

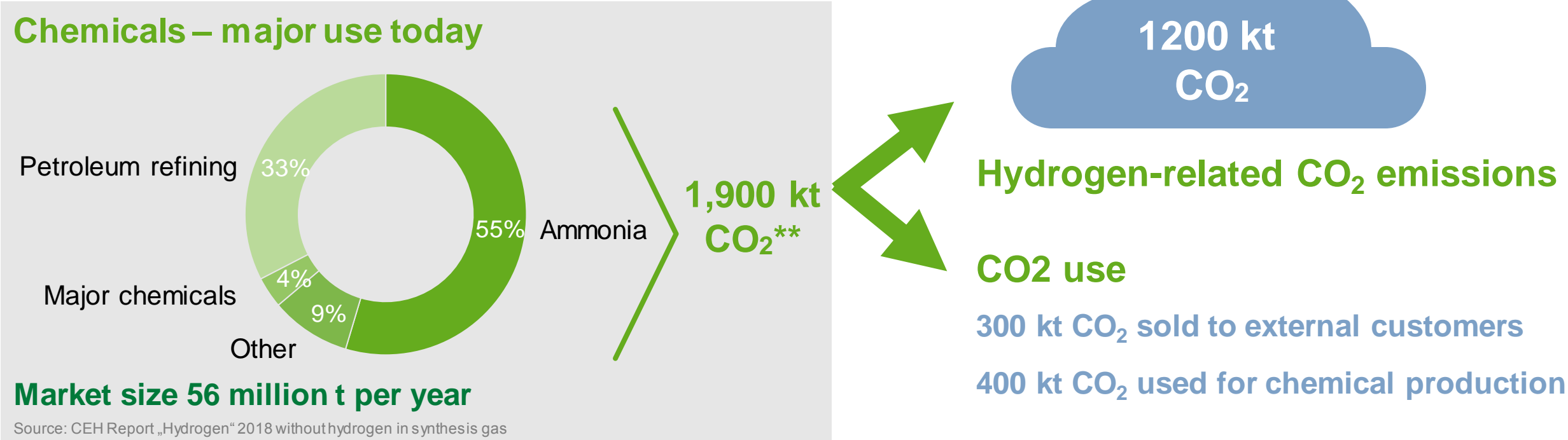
# EU's hydrogen strategy

with technology neutrality to success  
– Insights into methane pyrolysis –

Ifri Energy Breakfast Roundtable  
Diana Warnecke, 22.04.2020

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# Clean hydrogen will be crucial to reduce CO<sub>2</sub>-emissions in the chemical industry

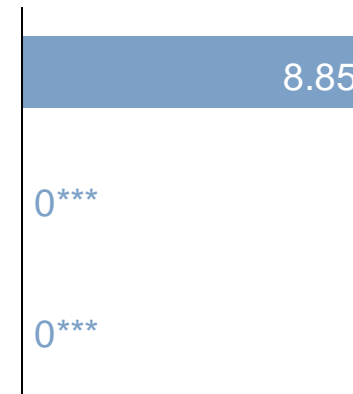


Together with the power plants and the steam crackers, hydrogen production belongs to the Top 3 emitters of BASF Ludwigshafen.

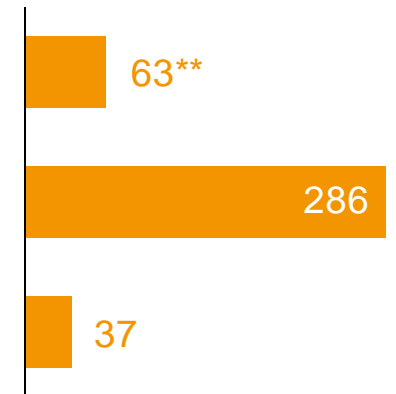
# Why is methane pyrolysis attractive?

State of the art	Steam reforming of natural gas	$\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow 4\text{H}_2 + \text{CO}_2$
Option 1	Water electrolysis	$2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
Option 2	Methane pyrolysis	$\text{CH}_4 \rightarrow 2\text{H}_2 + \text{C}$

Direct  
CO<sub>2</sub> emissions  
in kg CO<sub>2</sub>/kg hydrogen



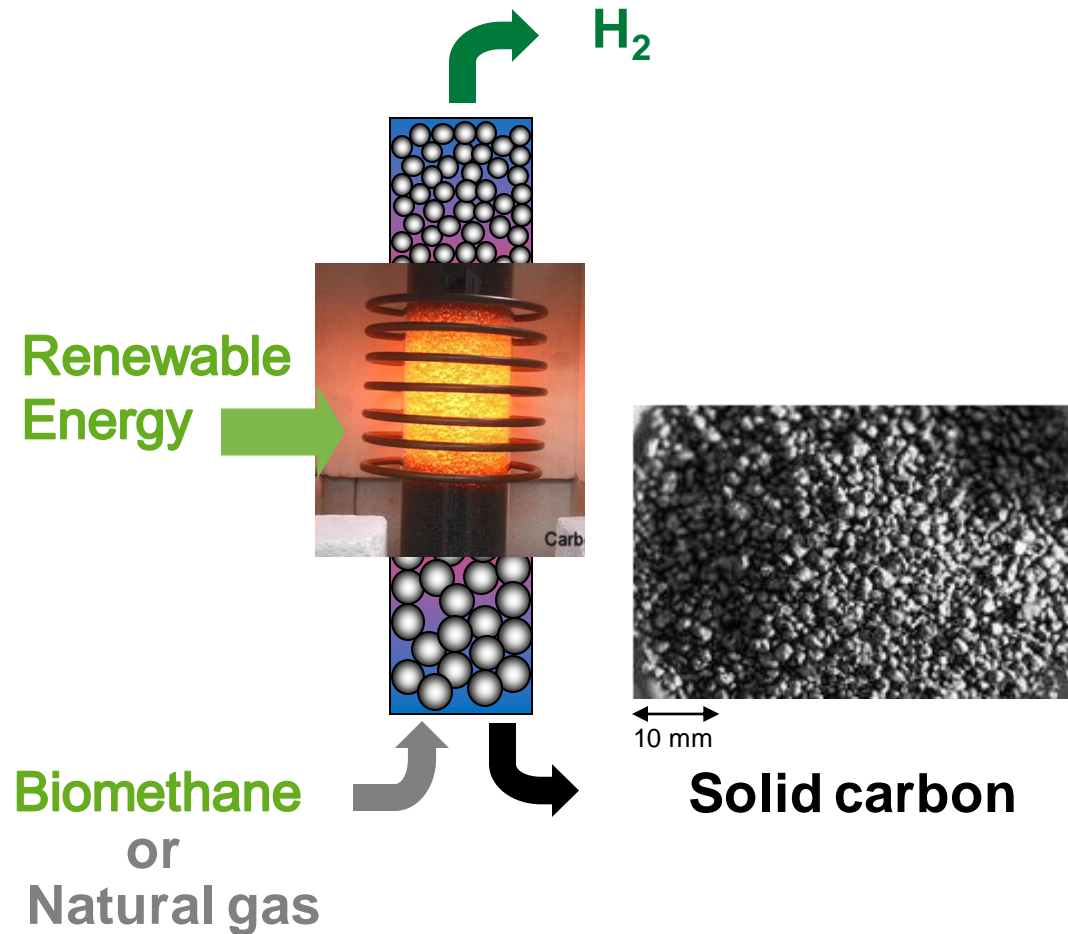
Minimum  
energy demand  
in kJ/mol hydrogen\*



**Methane pyrolysis presents a CO<sub>2</sub>-free and very energy-efficient production method for hydrogen**

\* Standard reaction enthalpy as approximation  
 \*\* using liquid water, with gaseous water 41  
 \*\*\* when using CO<sub>2</sub>-free electrical power

# First moving carbon beds for methane pyrolysis: Combined reaction and heat integration



## Options for carbon utilization and storage

### 1. Utilization in major carbon markets

- Aluminum – positive tests
  - CO<sub>2</sub> neutral hydrogen + CO<sub>2</sub> neutral aluminum
- Steel – positive tests
- Others (graphite substitutes, concrete admixtures, ...)

### 2. Storage/sequestration

- Soil improver / Terra preta
- Sequestration = CO<sub>2</sub> negative hydrogen (biogas)

# BASF led consortium evaluating methane pyrolysis since 2013

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## 2013 – 2017 Proof of Principle

Theoretical and experimental assessment of  
various reactor concepts

Carbon sample production on 100 kg scale

## Results

- Successful operation on lab scale
- Identification of promising reactor concepts
- **Successful carbon sample production and application testing**



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# BASF leads new methane pyrolysis consortium “Me<sup>2</sup>H<sub>2</sub>”<sup>\*</sup> since 2019

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## 2019 – 2022 Technology development

Short term operation over some days in a new enlarged reactor → targeting TRL 5

### Project and status

- Successful pre-experiments in existing reactor (1)
- Construction (2) and operation of new “Technikums” reactor
- Assessment of alternative pyrolysis technologies
- Assessment of options for carbon utilization
- Preparation of follow-up project for long term operation

