R&D Webcast for Investors and Analysts
on January 10, 2019

Carbon Management at BASF – R&D strategies to reduce CO_2

Dr. Martin Brudermüller

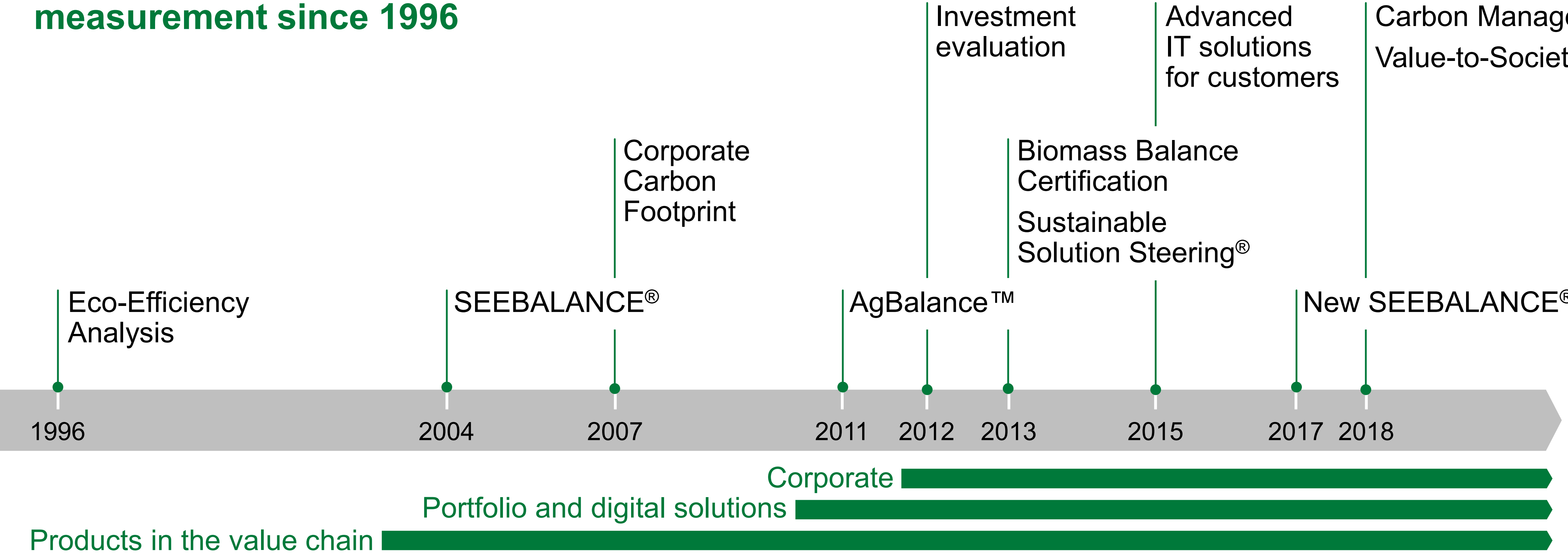
Chairman of the Board of Executive Directors
and Chief Technology Officer of BASF SE

Cautionary note regarding forward-looking statements

This presentation contains forward-looking statements. These statements are based on current estimates and projections of the Board of Executive Directors and currently available information. Forward-looking statements are not guarantees of the future developments and results outlined therein. These are dependent on a number of factors; they involve various risks and uncertainties; and they are based on assumptions that may not prove to be accurate. Such risk factors include those discussed in the Opportunities and Risks Report from page 111 to 118 of the BASF Report 2017. BASF does not assume any obligation to update the forward-looking statements contained in this presentation above and beyond the legal requirements.

BASF as a pioneer in developing tools for sustainability performance measurement

Systematic application of sustainability measurement since 1996



The Carbon Dioxide Challenge

BASF’s Carbon Management

Outlook

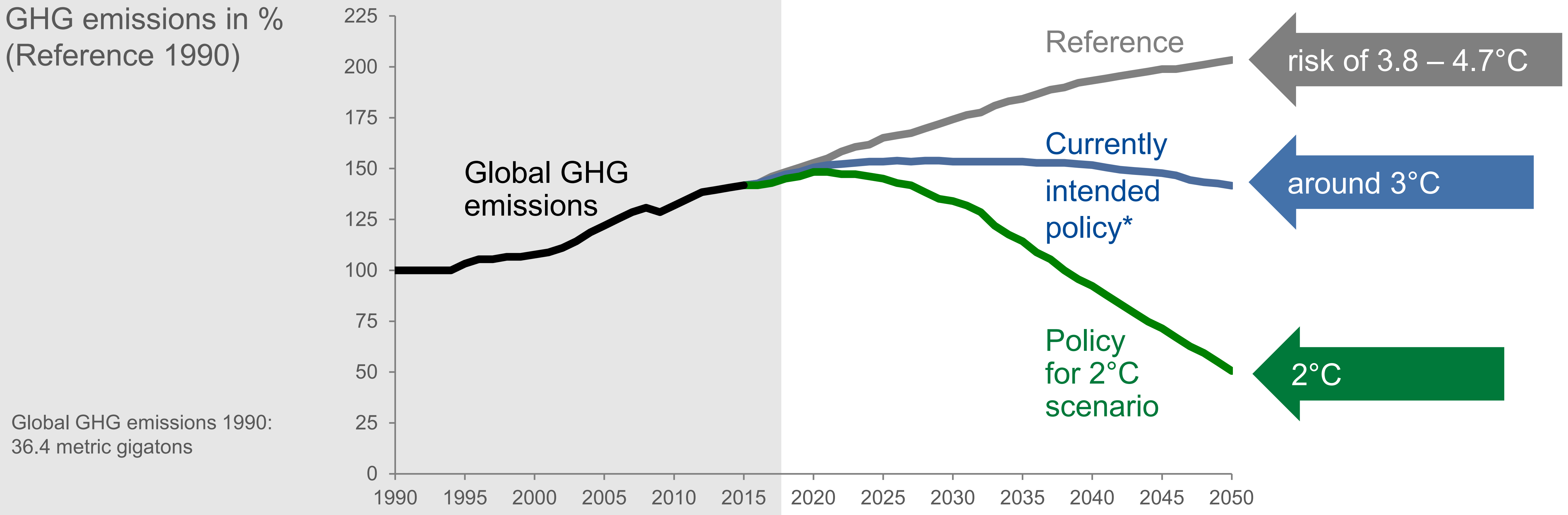
BASF
We create chemistry

The Carbon Dioxide Challenge

BASF's Carbon Management

Outlook

Global greenhouse gas (GHG) emission scenarios



Global GHG emissions 1990: 36.4 metric gigatons

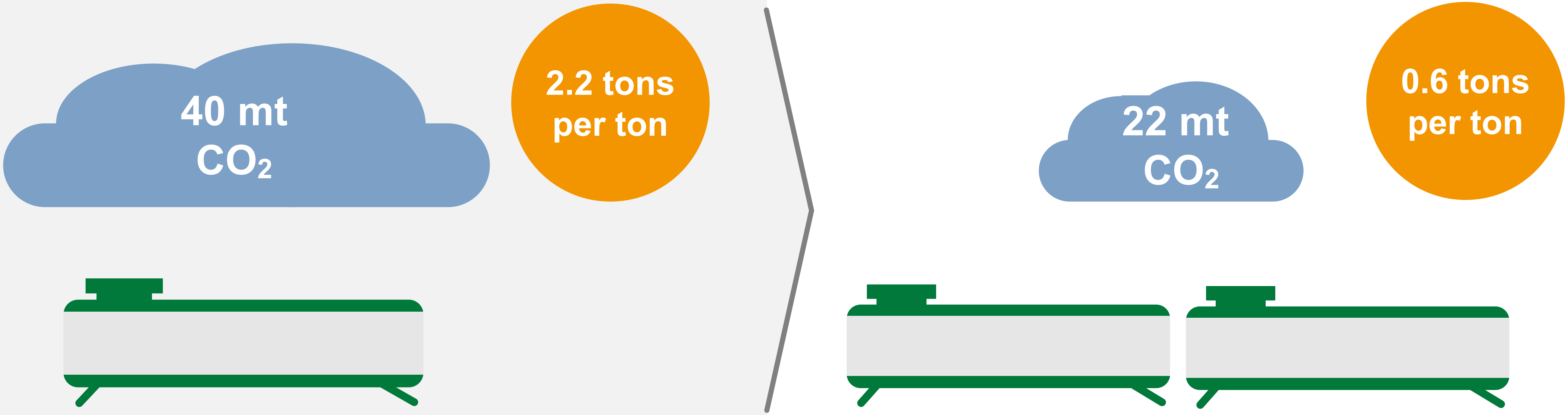
Source of global GHG emissions and future scenarios: JRC Global Energy and Climate Outlook 2016

* Implementation of Nationally Determined Contributions as expressed in Paris Agreement

BASF's successful greenhouse gas reduction

BASF's output in 1990

BASF's output in 2018



Since 1990, BASF has halved its emissions and doubled its sales volume

"mt" = million metric tons, "tons per ton" = metric tons CO_2 equivalents per metric ton sales product

BASF
We create chemistry

BASF’s carbon footprint 2017 and established measures

	source	make	use	end-of-life
	59 mt CO_2	23 mt CO_2	43* mt CO_2	20 mt CO_2
Established measures	Biomass balance Bio-based products and materials	Verbund concept and process optimization CO_2 as a feedstock	CO_2-saving BASF products and solutions	Biodegradable BASF products and materials

BASF commits to CO_2-neutral growth in its new corporate strategy. This requires a new approach to Carbon Management.

“mt” = million metric tons * thereof 36 mt from BASF’s oil and gas business

BASF's Carbon Management aims to decouple growth from CO_2 emissions

	source	***make***	***use***	***end-of-life***
Established measures	Biomass balance Bio-based products and materials	Verbund concept and process optimization CO_2 as a feedstock	CO_2-saving BASF products and solutions	Biodegradable BASF products and materials
New measures	ChemCycling Renewable energy	**Carbon Management Program**	New CO_2-saving BASF products and solutions	Close-the-loop solutions ChemCycling

The Carbon Dioxide Challenge

BASF's Carbon Management

Avoid CO_2 on site

Use CO_2 as a feedstock

Help customers avoid CO_2 (Accelerator products)

Outlook

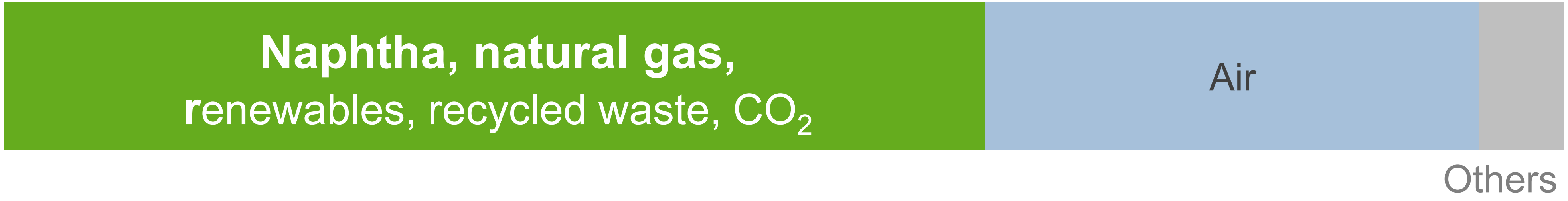
BASF
We create chemistry

BASF’s sales products in a nutshell

Chemical formula: $(C\,H_{3.1}O_{0.3}N_{0.2}\,X\,)_n$

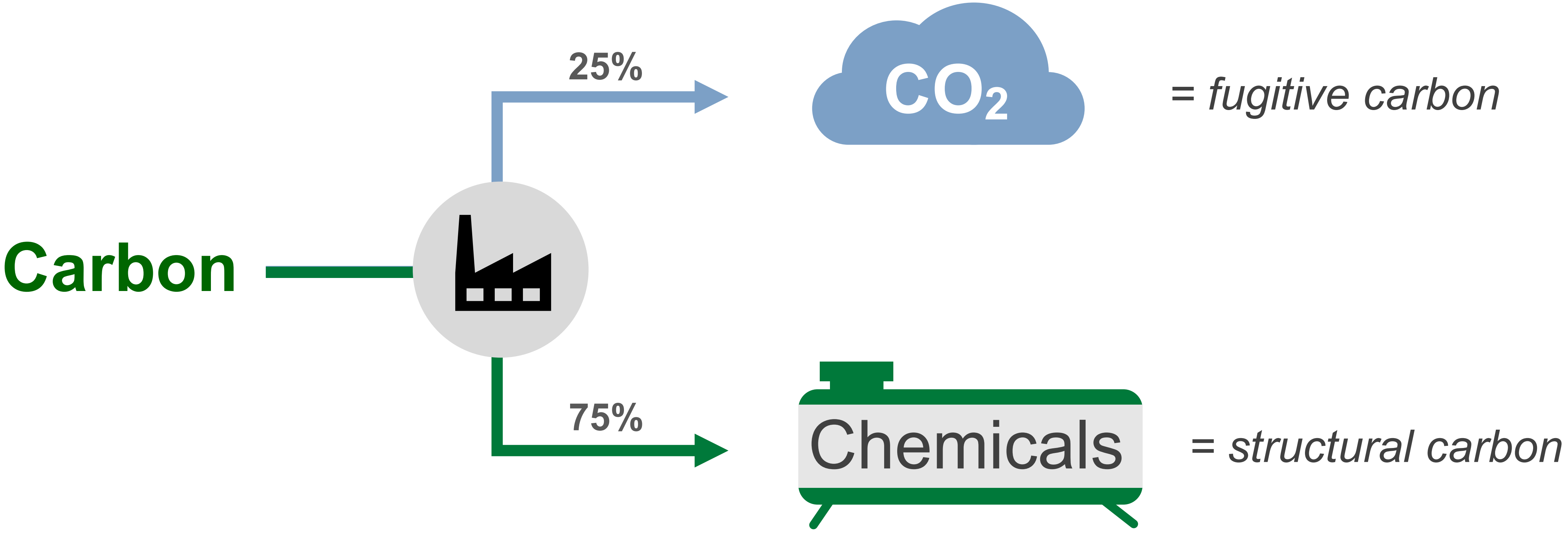
Composition:

Raw materials:



Chemistry is based on carbon and cannot be “decarbonized.”

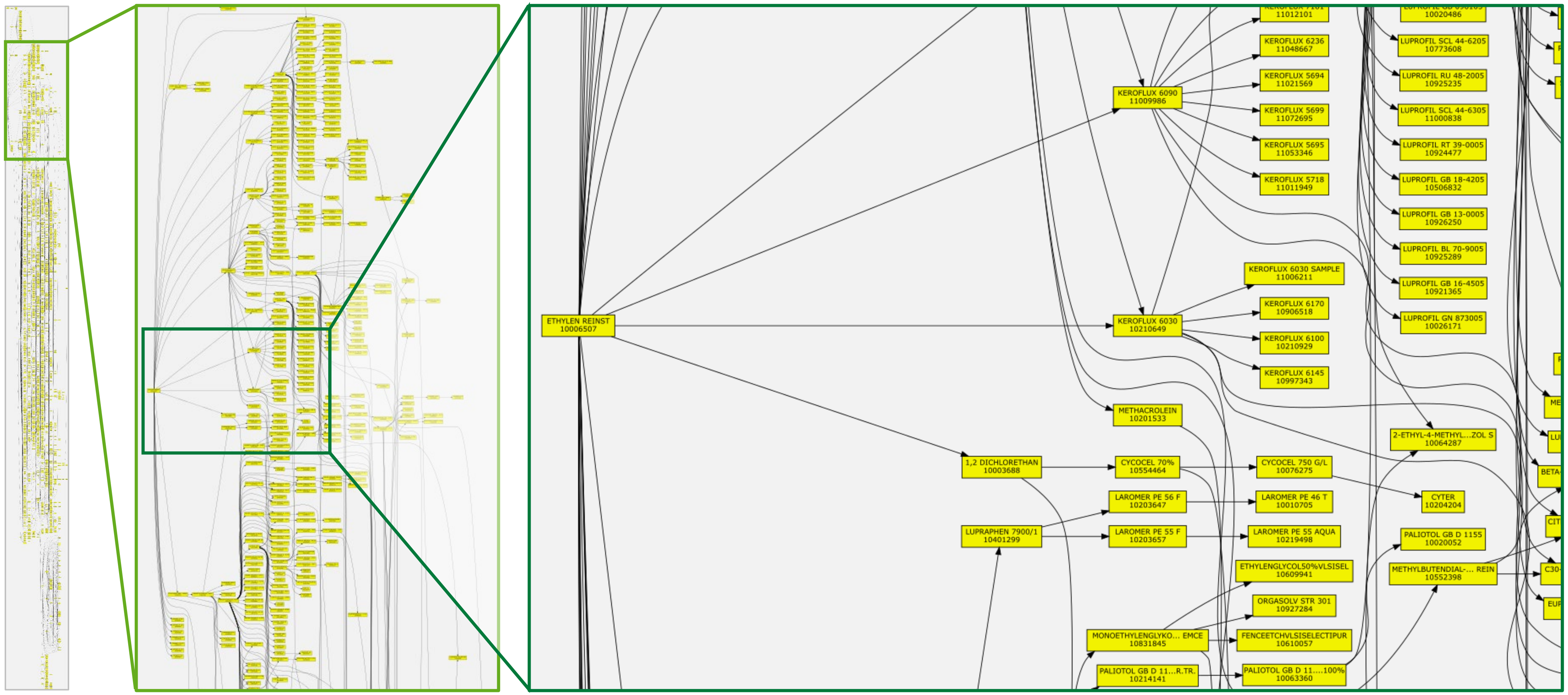
BASF's Carbon Management targets fugitive carbon



A Verbund is the ideal setup for Carbon Management.

BASF's Verbund avoids CO_2

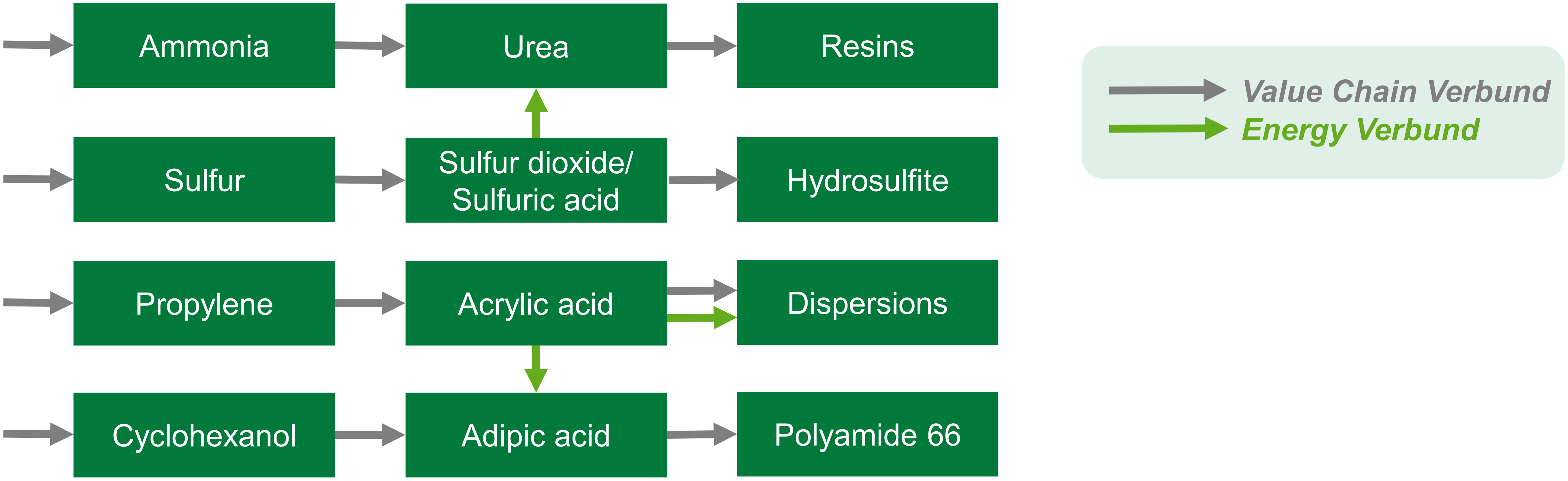
The full picture – for ethylene



BASF
We create chemistry

BASF's Verbund avoids CO_2

Synergies among selected value chains

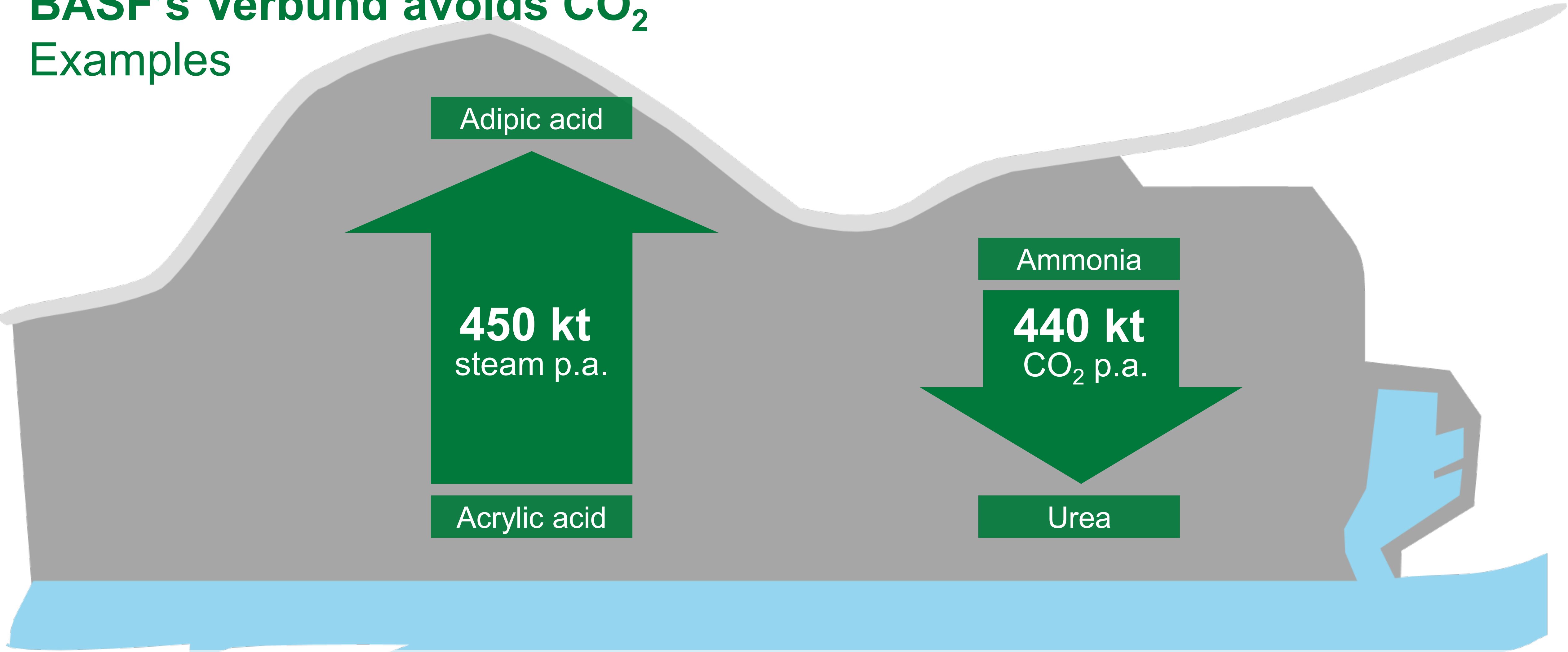


A Verbund optimizes the use of products and utilities.

BASF
We create chemistry

BASF’s Verbund avoids CO_2

Examples



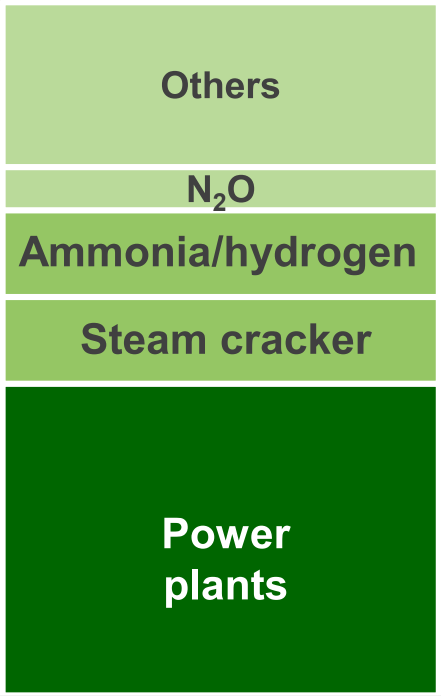
In total, BASF’s Verbund in Ludwigshafen avoids around 6 mt of CO_2 emissions.

 “kt” = thousand metric tons, “mt” = million metric tons

BASF’s Carbon Management

Measures at a glance

CO_2 emitters:



Measures:

- Process optimization, energy management, N_2O decomposition
- Clean hydrogen research, E-Furnace research, clean olefins research
- Purchase of renewable energy

BASF’s Carbon Management includes process optimization, technology research and the supply of renewable energy.

The Carbon Dioxide Challenge

BASF's Carbon Management

Avoid CO_2 on site

Use CO_2 as a feedstock

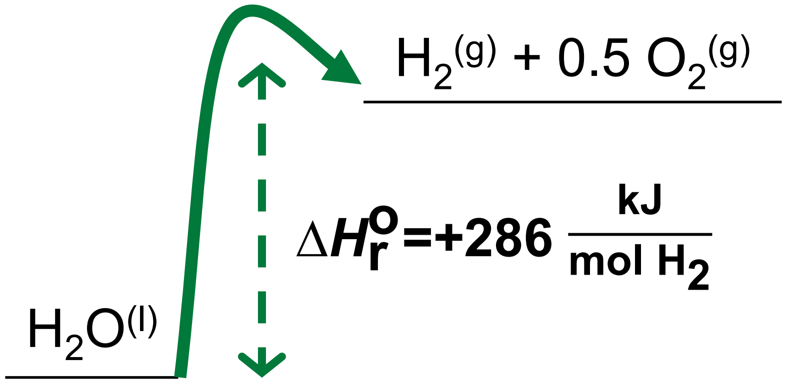
Help customers avoid CO_2 (Accelerator products)

Outlook

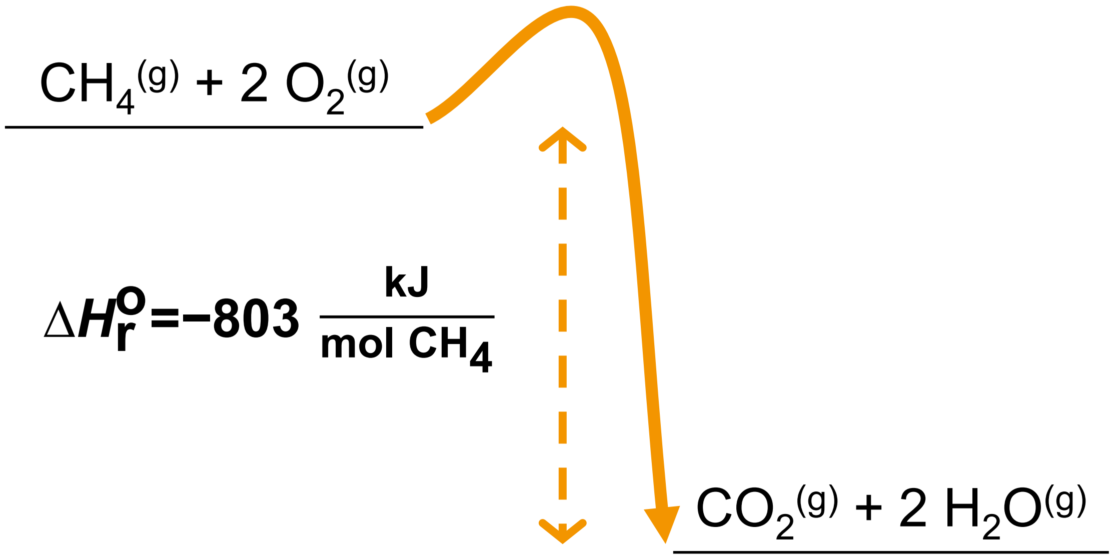
BASF
We create chemistry

Chemistry is energy

Thermodynamics of water electrolysis

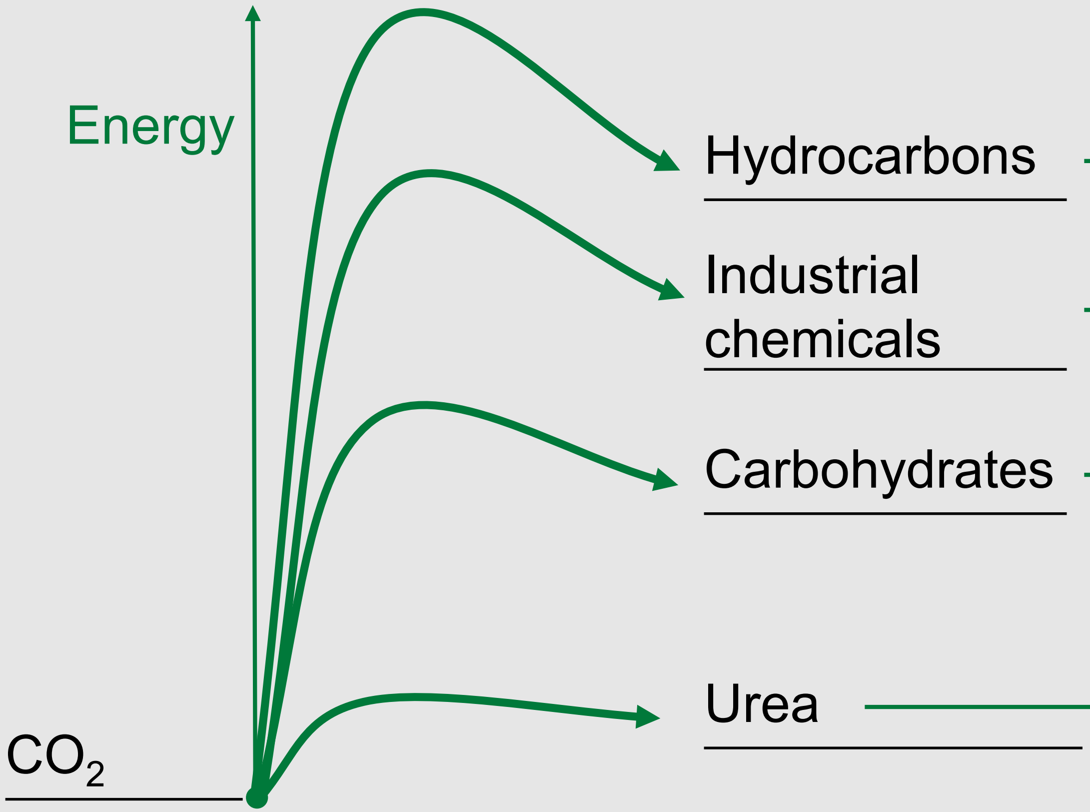


Thermodynamics of CO_2 formation



Water and carbon dioxide are very stable molecules.
Using them as chemical raw materials is very energy-intensive.

Using CO_2 as a feedstock is energy-intensive
Viable options are therefore limited



Synfuels

E.g., acrylic acid
→ BASF invests in R&D

Photosynthesis
→ BASF produces wood binders

Global CO_2 consumption: 115 mt p.a.
→ BASF produces AdBlue®

BASF is exploring new processes to make specialty chemicals from CO_2.

BASF
We create chemistry

 “mt” = million metric tons

Limited potential to use CO_2 as a feedstock in the chemical industry

CO_2 emissions in Germany 2017

905 mt CO_2

Chemical production in Germany 2017

48 mt CO_{2eq}

We need new breakthrough technologies to significantly reduce the CO_2 footprint.

BASF
We create chemistry

“mt” = million metric tons

The Carbon Dioxide Challenge

BASF's Carbon Management

Avoid CO_2 on site

Use CO_2 as a feedstock

Help customers avoid CO_2 (Accelerator products)

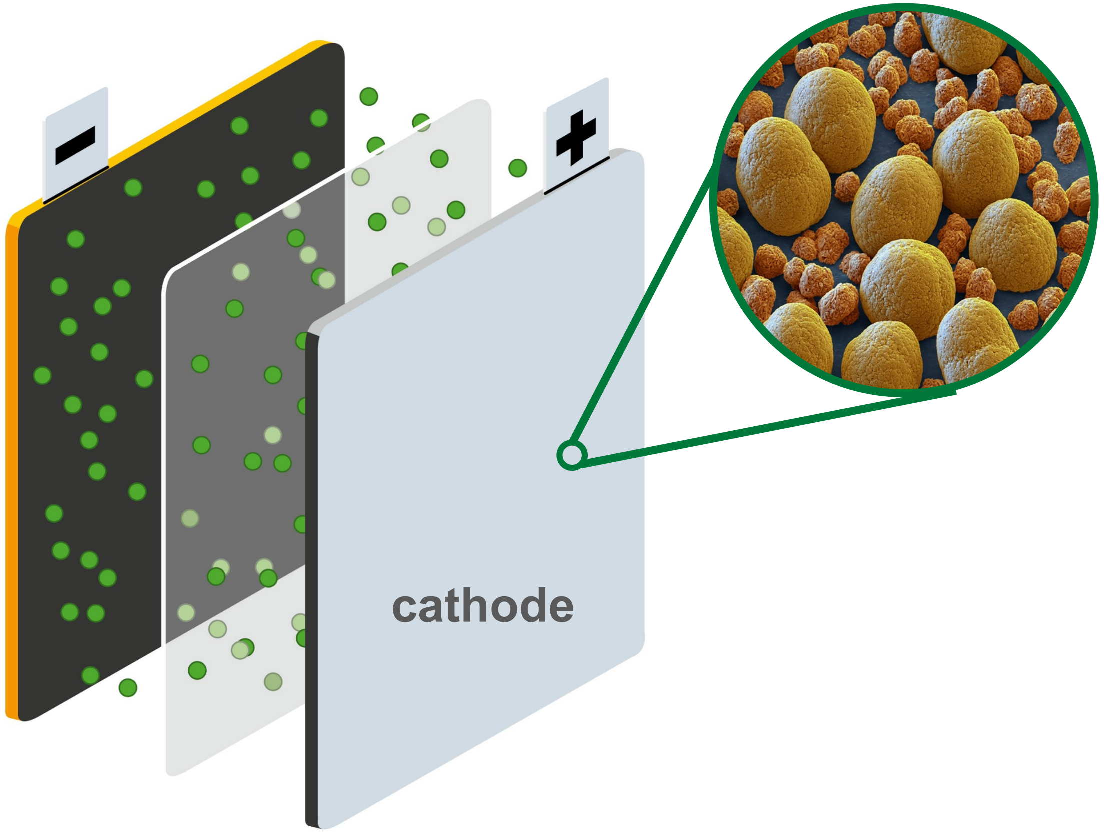
Outlook

BASF
We create chemistry

CO_2-saving innovative solutions

Mineral-based in-situ foam: Cavipor®

Enabling e-mobility: Cathode active materials



BASF
We create chemistry

The Carbon Dioxide Challenge

BASF's Carbon Management

Avoid CO_2 on-site

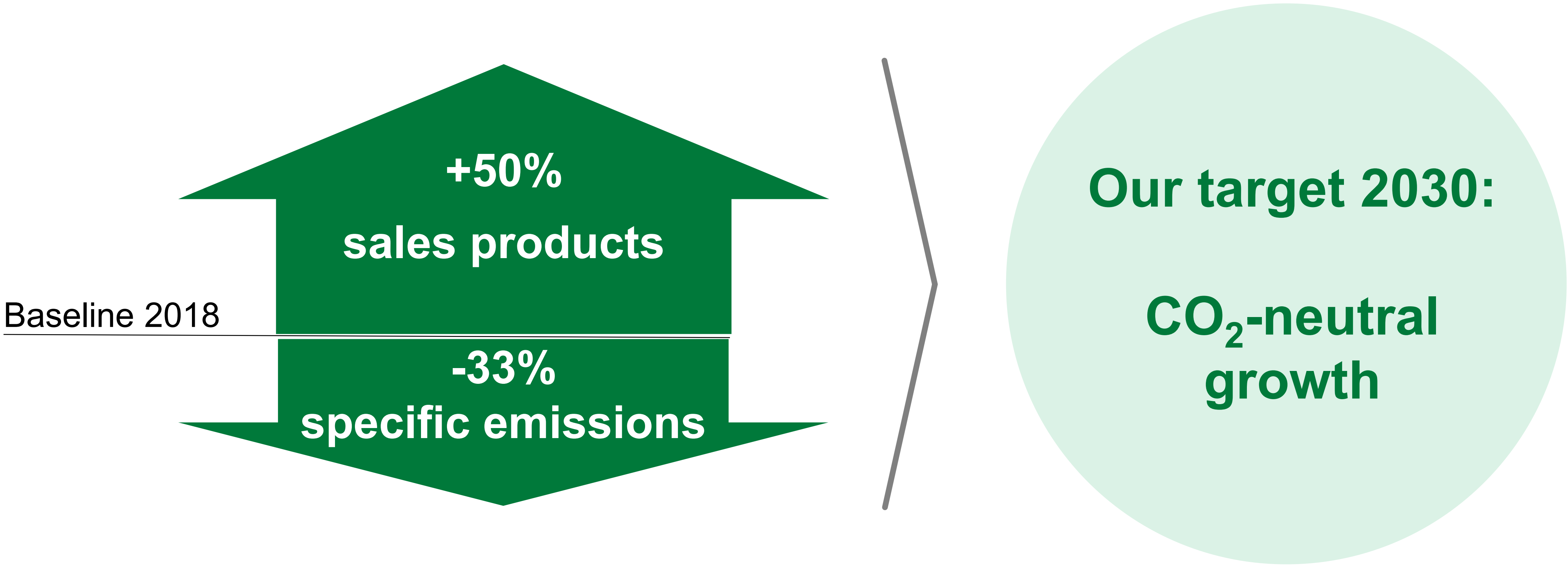
Use CO_2 as a feedstock

Help customers avoid CO_2 (Accelerator products)

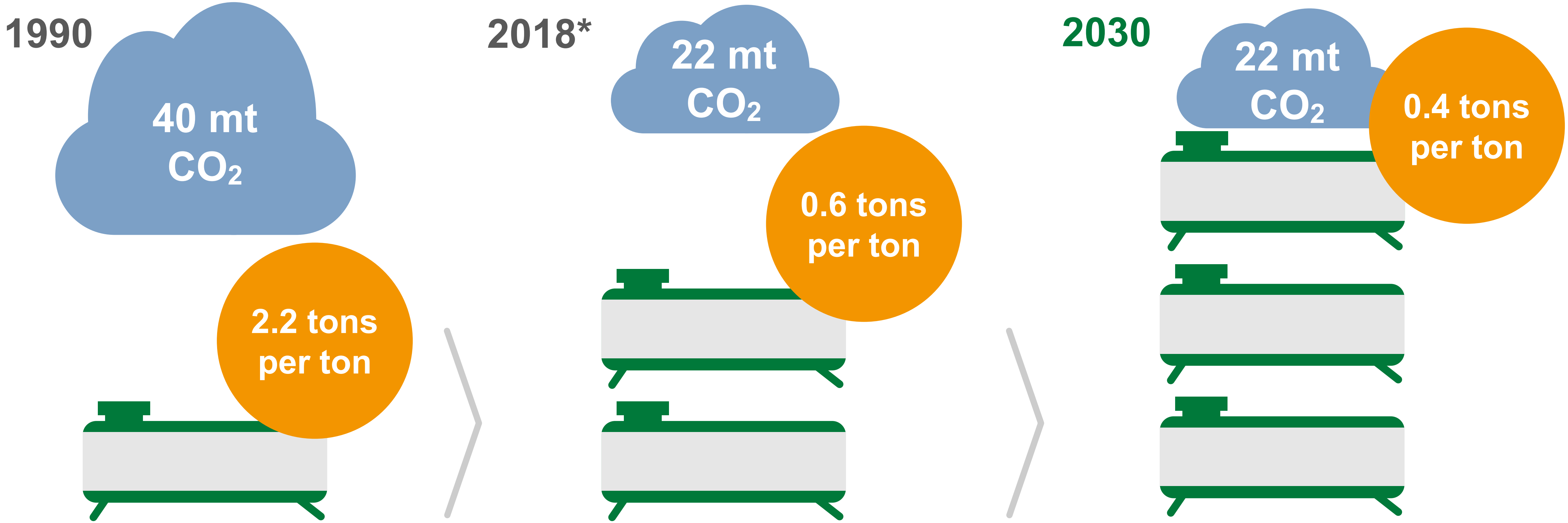
Outlook

BASF
We create chemistry

BASF's new CO_2 emission target



BASF’s new CO_2 emission target

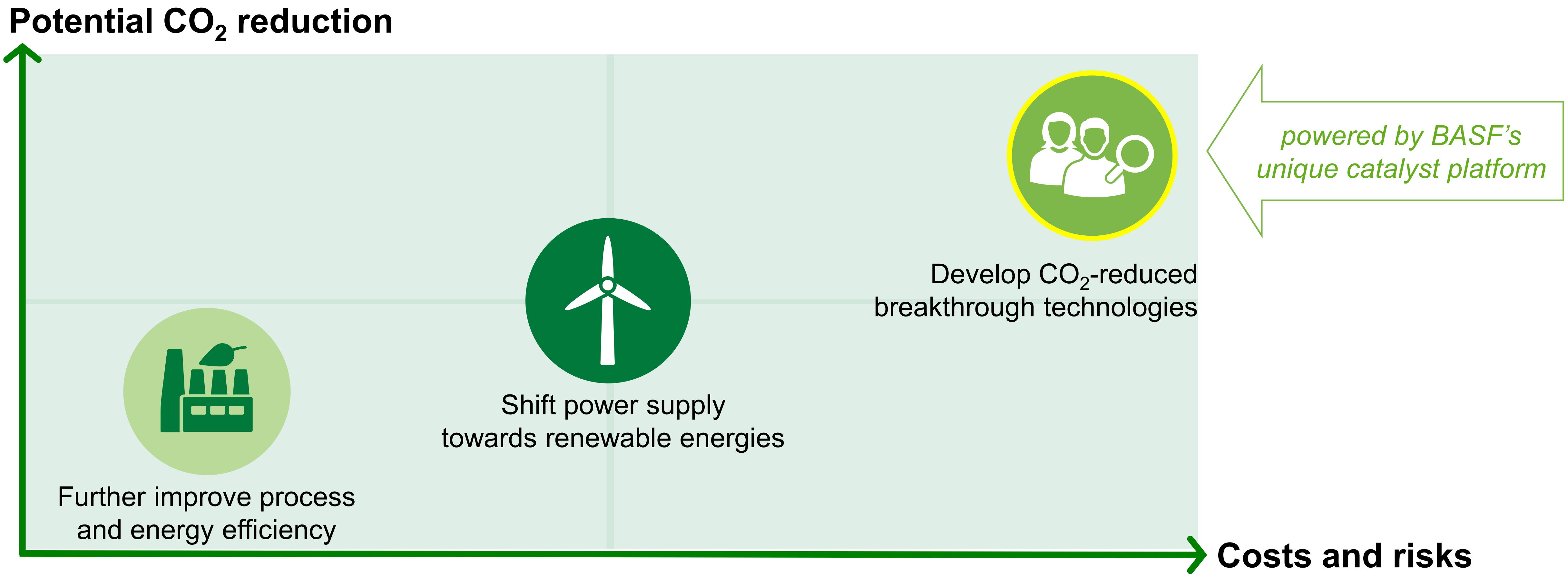


Until 2030, BASF aims to grow its output by 50% without increasing its CO_2 emissions.

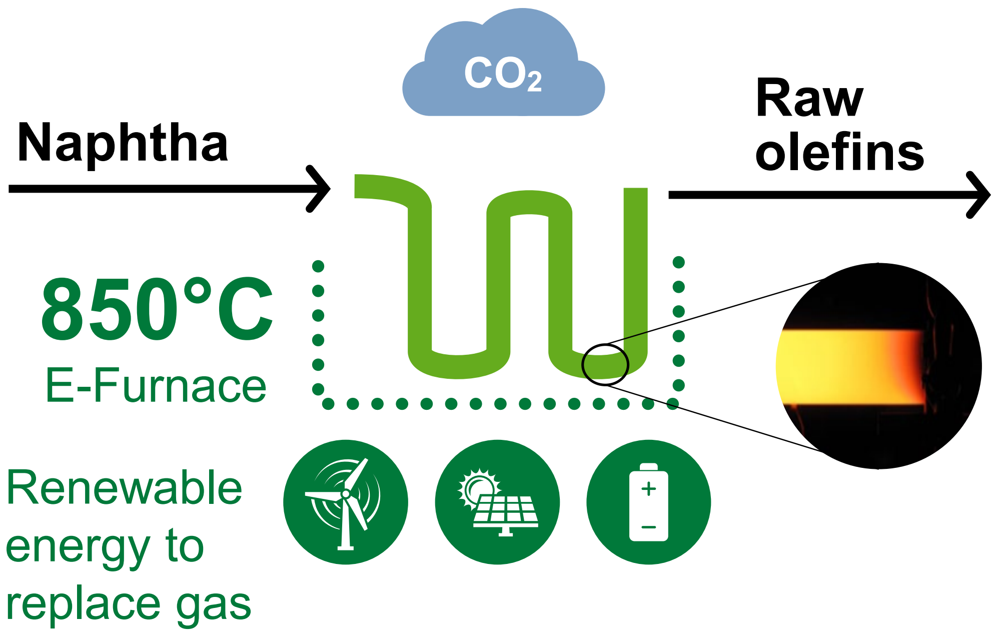
 “mt” = million metric tons, “tons per ton” = metric tons CO_2 equivalents per metric ton sales product * forecast

BASF
We create chemistry

BASF's Carbon Management – our focus today



E-Furnace: New technology for clean high-temperature reactions



Approach:

- Switch cracker coil heating from natural gas to electrical resistance heating, combining high current with low voltage
- Integrate an E-Furnace – to be newly engineered – into the steam cracker in Ludwigshafen

Next milestone:

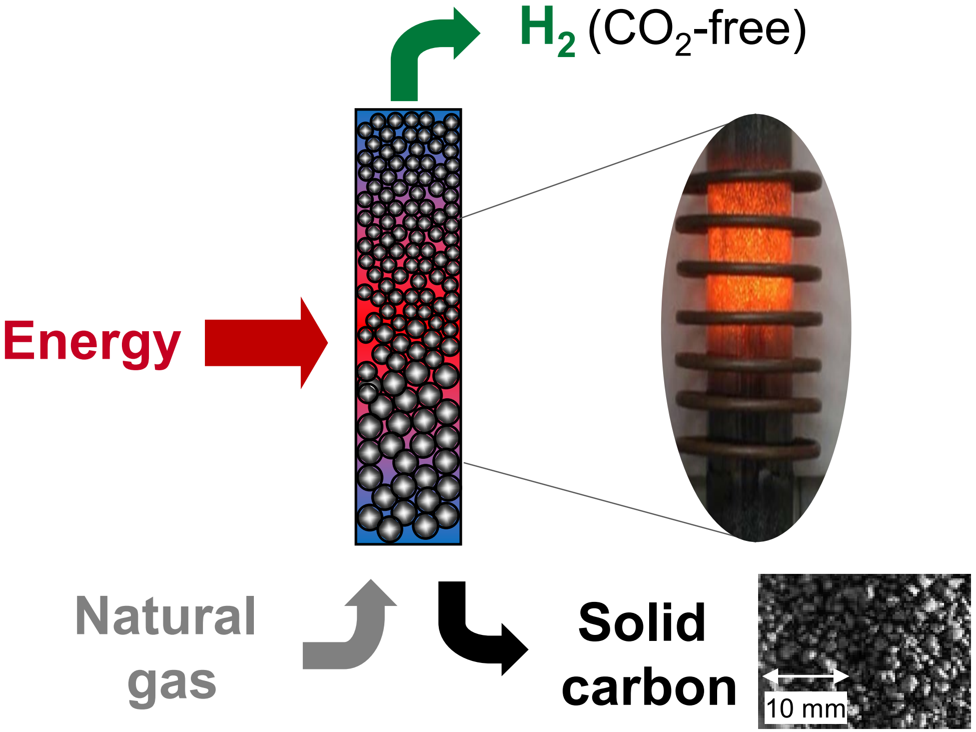
- Proof of material for steam cracker coils, i.e., study interaction of coil alloy with applied electric power

BASF aims to develop the world's first electrical heating concept for steam crackers (1,000°C) within the next five years. This requires the redesign of the entire furnace from the alloy composition to electric connectors and transformers.*

 * Government funding will be necessary due to high technological and commercial risk

BASF
We create chemistry

Methane pyrolysis:
New process for clean hydrogen



Approach:

- Decompose methane (CH_4) into hydrogen and solid carbon via thermal pyrolysis avoiding CO_2 as byproduct
- Design a moving carbon bed reactor that combines chemical reaction and heat integration

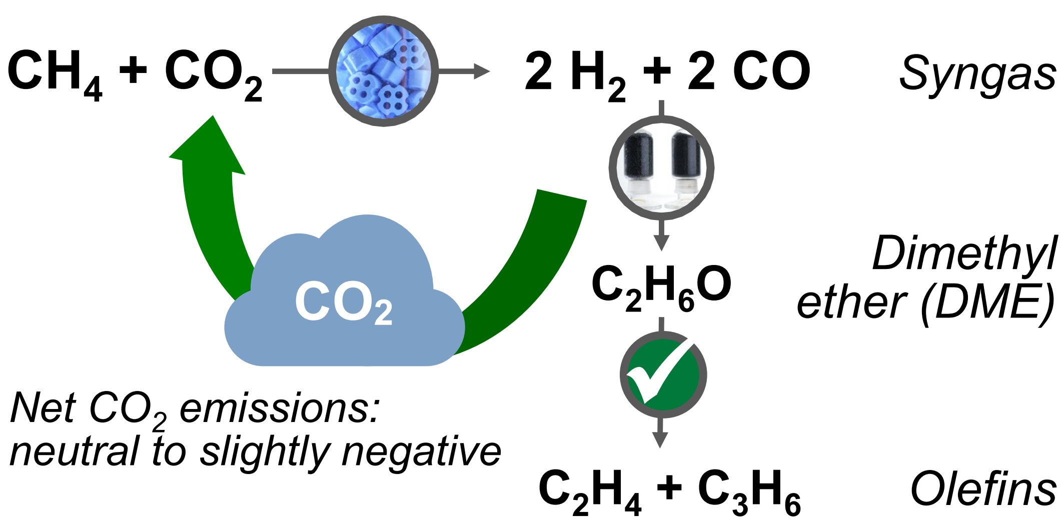
Next milestone:

- Proof of the heating concept, i.e., overcome carbon deposition, inhomogeneous flow and pulsations inside the reactor

BASF is developing a completely new reactor design for the pyrolysis of methane into hydrogen and solid carbon* and is evaluating options to utilize the byproduct solid carbon.

* Government funding will be necessary due to high technological and commercial risk

Dry reforming of methane and direct conversion of syngas to DME: New catalysts for clean olefins



Approach:

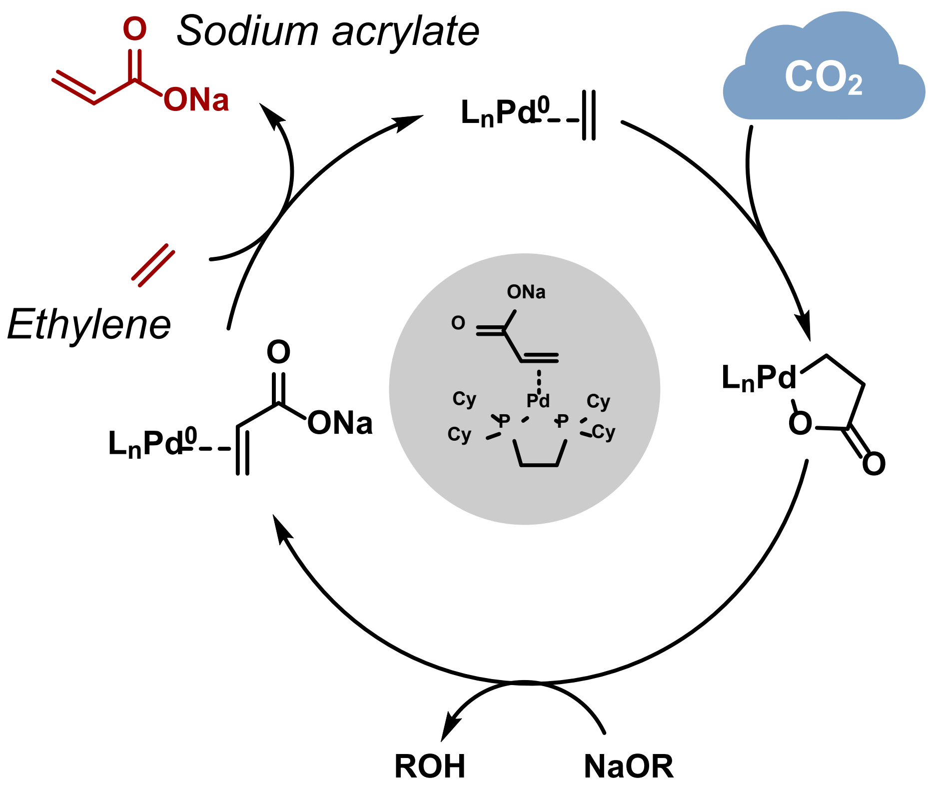
- Switch feedstock for olefins from naphtha to methane
- Produce CO-rich syngas via dry reforming of methane and convert the syngas into dimethyl ether (DME), an established precursor for olefins

Next milestone:

- Production trial for CO-rich syngas and completion of DME upscaling

BASF will commercialize its new generation of catalysts for the dry reforming of methane (planned for 2020) and the direct conversion of CO-rich syngas to DME (planned for 2022) in collaboration with Linde.

CO_2 as feedstock for superabsorbents: New chemistry for using CO_2



Approach:

- Evaluate the thermodynamically favored reaction of CO_2 with ethylene to sodium acrylate, which is the main raw material for superabsorbents
- Switch feedstock for superabsorbents from C3 (propylene → acrylic acid) to C2 + CO_2 (ethylene + CO_2 → sodium acrylate)

Next milestone:

- Catalyst activity and lifetime as well as energy demand for the base regeneration in target range

BASF is developing an industrial process for the catalytic formation of sodium acrylate based on CO_2 and ethylene.

BASF

We create chemistry