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## Hydrogen in the chemical industry and R&D needs

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Hydrogen October 22, 2018, Paris

**Roland Merger**  
Corporate Technology



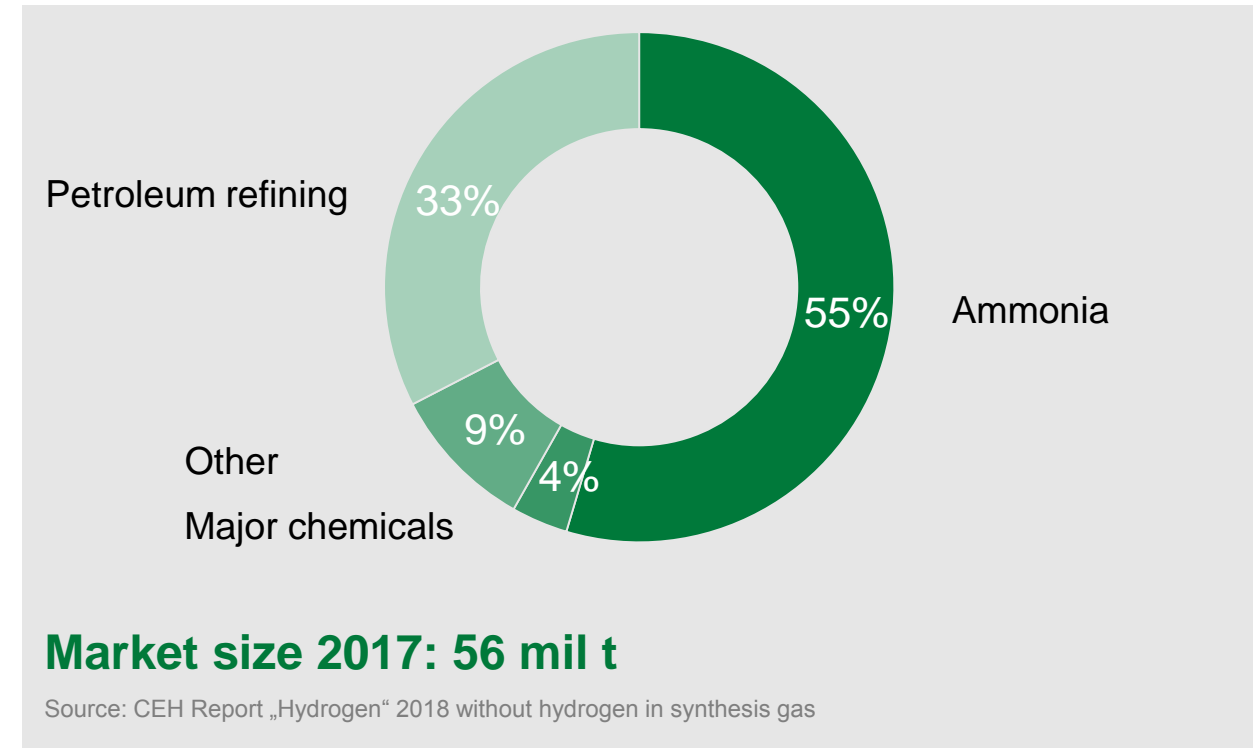
# Hydrogen – a key raw material for chemical production

## ■ Important uses:

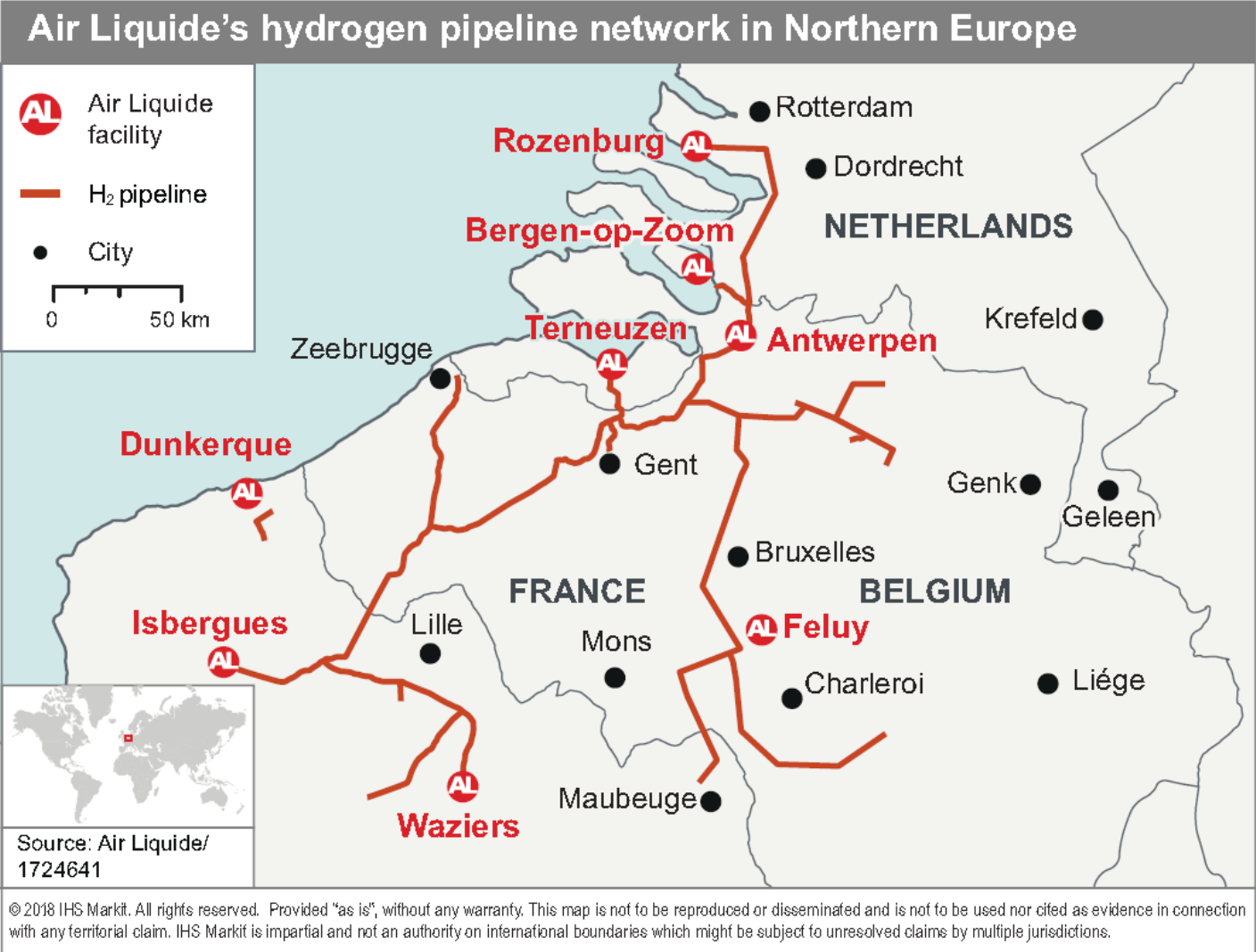
- ▶ **Ammonia** (→ fertilizers)
- ▶ **Naphtha, Gasoline, Diesel**
- ▶ **Chemicals** like
  - Cyclohexane (→ Plastics, Fibres)
  - Aniline (→ Plastics, Foams)
  - and a plethora of specialty chemicals

## ■ BASF Ludwigshafen:

- ▶ Capacity: 300 kt/a
- ▶ “**on purpose**” production from natural gas
- ▶ **byproduct hydrogen** from other processes is fully utilized



# Hydrogen is like lifeblood for chemistry





# Hydrogen is proposed for many future applications



Chemicals –  
major use today,  
56 million t



Energy storage



Energy carrier



Fuel

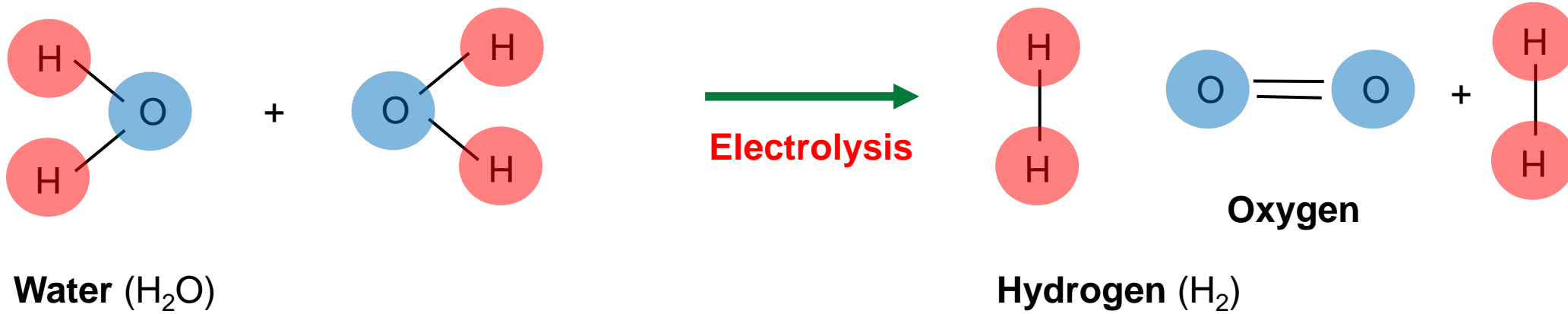


CO<sub>2</sub> utilization



**Increasing  
Hydrogen  
demand**

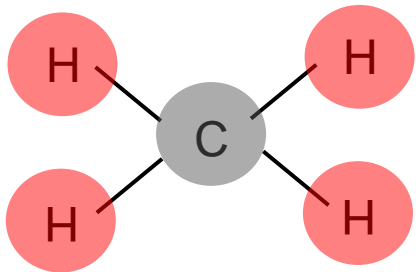
# Hydrogen (H<sub>2</sub>) production - principles



Hydrogen is produced from water using ***much Energy (= Power)*** with Oxygen as byproduct

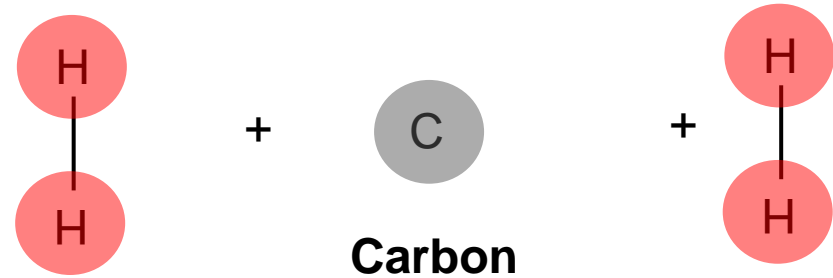
# Hydrogen (H<sub>2</sub>) production - principles

Natural Gas (methane, CH<sub>4</sub>)



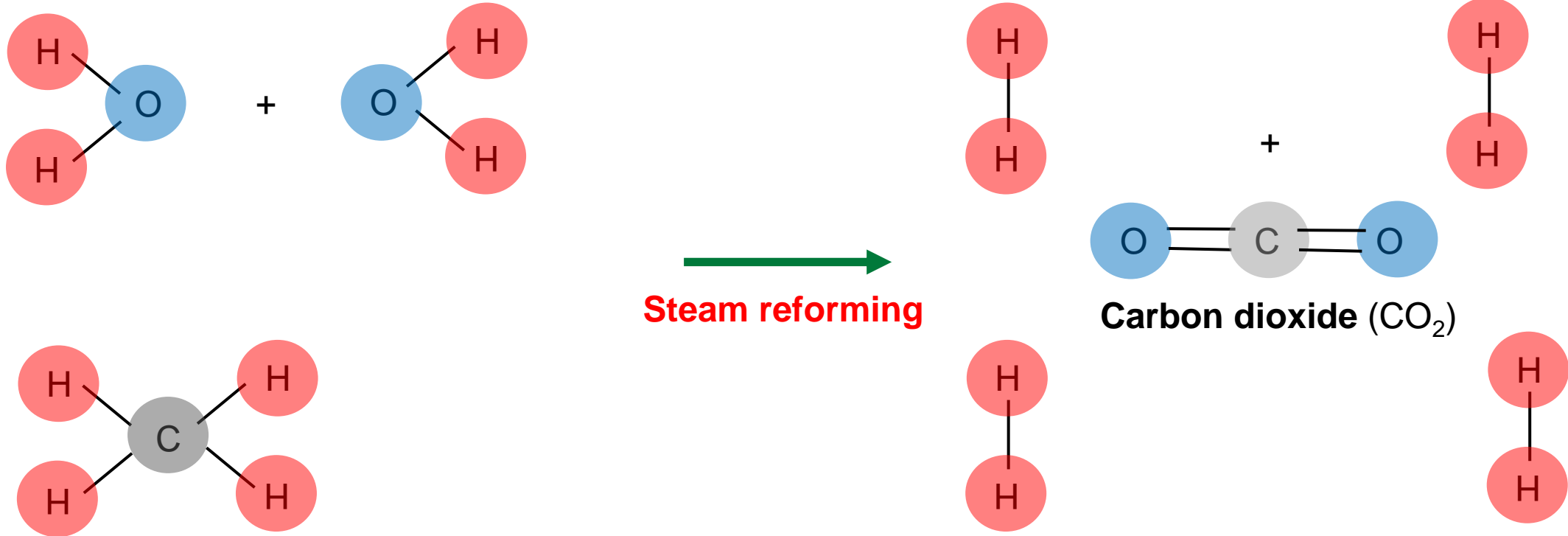
→  
Pyrolysis

Hydrogen (H<sub>2</sub>)



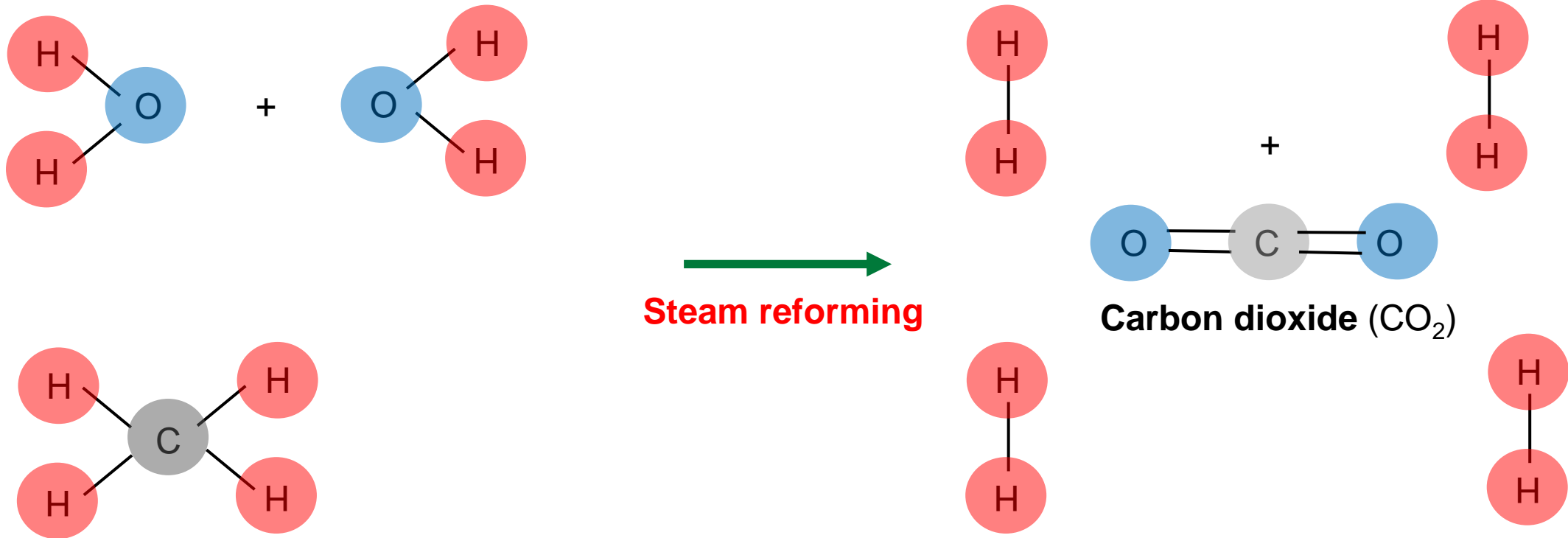
Hydrogen could be produced from natural gas using **little Energy** with solid carbon as byproduct

# Hydrogen (H<sub>2</sub>) production - principles



**Steam reforming** combines Hydrogen production from Water **and** Natural Gas in one Reactor

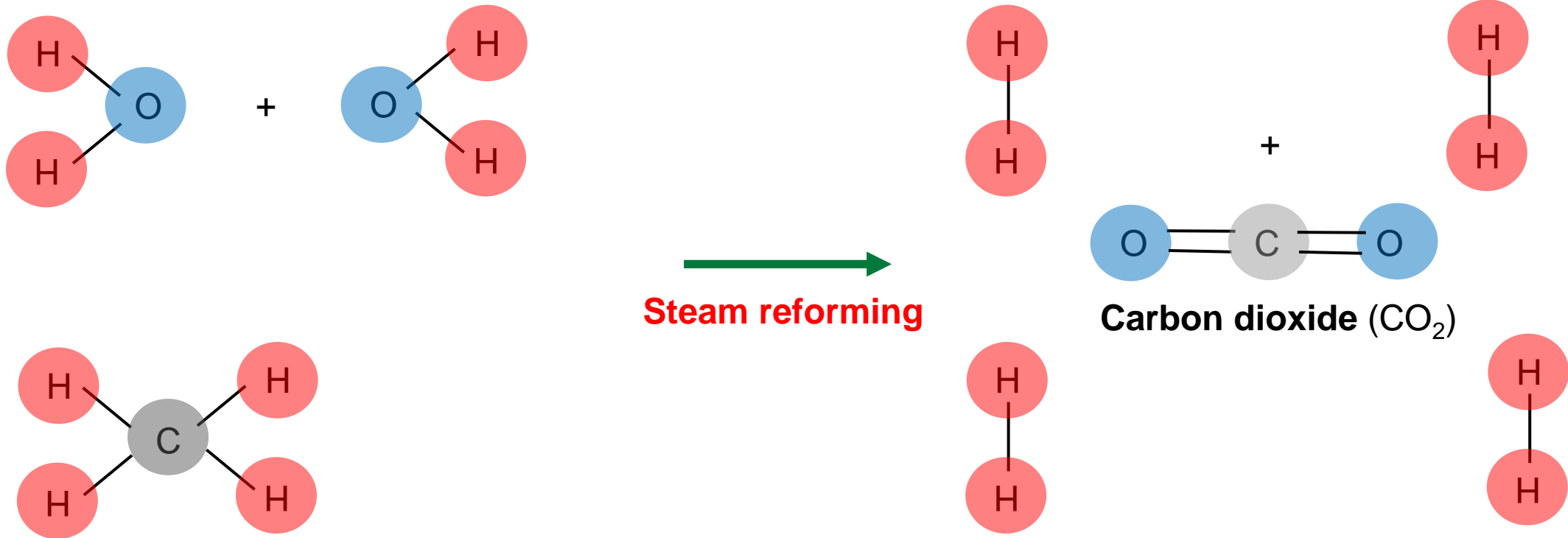
# Hydrogen (H<sub>2</sub>) production - principles



**Steam reforming** is the main production method for hydrogen globally



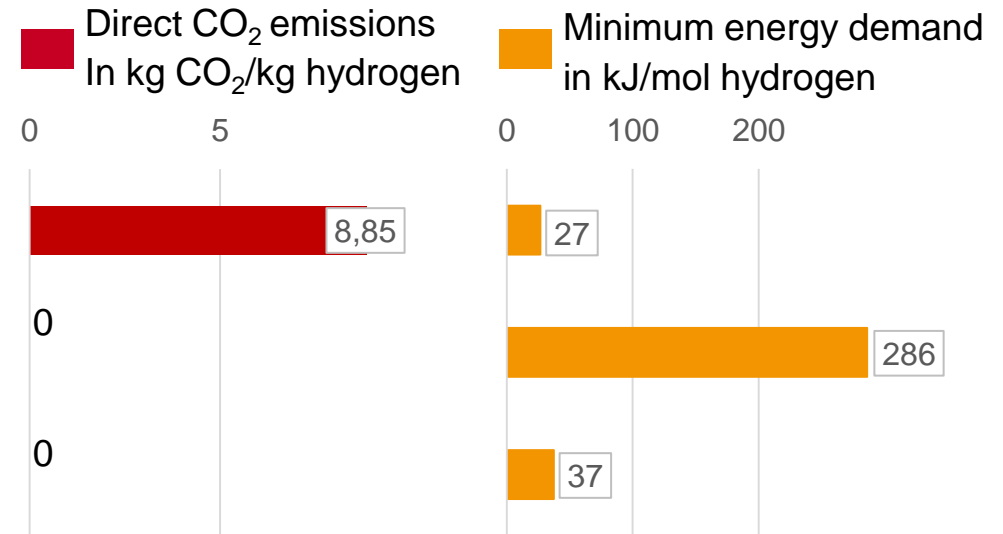
# Hydrogen (H<sub>2</sub>) production - principles



**Steam reforming** produces ca 9t of CO<sub>2</sub> per t of Hydrogen

# Towards a low carbon hydrogen production

NG Steam reforming	Mature technology, low improvement potential
Water electrolysis	Established technology, high potential for flexibility
Methane pyrolysis	Under development, potential for lower cost. Solid Carbon as byproduct



Either electrolysis or methane pyrolysis can be the preferred CO<sub>2</sub> free technology, depending on local conditions

# BASF leads a consortium evaluating methane pyrolysis since 2013

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the high throughput experimentation company

**BFI**  
VDEH-BETRIEBSFORSCHUNGSINSTITUT

**tu** technische universität  
dortmund

## 2013 – 2017 Basic, ambitious R&D

FfPaG-Project funded by BMBF 2013-2017

Carbon sample production on semi-pilot scale

## Results

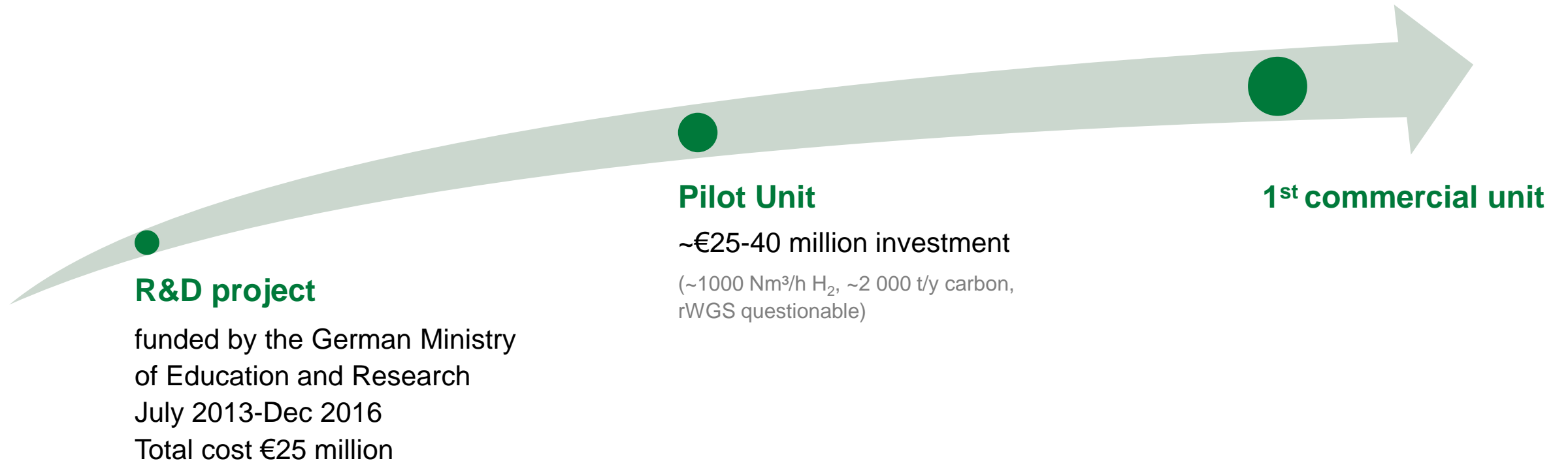
- Successful operation on lab scale
- Identification of promising reactor concepts
- **Successful carbon sample production and testing**
- But: Semi-pilot reactor was crashed during sample production



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# Project Outlook

## Methane Pyrolysis for Low Carb Hydrogen



# Hydrogen – which R&D does the chemical industry need?

## ■ Methane pyrolysis

- Successful operation on pilot scale
- Scale up via pilot to technical scale
- Uses for byproduct carbon
  - Steel industry
  - Aluminium production
  - Storage Options for Pyrolysis Carbon

## ■ Electrolysis

- Long-term behavior of flexible electrolysis plants harvesting renewable power
- Pilots for integration into chemical parks , investment optimization

## ■ Breakthrough technologies - long term research

- Metal oxide catalysis for hydrogen from water
- Photocatalytic water cleavage





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# Conventional and new hydrogen production processes

## Low Carbon Footprint for CO<sub>2</sub> utilization

