BASF‘s Road to Net Zero

Impulsvortrag Achema 2022

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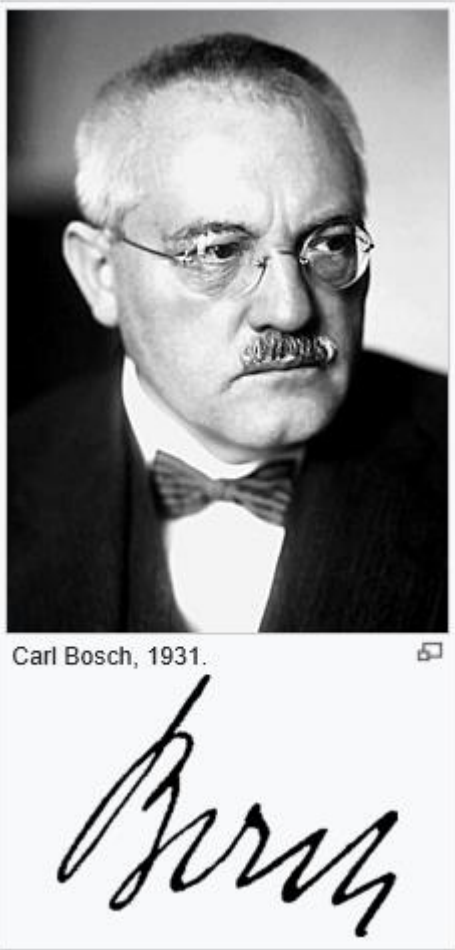
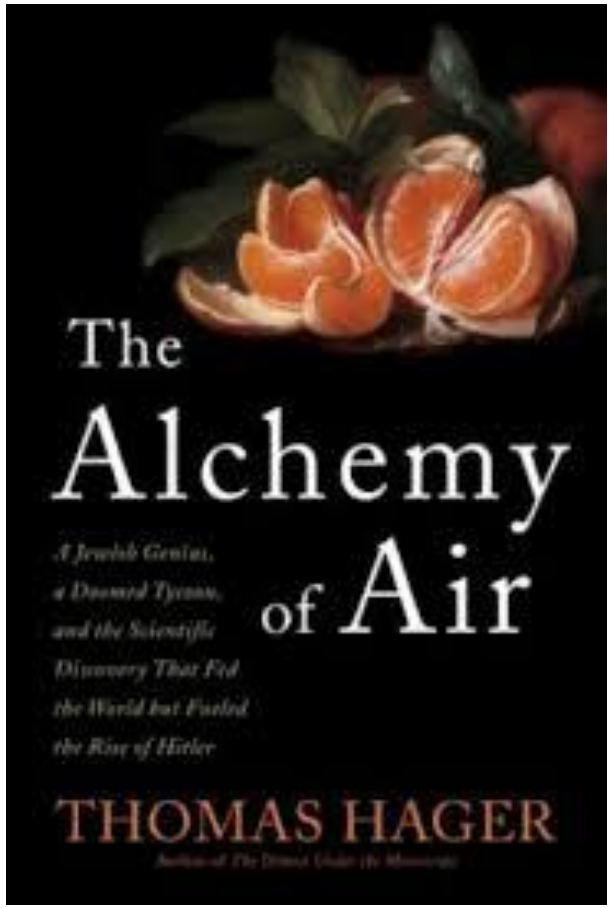
23. August, 2022

History of ammonia production and climate change

What do they have in common?



NH_3



Thomas Hager, The Alchemy of Air, 2008, Broadway Books, ISBN 978-0-307-35179-1

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History of ammonia process

Cited from the book “The Alchemy of Air”

Sir William Crookes 1898: inaugural Speech as President of the British Academy of Sciences

- Fear of (global) mass starvation due to lack of availability natural guano fertilizer (South America)

- Need for a synthetic fertilizer for wheat production

- Need to activate nitrogen out of air = “bread out of air”

… ”It is the chemist,” he said, “ who must come to the rescue…”

Out of this challenge evolved the development of the Haber-Bosch Ammonia Process

Carl Bosch realizes the need to combine chemistry & chemical engineering and founded the “Ammonia Lab” in Ludwigshafen, which is still the center of process research & development @ BASF today

Chemical basis of major CO_2 emission processes

Simplified primary reaction equations

Transportation & energy (e.g. combustion NG): $\mathbf{C}H_4 + 2\ O_2 \Rightarrow \mathbf{C}O_2 + 2\ H_2O$

Steel production: $2\ Fe_2O_3 + 3\ \mathbf{C} \Rightarrow 4\ Fe + 3\ \mathbf{C}O_2$

Construction: $Ca\mathbf{C}O_3 \Rightarrow CaO + \mathbf{C}O_2$

Chemicals (e.g. ammonia process): $0{,}7\ \mathbf{C}H_4 + H_2O + \underbrace{[0{,}2\ O_2 + 0{,}8\ N_2]}_{air} \Rightarrow 0{,}7\ \mathbf{C}O_2 + 1{,}6\ NH_3$

All CO_2 emissions have a chemical origin, can the chemist come to the rescue (again)?

Our commitments to reaching the Paris Climate Agreement

25%

CO_2 emissions reduction (compared with 2018)[1]

net zero

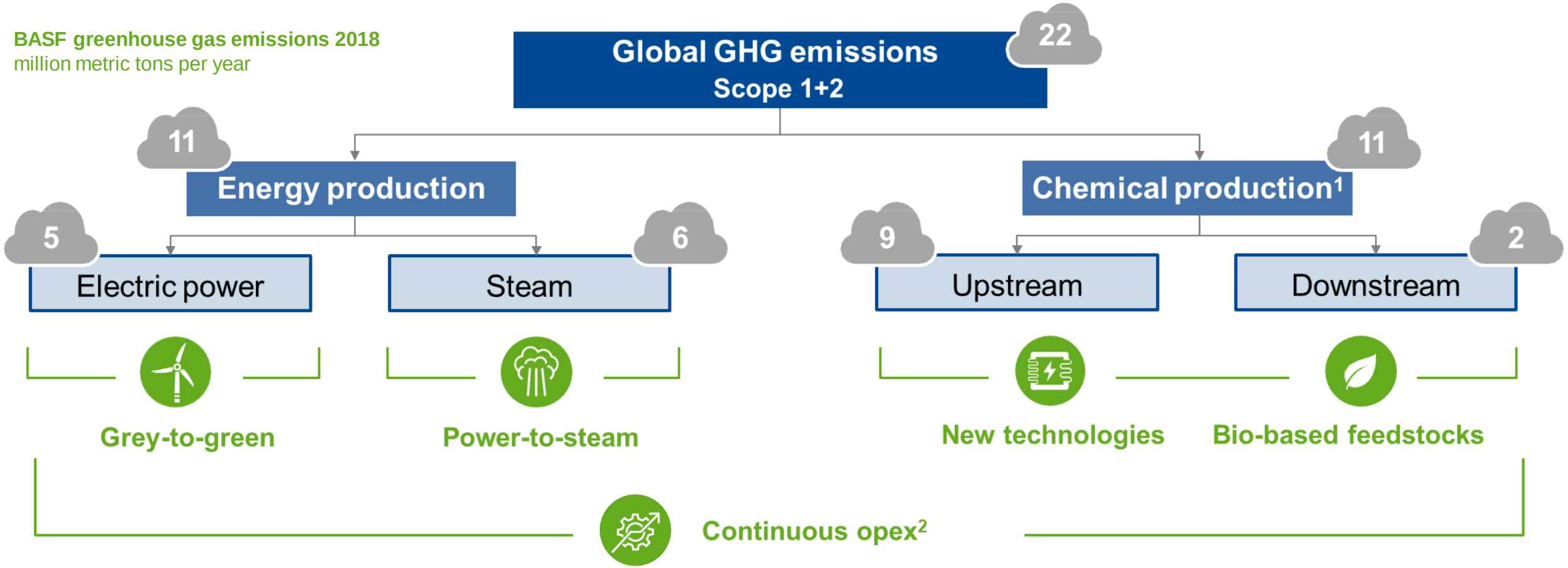
CO_2 emissions[1]

[1] Scope 1 and Scope 2; 2030 target compared with 1990: 60% CO_2 reduction

Net Zero Accelerator

Creating transparency and ownership

BASF greenhouse gas emissions 2018
million metric tons per year



Regulation asks: „Who is emitting“? For mitigation we need to know: „Why?“

Source: BASF Capital Markets Day, March 26, 2021 I Keynote

[1] Includes emissions from process energy [2] Operational excellence measures

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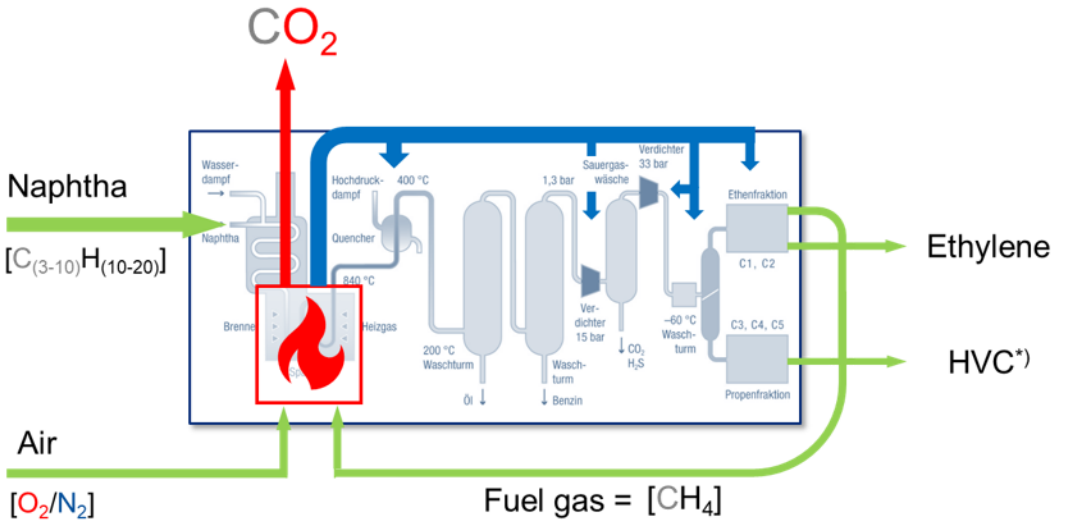
Why are we emitting?

Identifying the basic technological principles



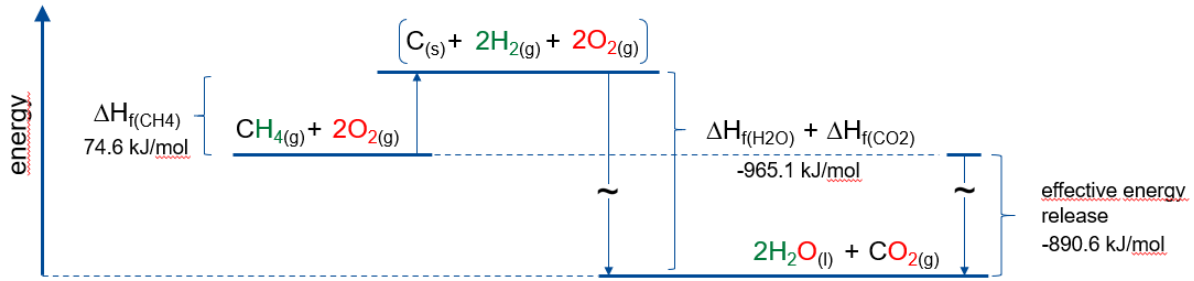
Schematic of Steam Cracker by BASF SE from BASF.com education website 2019

= combustion process = internal **energy** (steam) flow

*) HVC = High Value Chemicals: Propylene, But(adi)enes, C5-Olefins & Benzene

Combustion of methane

Hess cycle



$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$ $\Delta H_{f(H2O)} = 2 \times -285.8 = -571.6$ kJ/mol **59%**

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H_{f(CO2)} = \frac{-393.5 \text{ kJ/mol}}{-965.1 \text{ kJ/mol}} +$ **41%**

We base our technological analysis on chemical, thermodynamic and process engineering basic principles & facts

Business cases will vary over time, but thermodynamics is here to stay

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Why we need an energy transformation

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Around 80% of all scope 1&2 emissions are energy related; **controlling emissions = controlling energy**

Instead of the historical evolution of use of energy carriers with increasing energy density (wood -> oil/gas -> nuclear), we are now faced with an **increased energy demand** to **activate** thermodynamically “dead” molecules, **CO_2** e.g. for CCU (MeOH) and **H_2O** for green H_2

Hence, the **key enabler** for this transformation is access to renewable electrical energy and/or renewable energy carrier molecules in large quantities and at attractive prices (e.g. producer economics)

We need **breakthrough technologies** to 1) achieve -80% to -90% reduction of GHG emissions from chemical processes and 2) decouple generation of emissions from (future) growth

We (still) need **chemists & (chemical) engineers**!

We can build on **thermodynamics** to identify (energy) efficient solutions and leverage basic principles

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Factsheet

Summary

- Large potential for GHG emission reduction in the chemical industry has already been tapped. A further substantial reduction will require the use of, in some cases, completely new technologies.
- With our Carbon Management R&D Program, we aim to provide almost GHG emission-free basic chemicals. These are responsible for around 70% of the GHG emissions of the chemical industry.
- The high amount of electricity needed for these technologies must come from renewable sources and needs to be available at competitive prices.
- Globally harmonised CO_2 pricing is a prerequisite for the transformation towards a climate-friendly and internationally competitive chemical industry. As long as such a mechanism does not exist, policy instruments must be designed to make low-CO_2 production competitive.

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