



# Chemistry and Sustainability: A Perfect Match

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Member of the Board and CTO of BASF SE

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July 2023 was the hottest month ever measured on earth.  
Solutions are urgently needed.

“The era of global warming has ended – the era of global boiling has arrived”

*António Guterres,  
United Nations  
Secretary-General*



# Sustainability at BASF – our central goal

**Sustainability**  
is key to our  
target...

**2050  
Net Zero  
CO<sub>2</sub>  
emissions<sup>1</sup>**

**Chemistry is  
the solution to  
fight climate  
change...**

...and **innovation  
power in  
chemistry**  
gives us strong  
tailwind!



<sup>1</sup> Scope 1 and Scope 2



# BASF contributes to the global sustainability development

We support the 17 UN Sustainability Development Goals (SDGs) through 8 sustainability categories

Climate Change & Energy  
Resource Efficiency  
Circular Economy  
Pollution Reduction  
Water Protection  
Biodiversity  
Zero Hunger & Poverty  
Health & Safety



# Our path to success: measurability and transparency

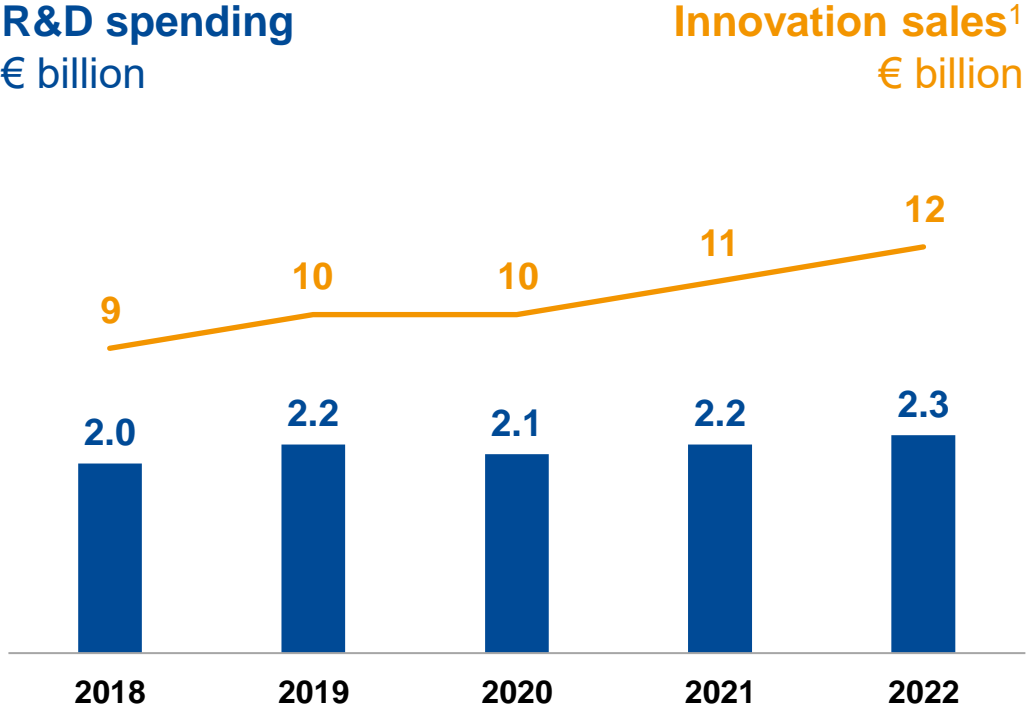
## The TripleS method – developed by BASF, adopted by the industry



- The method has been established at BASF for more than 10 years and acts as a strong **innovation driver**
- Approximately **45,000 products** are analyzed and classified worldwide
- Each product in its application can be assigned to one of **5 TripleS segments**
- Portfolio steered toward **climate protection, resource efficiency and circular economy** with Pioneer and Contributor products
- The World Business Council for Sustainable Development **adopted** BASF's TripleS logic for its Portfolio Sustainability Assessment (PSA)

# Our path to success: research and product portfolio

## BASF R&D spending and innovation sales 2022



## Product examples



Infinergy®



Ni-Co-Al Cathode Battery Materials



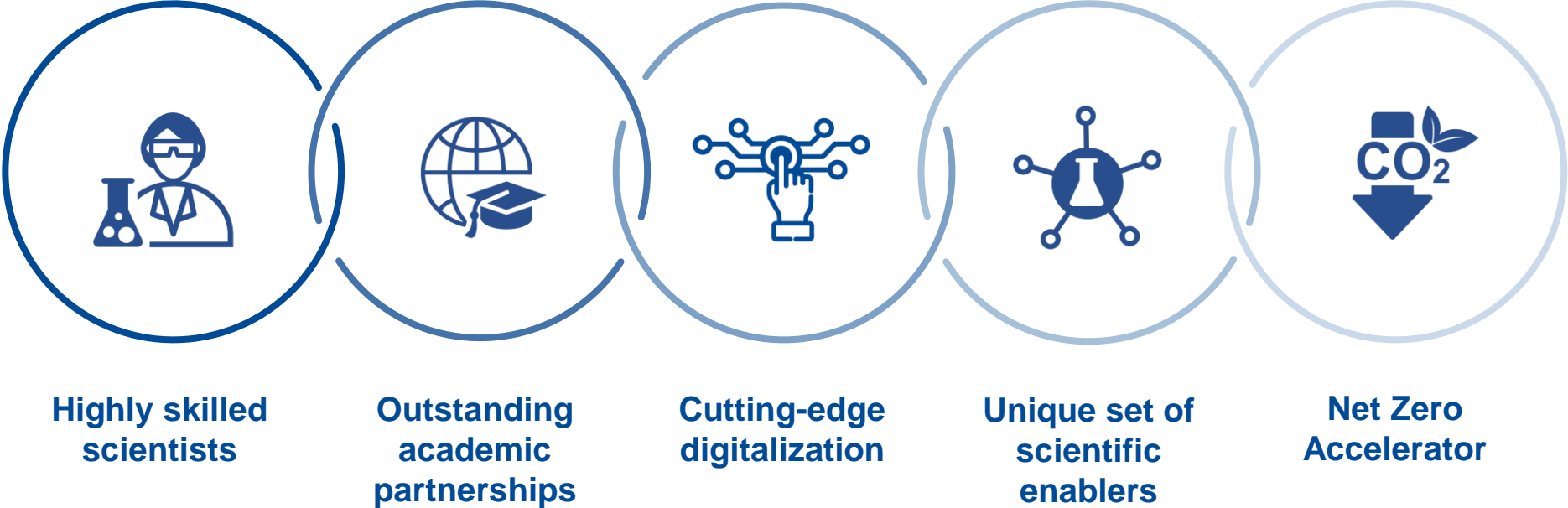
Revysol®

Continuous commitment to innovation is paying off

<sup>1</sup> Sales from innovations launched in the past five years

# Our path to success: key enablers

We are **well-equipped with all key enablers** necessary to research, develop and accelerate sustainable products:





# Highly skilled scientists



**>500**  
publications  
in 2022

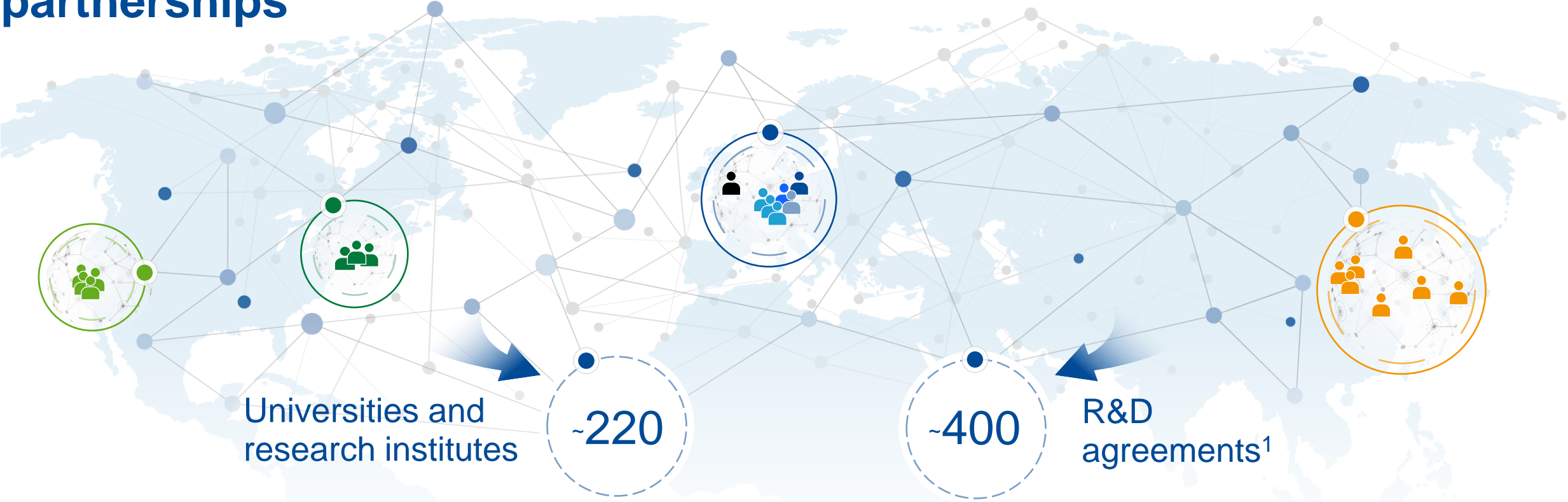
**345**  
R&D experts

**>1,000**  
patents  
in 2022

**40%**  
in sustainability



# Connected research through outstanding academic partnerships



Universities and research institutes

~220

~400

R&D agreements<sup>1</sup>

**CARA**

California Research Alliance

**NORA**

North America Open Research Alliance

**BARI**

British Alliance for Research and Innovation

**JONAS**

Joint Research Network on Advanced Materials and Systems

**BasCat**

UniCat BASF Joint Lab

**CaRLa**

Catalysis Research Laboratory

**BELLA**

Battery and Electrochemistry Laboratory

**NAO**

Network for Asian Open Research

<sup>1</sup> in the past 12 months



# Project with academic partners: high entropy alloys (HEA)

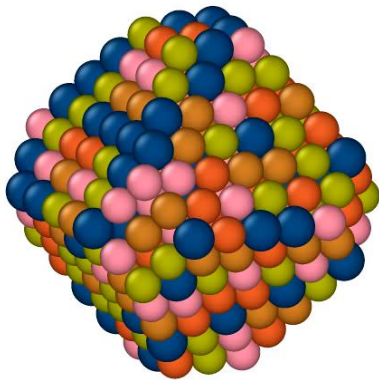


Reduction of precious metals:  
New material class HEA

Systematic reduction of  
experiments

Experiments in BASF labs for  
sustainable applications

- Ir
- Co
- Fe
- Ni
- Cu
- ...



Potential compositions:  
>100,000 equimolars  
infinite non-equimolars

Experimental  
evidence<sup>1</sup>

CARA academic experts  
proof of concept in the lab

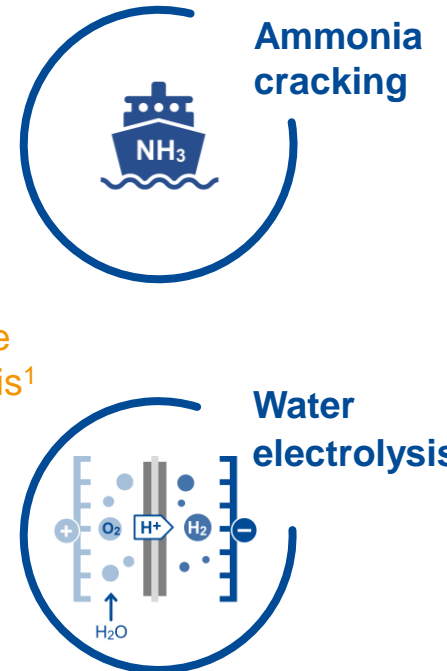


Machine learning  
boosted quantum  
chemistry<sup>2</sup>

BASF Supercomputer  
>1 year of work → 2 weeks

5 lead compositions for water electrolysis

Scalable  
synthesis<sup>1</sup>



<sup>1</sup> in collaborations with UC Berkeley and Stanford University

<sup>2</sup> Modelling capability development in collaboration with EPFL, Switzerland



# Curiosity enables fundamentally new research approaches



## Computing power:

With **3.0 petaflops**, we are the leader in chemical industry research



Since 2017 used by **400 employees** globally

Average tasks per day: **20,000**

# Cutting-edge digitalization: Automated image analysis – powered by machine learning



## Problem:

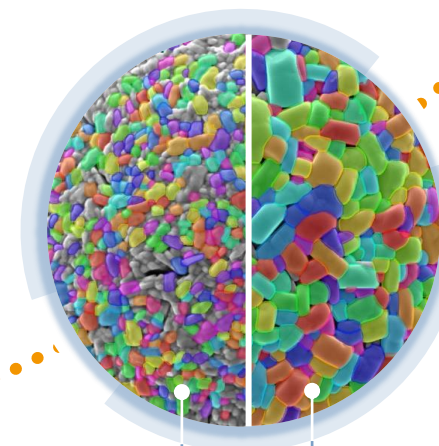
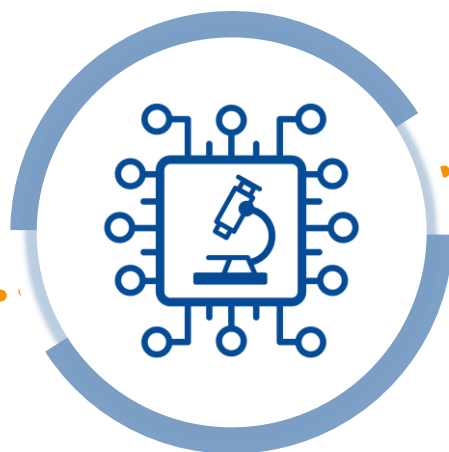
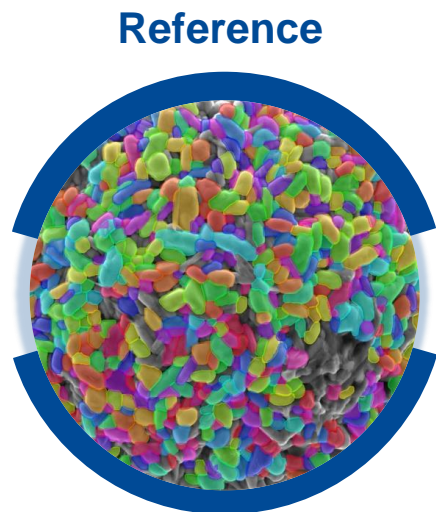
Manual image analysis of particle size distribution in cathode active materials (CAM)

## Approach:

Automated analysis of electron microscopy images supported by machine learning

## Result:

- Acceleration in CAM development
- Control of particle size<sup>1/</sup> properties by targeted doping



**Doping A**  
**Bigger particles:**  
more stability, longer lifespan, less power

**Doping B**  
**Smaller particles:**  
less stability, shorter lifespan, more power



# Unique set of scientific enablers





# Net Zero Accelerator – strongly connected to R&D



Net Zero technologies – Strategies & prioritizing  
Steering activities in three Net Zero areas:

Access to  
renewable energy  
.....  
Stationary energy  
storage

Renewable  
energies

Circularity

Renewable carbon  
.....  
Chemical recycling

Energy vectors  
.....  
CO<sub>2</sub> removal

Carbon  
abatement



# BASF's Hy4Chem-EI: PEM<sup>1</sup> water electrolysis in Ludwigshafen

## Funded by: Federal and State Government



Construction of a **54 megawatt water electrolyzer** together with Siemens Energy to **produce CO<sub>2</sub>-free hydrogen**

**CO<sub>2</sub>-free process, using energy from renewable sources**

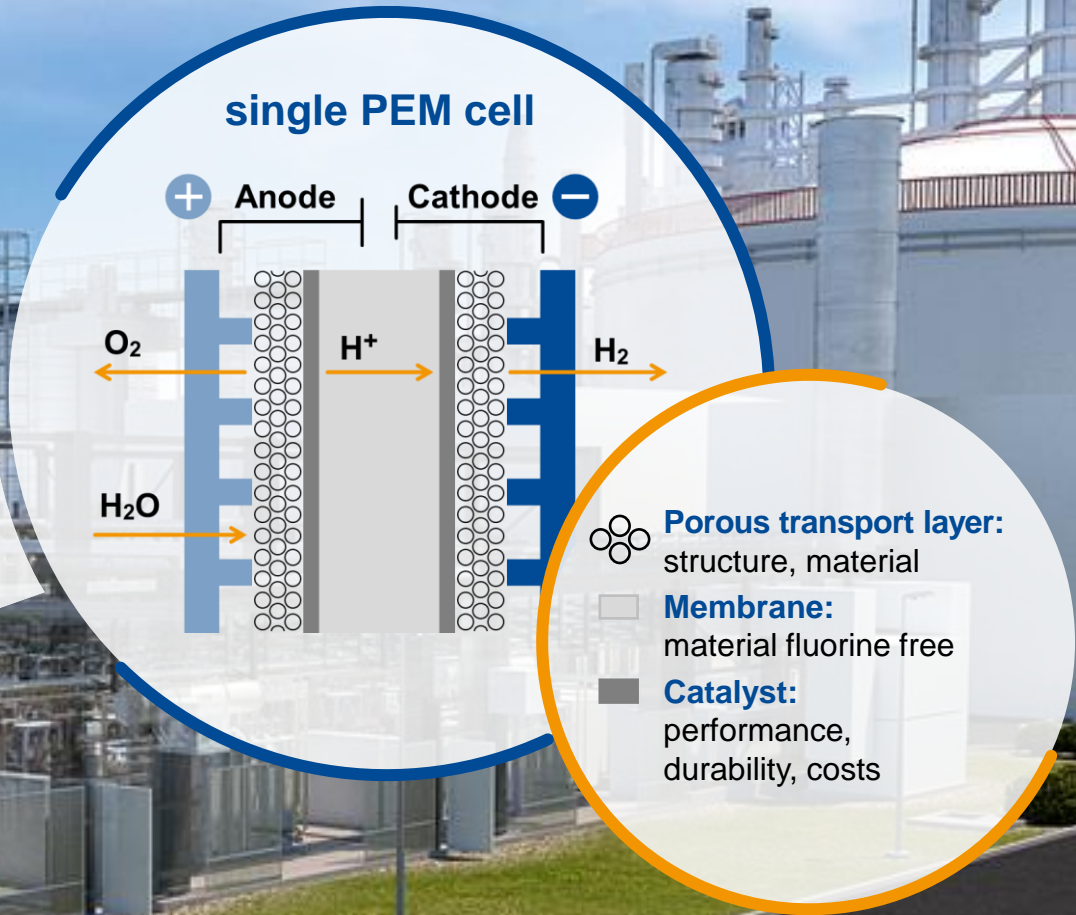


From left to right: Katrin Eder, Melanie Maas-Brunner, Malu Dreyer, Franziska Brantner  
© Siemens Energy, 2023 <sup>1</sup> Proton Exchange Membrane





# BASF's Hy4Chem-NG: next-generation material and product development

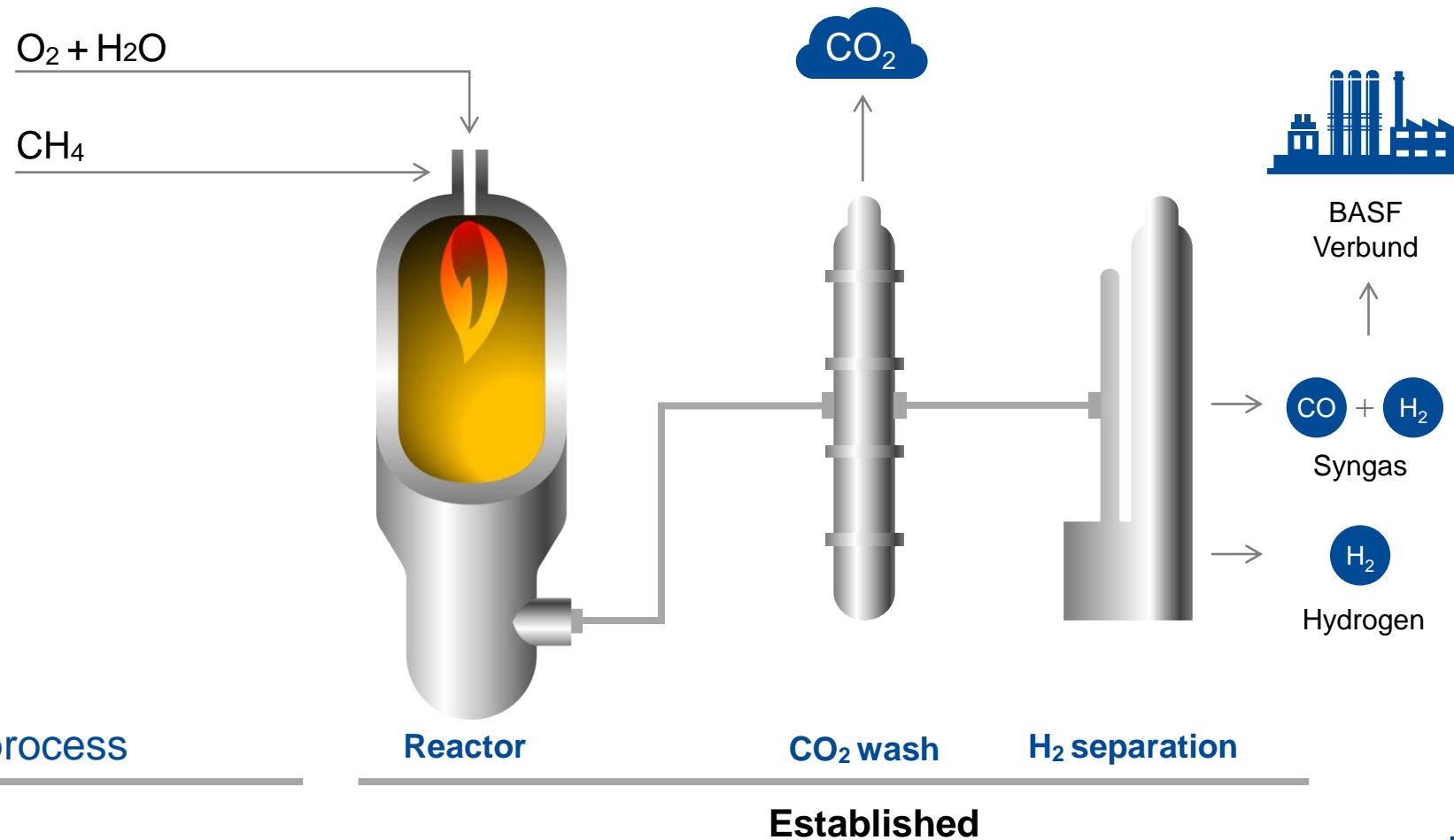




# Carbon abatement – syngas production



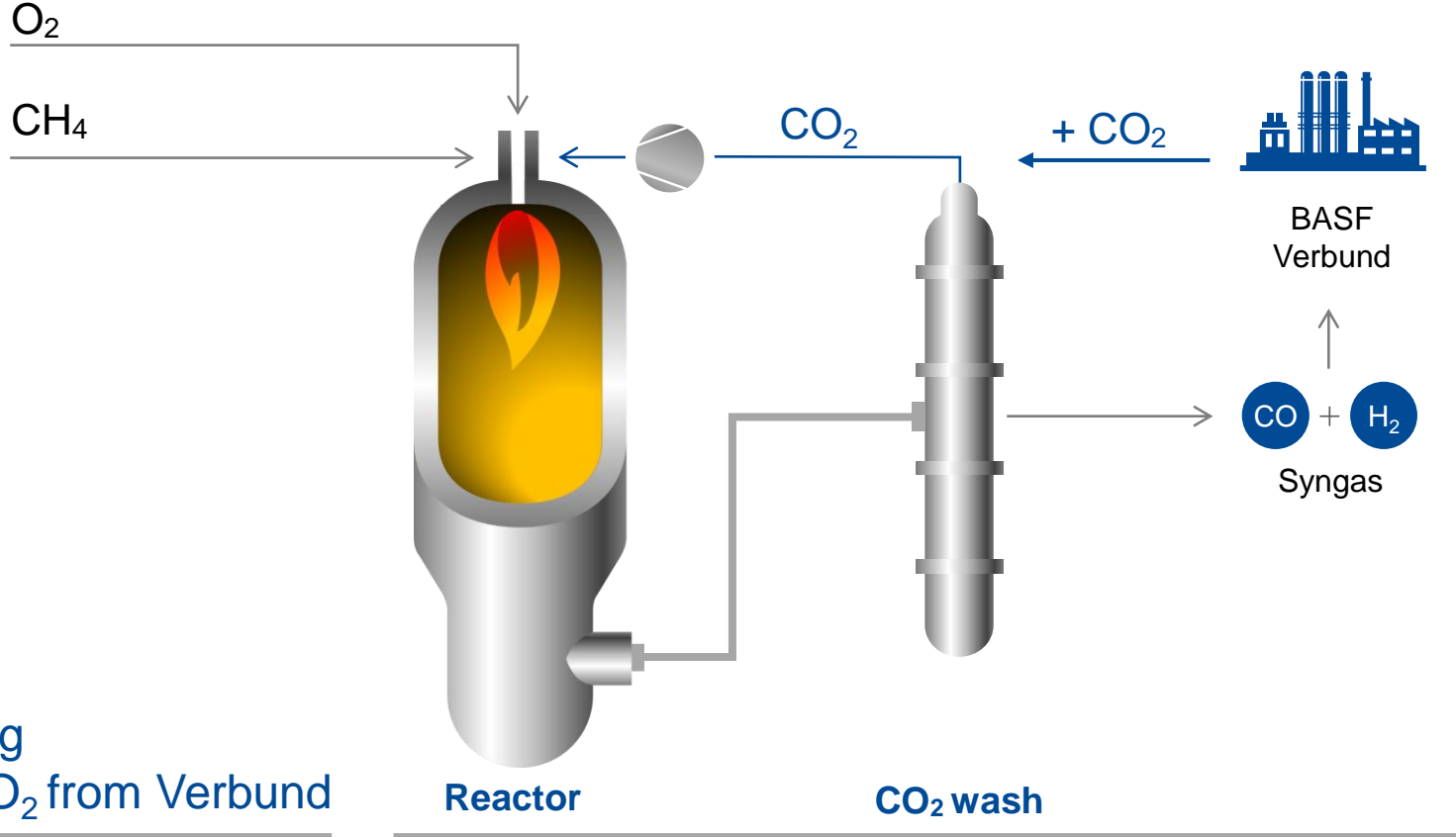
Syngas (mixture of CO + H<sub>2</sub>): starting material for a wide range of products



# Carbon abatement – carbon capture and utilization<sup>1</sup>



Syngas (mixture of CO + H<sub>2</sub>): starting material for a wide range of products



- Solution:**
- 1. CO<sub>2</sub> recycling
  - 2. Additional CO<sub>2</sub> from Verbund

**NEW!**

Gefördert durch:  
 Bundesministerium  
für Wirtschaft  
und Klimaschutz  
aufgrund eines Beschlusses  
des Deutschen Bundestages

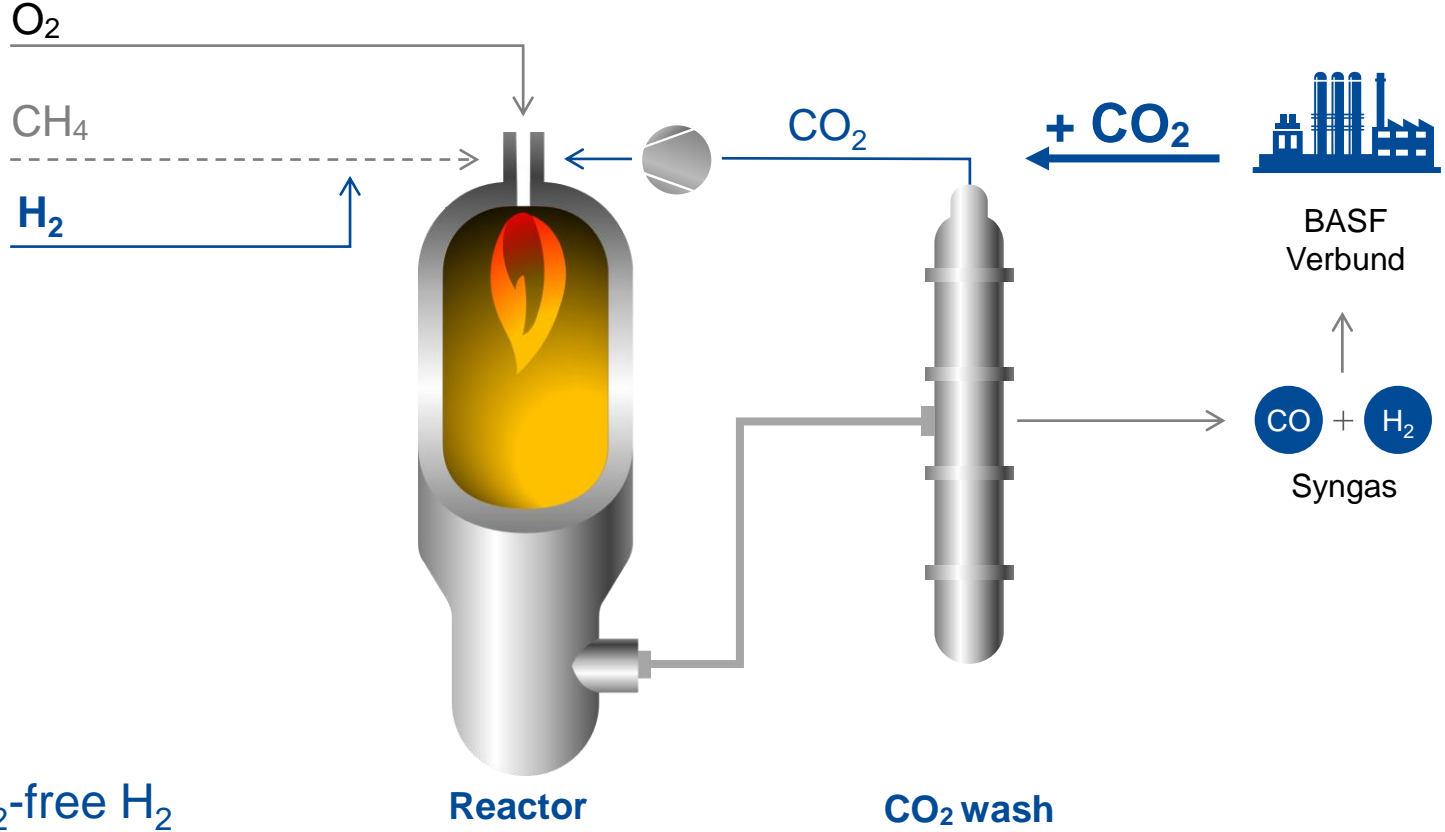
<sup>1</sup> with IEC/TU  
Bergakademie  
Freiberg



# Carbon abatement – enhanced carbon capture and utilization<sup>1</sup>



Syngas (mixture of CO + H<sub>2</sub>): starting material for a wide range of products



**Outlook:**  
Add-mixing CO<sub>2</sub>-free H<sub>2</sub>

Long term

Gefördert durch:  
 Bundesministerium für Wirtschaft und Klimaschutz  
 aufgrund eines Beschlusses des Deutschen Bundestages

<sup>1</sup> with IEC/TU Bergakademie Freiberg



# Contribution to **sustainability**: Many examples at BASF for all industries





# Contribution to sustainability

Highlights presented today





We create chemistry