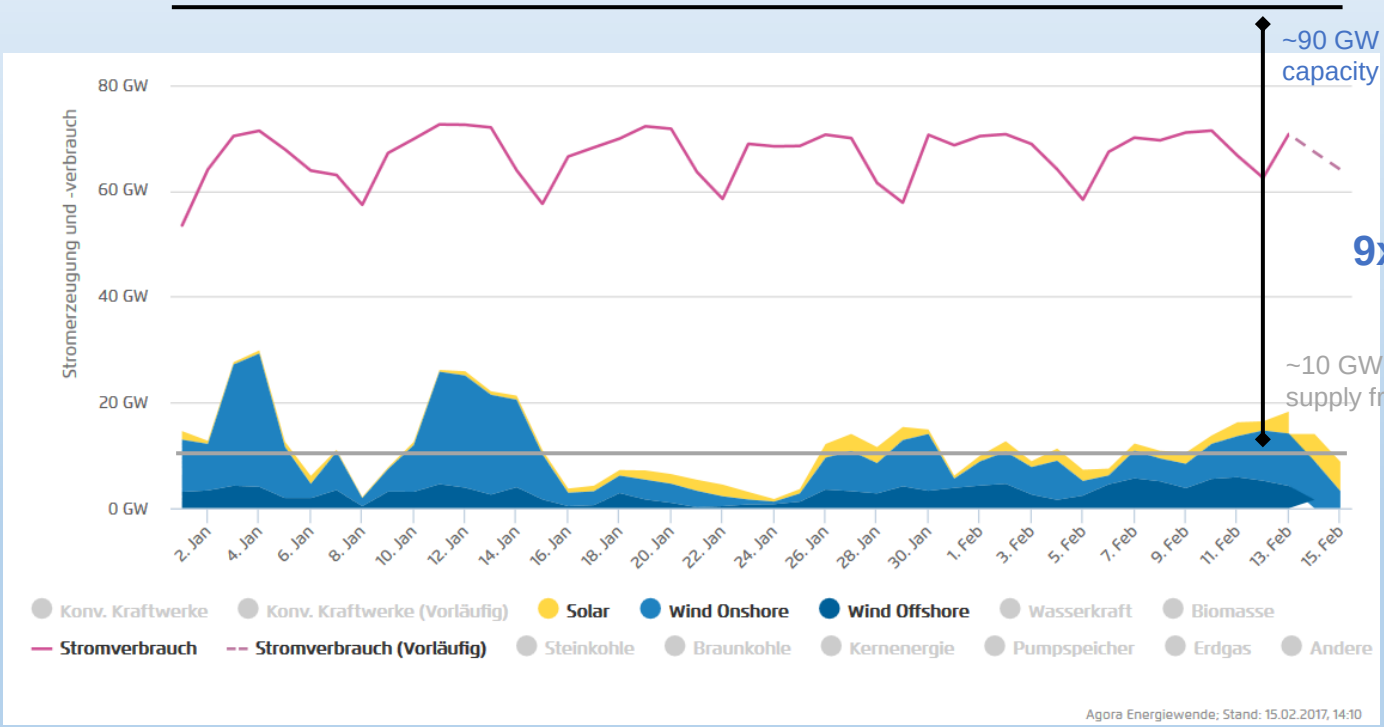


Hydrogen enables seasonal storage avoiding massive curtailment



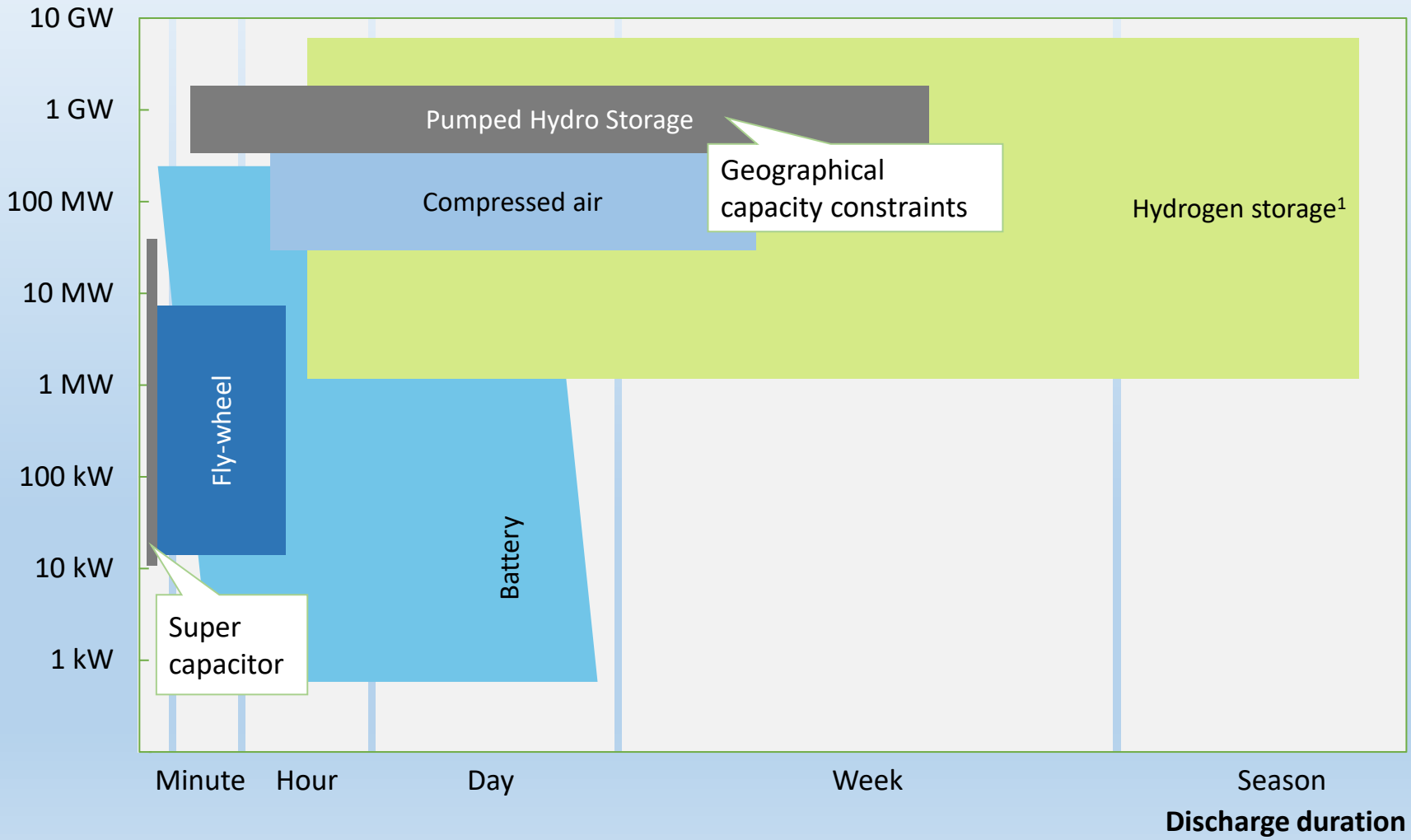
Source: EC 2050 scenario, McKinsey analysis

An all-electric world requires large overcapacities



- Very low share of RES during winter time
- A major electrification of heating & transport requires significant overcapacities
- Every additional kWh in winter time is a burden for the power system

Hydrogen for long-term carbon-free energy storage

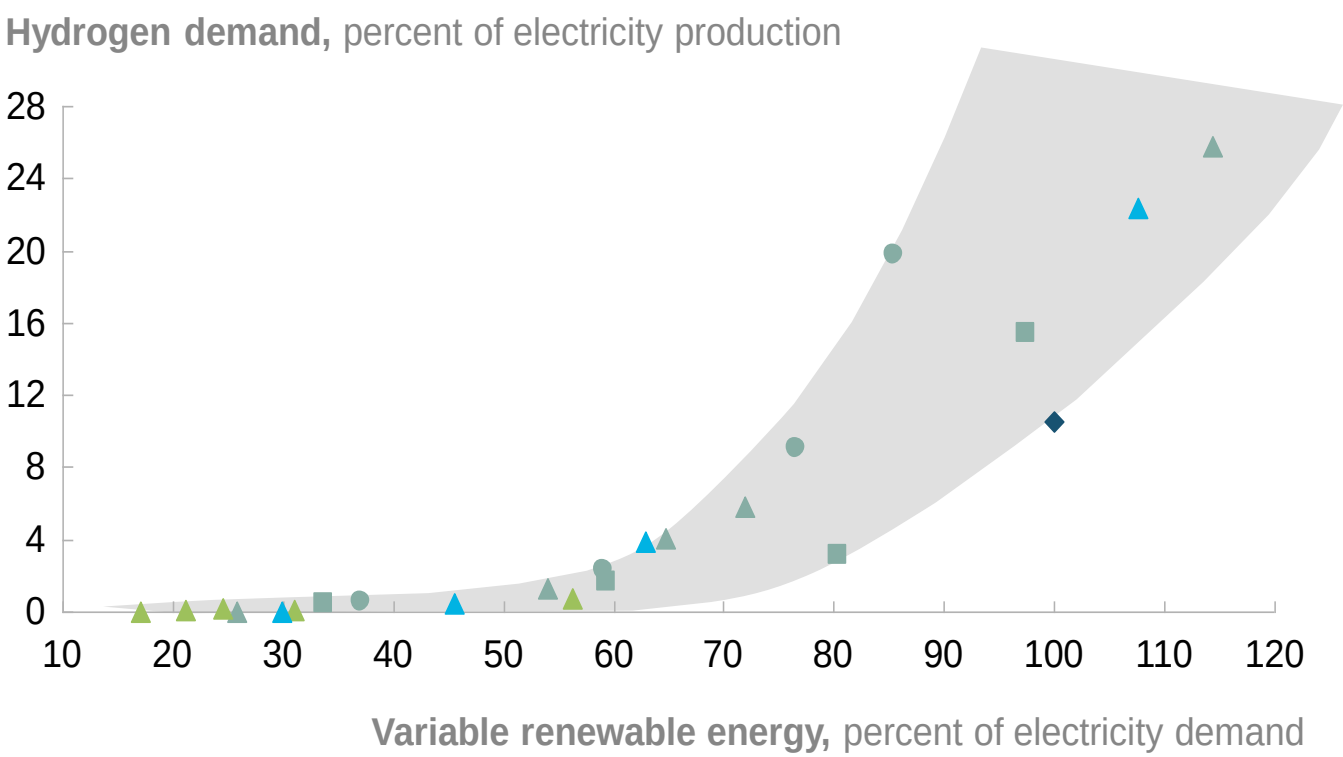


1 IEA data updated due to recent developments in building numerous 1MW hydrogen storage tanks

Source: IEA Energy Technology Roadmap Hydrogen and Fuel Cells, JRC Scientific and Policy Report 2013

Hydrogen storage increases exponentially with the variable energy share

Overview of study results



Colors

- Germany
- Sweden
- Spain
- Europe

Shapes

- ○ Fraunhofer (storage & sector coupling)
- △ McKinsey
- ◇ RWTH Aachen (power only)
- □ Sterner & Stadler[3] (mean)

1 Simulation of Germany Energy Systems; most-efficient/least-cost modeling to achieve 2 degree scenario in Germany in 2050 based on hour-based simulation of electricity generation and demand; no regional distribution issues assumed (would rather increase need for storage), no increases/ decreases in energy imports and exports

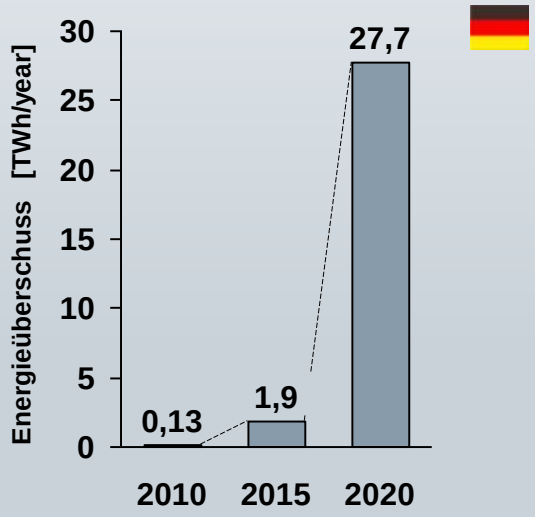
2 Simulation of storage requirements for 100% European RES; considers only storage for power sector, could be considered a lower bound for total hydrogen pathway

3 Converted to shares based on projections of total power demand until 2050

SOURCE: Fraunhofer , BMW, RWTH Aachen, Sterner und Stadler (2014): Energiespeicher - Bedarf, Technologien, Integration, McKinsey

Excess RE production could feed FCEVs
German Example

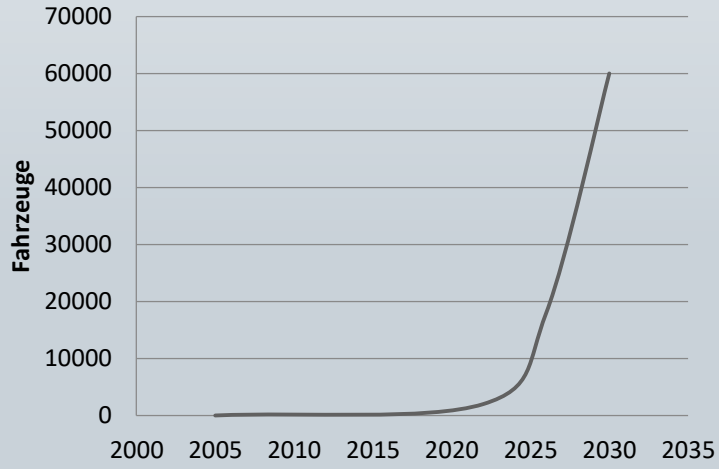
- Aussagen zur Überschussproduktion durch Erneuerbare Energien differieren deutlich. Die Spannweite reicht von 0 (DENA, BCG) bis >40 TWh für 2030.



Quelle: EnBW (Münch), BMU Strategie-Workshop, 05.09.12

1 TWh Überschussproduktion ist äquivalent zu (**2015: 4,7TWh in D**):

- ≈ 20.000 t H_2
- ≈ 2 Mrd km H_2-Mobilität (@ 1kg/100 km)
- ≈ 150.000 Brennstoffzellenfahrzeuge (@ 14.000 km/y) **(705.000 FCEVs in 2015)**



Prognose für Bestand von FCEV Fahrzeugen

Bei Eintreten DENA Maximalszenario (40TWh) wäre theoretisch die Versorgung von bis zu 6 Mio. FCEV in 2030 möglich

Multitalent Hydrogen

Hydrogen is

- an energy carrier,
- a fuel and
- a raw material

that offers a clean, sustainable, and flexible option to convert renewable electricity into a chemical energy carrier for use in mobility, heat and industrialerial applications. (steel, chemical, refineries, etc.)

As the “gaseous form of electricity”, it is an enabler for sectoral integration.

Hydrogen will play a major role in global RE systems

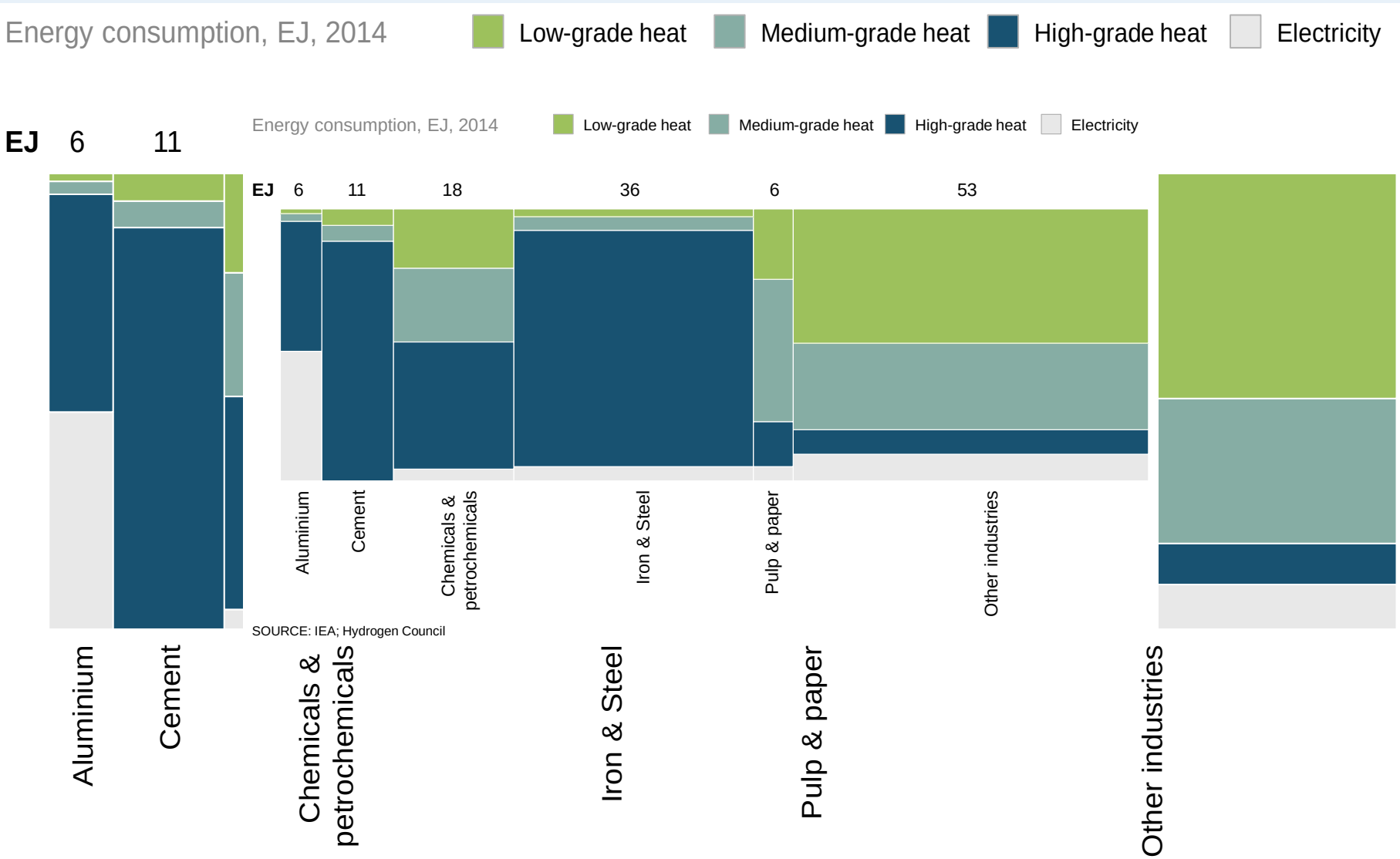
2030 milestones (estimates)

- ~250 TWh of excess electricity converted to hydrogen through electrolysis
- ~20 large power plants generating ~200 TWh of electricity from clean hydrogen
- ~10 ships transporting a total of ~100 thousand tons hydrogen per year
- ~65 billion cubic meters of gaseous hydrogen stored in underground caverns

2050 vision

- 2 EJ of hydrogen produced from excess electricity; 9 EJ of power produced from clean hydrogen
- 8 EJ of hydrogen transported/shipped overseas
- 18 EJ of hydrogen buffered in strategic reserves

Situation today: High grade heat is the largest energy use in heavy industry



SOURCE: IEA; Hydrogen Council

Hydrogen can enable decarbonization of industry energy use

Hydrogen can significantly reduce carbon emissions from industrial processes requiring heat, eliminating as much as 1 gigaton of CO_2 annually by 2050.

- **2030 milestones (estimates)**

One in ten steel and chemical plants in Europe, North America and Japan using hydrogen for low-carbon production; 4 million tons additional hydrogen used

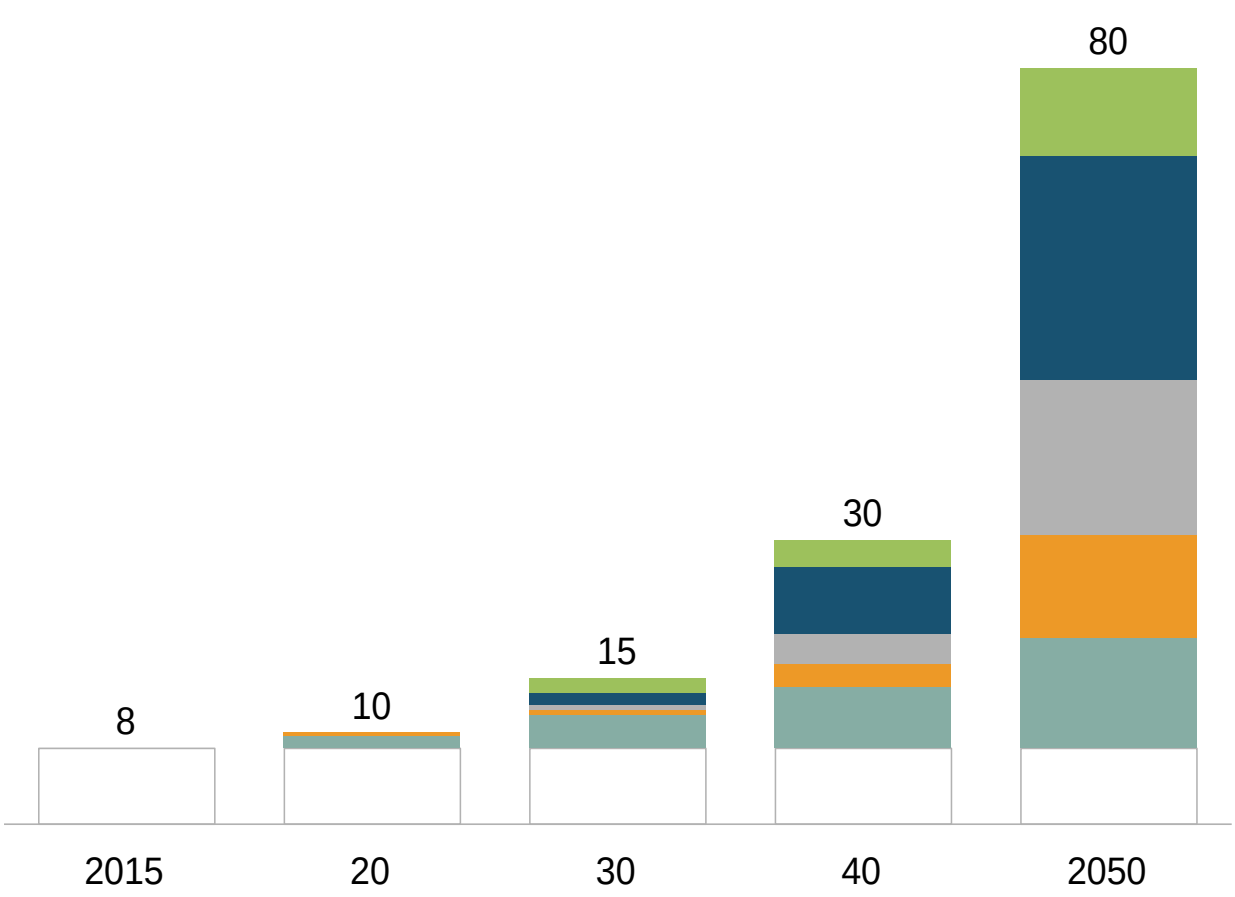
- **2050 targets**

12% of final industry energy demand (16 EJ) could be met with hydrogen – **up to 23% of high-grade heat** (over 400 degrees), 8% of medium-grade heat (100-400) and 4% of low-grade heat (under 100)

1 gigaton of CO_2 abated

Hydrogen demand could increase by 10 in 2050

Global Energy demand supplied with hydrogen, Exajoule (EJ)



1 Power gene-ration, buffering

4 Transportation

5 Industry energy

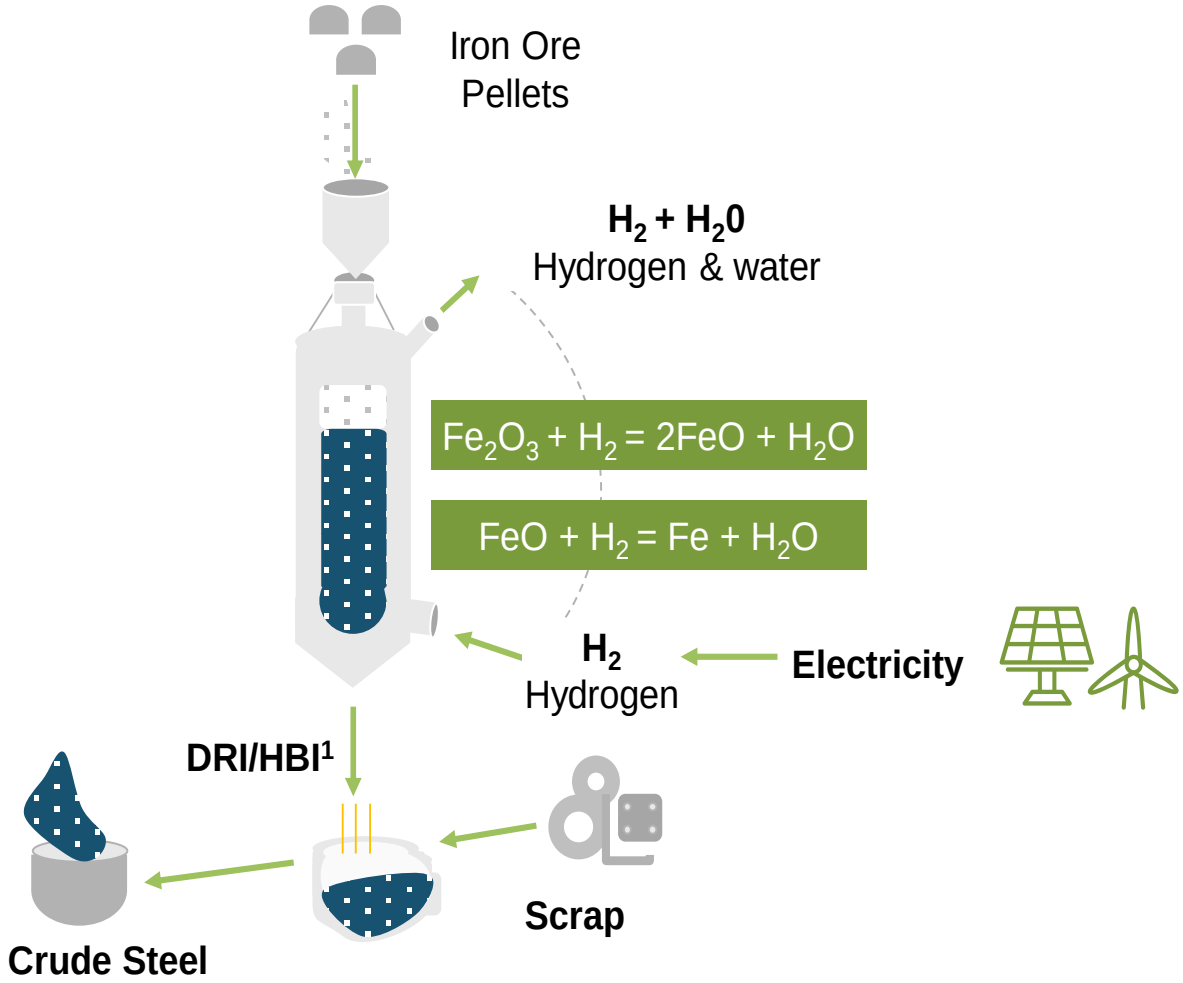
6 Building heating and power

7 Feedstock, CCU, DRI

Current H_2 market

SOURCE: Hydrogen Council, IEA ETP Hydrogen and Fuel Cells CBS, National Energy Outlook 2016

Hydrogen-based reduction allows emission-free iron making

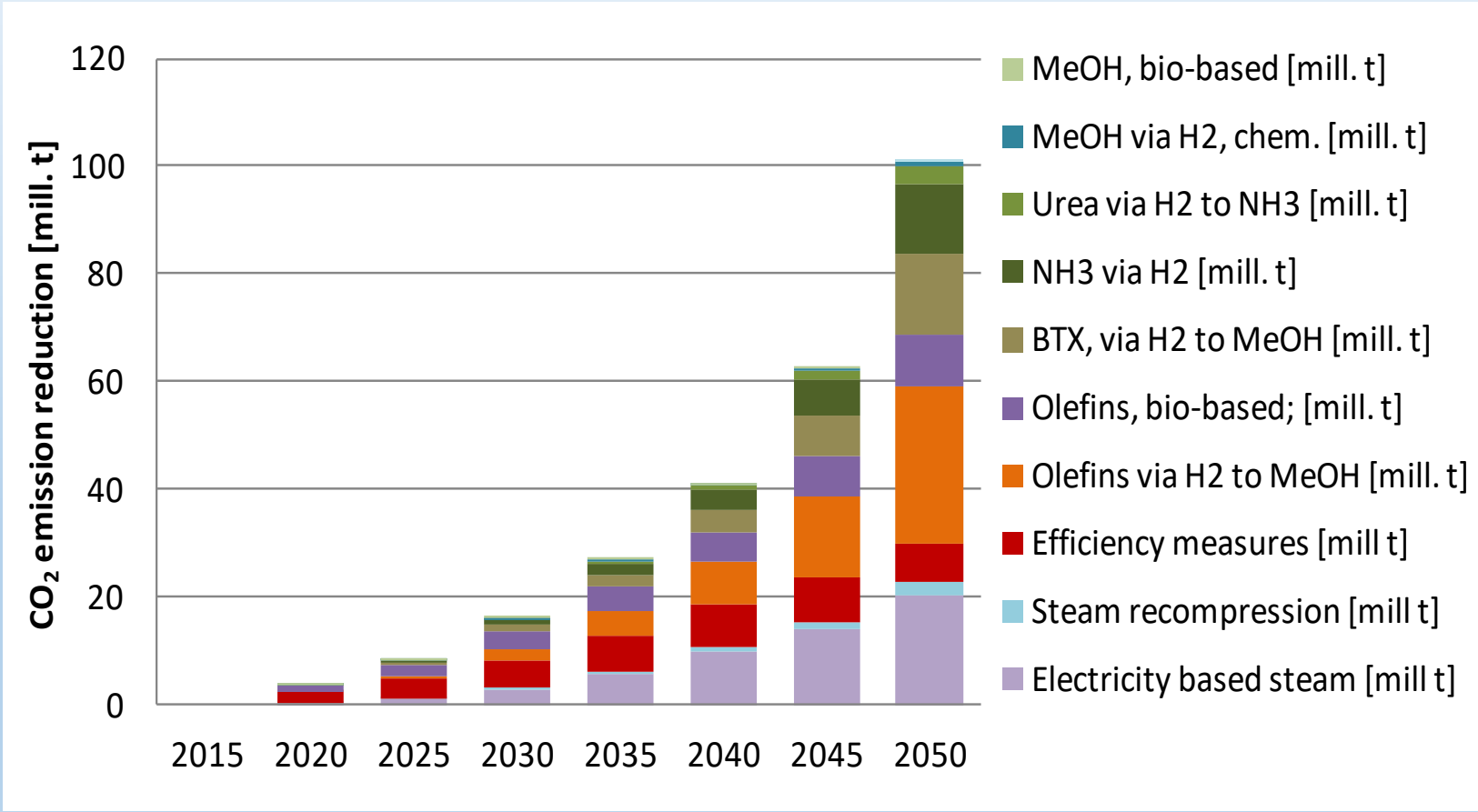


1 Direct reduced iron / Hot briquetted iron

SOURCE: LKAB: HYBRIT – Iron Ore to Steel based on Hydrogen; Lulea, 2016

Chemical Industry – Dechema Study 2017
CO_2 emission reductions – via green hydrogen

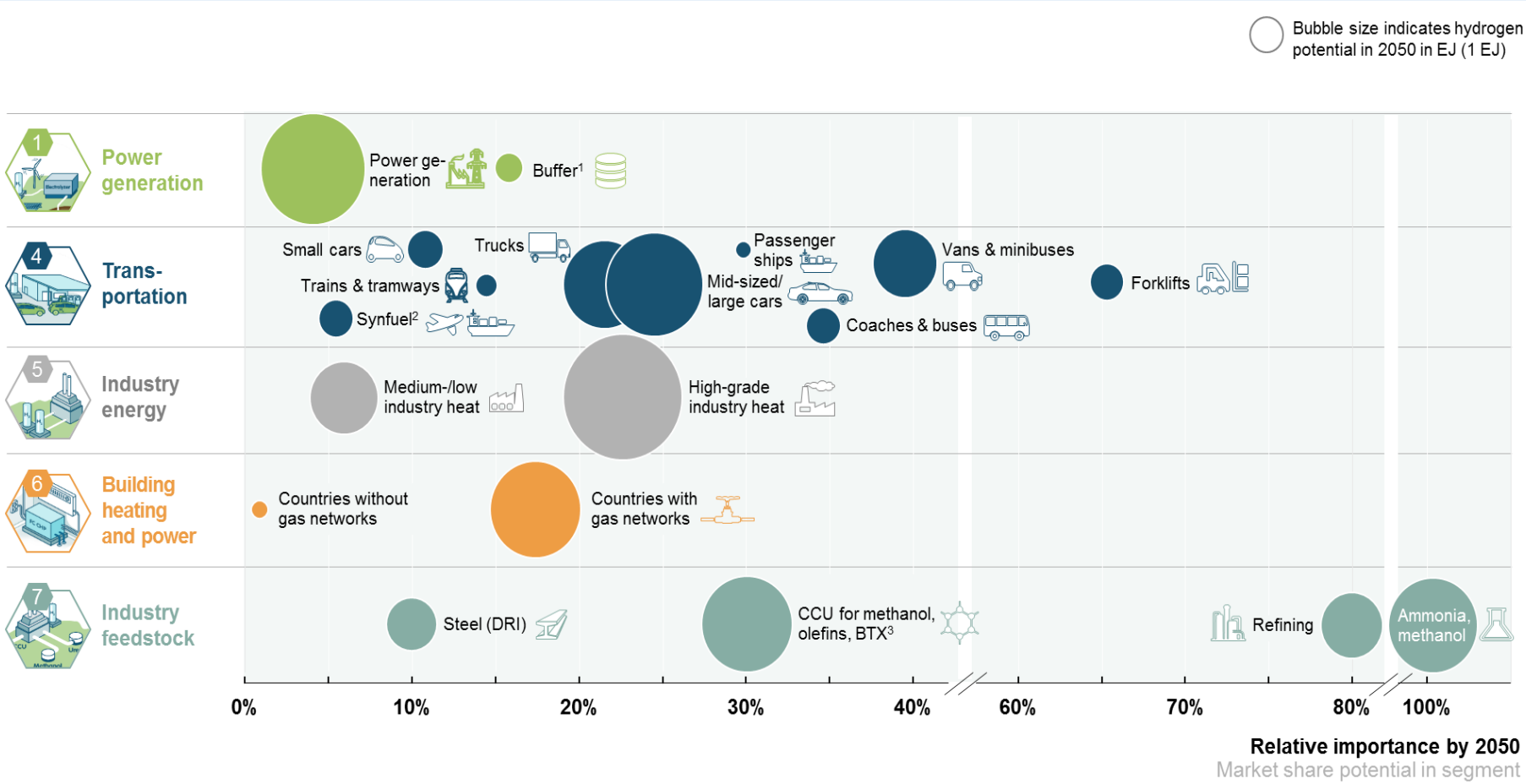
Ambitious: CO_2 emission reductions, chemicals only



BTX=Benzene, toluene and xylene

Source: Dechema Study

Hydrogen plays a critical role in low-carbon tech portofolio

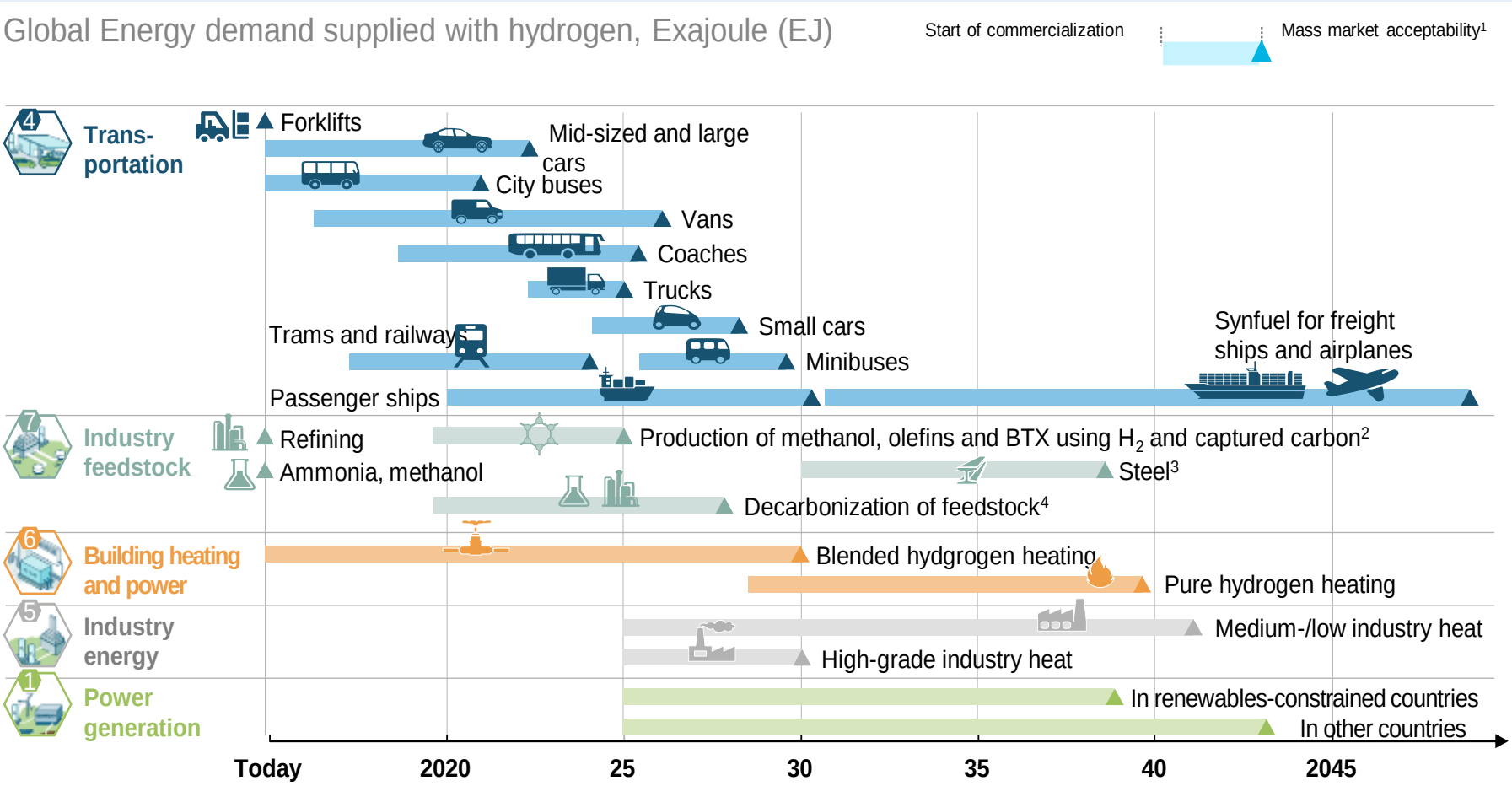


1 Percent of total annual growth in hydrogen and variable renewable power demand
2 For aviation and freight ships
3 Percent of total methanol, olefin, BTX production using olefins and captured carbon

SOURCE: Hydrogen Council

Hydrogen technology ready for deployment

Hydrogen Europe

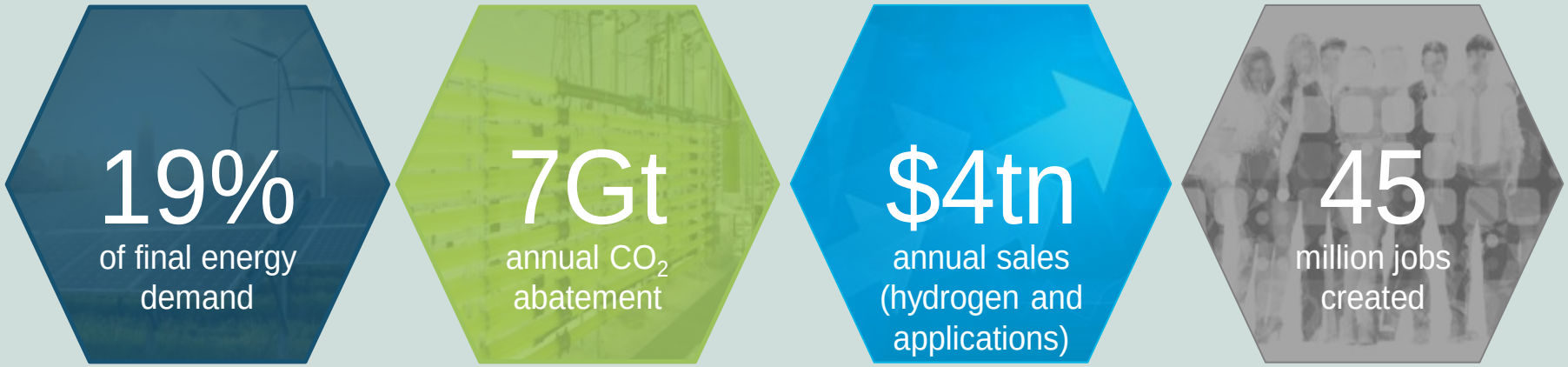


1 Mass market acceptability defined as sales >1% within segment in priority markets
2 Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock
3 DRI with green H_2, iron reduction in blast furnaces and other low-carbon steel making processes using H_2
4 Market share refers to the amount of feedstock that is produced from low-carbon sources

SOURCE: Hydrogen Council

Hydrogen vision for 2050

2050 hydrogen vision (annual figures for 2050)



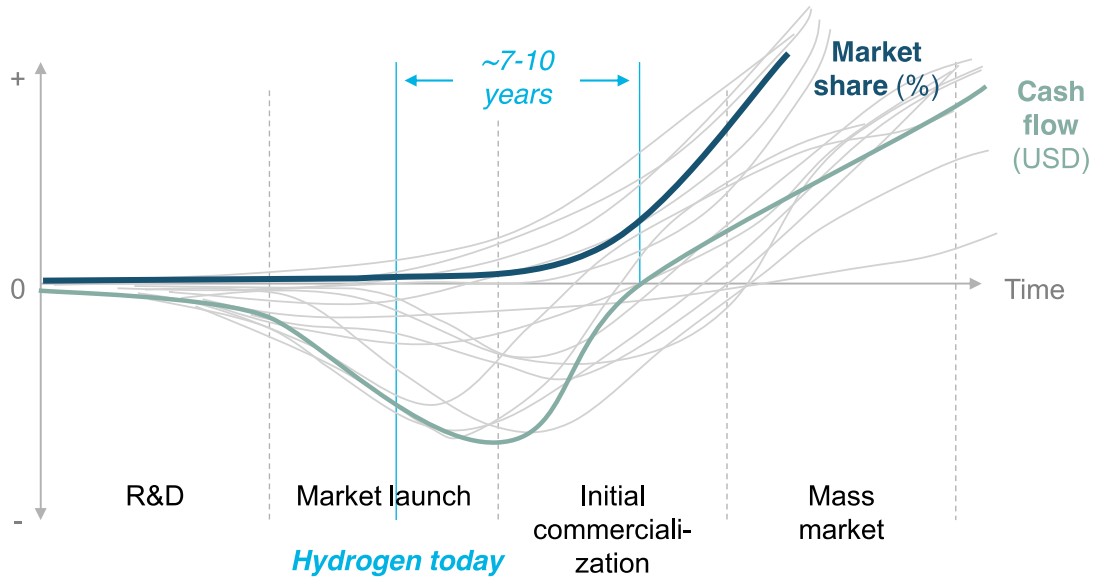
SOURCE: Hydrogen Council, IEA ETP Hydrogen and Fuel Cells CBS, National Energy Outlook 2016”

Legal framework good for investments?

In order to reach this target investments are needed now

PRELIMINARY
ILLUSTRATIVE

Hydrogen technologies are ready to be launched and scaled up…



…requiring significant investments in manufacturing facilities and infrastructure

USD billion, 2018-2030

240 bn

Infrastructure investments (project finance, corporate debt..)

Hydrogen production, hydrogen refueling stations, distribution (liquefaction plants, shipping, trucks, pipelines)

215 bn

Scaling up manufacturing (corporate debt..)

Scaling up manufacturing for fuel cell and components, new R&D for components and new models

20+ bn

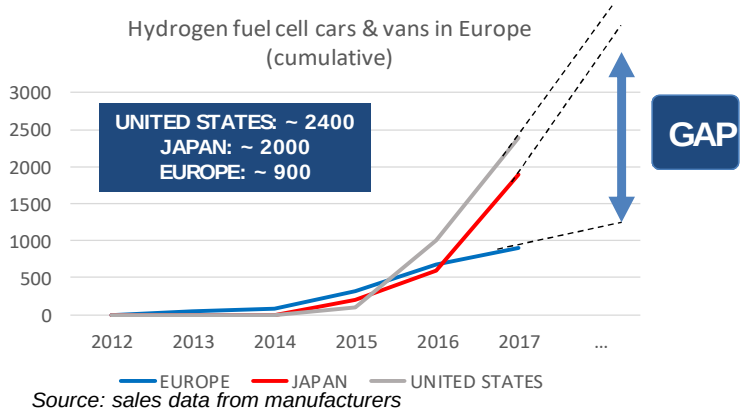
New business (venture capital/equity)

Investments in end-use applications, e.g., FCEV taxi and truck fleets, financing of CHPs in buildings, …

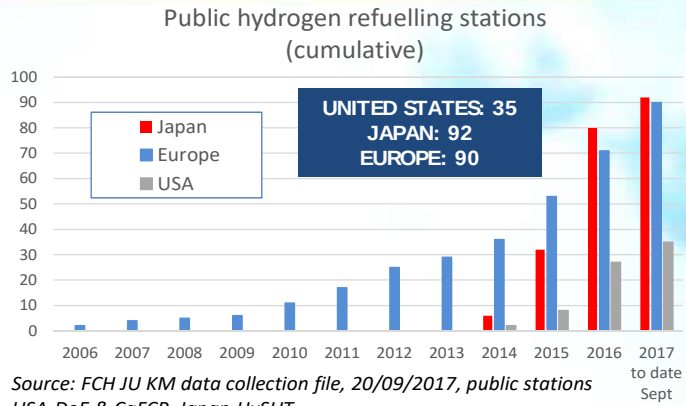
SOURCE: Hydrogen Council

European reality!

Europe has the technology but need to accelerate the mass deployment!



Source: sales data from manufacturers



Source: FCH JU KM data collection file, 20/09/2017, public stations
USA-DoE & CaFCP, Japan-HySUT
To date ca. S1 2017

Europe & Japan are today leading in # of HRS. EU had the lead in number of FCV & HRS on the market but recently US & JP overtook EU. **<u>One important reason is policy!</u>**
e.g. JP heavily subsidises the FCV & CA has ZEV mandate + subsidy

2017 Mobility package in Nov. is chance to catch-up again!

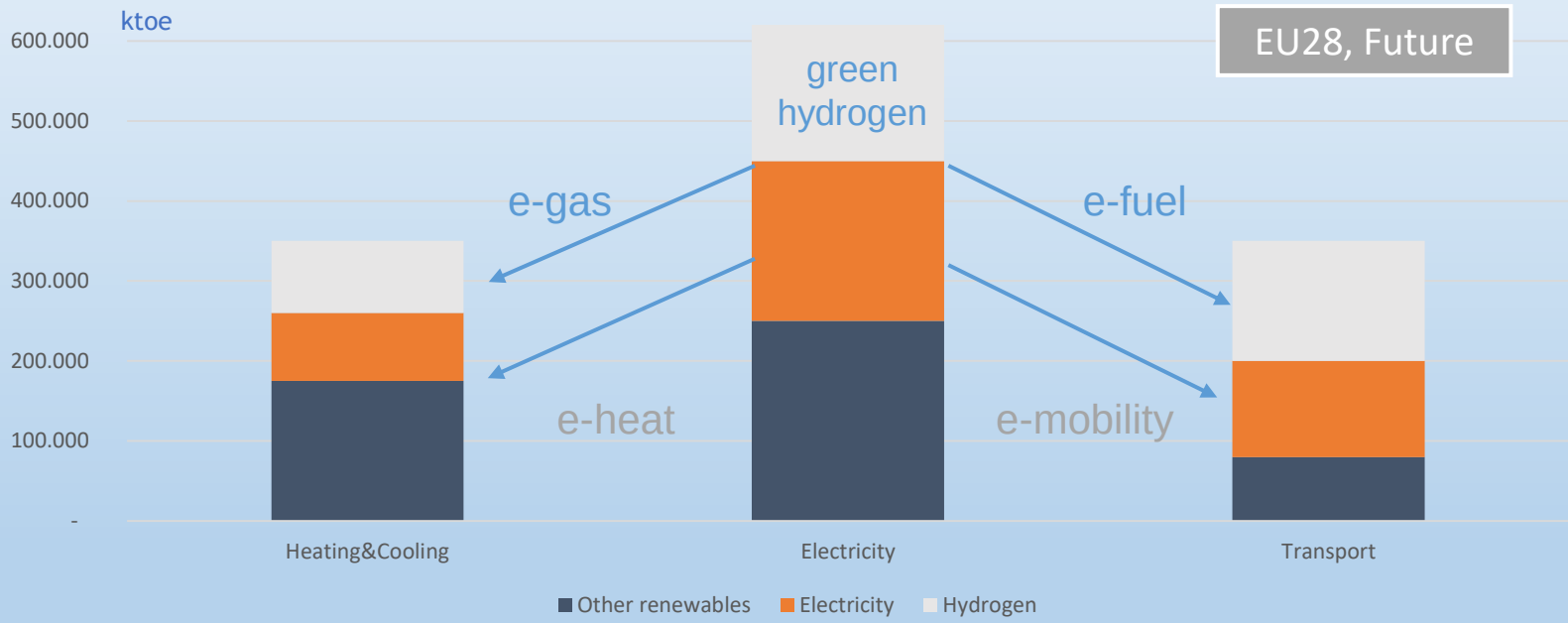
Chinese reality!

Fuel cell vehicle & hydrogen filling station

燃料电池车和加氢站

	2020	2025	2030
FCV number (unit) 燃料电池车数量（辆）	5000	50000	1M
FC Stack power density （kW/KG） 燃料电池电堆比功率（kW/KG）	2	2.5	2.5
FC durability (Hour) 燃料电池耐久性（小时）	5000	6000	8000
Filling Station (unit) 加氢站	>100	>300	>1000

A future scenario with green hydrogen



- Hydrogen connects the power sector with the heating & cooling and the transport sectors (→ sector integration)
- Hydrogen promises a better integration of and more renewables in all sectors

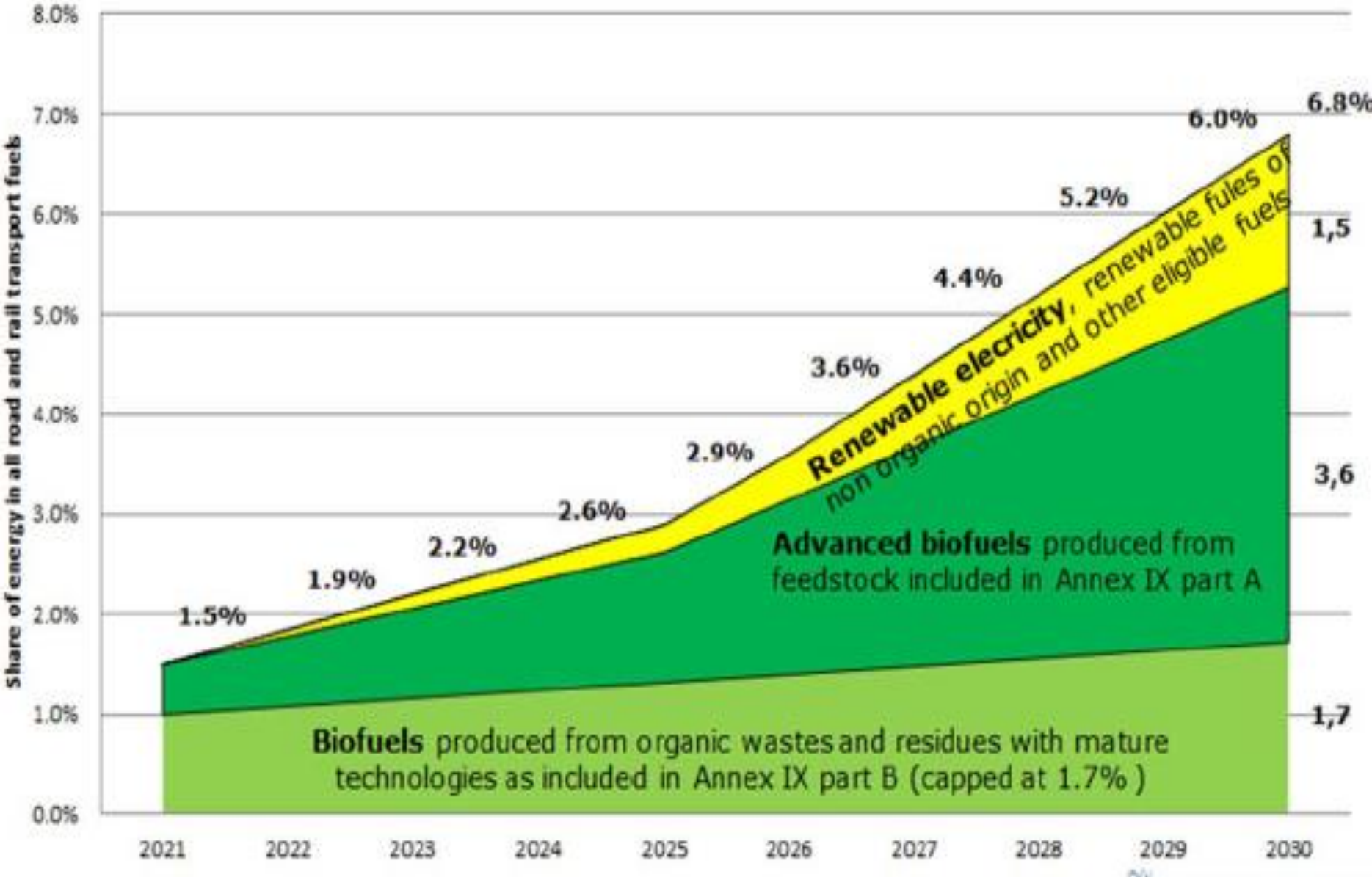
Data source: EUROSTAT, Shares 2014

EU's answer:
Clean Energy Package regarding renewable gas

Renewable Energy Directive (RED II)

- Stricter criteria for bioenergy in heating & cooling, electricity and transport
- Increasing renewable share for fuel production (2030: 6,8%/9%). Gap needs to be filled by advanced biofuels and renewable fuels of non-biological origin
- Increase renewable share in heating and cooling sector (1% /2% per year)
- Long-term power purchase agreements accepted for the supply of electricity to electrolysers (Draft Report)

Renewable gas in the Clean Energy Package

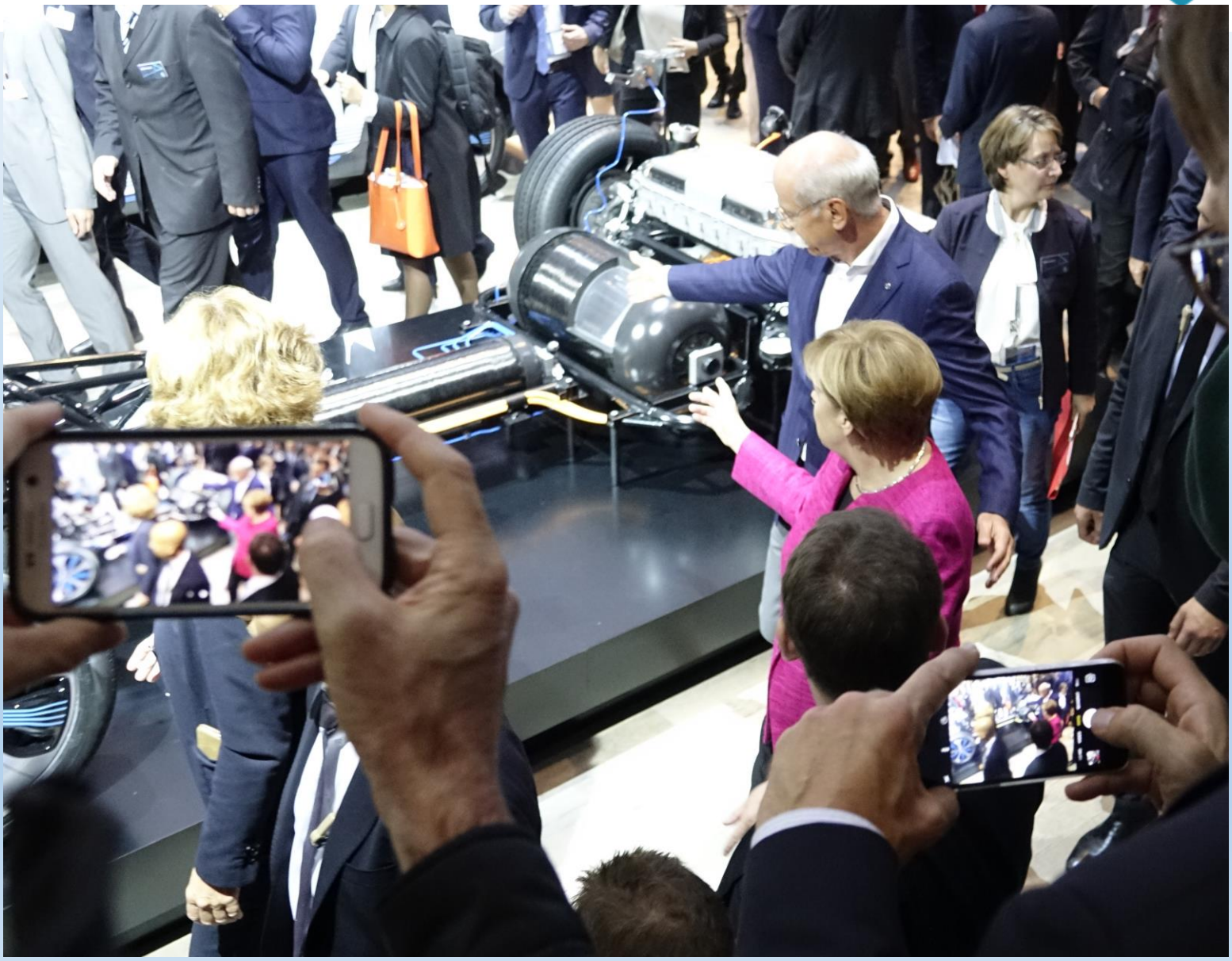


RED II so far to much focused on electricity only

- An all-electric scenario seems not feasible, but fossil oil and gas will be shut out unless they can show large-scale renewable options for the future
- Hydrogen is the perfect match for natural gas and biogas / bio- methane
- Green hydrogen is ready for “Sectoral Integration”

Definition: Sectoral Integration

Mobility Package: Where are the Europeans?



Mobility Package – overview and analysis

'Europe on the Move'

- Commission communication that contains a wide-ranging set of initiatives (1st half submitted before summer)
- 2nd half expected in autumn
  (including CO2 standards for light vehicles and CVD)
- **Almost all references to hydrogen in the communication have been deleted**
- Strong push for battery electric vehicle

Clean Vehicle Directive: Wishlist for November

- **Zero-emission mandate for local/regional authorities (10-20%) per procurement with technology-neutrality.**
- Clean means zero-emission tailpipe
- The mandate/obligations pushed onto operators should be in line with EU pathways (e.g.: CO2 reduction for 2030/2050).
- Public funds = key success factors for public bodies that have it more difficult to finance such transition.

Fuel Cells: “Better than Battery?”

- FCEVs represent e-mobility at the same level as BEVs (zero-emission tailpipe!)
- Much shorter refuelling/refilling time.
- Flexibility to the grid, hence more integration of RE.
- Fuel cells are to 97-99% recyclable (batteries?)
- Batteries would lead to a big dependency on Asia especially China because of the dominance in factories, patents, some raw materials.
- FCEVs guarantee jobs in the value chain as they have approximately the same number of components as ICE compared to BEVs with only 200 components.

Summary: How to kick-off the hydrogen economy?

- Uptake requires hydrogen to be cost-competitive with current processes and fuels.

- A reform of the energy market can accelerate the competitiveness.
  (feed-in tariffs, curtailment management, seasonal balancing, remuneration, carbon pricing)

- Clear national (EU) action plans for the development of hydrogen within and across sectors can kick-start the roadmap.

  (➔ SOON **Sectoral integration**)

EU Commission more and more believes in hydrogen