Kilian Crone, Quebec, February 2020

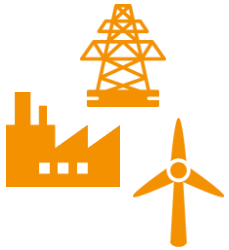
HYDROGEN IN THE (GERMAN) ENERGY TRANSITION

DENA - FOUR PILLARS

ENERGY EFFICIENCY

Think tank and moderator for the establishment of the energy transition

INTELLIGENT ENERGY SYSTEMS



Integration, optimisation and think tank

STAKEHOLDER PROCESSES

Moderator at the interface between politics, commerce and society

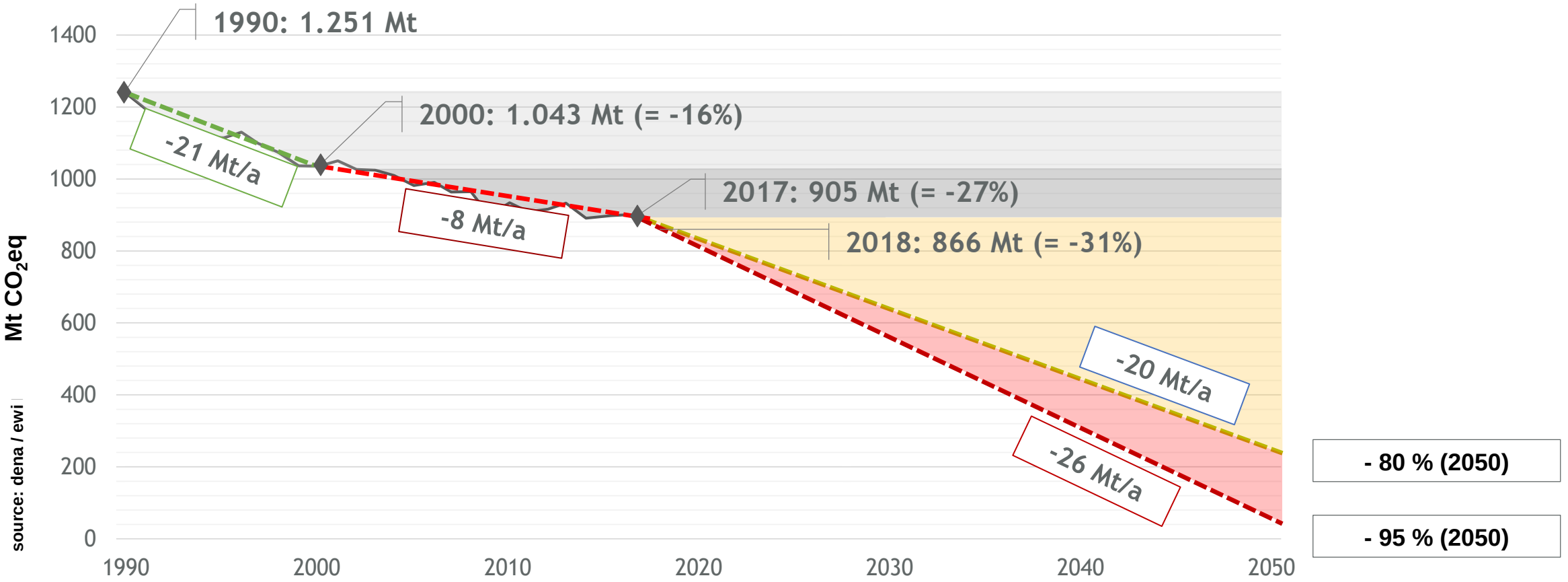
INTERNATIONAL ACTIVITIES

Marketing the energy transition abroad

dena German Energy Agency

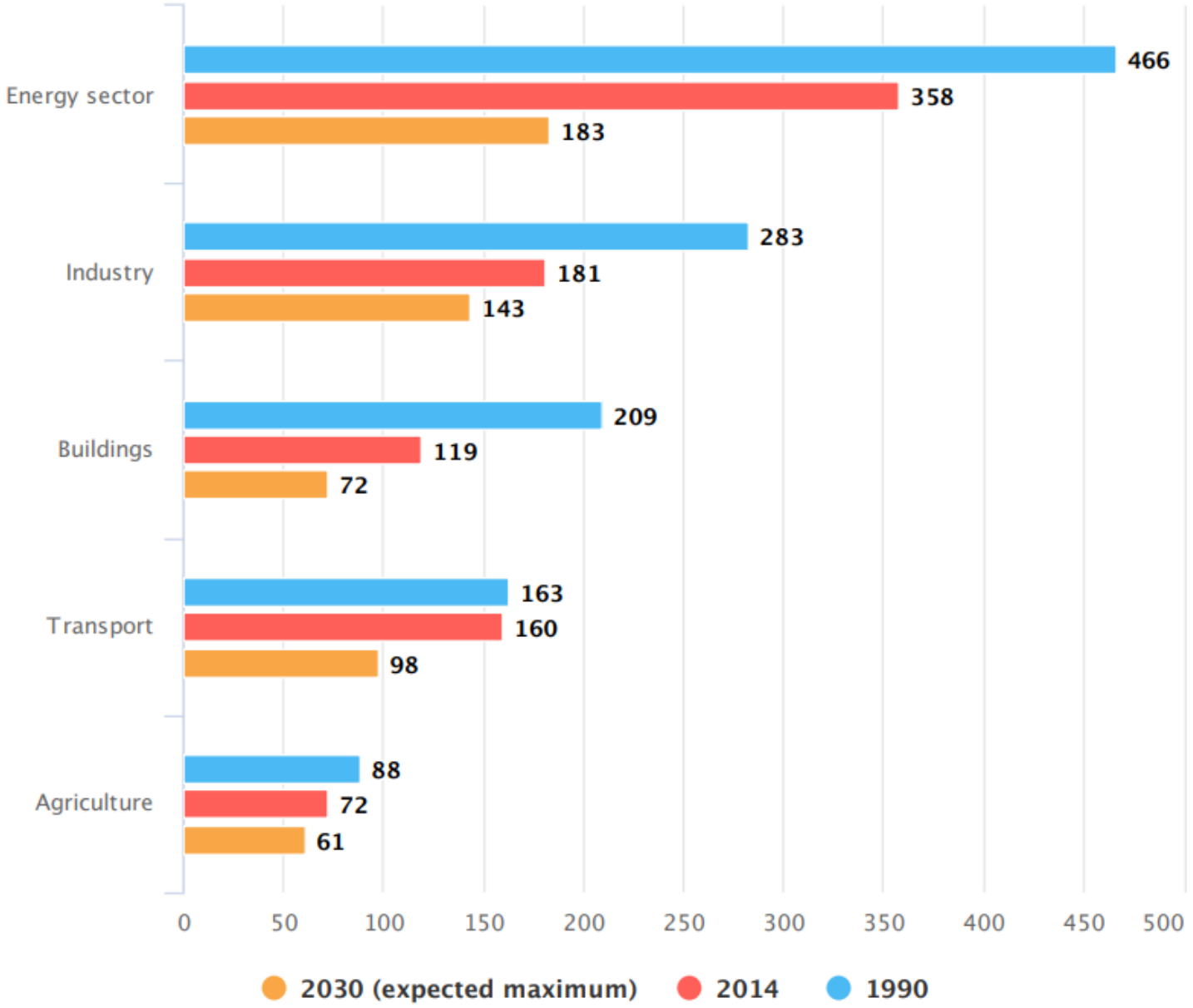
THE CHALLENGE OF GHG REDUCTION

Development of greenhouse gas emissions in Germany



dena German Energy Agency

CLIMATE ACTION PLAN: 2030 TARGETS



- **Ambitious targets in all sectors**
- **Challenge: inertia in buildings (renovation rate) and transport sector (vehicle fleet)**
- **Recent successes in coal phase-out may be offsett by challenge to increase renewable capacity**

The sector targets in 2030 from the Climate Protection Plan 2050 (in million tonnes CO2eq)
Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2017)

dena
German Energy Agency

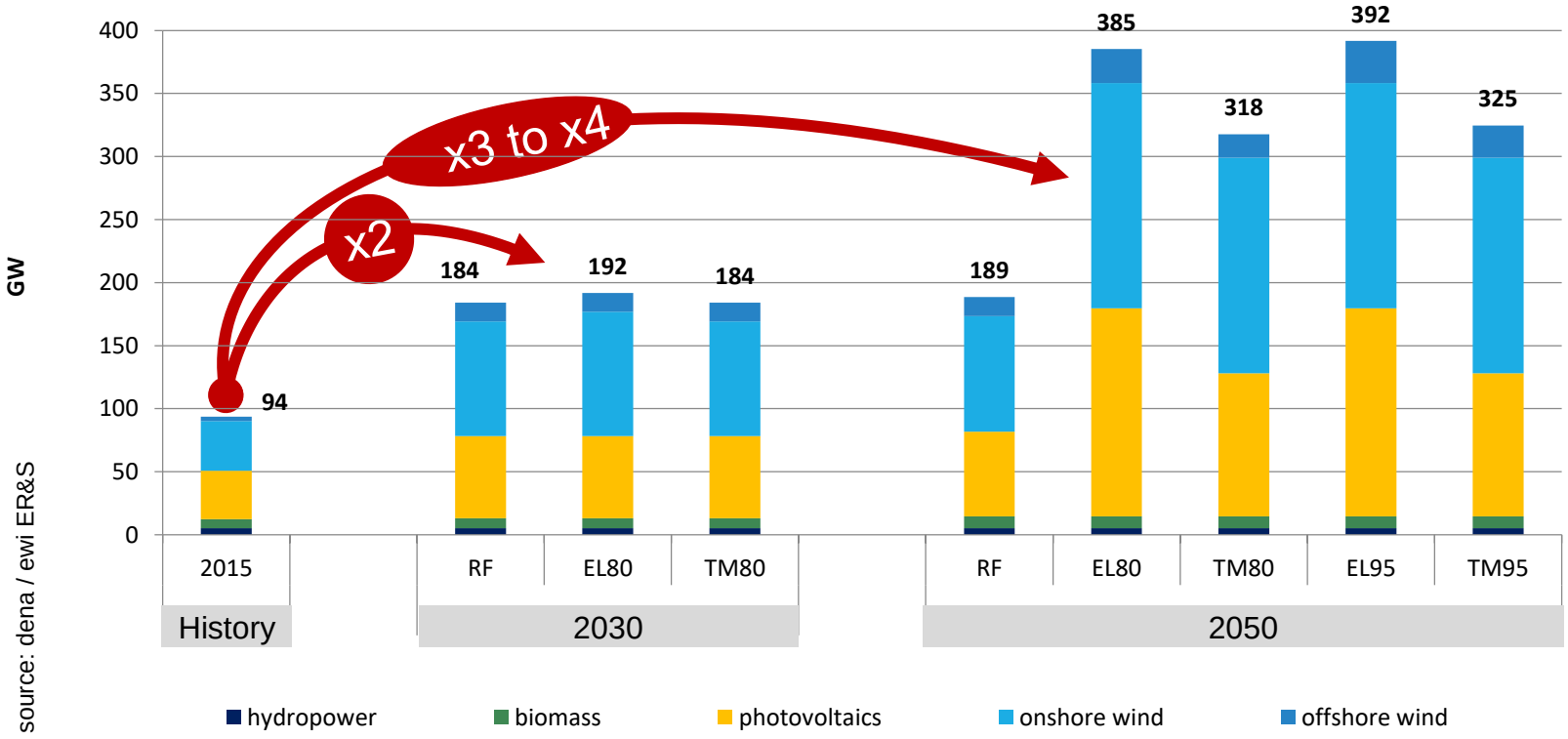
EUROPEAN PERSPECTIVE

- **Strong infrastrucutre integration: European approach needed**
- **Large capacities can enable retrofitting of existing infrastructure**

Source: Carvalho et al. Resilience of natural gas networks during conflicts, crises and disruptions

RENEWABLES: STRONG CAPACITY GROWTH

Installed capacity of renewable energy in power generation

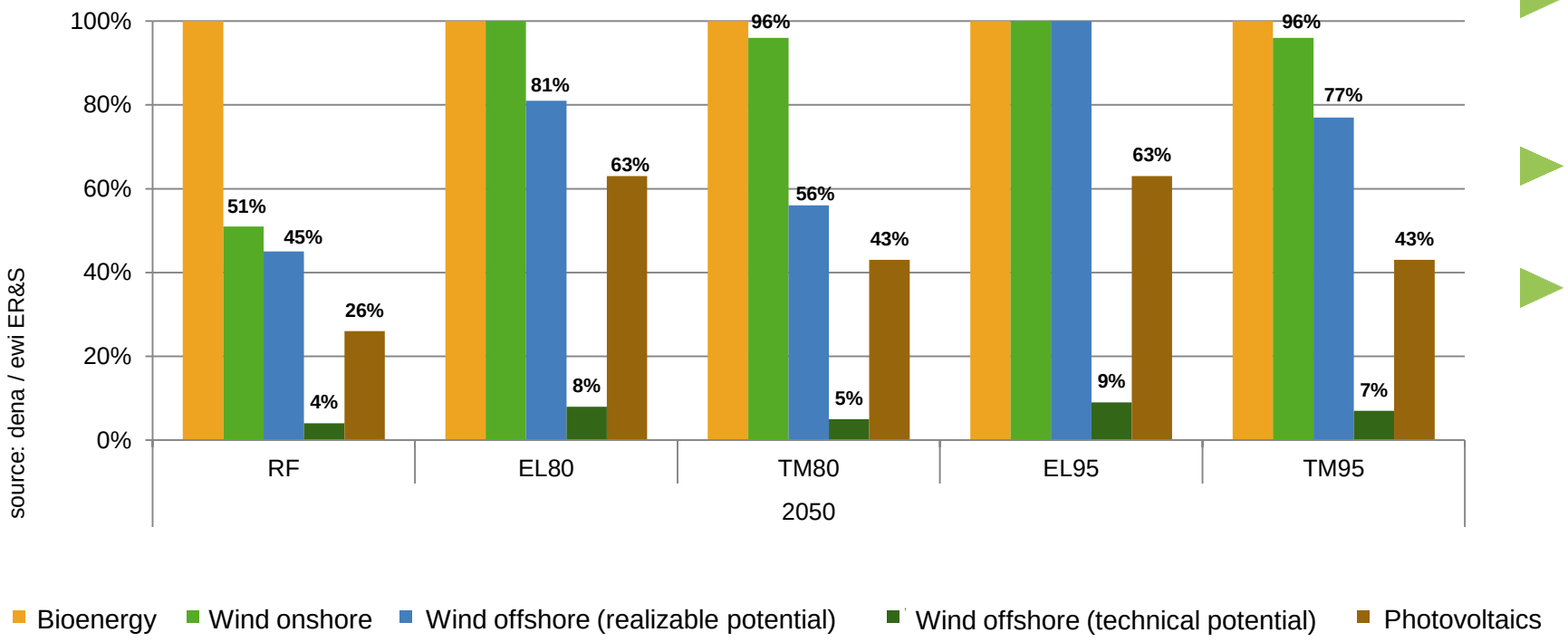


source: dena / ewi ER&S

- In each target scenario, more than 300 GW of RES capacity will be installed in 2050.
  EL scenarios nearly 400 GW.
- The largest contribution is by onshore wind energy (at least 170 GW in all scenarios) and photovoltaics (at least 114 GW).

dena German Energy Agency

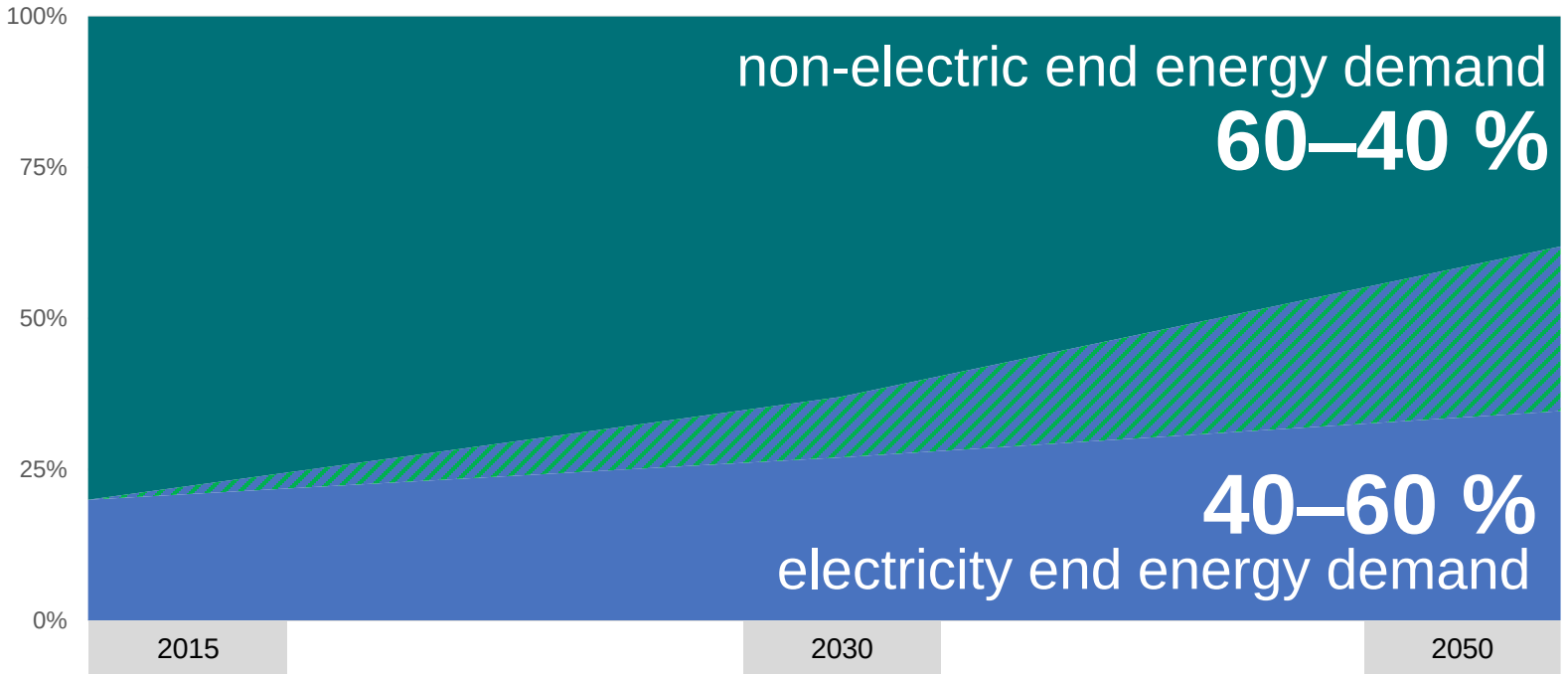
EXHAUSTING THE DOMESTIC POTENTIAL FOR RENEWABLE ENERGY



- The potential limits of wind onshore are almost fully exploited in each target scenario.
- The potential limits of bioenergy are fully reached in all scenarios.
- Differences in potential limits are more likely to exist between scenario storylines (EL vs. TM) than between climate goals (80 vs. 95 percent).

POWERFUELS AS THE MISSING LINK

Despite further electricification of end energy use still **significant demand for non-electric end energy**



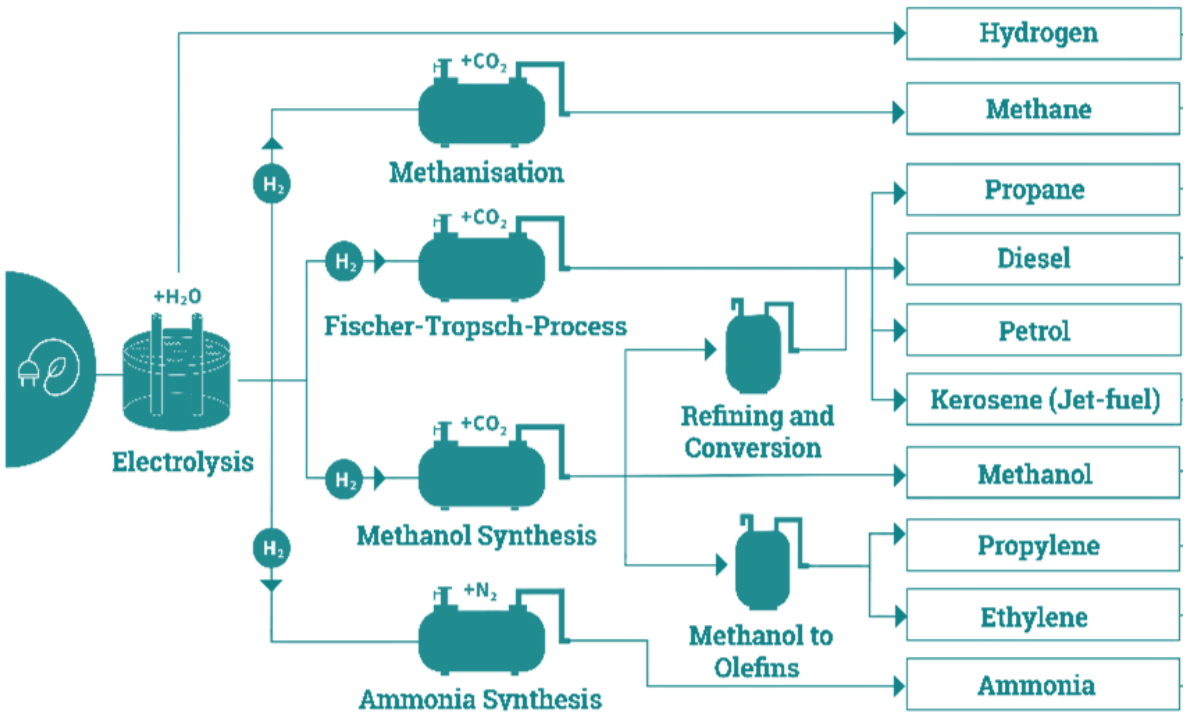
- In all scenarios, there will be a significant need for climate-neutral electricity-based gaseous and liquid fuels and feedstocks (powerfuels).
- **A successful energy transition requires powerfuels as a third pillar.**

dena German Energy Agency

WHAT ARE POWERFUELS?

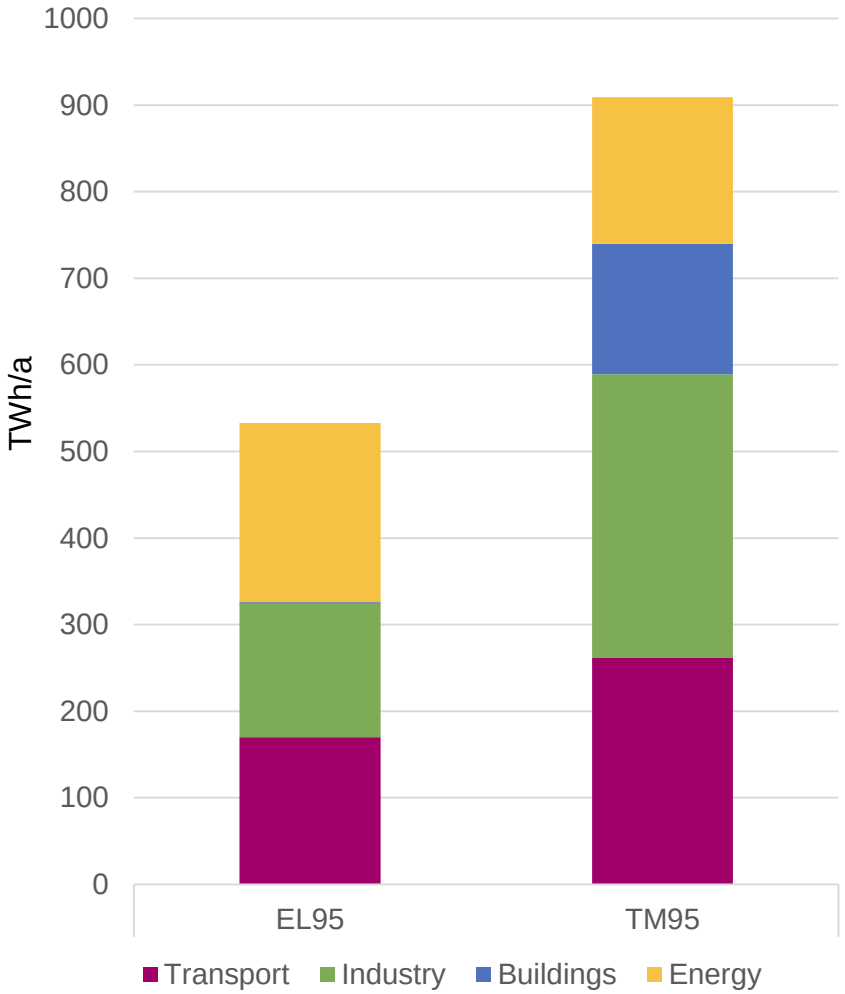
POWERFUELS

- Synthetic **gaseous or liquid** fuels based on (green) electricity
- Deliver **energy or basic materials** feedstock for many use cases
- Are an renewable alternative to fossil resources to **avoid CO_2 emissions**



dena German Energy Agency

POWERFUELS ARE AN OPPORTUNITY IN ALL SECTORS



- Energy: (Power-to) Gas-fired power plants account for a large share of on-demand generation capacity (56GW in 2030), balancing intermittency of renewables. Power-to-Gas as **energy storage** (15GW) contributes flexibilities.
- Buildings: (Hydrocarbon) Powerfuels use depends on the assumptions regarding renovation rates and use of heat pumps: TM sees use of powerfuels for heating.
- Industry: Applications for hydrogen are gradually gaining relevance, especially **steel and chemical**. Synthetic methane remains important for some industry processes.
- Transport: The diversity of energy sources in the transport sector is increasing. Electricity and hydrogen are becoming the central energy sources in **road transport**.

4 REASONS FOR POWERFUELS

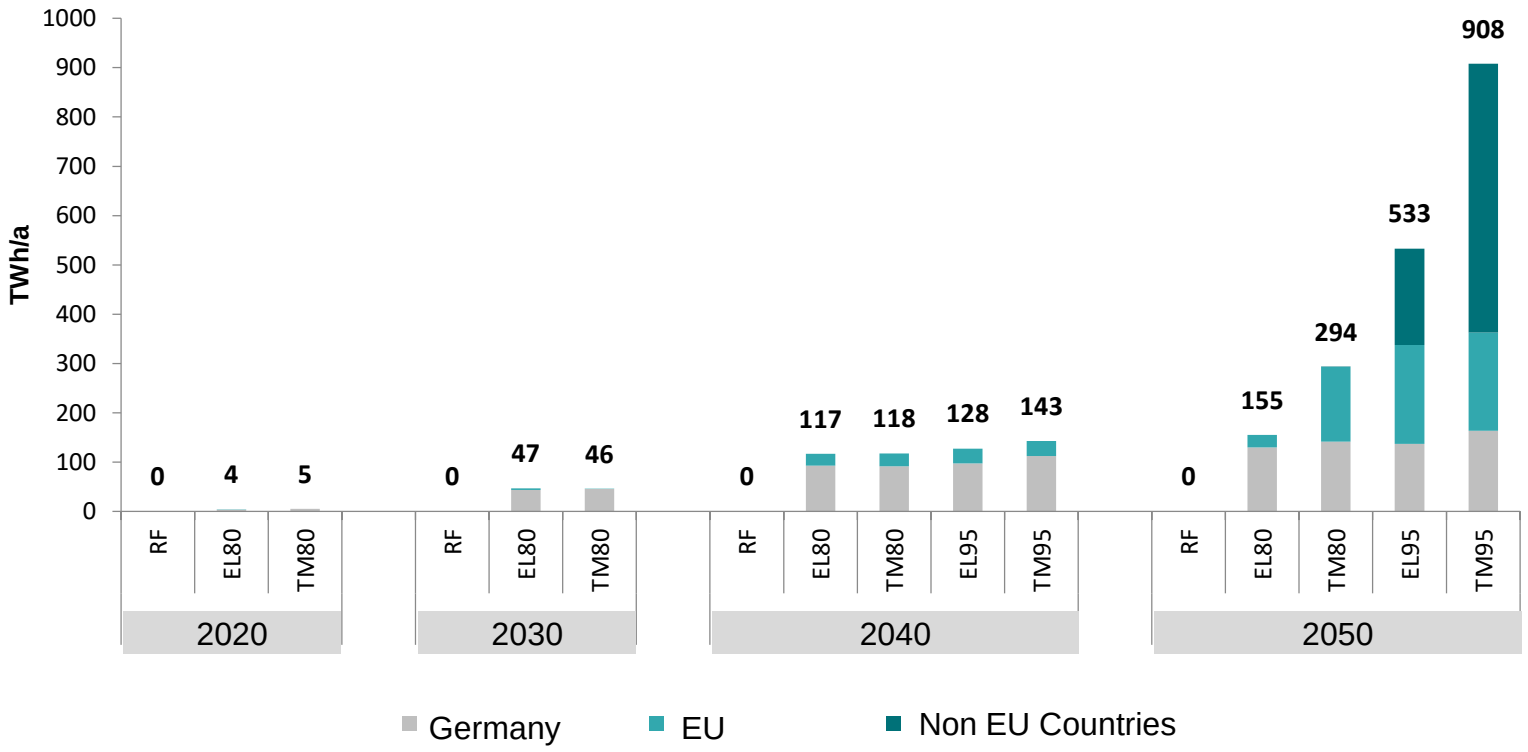
1. Powerfuels are a climate-friendly solutions to applications with no viable alternatives

2. Powerfuels could reduce the cost of energy transition by utilising existing infrastructures and providing long-term storage

3. Powerfuels could accelerate the de-fossilization of existing end-use equipment as green drop-in alternative to fossil fuels

4. Powerfuels allow local potentials of renewable energy production to be traded, stored and transported on a global market

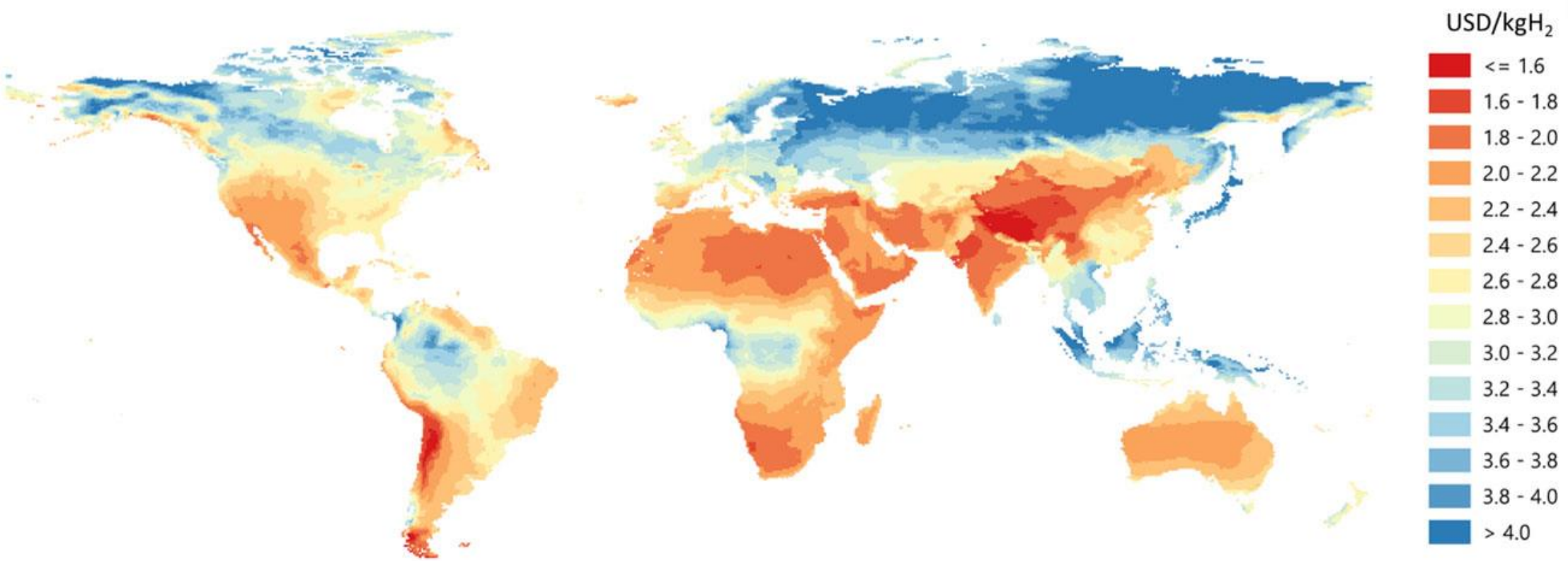
POWERFUELS WILL INCREASINGLY BE PRODUCED ABROAD AND IMPORTED



- **Powerfuels are also produced in Germany, but increasingly imported from European and non-European countries.**
- Considering transport capacity, especially hydrogen will be produced regionally in Germany.

dena German Energy Agency

GREEN HYDROGEN PRODUCTION COSTS DIFFER VASTLY ACROSS REGIONS

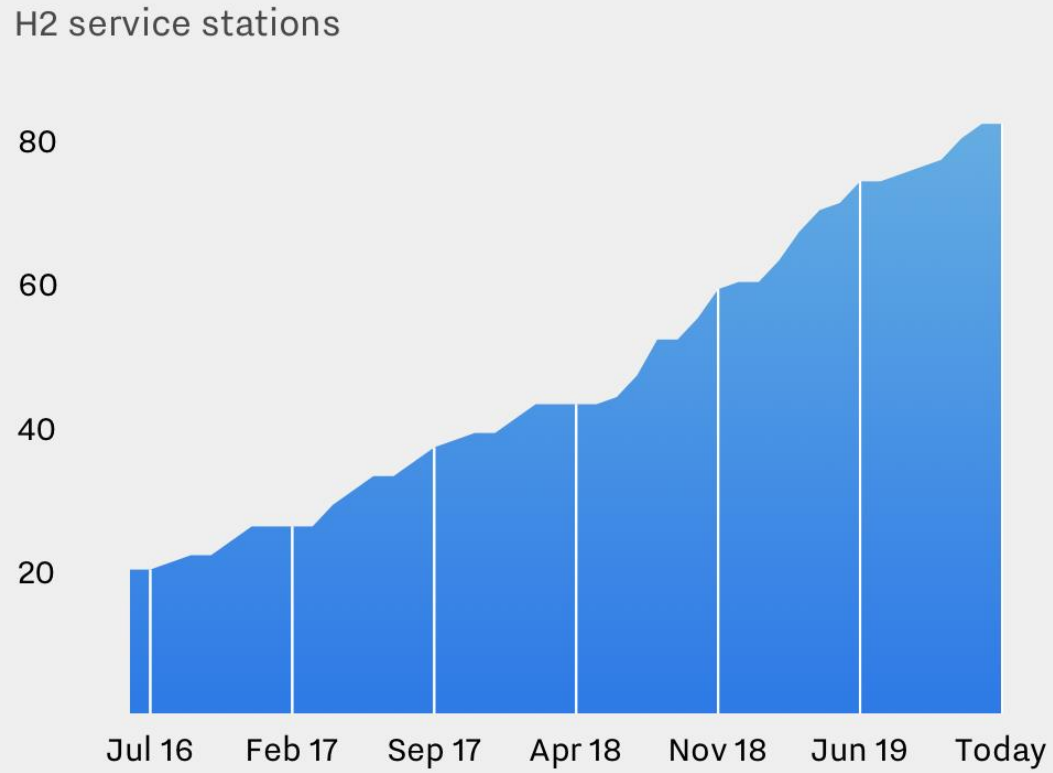


Hydrogen costs from hybrid solar PV and onshore wind systems in the long term, Source: IEA The future of hydrogen (2019)

dena German Energy Agency

STATUS QUO: ACHIEVEMENTS AND CHALLENGES IN GERMANY

HYDROGEN IN ROAD TRANSPORT



Source: H2 Mobility

INFRASTRUCTURE

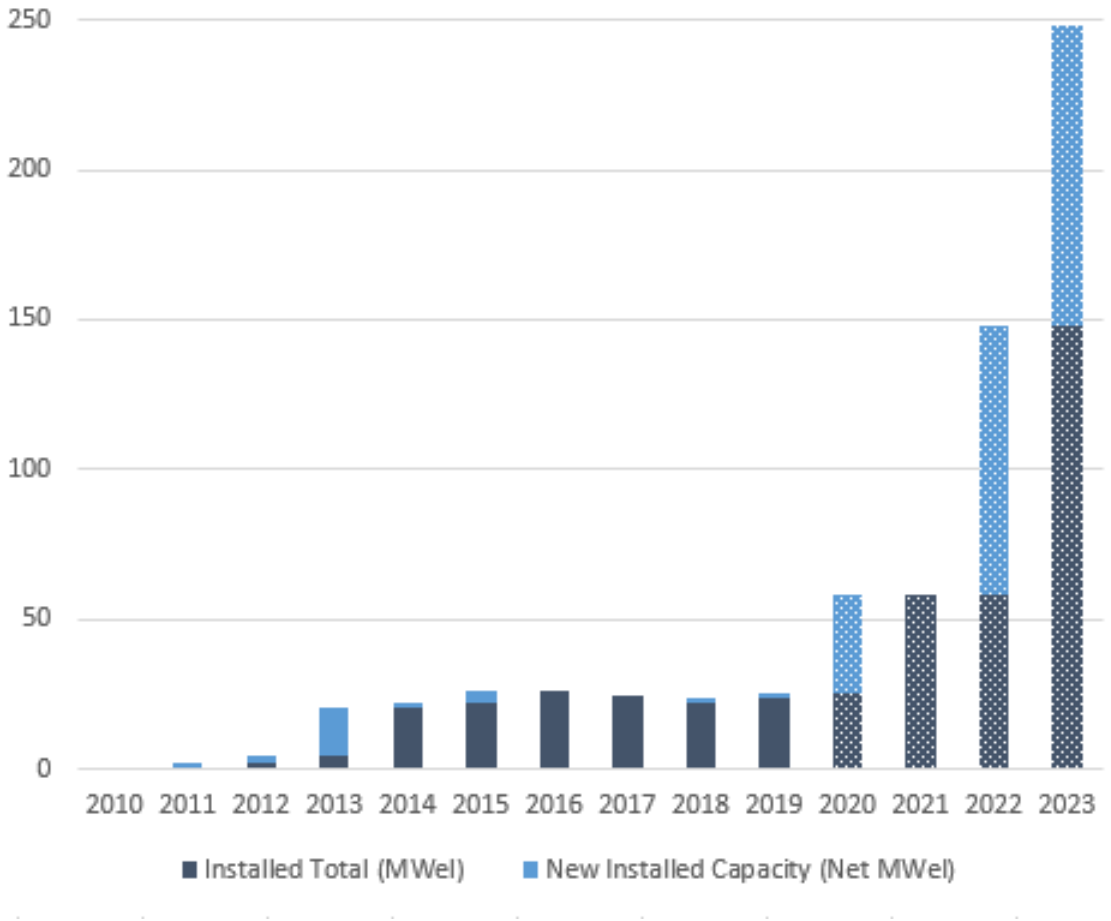
- Goal: 100 refuelling stations by 2020; 400 stations nationwide by 2025
- Operating consortium “H2 Mobility”, capex subsidy; Air Liquide, Daimler, Linde, OMV, Shell and Total

VEHICLES

- Subsidies of 4,000€ for consumers; up to 21,000€ for commercial fleets
- Total 392 (Jan 1st 2019)

dena German Energy Agency

PROJECTED GROWTH OF POWER-TO-X CAPACITY



H2 PROJECTS GERMANY

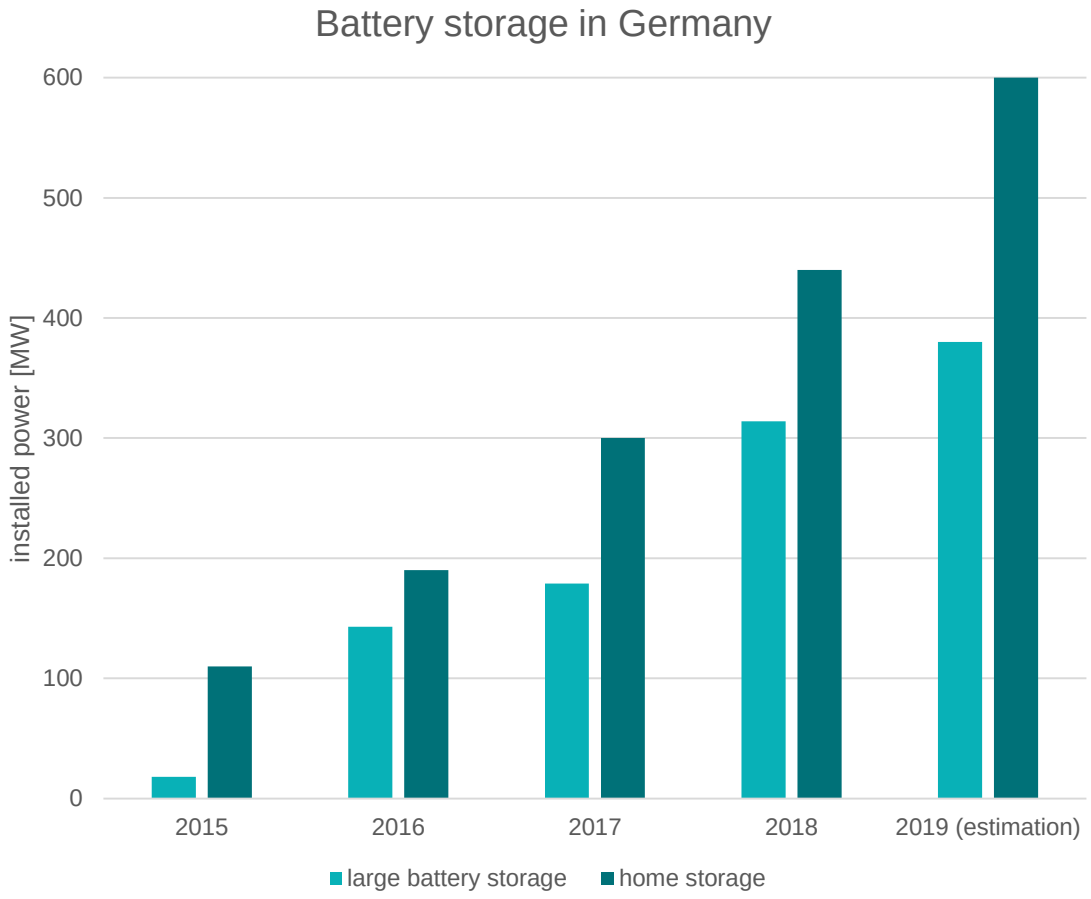
- Number of projects
  - 28 running by 2023
  - Over 40 in proposal
- Nature of projects
  - Installed capacities range from small to several MWel, proposed ones up to 100MW
  - Located nationwide

Source: IEA Project Development Data 2019

dena German Energy Agency

FLEXIBILITY POTENTIALS: ENERGY STORAGE
SEASONAL VS SHORT-TERM

- **4th largest gas storage capacity in the world, 25% of annual gas demand**
- **61% of gas storage are salt caverns, potentially suited to pure H2 storage**
- **While potential for pump storage is fully developed, battery storage is growing strongly**



Source: BVES , 2019

dena German Energy Agency

ROADBLOCKS ON THE WAY TO A HYDROGEN ECONOMY

Supply

All final consumer charges apply, including renewable surcharge (6.41ct/kWh), grid charges (7.22ct/kWh) and taxes (9.61ct/kWh)

Regulation

Limited gas grid injection (10% allowed, but often below); limited ability to receive credits for hydrogen in transportation and industry

Demand

No premium to be earned: no penalty for fossil fuels (modest carbon tax coming in 2021), no special recognition in transport fuel rules (coming with RED II)

OUTLOOK

powered by dena German Energy Agency

TIMELINE: HYDROGEN POLICY

- July 2019: government announces **“Real Laboratories“: 20 hydrogen projects** with **380 MWel** planned capacity to try out various aspects of system integration
- November 2019: **2 federal government conferences** on hydrogen; conclusion of „Gas 2030“ stakeholder process
- February 2020: expected finalisation of **national hydrogen strategy**; first draft includes a comprehensive use of hydrogen in **transport and industry** with an emphasis on **international cooperation**
- Upcoming: national implementation of EU Renewable Energy Directive II, enabling hydrogen use in transport sector and beyond

KEY ELEMENTS OF A GERMAN HYDROGEN STRATEGY

- **First application in industry and transport**
  - Pure hydrogen in road and rail, with some perspective in aviation and maritime
  - Ambitious target for use in transportation
  - Industry: emphasis on existing hydrogen consumers (refineries, chemical) and steel
  - Openness towards blue hydrogen in initial stages
- **Emphasis on technology export, and energy import**
  - Continuing and strenghtening R&D efforts
  - International cooperation already in early stages
  - Focus on import of liquids, such as methanol, ammonia, LOHC
- **Cooperation between industry, research, federal/state governments**

GLOBAL ALLIANCE POWERFUELS
MEMBERS

The initiative was initiated by dena in September 2018, founded by renowned corporate members, covering many different industries, countries and all parts of the value chain

dena German Energy Agency

GLOBAL ALLIANCE POWERFUELS
PARTNERS

The International Partners Network is a collaboration amongst global **initiatives, think tanks, initiatives, associations and research institutions** to further enhance the discussion and development of Powerfuels globally, all whilst acting in line with the overall Alliance goals.

GLOBAL ALLIANCE POWER FUELS

1	**Raise awareness and acceptance** of Powerfuels as missing link to reach global climate targets.
2	Support further **enhancement of regulatory frameworks** with a first focus on Europe as demand region.
3	**Stimulate project development** to globally enable production capacities on industrial scale, thus increasing cost competitiveness with fossil fuels.

THANK YOU.

Kilian Crone
Senior Expert
crone@dena.de