R&D Webcast for Investors and Analysts
Speech (including slides)
January 10, 2019

Dr. Martin Brudermüller
Chairman of the Board of Executive Directors
and Chief Technology Officer of BASF SE

The spoken word applies.

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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
We create chemistry

Dear Ladies and Gentlemen,

A warm welcome to our webcast on BASF's Carbon Management and the R&D strategies to reduce CO_2 emissions.

Today, I speak to you in a dual role as CEO and CTO. The importance of innovation for BASF is highlighted by this particular constellation, and also expressed in the purpose of our company: "We create chemistry for a sustainable future." This means that we not only produce chemicals, we also create innovative solutions for the needs and challenges of our customers, building on BASF's unique tradition of innovation power and technological know-how. We are proud of this heritage, and we aspire to be a leader in innovation in future as well.

Therefore, we run an innovation platform that is unrivaled in the chemical industry with regard to competencies, resources and diversity.

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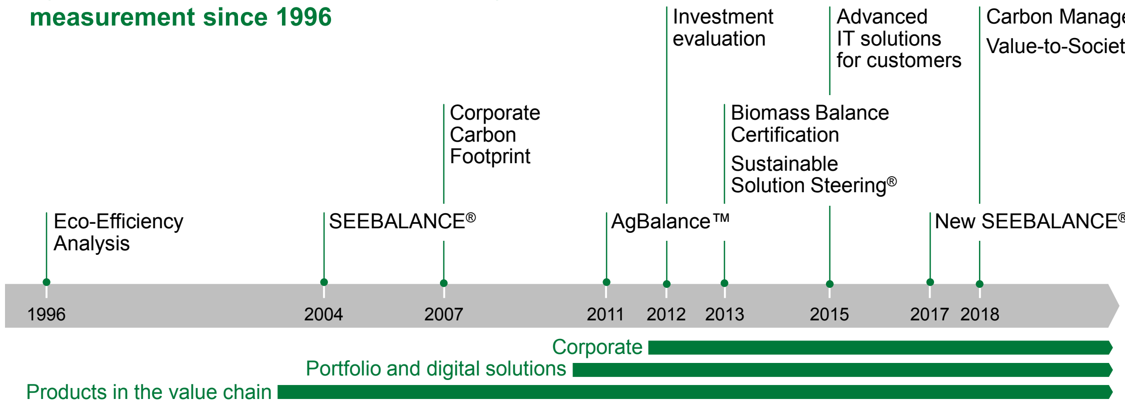
BASF as a pioneer in developing tools for sustainability performance measurement

Systematic application of sustainability measurement since 1996



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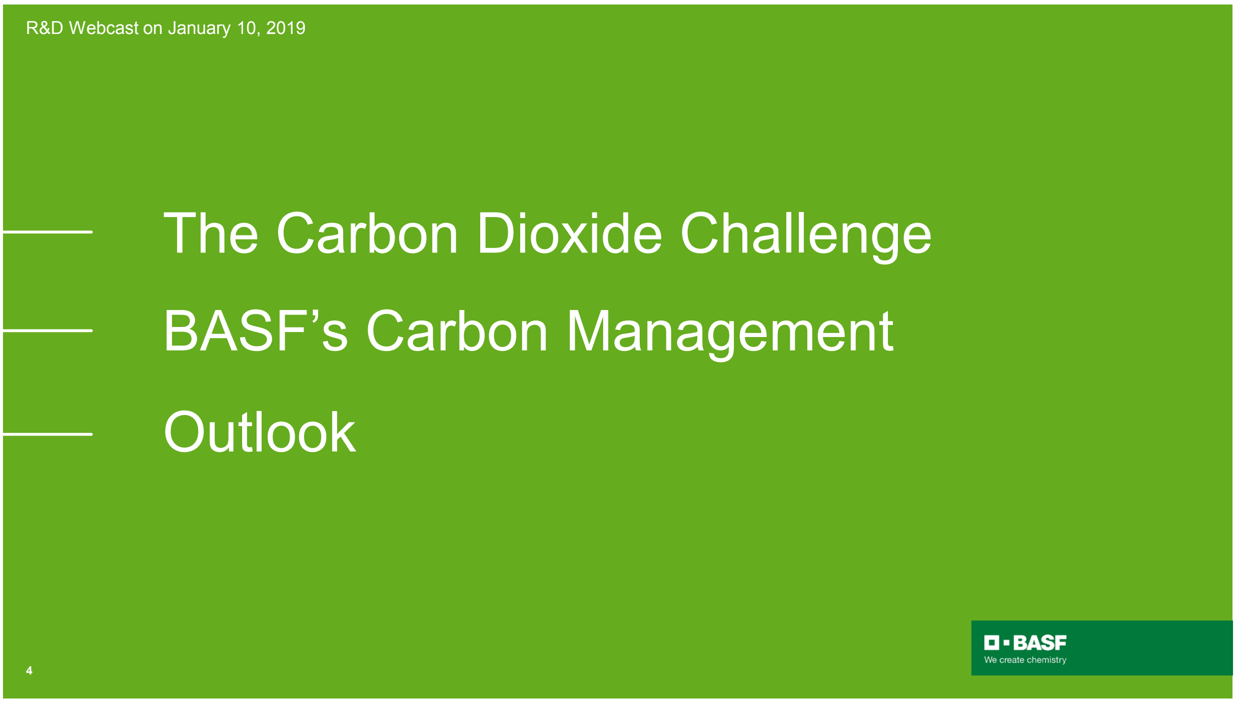
BASF is a pioneer in sustainability in the chemical industry. More than twenty years back, we have developed the eco-efficiency analysis that enabled, for the first time, the assessment of contributions from chemical products and solutions to a sustainable development. This method was further enhanced in the SEEBALANCE and AgBalance tools.

To the best of our knowledge, BASF is the only industrial company that publishes a comprehensive corporate CO_2 footprint since 2008, including the supply chain as well as the customer industries.

Our biomass balance approach is just another innovation by BASF, replacing fossil resources right at the start of our Verbund value chains with bio-based raw materials. Thus, customers are able to buy any BASF product as certified bio-based without any new qualification or approval. Once more, the flexibility of our Verbund system is demonstrated here in the context of sustainability.

We are convinced that a company’s business activities have to be assessed holistically, including positive as well as negative impacts on society and the environment. Therefore, we have developed the Value-to-Society methodology to assess all the different factors in common monetary terms. We strive to further enhance our positive contributions to society and minimize the negative impacts of our business activities. In brief: We want to increase our Value-to-Society.

Sustainability is an integral part of BASF. It is firmly anchored in our investment decisions, portfolio management and innovation. With our new strategy, we have set ourselves ambitious non-financial goals. One of these goals is the focus of today’s event: greenhouse gas emissions and BASF’s Carbon Management.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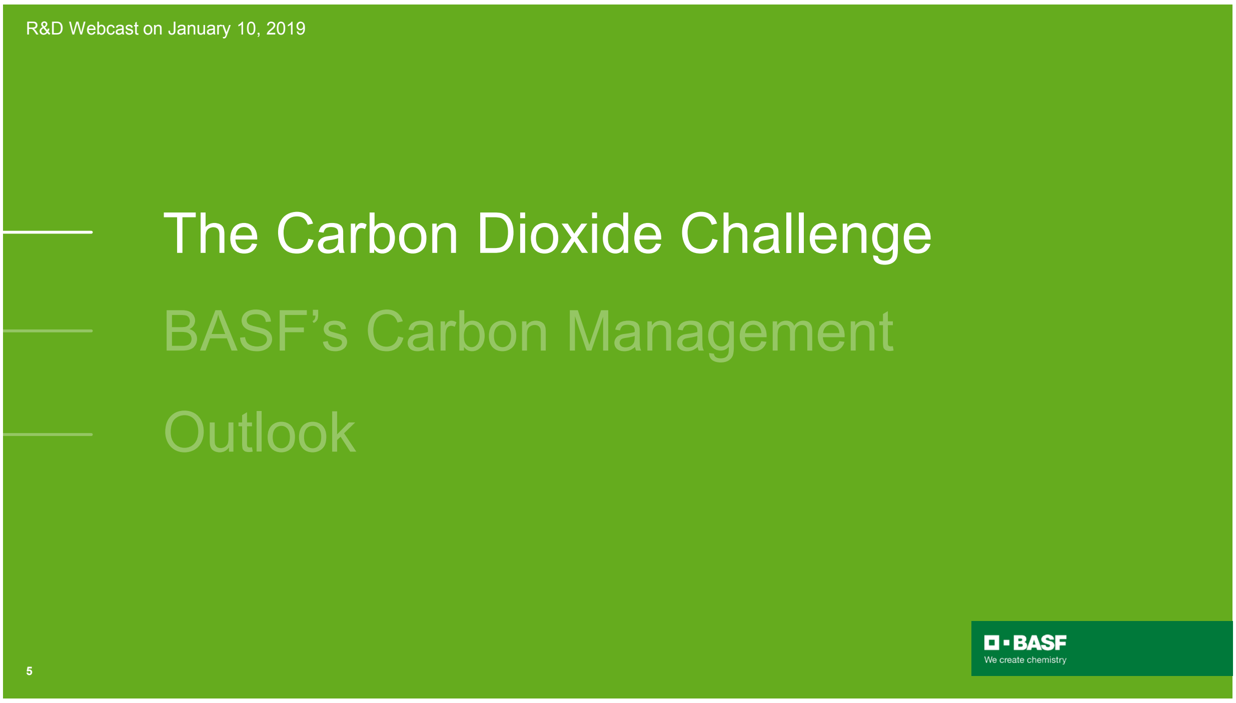
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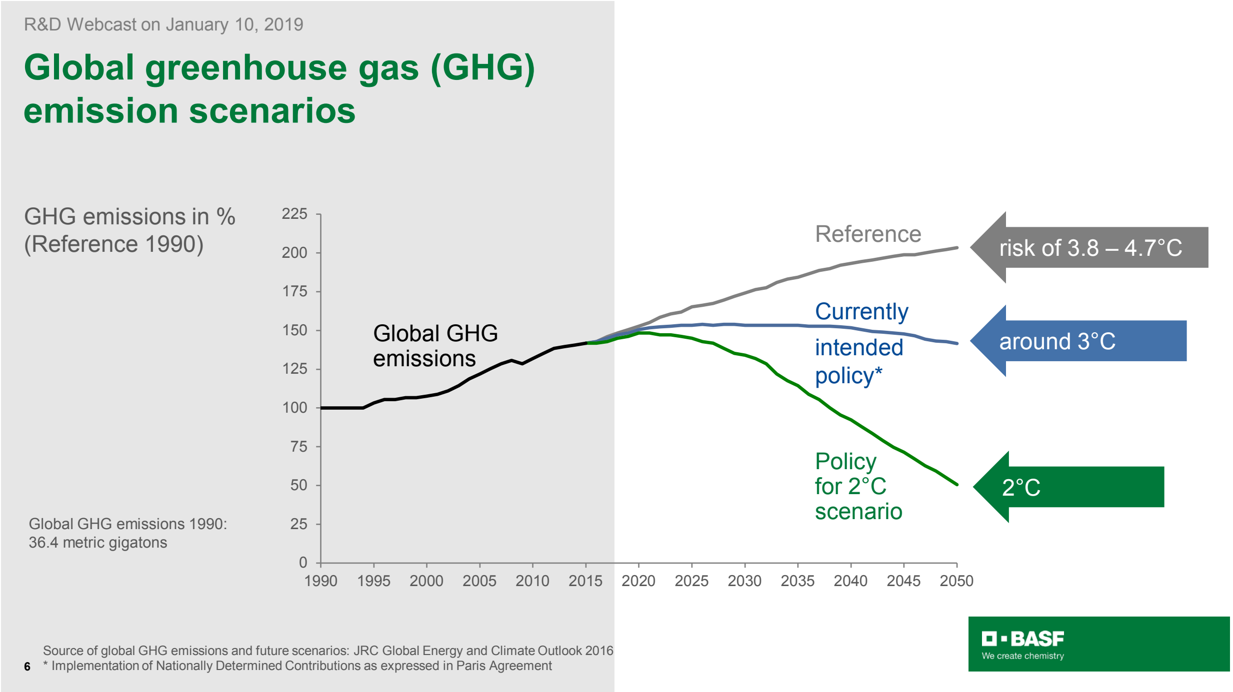
Let’s start with a look at global greenhouse gas emissions and BASF’s position in this perspective. In the main part of my talk, I will present our Carbon Management to you. Then, let us take a look at the future of carbon resources.

Global greenhouse gas emissions and the associated man-made climate change are among the most pressing challenges of our time.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Global greenhouse gas (GHG) emission scenarios
GHG emissions in %
(Reference 1990)
225
200
175
150
125
100
75
50
25
0
1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
Global GHG emissions
Reference
Currently intended policy*
Policy for 2°C scenario
risk of 3.8 – 4.7°C
around 3°C
2°C
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
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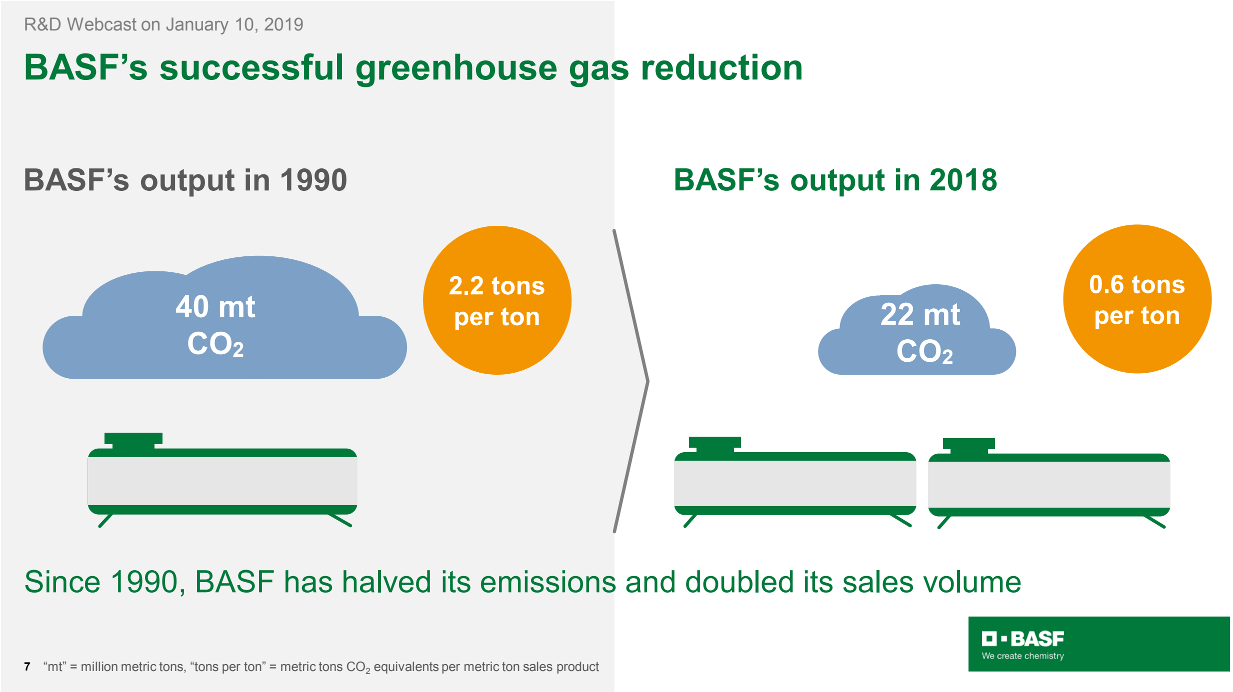
On this slide, global greenhouse gas emissions are depicted on an indexed scale with the emissions of the year 1990 as a reference.

If the development of the last 30 years continues, our planet will warm up by more than 4°C. I will not talk about the consequences today as we are all well aware of the situation.

Based on this awareness, politicians have reached an agreement on global climate goals at COP21 in Paris. The subsequent national commitments of the subscribing countries will, if executed, lead us to the blue graph in the diagram. You will see immediately that this is not sufficient as the resulting global warming still amounts to 3°C.

To stay at or below 2°C, the world has to stick to the emission scenario depicted in green. You see how large the difference is in comparison to the existing commitments.

One general remark: When we talk about CO_2, we actually mean CO_2 equivalents, always including other greenhouse gases.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BASF’s successful greenhouse gas reduction
BASF’s output in 1990
40 mt CO_2
2.2 tons per ton
BASF’s output in 2018
22 mt CO_2
0.6 tons per ton
Since 1990, BASF has halved its emissions and doubled its sales volume
7 “mt” = million metric tons, “tons per ton” = metric tons CO_2 equivalents per metric ton sales product
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BASF has already shown that greenhouse gas emissions can indeed be avoided on a large scale: Since 1990, we have doubled our production volumes and nevertheless cut our greenhouse gas emissions in halves. This means that we have reduced our emissions from 2.2 tons of CO_2 equivalents per ton of sales product in 1990 to 0.6 tons in 2017, a reduction of more than 70%.

We are proud of this achievement, and I think we have set an impressive benchmark. The flipside of the coin is that further improvements are increasingly difficult to achieve due to technological barriers and limitations imposed by the laws of nature.

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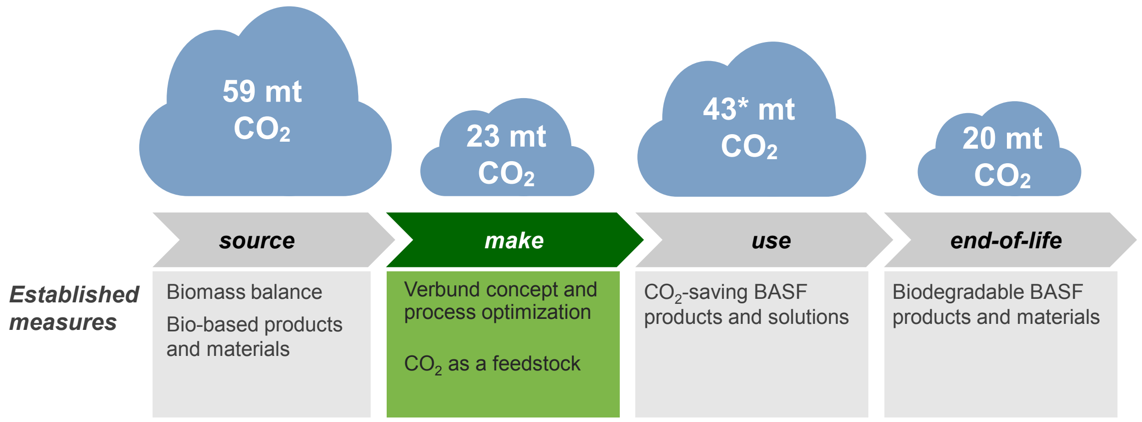
BASF's carbon footprint 2017 and established measures



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

8 "mt" = million metric tons * thereof 36 mt from BASF's oil and gas business

Reducing specific greenhouse gas emissions by more than 70% was a pioneering achievement. However, this does not change the fact that BASF still is a large greenhouse gas emitter. We make this very transparent, again as a pioneer in this field. For 11 years, BASF has been publishing a comprehensive corporate carbon footprint with a holistic scope, including the sourcing of raw materials as well as our customers' processes and the disposal of the products at the end of their service life. As an example, you can see our corporate carbon footprint of the year 2017 on this slide. What is more important, we do not only analyze this annually, we also take action in all steps of the value chains. In doing so, we create innovative solutions such as, for example, the aforementioned biomass balance approach or new biodegradable products. At BASF, sustainability has always been a driver for innovation.

The emissions generated in our own production processes, called "make" on this slide, could be reduced because we continuously optimized our "Verbund." This included the utilization of CO_2 as a chemical raw material. At our Ludwigshafen site, we convert more than 400,000 tons of CO_2 to a sales product that you all know from your daily life. I will tell you the story later in my presentation.

We have realized that the successful measures of the past will not be sufficient in the future. Our assets are highly optimized, we are unable to further reduce emissions significantly from here. Therefore, any growth of production volumes will inevitably lead to increasing emissions.

However, we want to remain the leading chemical company in the future, and that means to grow our production volumes further and enhance our performance. At the same time, we want to remain a pioneer in climate protection, and we will therefore need to break new ground to overcome this dilemma.

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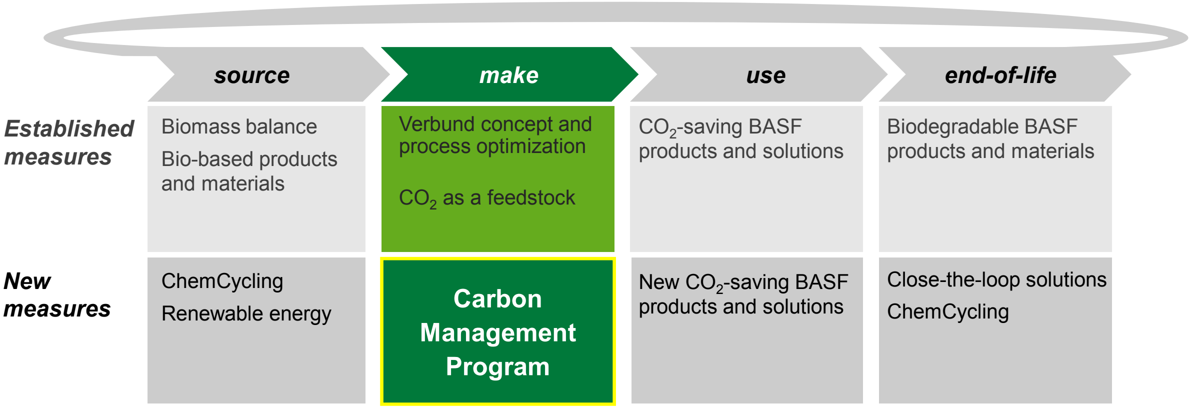
BASF's Carbon Management aims to decouple growth from CO_2 emissions



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“Carbon Management” is how we call our new path forward to reconcile production growth and climate protection. It will help us to even further reduce the specific CO_2 emissions per ton of sales product. It includes the Carbon Management research program that targets fundamentally new, CO_2-efficient production technologies.

In addition, we also look at our raw material mix, and we develop recyclable and biodegradable products together with our customers. To “close the loop,” we have started the co-called “ChemCycling” project that converts waste streams into raw materials for our Verbund.


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BASF's Carbon Management
Avoid CO_2 on site
Use CO_2 as a feedstock
Help customers avoid CO_2 (Accelerator products)
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So, what does Carbon Management mean for BASF? Various concepts for the reduction of CO_2 emissions are discussed. Many of them appear questionable to us when we consider their energy requirements.

From our point of view, avoiding the generation of CO_2 directly in the chemical processes has to be in focus. Therefore, this is the first priority in our Carbon Management program.

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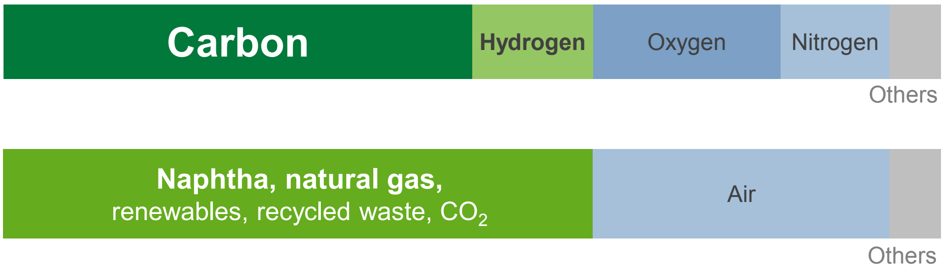
BASF's sales products in a nutshell

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."

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Why do we talk about "Carbon Management" and not about "decarbonization"? Simply because we cannot talk about emissions and the efficiency of our production without talking about our products.

Today, you have the rare occasion to see "the" BASF product. Of course, it does not exist, but the average chemical formula is depicted on this slide, together with the corresponding composition as weight distribution of the chemical elements per kilogram.

This average product contains 50% of carbon, another 21% of hydrogen. Both elements stem from naphtha and natural gas as well as, to a small share, renewable raw materials. Some of the carbon is even extracted from the CO_2 that BASF emits, I will come to this later.

Oxygen and nitrogen account for around 30%. The raw material for both is the air.

This slide exemplifies that the chemical industry cannot be "decarbonized." Chemistry is about the conversion of carbonaceous materials, and the vast majority of materials we use every day contains carbon. Not using carbon is not an option, but we can manage it, we can do Carbon Management.

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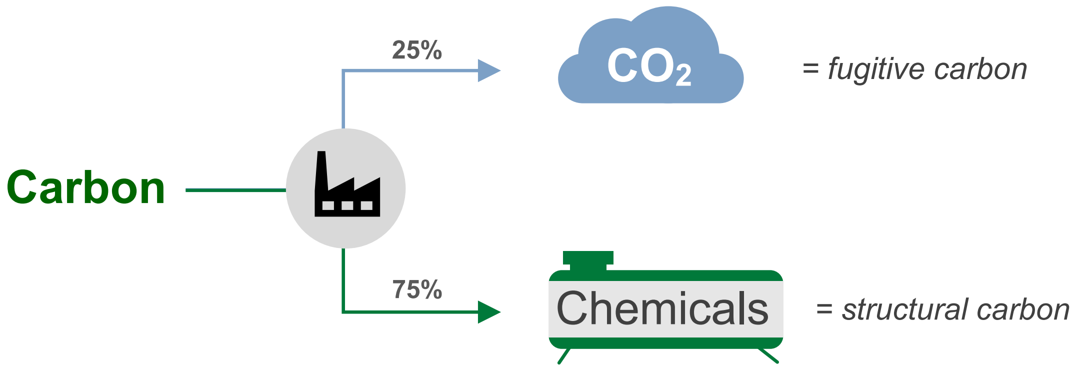
BASF's Carbon Management targets fugitive carbon



A Verbund is the ideal setup for Carbon Management.

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Management needs transparency. So, let's look at BASF's carbon balance. 75% of the carbon is converted to products, we call this "structural carbon."

Unfortunately, chemical conversions are very energy intensive overall due to the laws of nature. As a consequence, 25% of the carbon is consumed for the necessary process energy and thereby converted to CO_2, we call this "fugitive carbon."

Please note that we have already taken out the discontinued oil and gas operation from this calculation.

Carbon Management targets the fugitive carbon. Besides the environmental burden, every ton of CO_2 emissions also means a loss of value for BASF.

It is not possible to minimize losses more efficiently and make better use of byproducts than in the BASF Verbund. The Verbund is highly efficient for the management of chemical value chains and therefore also ideal for successful Carbon Management.

By the way, we also address the structural carbon, e.g., with our new ChemCycling approach.

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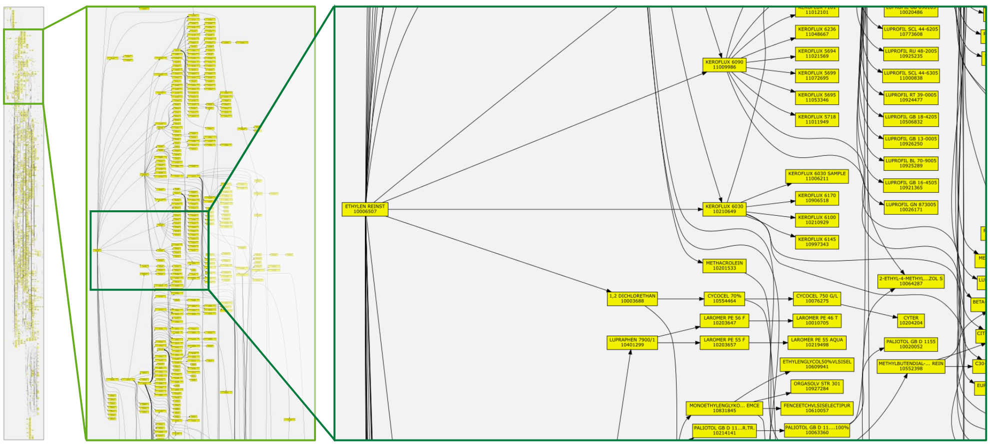
BASF's Verbund avoids CO_2

The full picture – for ethylene



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We steer our Verbund with the support of our proprietary Verbund simulator. It mirrors every step in our value chains and connects all products in a network where you can drill down to the individual products and their raw materials and energy profile. This allows us to steer the production very precisely.

As an example, you can see an excerpt of the network here. Already quite complex, it only describes the value chains based on ethylene, a small part of our Verbund.

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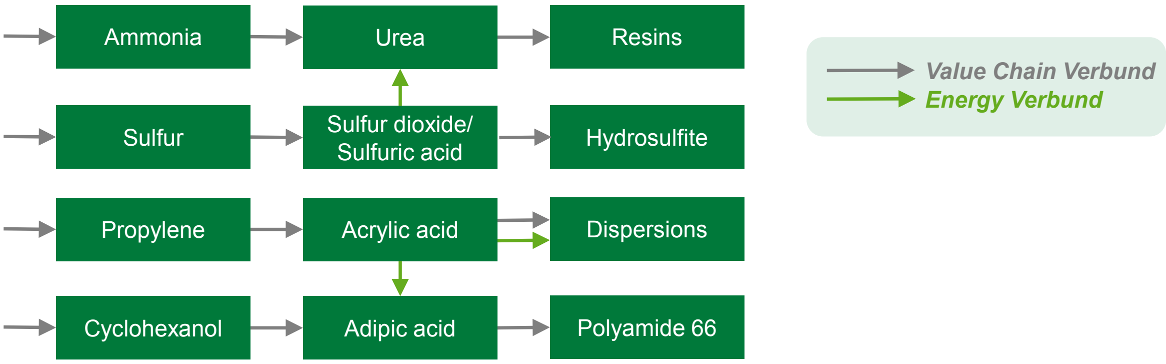
BASF's Verbund avoids CO_2

Synergies among selected value chains



A Verbund optimizes the use of products and utilities.

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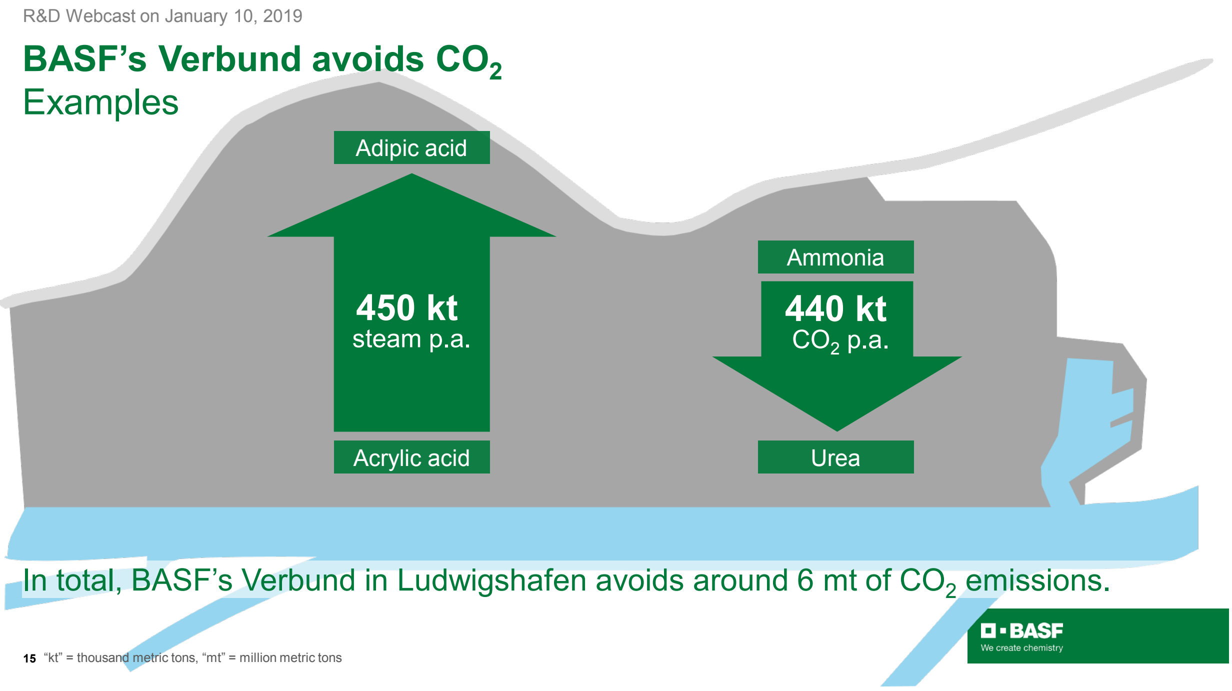
Let me show you some examples for the efficiency gains of our Verbund. This slide shows a simplified illustration of some Verbund value chains in the horizontal rows. Some of these value chains are also run by other chemical companies in an integrated way. However, the unique integration in BASF's Verbund allows for huge optimization across the value chains.

As an example, burning sulfur for the synthesis of sulfuric acid generates steam – as this chemical reaction releases energy. The steam from this plant is utilized in the urea plant next door as the synthesis of urea consumes energy. Thus, we do not only avoid CO_2 emissions through efficient processes, we also reduce emissions through the smart integration of different processes. This would be difficult to steer in a simple Chempark with several independent companies.

To sum it up: BASF's production Verbund perfectly minimizes the consumption of raw materials and energy and the generation of side products.



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BASF's Verbund avoids CO_2
Examples
Adipic acid
450 kt
steam p.a.
Acrylic acid
Ammonia
440 kt
CO_2 p.a.
Urea
In total, BASF's Verbund in Ludwigshafen avoids around 6 mt of CO_2 emissions.
15 "kt" = thousand metric tons, "mt" = million metric tons
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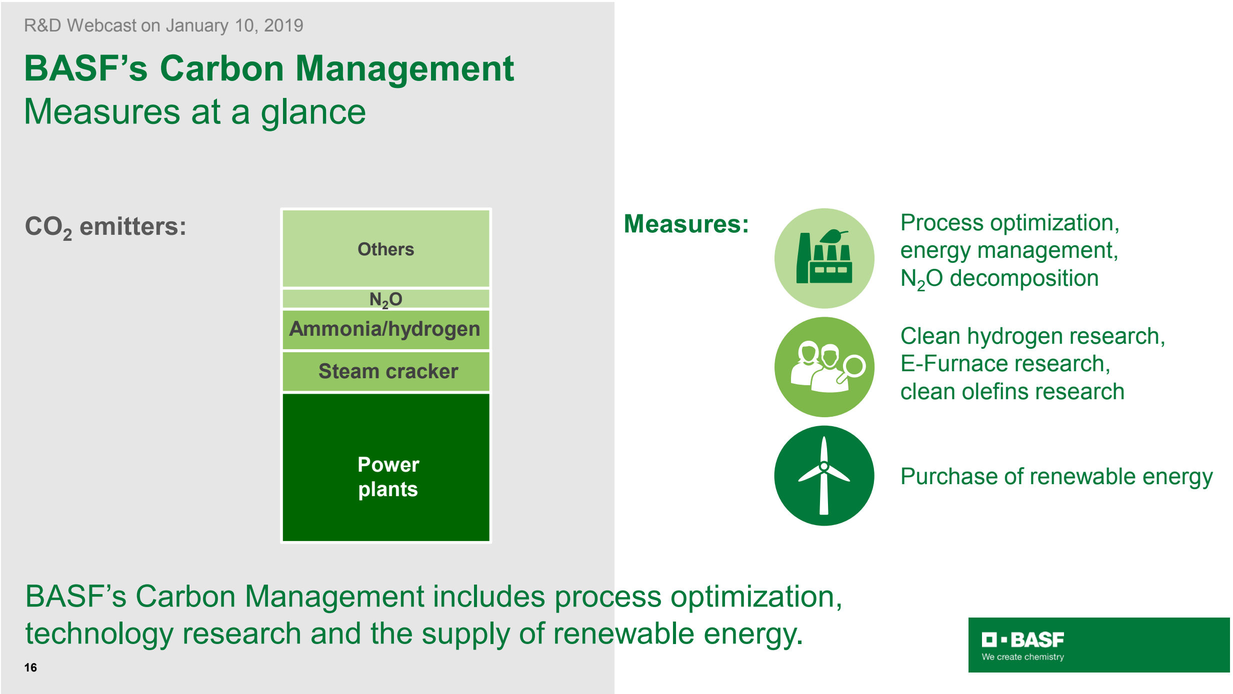
Ludwigshafen is our largest Verbund site. Here, we make use of approximately 10 million tons of excess steam per year instead of wasting it. Our acrylic acid plants, for instance, provide the necessary steam for the plant where adipic acid is synthesized, an important intermediate for the production of polyamides.

To produce urea, you need nitrogen, carbon and oxygen in the molecule. Nitrogen stems from the precursor molecule ammonia. Hardly believable, but carbon and oxygen come from CO_2! In the urea plant, we overall utilize roughly 440 kilotons of CO_2 per year as a raw material that are emitted by the ammonia plant as an off-gas.

By the way, urea is the only large scale chemical product that can be made from CO_2 with competitive economics and acceptable energy consumption.

The Verbund site in Ludwigshafen avoids approximately 6 million tons of CO_2 emissions per year through the clever integration of plants. Nevertheless, it still is a large emitter of CO_2 with more than 8 million tons per year. Therefore, we will not rest on our laurels.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BASF’s Carbon Management
Measures at a glance
CO_2 emitters:
Others
N_2O
Ammonia/hydrogen
Steam cracker
Power plants
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.
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So, let’s have a look at the large CO_2 emitters at our Verbund site in Ludwigshafen.

Almost half of the emissions are generated in our power plants – we have three of them, very efficient combined heat and power plants, but still the largest source of emissions. The steam cracker and the ammonia production emit approximately 1 million ton of CO_2 per year each. Beyond this, there are many others, as diverse as our bundle of measures to tackle the emissions.

Briefly outlined, our Carbon Management is based on three pillars:

- Firstly, we continuously optimize our Verbund.
- Secondly, we invest in the development of new, CO_2-efficient processes.
- And thirdly, we will gradually shift our external energy supply to renewable sources.

Our growth strategy will inevitably lead to higher CO_2 emissions if we do not counteract with the described measures. Only with our effective and efficient Carbon Management, we will achieve CO_2-neutral growth.


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Avoid CO_2 on site
Use CO_2 as a feedstock
Help customers avoid CO_2 (Accelerator products)
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There is another obvious idea that is widely discussed: Why not take the CO_2 emissions back to the production of chemicals as a raw material? At a first glance, this idea sounds very good. However, I would like to show you why this option is fairly limited and only makes sense in a very few cases.

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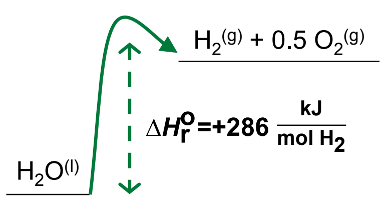
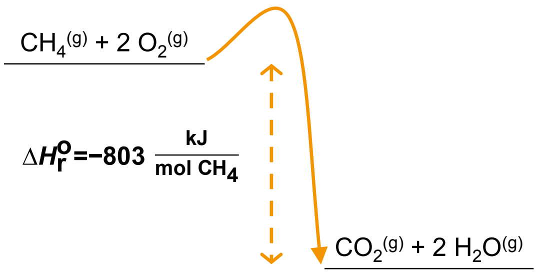
Chemistry is energy

Thermodynamics of water electrolysis



Thermodynamics of CO_2 formation



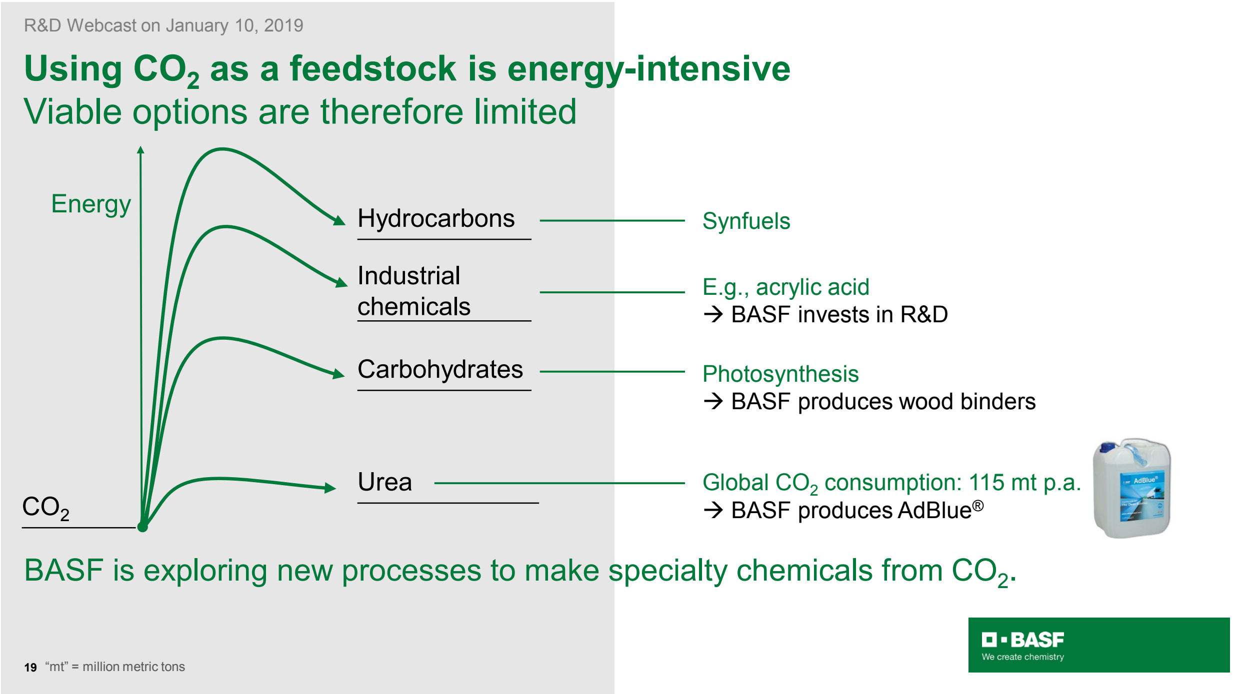
Water and carbon dioxide are very stable molecules.
Using them as chemical raw materials is very energy-intensive.

No worries, this slide looks fiercer than it really is, but I have to get a little bit more scientific during the next minutes.

You can see two energy diagrams: for the electrolysis of water, H_2O, on the left side, and for the combustion of methane to CO_2 on the right side. Low energy, lower position in the diagram; high energy, upper position. Chemical reactions from left (raw materials) to right (products).

Water and CO_2 are extremely simple and stable molecules. This is why they are everywhere in nature. Casually speaking, the atoms in these molecules are very happy, no drive to change for them as they are on a low energy level in these molecules.

If you want to activate water or CO_2 for chemical reactions, if you want to use them as raw materials, you have to invest a lot of energy. Unfortunately, this is thermodynamics, these fundamental laws of nature cannot be overcome by intelligent synthesis pathways or clever catalysts. Just think of the Bunsen burner in your chemistry lessons at school: Chemistry needs energy.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Using CO_2 as a feedstock is energy-intensive
Viable options are therefore limited
Energy
CO_2
Hydrocarbons
Industrial chemicals
Carbohydrates
Urea
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.
19 "mt" = million metric tons
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Using CO_2 as a raw material for chemical reactions is extremely energy-intensive. There is one prominent exception: urea, a molecule with a structure similar to CO_2. As already mentioned some minutes ago, this reaction is commercially exploited on a large scale for many years already.

With 115 million tons, almost the entire amount of the 120 million tons of CO_2 globally used as a chemical raw material is dedicated to the production of urea. BASF is an important supplier of urea, for example under the brand name "AdBlue" for diesel exhaust gas treatment.

Nature's photosynthesis is very successful in converting CO_2 to sugars, carbohydrates, wood and others. This already is more energy-intensive than the urea production, but still far less energy-intensive than the synthesis of industrial chemicals or synthetic fuels from CO_2.

Nature has brought the necessary, very complex biochemical systems for the photosynthesis of biomass to perfection. We don't do this at BASF, human technology cannot compete with nature here. At least, BASF produces binders that enable the utilization of wood and other natural fibers as a versatile material.

Producing industrial chemicals or even synthetic fuels from CO_2 would only make sense, if large amounts of CO_2-free energy were available at very low costs. Run with fossil energy, these processes would generate as much as or even more CO_2 than they use as raw material. This would not make sense at all. Therefore, BASF only pursues research projects for a few selected synthesis pathways starting from CO_2.

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

CO_2 emissions in Germany 2017 | **Chemical production in Germany 2017**

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

 "mt" = million metric tons

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Let's assume for a moment that the energy challenge has been overcome, and there is sufficient low-cost CO_2-free energy available. Let's also assume we would be able to convert CO_2 to hydrocarbons and thus serve the entire demand for carbon of the chemical industry with CO_2. What would be the consequences for the world's CO_2 emissions?

For instance, CO_2 emissions in Germany currently amount to 905 million tons per year, but the carbon demand of the German chemical industry corresponds to not more than 48 million tons of CO_2, only 5%. This means that channeling back CO_2 emissions as a raw material into the chemical industry would not only be energy-intensive, it would also not move the needle with regards to emission reduction and climate change mitigation.

Instead, we must avoid emissions on a large scale in every aspect of our daily life: transportation, housing, food supply and many more. This needs innovation, breakthrough innovation with products and solutions from chemistry.

In addition to this, chemical industry, of course, has to contribute its share. We have to develop entirely new production processes that avoid CO_2 emissions on a large scale. BASF is breaking new ground with its pioneering Carbon Management research program.

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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)

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To look at our activities more comprehensively, I would like to cast a spotlight on those BASF products and solutions that particularly contribute to a sustainable development at our customers. We call them “Accelerators,” they are the category of outperformers in our portfolio segmentation tool “Sustainable Solution Steering.”

Today, I would like to briefly present two Accelerator examples to you. How do they help our customers to avoid CO_2 emissions in their applications?

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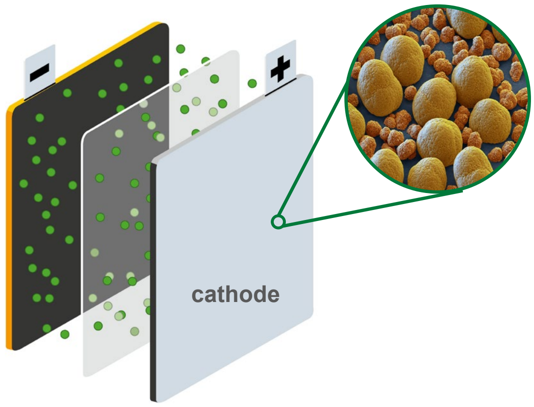
CO_2-saving innovative solutions

Mineral-based in-situ foam: Cavipor®

Enabling e-mobility: Cathode active materials



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Housing and individual transportation are two areas of our lives with very high CO_2 emissions associated to them.

For decades, no other company was as innovative as BASF in the area of insulation materials. Our insulation materials have an excellent CO_2 footprint across the product lifecycle.

Today, I am proud to introduce “Cavipor” to you, our brand-new mineral insulation material: insulation performance equal to expanded polystyrene, very good flammability rating, hydrophobic, open for vapor diffusion, sound-absorbing. Cavipor is delivered as a suspension to the construction site, and is then foamed in-situ with pressurized air into cavities of a building’s shell. When dry, the foam contains more than 80% of inorganic materials such as, for example, gipsum, and may therefore be disposed of as normal demolition rubble at the end of its service life.

The transport sector is BASF’s most important customer industry. This sector is responsible for 14% of the global greenhouse gas emissions. Electromobility, combined with renewable energies, can reduce CO_2 emissions significantly. To achieve this, high-performance batteries are pivotal, and batteries are pure chemistry.

BASF is very active in this development, and we are present in the growing markets with innovative cathode active materials that determine the capacity and performance of a Lithium-ion-battery. The art is in the fine balance of the chemical composition and in the layering and doping technologies in order to achieve fast and deep lithium release or charging. We have set ourselves ambitious goals: By 2025, we want to double the range and the lifetime of the batteries while cutting costs and size in halves and reducing charging times by 75%.


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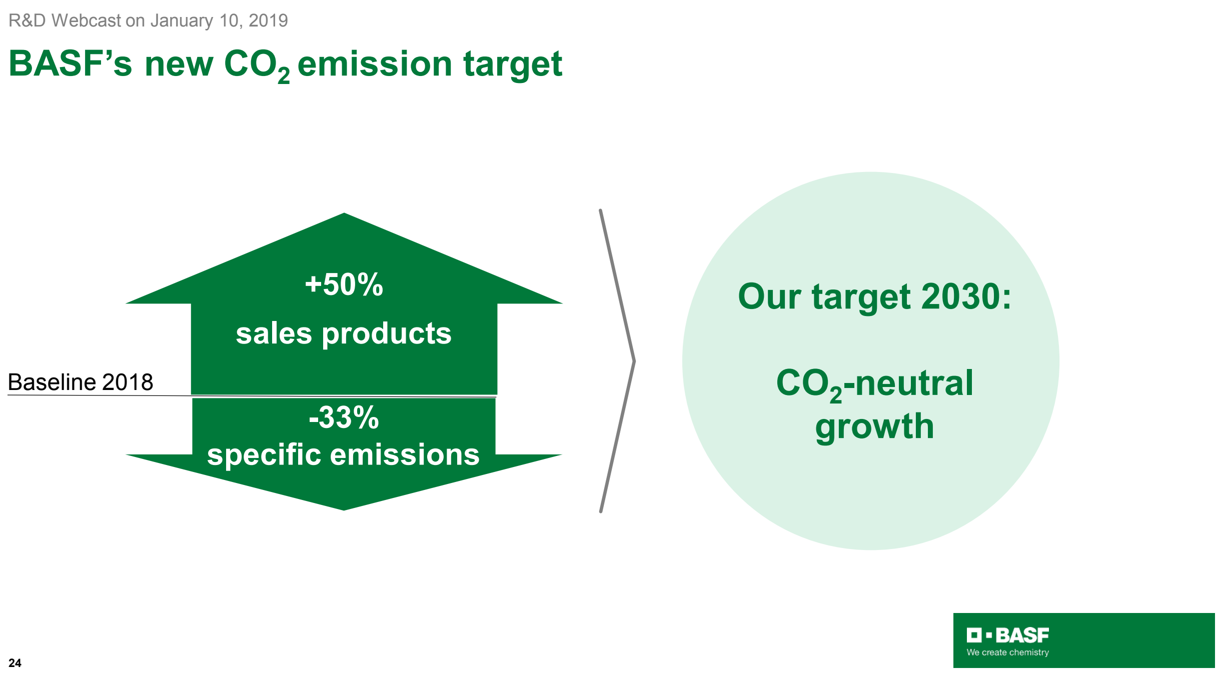
So far, we have talked about climate protection and the necessary Carbon Management. I have elaborated on the key challenge to avoid CO_2 emissions on a substantial scale.

In the outlook, I would now like to present BASF's new climate protection goals to you and four specific projects of our Carbon Management program.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BASF's new CO2 emission target
+50%
sales products
Baseline 2018
-33%
specific emissions
Our target 2030:
CO2-neutral growth
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It is our ambition to be the leading chemical company, and to continue to set the pace in the industry. We want to further increase our production volumes. In July 2018, for instance, we have announced the planned investment into a new Verbund site in Guangdong, China.

We want to grow, but this growth shall be CO_2-neutral. Despite our growth, we strive to keep our CO_2 emissions at the current level. This is very ambitious as it means further reducing specific emissions significantly at our already highly optimized production sites. We are indeed confident to reduce specific CO_2 emissions by one third again and thus offset a production volume growth of up to 50% until 2030.

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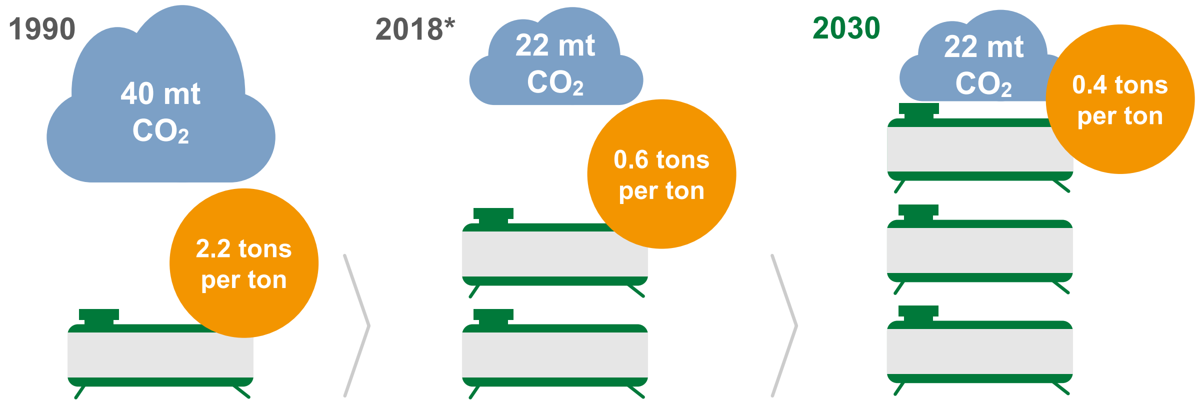
BASF’s new CO_2 emission target



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

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

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In the past, BASF has succeeded in doubling its production while cutting emissions into halves. We have significantly optimized our assets, and meaningful investments were necessary to do so.

Our new goal is very ambitious because already highly optimized assets serve as the baseline. We will mainly reach this goal through further process optimization and the procurement of renewable energy. However, we are aware of the limitations of these measures in the long term. Therefore, we work on breakthrough process innovations to have additional options to further reduce CO_2 emissions beyond 2030.

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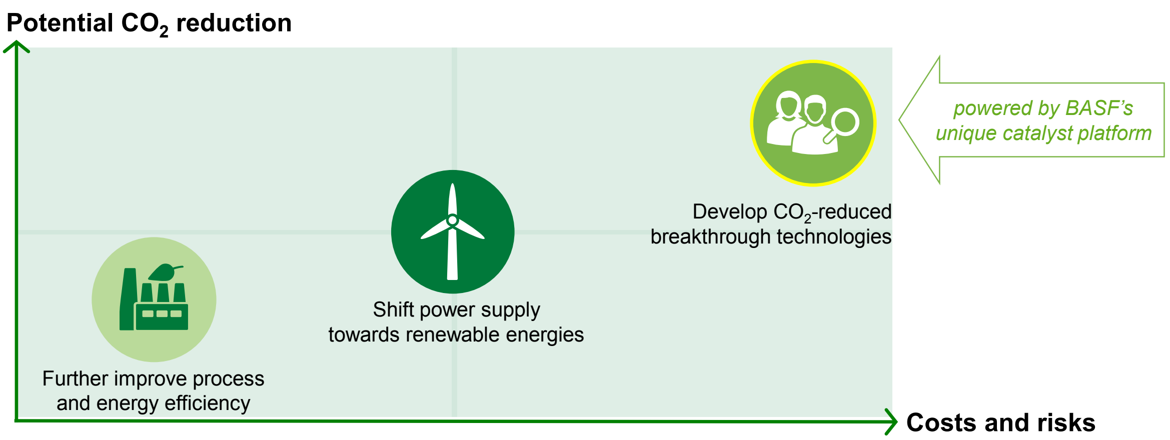
BASF's Carbon Management – our focus today



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The broad portfolio of measures that I have just mentioned helps us diversify the chances of success to achieve our emission reduction goal.

Process optimization does not result in quantum leaps, it rather delivers gradual improvements. At the same time, it carries a low execution risk as we have successfully optimized processes for 150 years already.

The shift of BASF's external power supply towards renewable energies has a greater CO_2 reduction potential. As an illustration: The electricity demand of the German chemical industry amounts to approximately 50 terawatt hours per year, equaling 25% of the renewable energy produced in Germany today. With increasing CO_2 reduction efforts, electricity demand will continue to grow. Availability and costs are the key to success for the transformation in this field.

Yet, the greatest potential clearly lies in fundamentally new, CO_2-efficient processes and technologies. This is where BASF can leverage its unique innovation power. We concentrate on only a handful of basic petrochemicals that nevertheless represent 70% of the CO_2 emissions of the chemical industry. As a chemical company, you may well shift your portfolio towards CO_2-light downstream specialties, but you will still have to buy CO_2-intensive petrochemicals with their emissions "backpack" from somewhere.

Thus, who if not BASF should take the challenge? No other company runs an equally comprehensive R&D program in this area, also because no other company commands a catalysis platform like BASF's. We build on our wealth of expertise and experience in this field to strive for game-changing innovation. These are truly new grounds, and we could certainly invest our research budget elsewhere with lower risks.

However, looking at the challenge presented by CO_2 emissions and climate change, we want to and we must live up to our company purpose: “We create chemistry for a sustainable future.”

At the end of my presentation, I would now like to present four specific projects of our Carbon Management program to you. They address BASF’s most important petrochemicals and largest CO_2 emitters.

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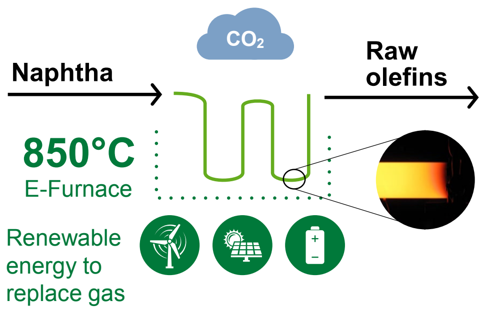
E-Furnace:
New technology for clean high-temperature reactions



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.*

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

Burning fossil fuels is the largest source of CO_2 in the chemical industry because energy is needed to perform chemical reactions.

Steam crackers, for example, must reach a temperature of 850°C to break down naphtha into olefins and convert it to aromatics.

If this energy could come from renewable electricity instead of the natural gas typically used today, CO_2 emissions could be dramatically reduced by as much as 90%.

BASF therefore aims to develop the world's first electrical heating concept for steam crackers within the next five years. At the same time, material testing will be necessary to determine which metallic materials can withstand the high electrical currents and are suitable for use in this type of high-temperature reactor.

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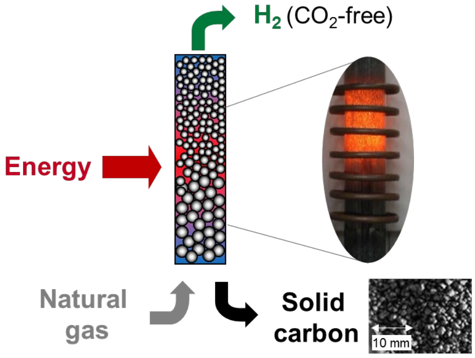
Methane pyrolysis: New process for clean hydrogen



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

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The production of hydrogen also releases significant volumes of CO_2.

The chemical industry uses large quantities of hydrogen as a reactant. At BASF, it is used, for example, in ammonia synthesis. Furthermore, hydrogen will also be essential for many sustainable energy carrier and energy storage applications in the future.

Together with cooperation partners, BASF is therefore developing a new process technology to produce hydrogen from natural gas. This technology splits methane directly into its components hydrogen and carbon. The resulting solid carbon can potentially be used in steel or aluminum production, for example.

This methane pyrolysis process requires comparatively little energy. If this energy comes from renewable sources, hydrogen can be produced on an industrial scale without CO_2 emissions.

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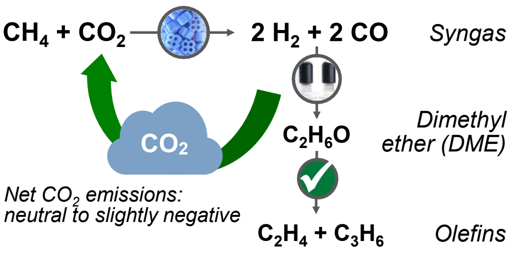
Dry reforming of methane and direct conversion of syngas to DME: New catalysts for clean olefins



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.

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As a central, high-volume intermediate, olefins represent an especially important area where BASF is looking to develop new low-emission processes. The considerable CO_2 emissions resulting from current production methods in the steam cracker could also be significantly reduced through “dry reforming” of methane. This process creates a syngas which is then transformed into olefins via an intermediate step of dimethyl ether.

BASF researchers have now been able to find a way to do this for the first time – thanks to new, high-performance catalyst systems. These new-generation catalysts are being marketed in cooperation with Linde. Depending on the availability of raw materials and renewable electricity, this innovative process could then be a very attractive complement or alternative to the potential electrical heating of steam crackers.

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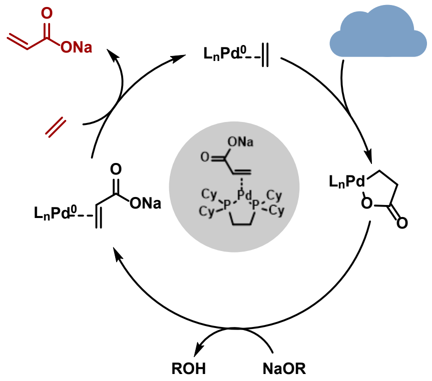
CO_2 as feedstock for superabsorbents: New chemistry for using CO_2



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.

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BASF is also presenting a new approach for using CO_2 as a chemical feedstock: the production of sodium acrylate from ethylene and CO_2.

Sodium acrylate is the most important starting material for superabsorbents, which are widely used in diapers and other hygiene products, an application with a global demand of around 2.7 million tons per year.

A few years ago, researchers at the BASF-supported Catalysis Research Laboratory (CaRLa) at the University of Heidelberg were able for the first time to successfully close the “catalyst cycle” for this reaction. This cycle, depicted on the slide, consists of a specific series of chemical reactions that have to happen again and again (really tenths of thousands of times) in the very same way for a successful catalytic process.

In the meantime, BASF experts have made important progress in scaling up this process to industrial scale and have demonstrated that it can be successfully implemented at laboratory scale in a mini plant. Compared to the current propylene-based production method for superabsorbents, in the new process CO_2 could replace around 30% of the fossil fuels.

With these examples from our R&D program, we have come to the end of my presentation. Many thanks for your kind attention.