



# Fraunhofer Institute for Solar Energy Systems ISE

## Research for the Energy Transformation



### Directors

Prof. Dr. Hans-Martin Henning

Dr. Andreas Bett

### Staff

ca. 1200

### Budget 2019 (preliminary)

Operation €92.3 million

Investment €10.3 million

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Total €102.6 million

# Fraunhofer ISE

## Areas of Concentration

### ENERGY TECHNOLOGIES AND SYSTEMS

Prof. Dr. Hans-Martin Henning

Energy Efficient Buildings



Solar Thermal Power Plants and Industrial Processes



Hydrogen Technologies and Electrical Energy Storage



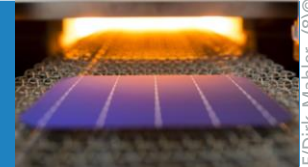
Power Electronics, Grids and Smart Systems



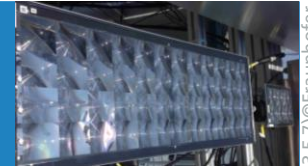
### PHOTOVOLTAICS

Dr. Andreas Bett

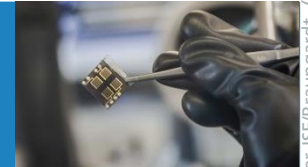
Silicon Photovoltaics



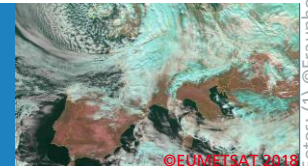
III-V and Concentrator Photovoltaics



Emerging Photovoltaic Technologies

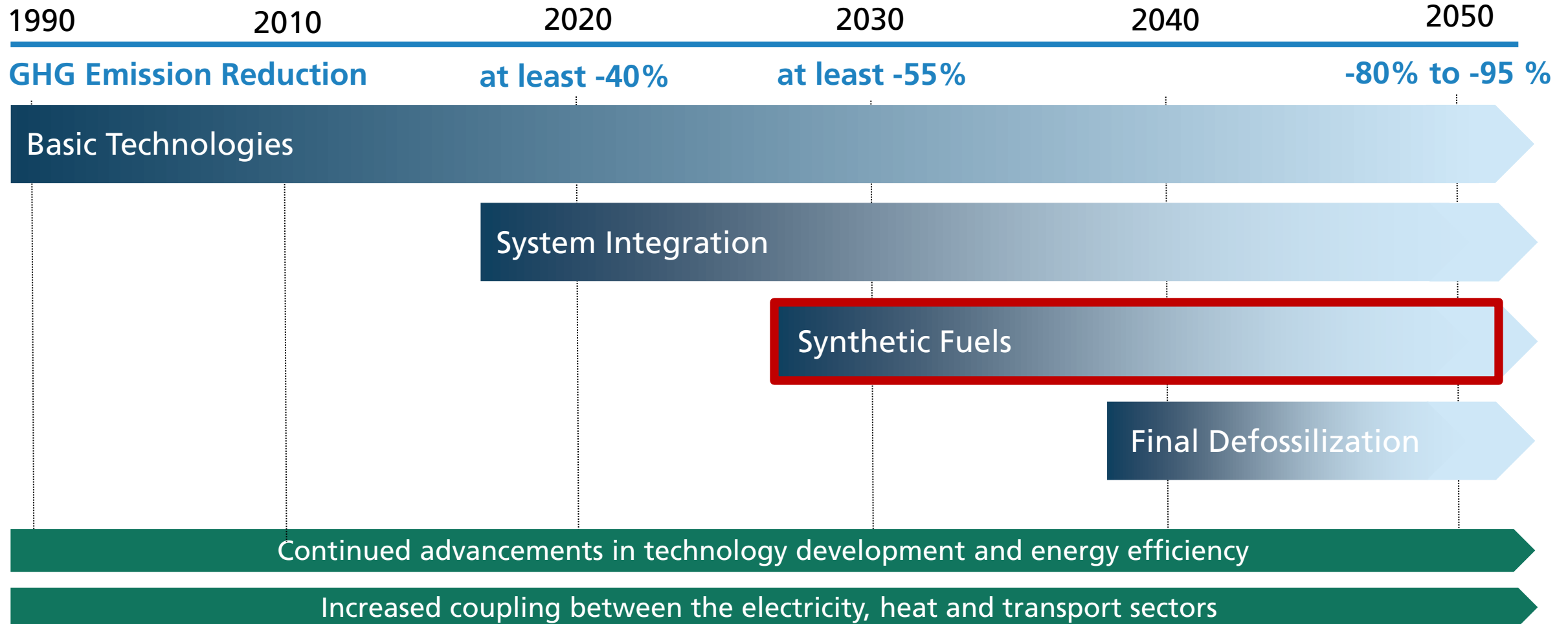


Photovoltaic Modules and Power Plants



# Targets and Phases of the Energy Transformation in Germany

## A Cost and Climate Compatible Transformation of the Energy System



4 Source: acatech/Leopoldina/Akademienunion| »Sektorkopplung - Optionen für die nächste Phase der Energiewende«

# The National Hydrogen Strategy (June 2020)

## Realize the Potential, Seize the opportunities



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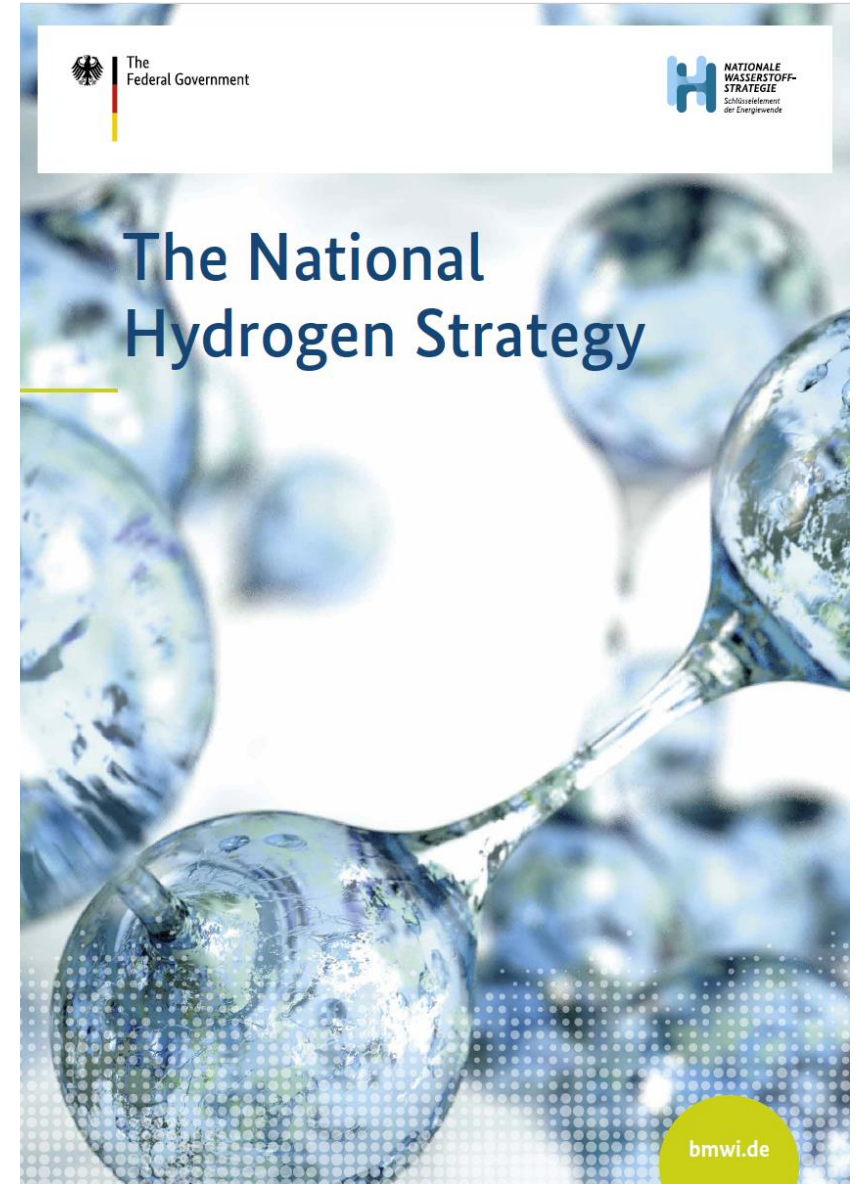
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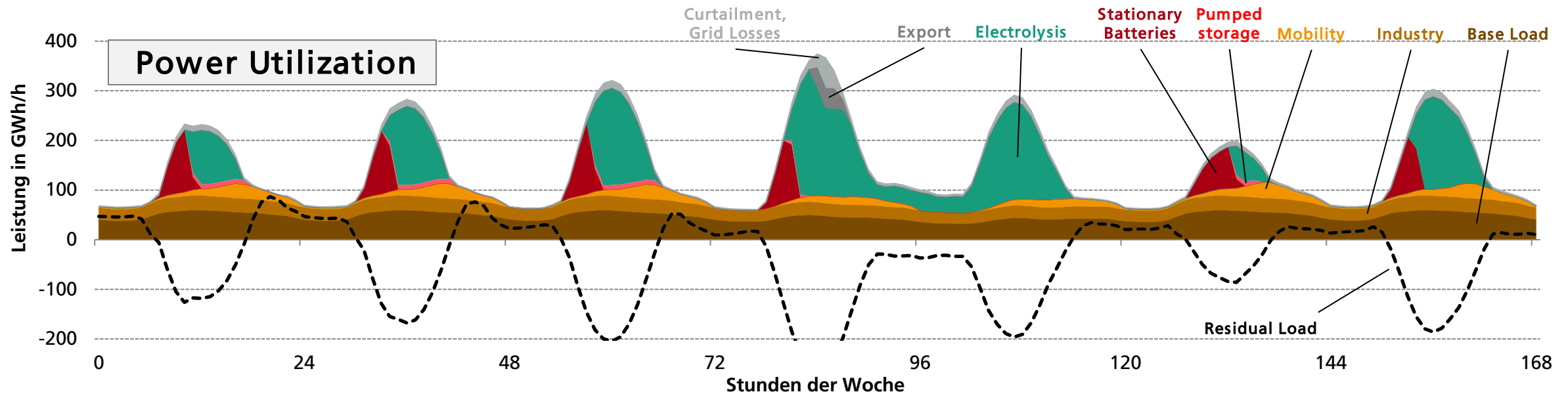
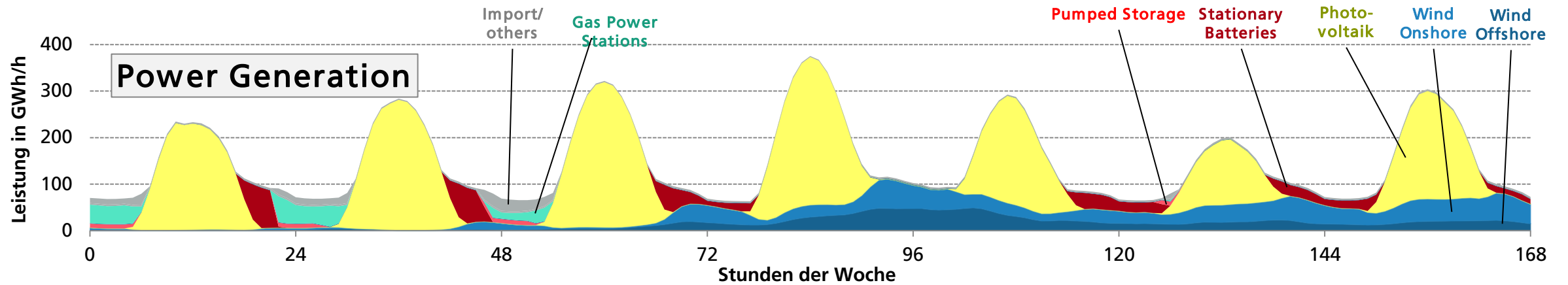
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- **€ 7 billion for hydrogen technologies**
- **€ 2 billion for international partnerships**
  - Hydrogen production in industrial scale, reduction of costs
  - Use of hydrogen in industry and transportation
  - Development of infrastructure
  - Focus and increase Hydrogen Research
  - Increase **international dimension, intensify energy partnerships**
  - Improve the regulatory framework



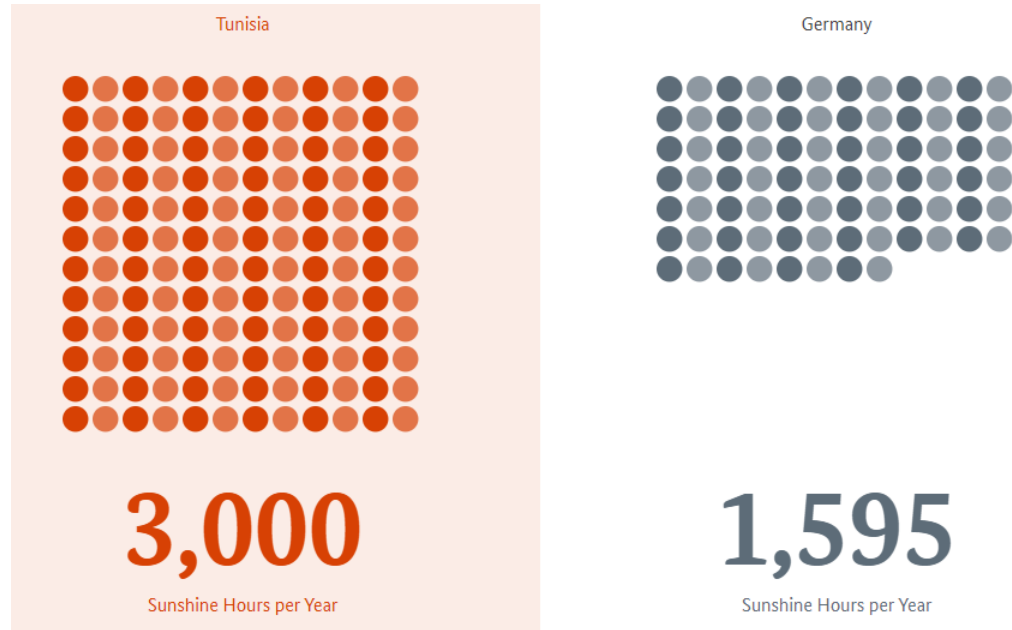
# A glimpse from the future

## Electricity Production in Germany – Example: Summer week in 2050

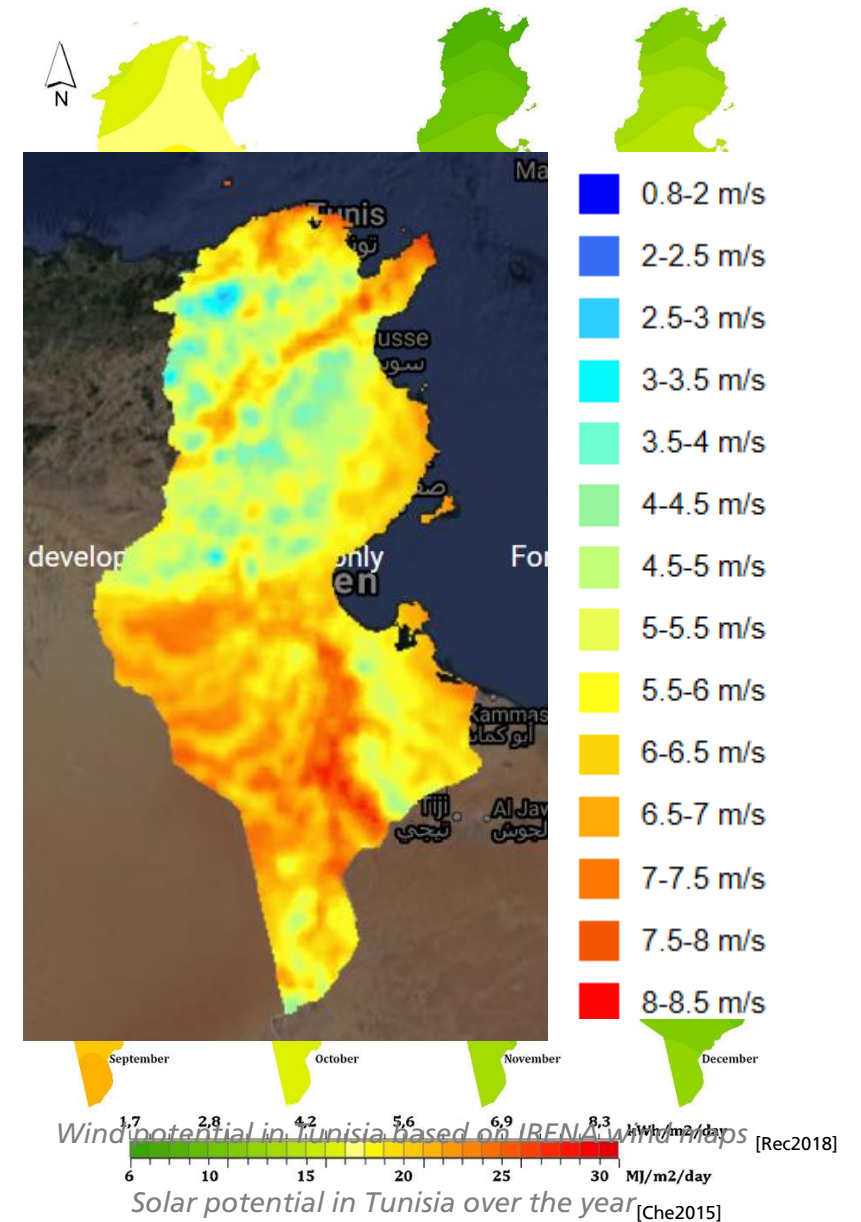


# And that could be the same in Tunisia in 2050

- Two times more sunshines hours per year in Tunisia than in Germany (diagram below [Par2020])



- From May to August: between 7 and 8.5 kWh/m<sup>2</sup>/day (adjacent diagram [Che2015])



# Power to X is an indeed pillar for sustainable energy system

## The Future Demand in Germany

- Significant demand of H<sub>2</sub> and H<sub>2</sub> based carriers
- DE: Ramp-up of PtX:
  - PtX 2030: Ø 57 TWh
  - PtX 2050: Ø 579 TWh
  - Import: 40-744 TWh
- *The scale is somehow defined but which X?*

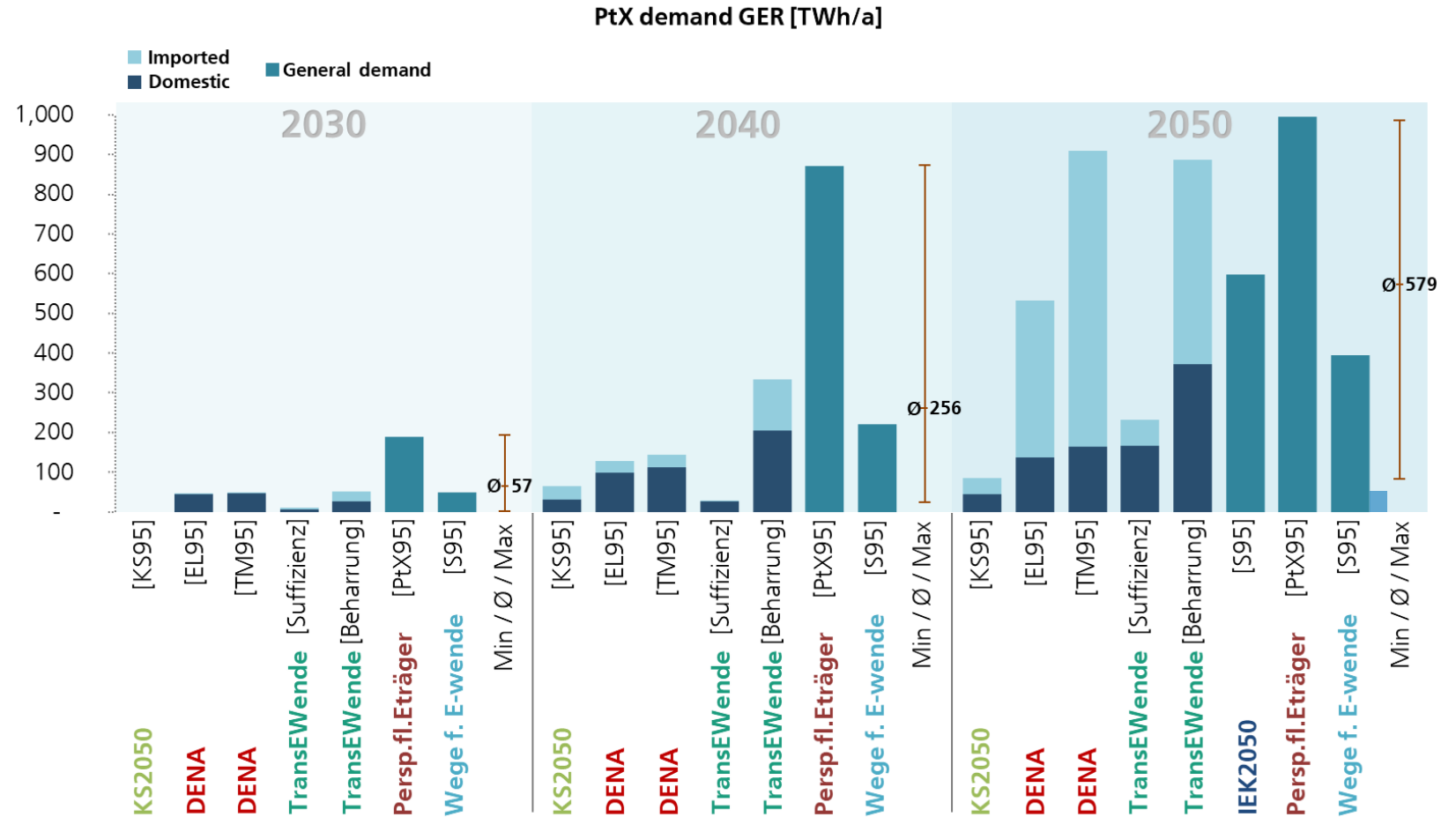
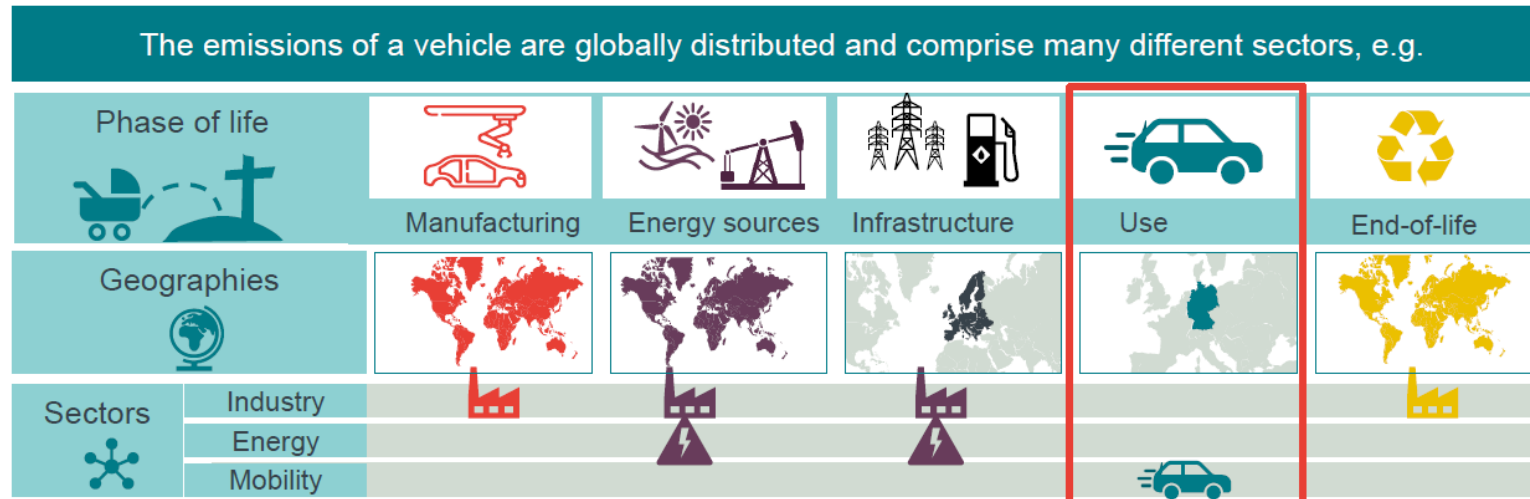


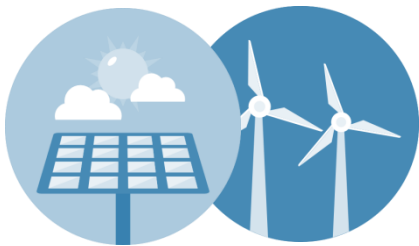
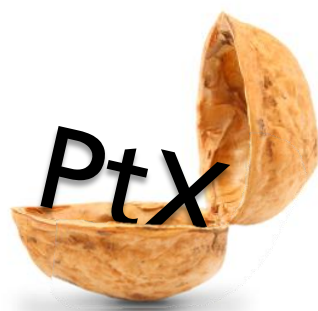
Chart: Forecast of the demand for PtX energy carriers in Germany (based on various published studies) <sup>[1]</sup>

# Boundary conditions are..

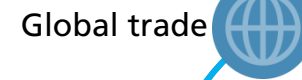


- We need to **be careful** selecting the future technologies! Location of emissions only varies and comprehensive TEA&LCA is imperative for defining the future sustainable technology portfolio
  - „no single technology suitable for tackling the problem alone, rather an optimum mix“
- We have to maximize the „**Return on Invest**“ with these future technologies
  - **Return** : GHG savings over life time
  - **on Invest**: GHG budget used for new technologies → **A benefit for PtX**

# Power-to-X in a Nutshell



Substitution of fossil based energy with (cheaper) **Renewable Electricity**



Renewable Energy packed into chemical molecules



Global industries



Fossil resources: Hydrocarbons as the driving force behind our society

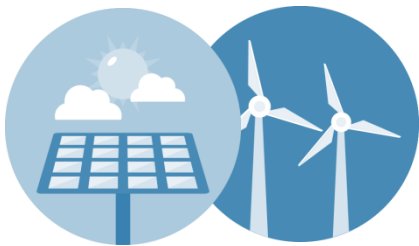
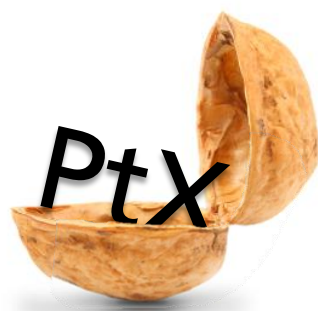


Anthropogenic greenhouse effect

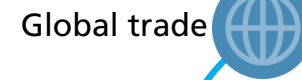
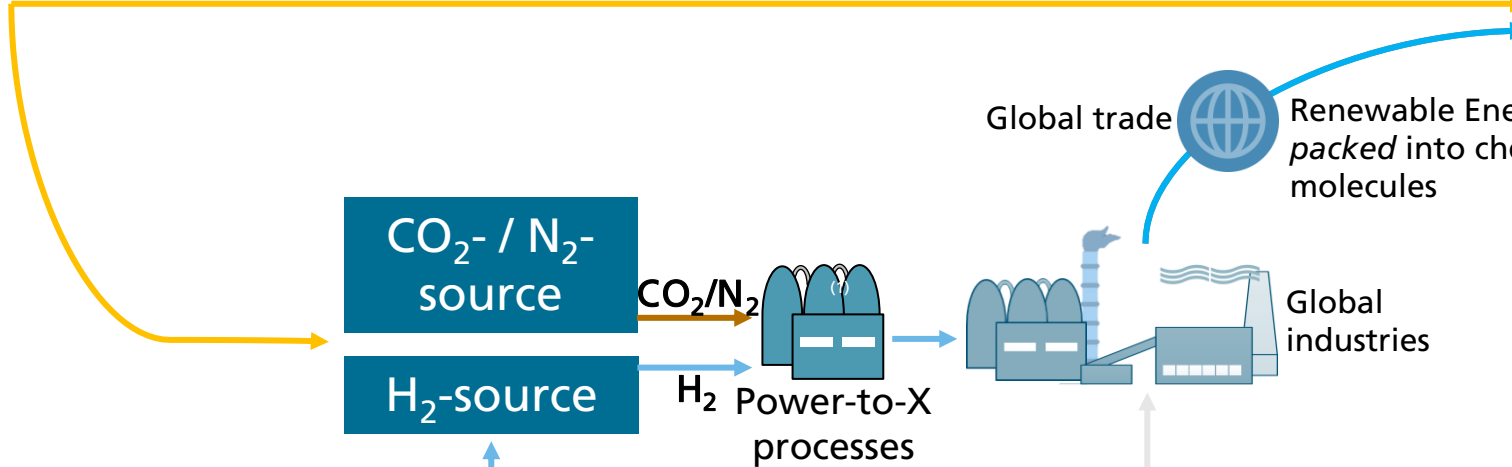
Our global economy: demand for fuels, chemicals & electricity

(1): <https://www.convertwithcontent.com>

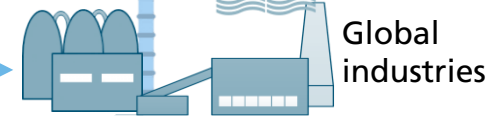
# Power-to-X in a Nutshell



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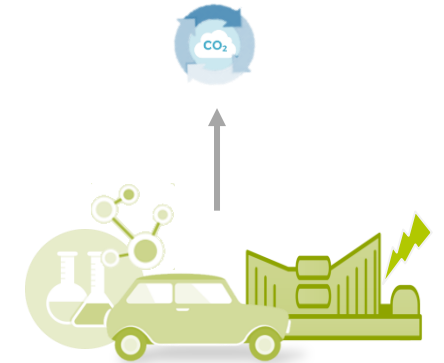
Renewable Energy packed into chemical molecules



Global industries



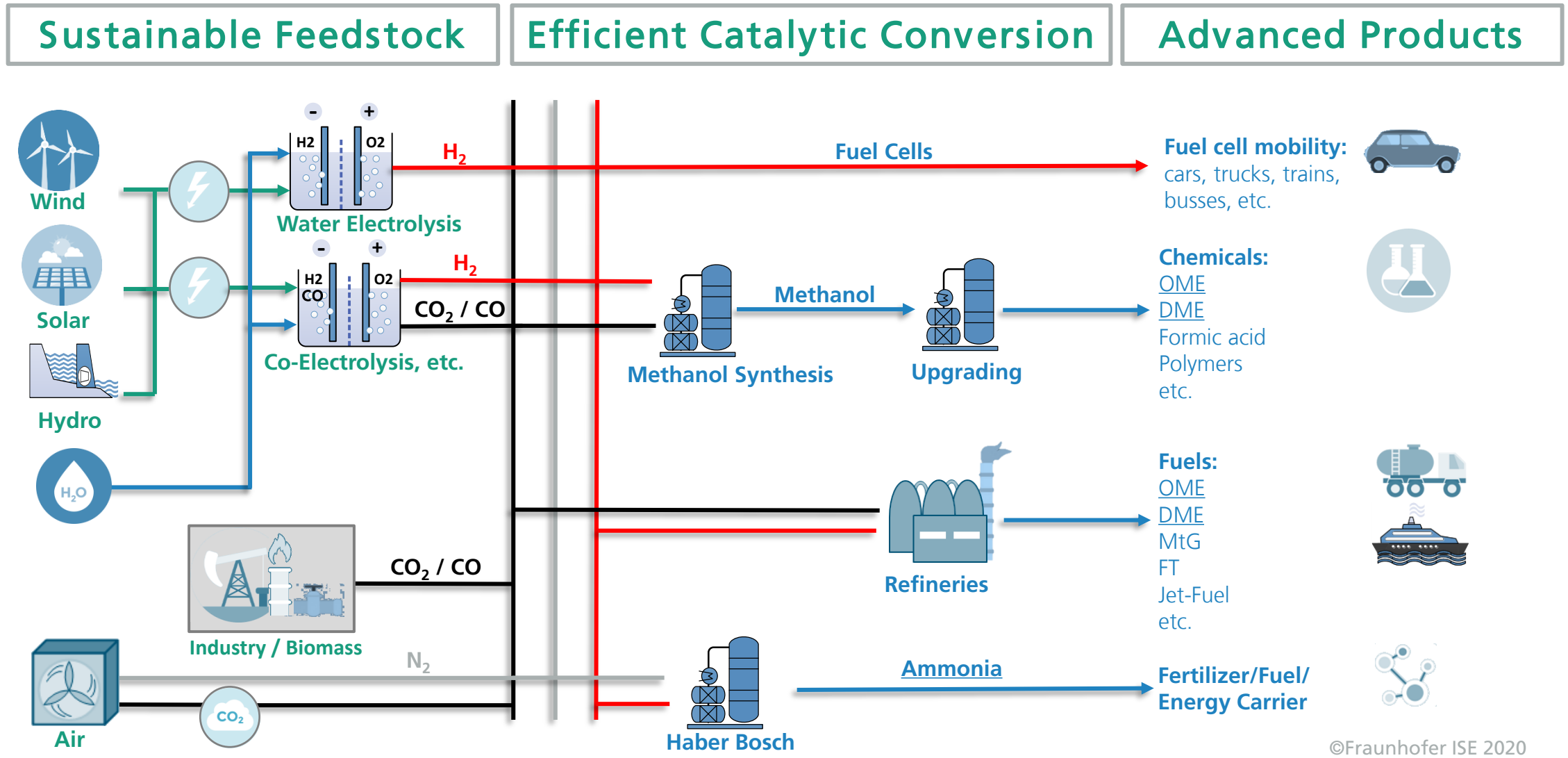
Fossil resources: Hydrocarbons as the driving force behind our society



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# Power to Liquids process chain investigated at Fraunhofer ISE



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# FhISE Study

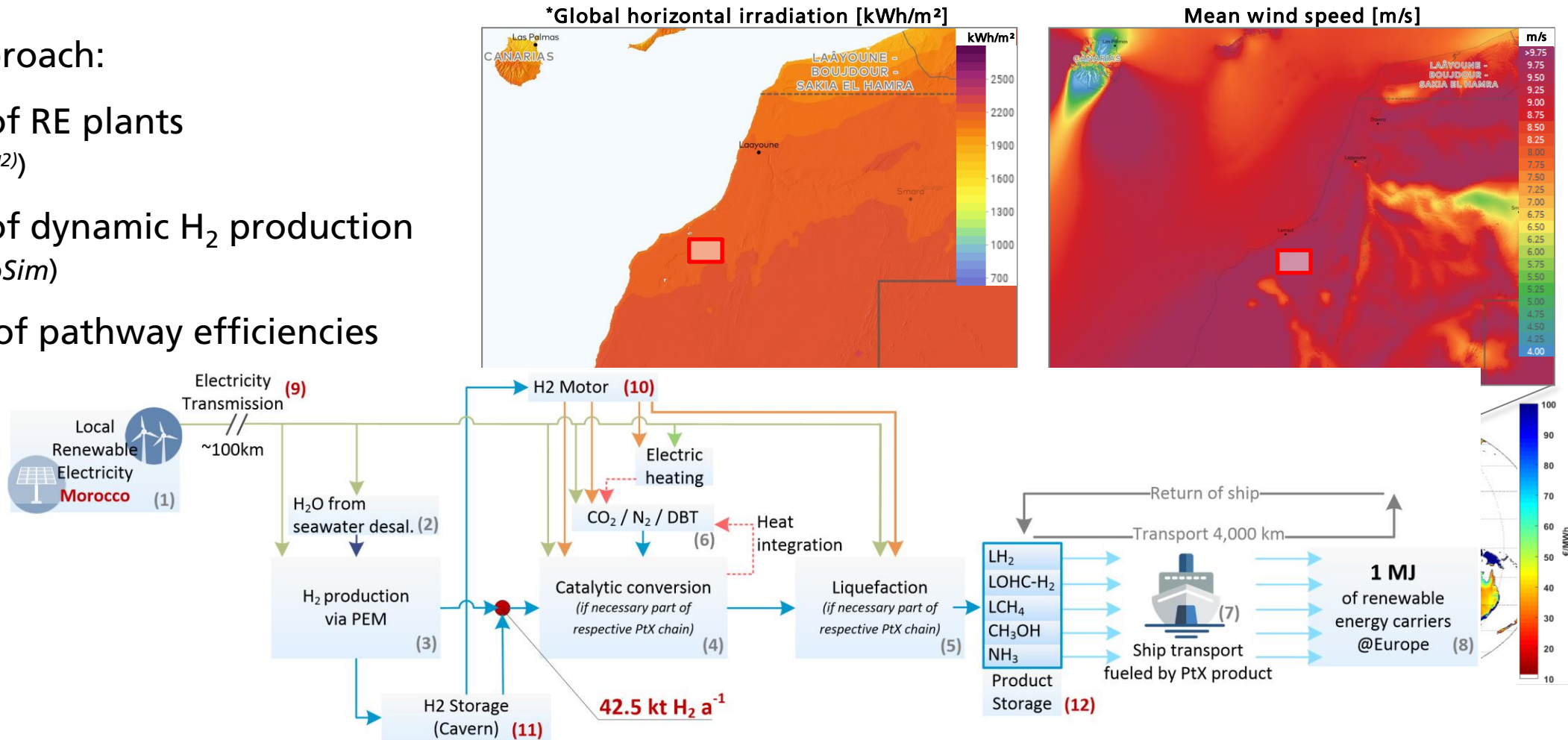
## Energy and cost efficiency of imported PtX products

# FhISE Study: Energy and cost efficiency of imported PtX products

## PtX Location and methodical approach

### Methodical approach:

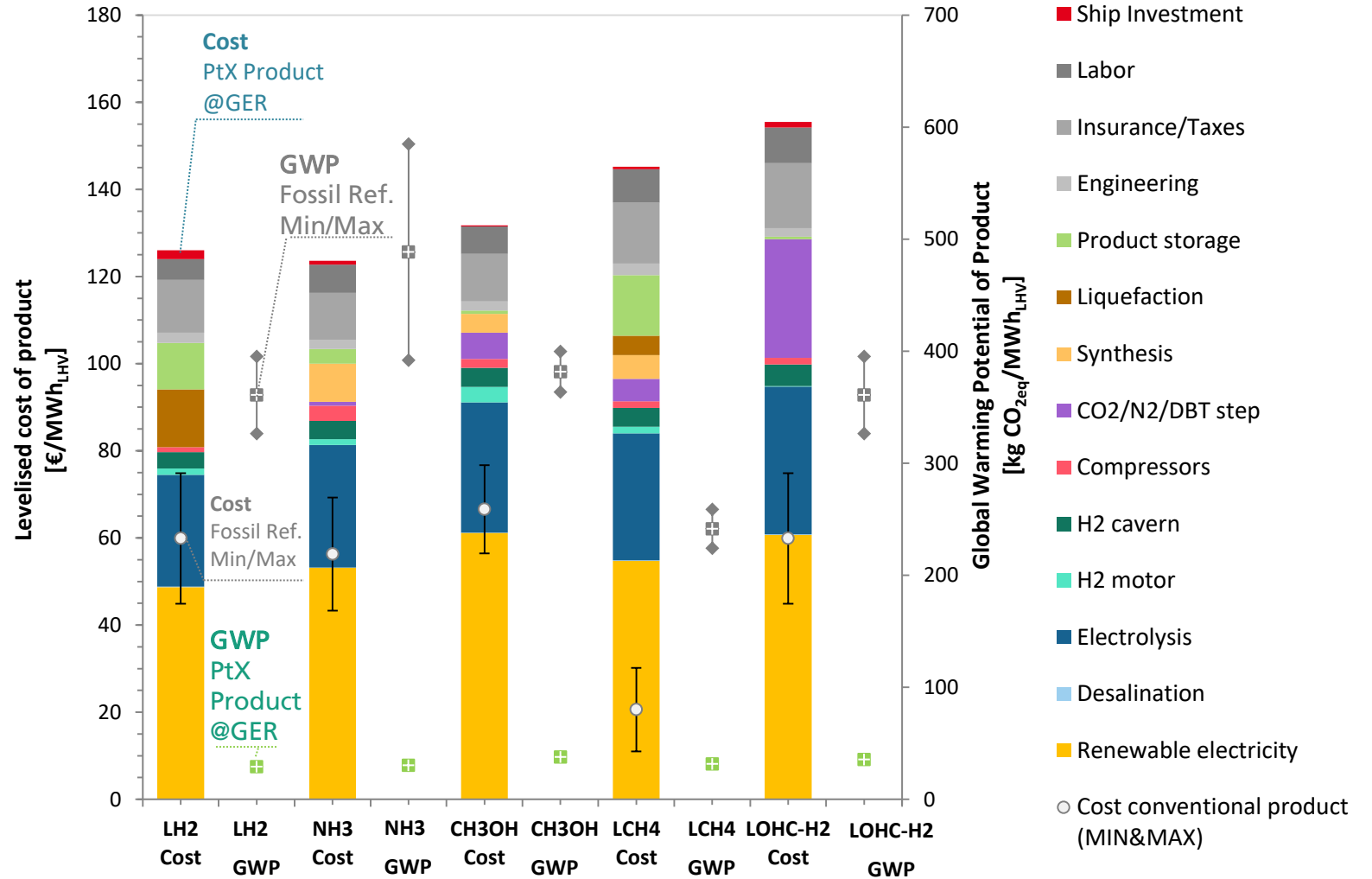
- Simulation of RE plants (NREL-tool SAM<sup>2</sup>)
- Simulation of dynamic H<sub>2</sub> production (ISE-Tool: H2ProSim)
- Calculation of pathway efficiencies and costs



# FhISE Study: Energy and cost efficiency of imported PtX products

## Germany: Import of PtX products as promising pathway

- Levelised cost of PtX products between 124 - 156 € per MWh (incl. shipping)
- Ship transport does not significantly affect the cost and efficiencies of the PtX pathways (MAR to GER ~ 4000km)
- Water provision via desalination with negligible impact on pathway efficiency and costs
- High initial investment for LOHC-medium (DBT)
- CO<sub>2</sub> avoidance cost 147 (NH<sub>3</sub>) – 594 (LCH<sub>4</sub>) € per t<sub>CO<sub>2</sub>eq.</sub> for fossil parity



# Selected PtX activities at Fraunhofer ISE & Worldwide



# Power-to-X Pilot plants



PtH<sub>2</sub>

Mainz GER  
6MWel PEM  
*since 2015*



PtL (Methanol)

Bláa Lónið ISL  
4-5 million L a<sup>-1</sup>  
*since 2015*



PtCH<sub>4</sub>

Werlte GER  
6MWel PEM  
*since 2013*



PtL (FT e.g. Diesel)

Dresden GER  
<1000 L a<sup>-1</sup>  
*since 2014*

# Selected Power to X Projects in Germany with Contributions of Fraunhofer ISE



## Carbon2Chem® Power to Methanol

CO<sub>2</sub> capture from steel  
gases / bioethanol  
production



## C3-Mobility& NAMOSYN

Production of  
electricity based  
synthetic fuels  
incl. motor testing



## LtP PtG BW

H<sub>2</sub> production via  
hydropower

*since 2016*  
*Wyhlen GER*



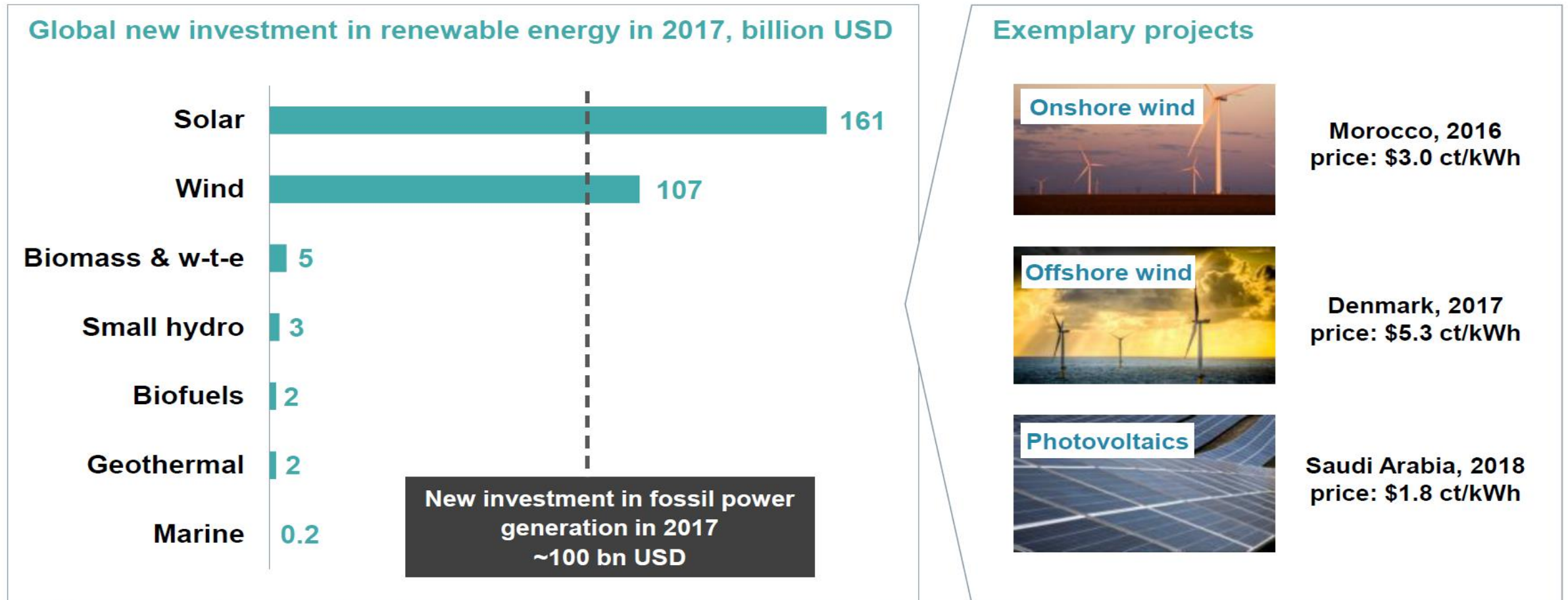
## TransDE

Focus on a sustainable  
infrastructure  
transformation

# Take Home Messages

# Global Investments in Renewable Energy

Exceeding the fossil power generation investment → We are on the right track



Source: UN Environment, Bloomberg New Energy Finance - New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.

Source: Agora (2018) Low cost renewables

21 Source: Siemens AG

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FHG-SK: ISE-Public

# Summary & Conclusions

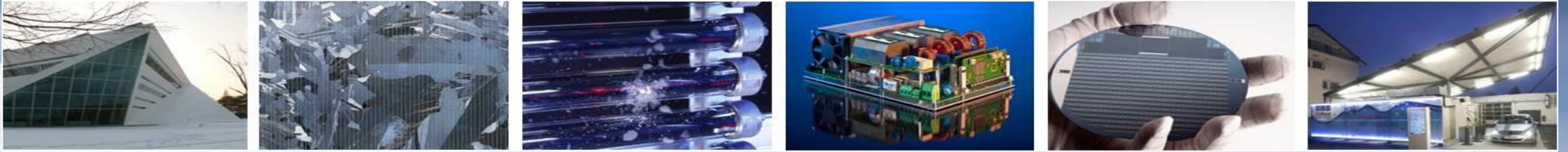
**Think big !**

- REMoD: Renewable energies (solar, wind) will be dominant and the importance of **sector coupling (PtX)**
- PtX in the GW scale needed – electrolysis as key technology
- **Large scale hydrogen** production will be starting globally in the 2020s
- **Global transport** and **trade** of renewable energy carriers PtX is required (and is beginning now, i.e. Japan/Australia)
- Regulatoric framework is important: **well-to-weel** / tank-to-weel / CO<sub>2</sub> pricing
- **Methanol** is a promising platform molecule in terms of TRL, costs, **system efficiency**, logistics and ecology
- **Ammonia** is promising in terms of cost and efficiency
- Synthetic fuel as key enabler for future zero emission ICE's



**Put the sunshine  
in the tank**

# Thank you for your kind attention!



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