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Israeli – German Meeting Series

Planetary Boundaries – The Great Transition
German perspective and challenges

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Introduction

- multiple challenges determine the needs for action today

What determines the challenges of today?

Planetary boundaries make it very vivid and clear where we are already living (clearly) beyond our means today

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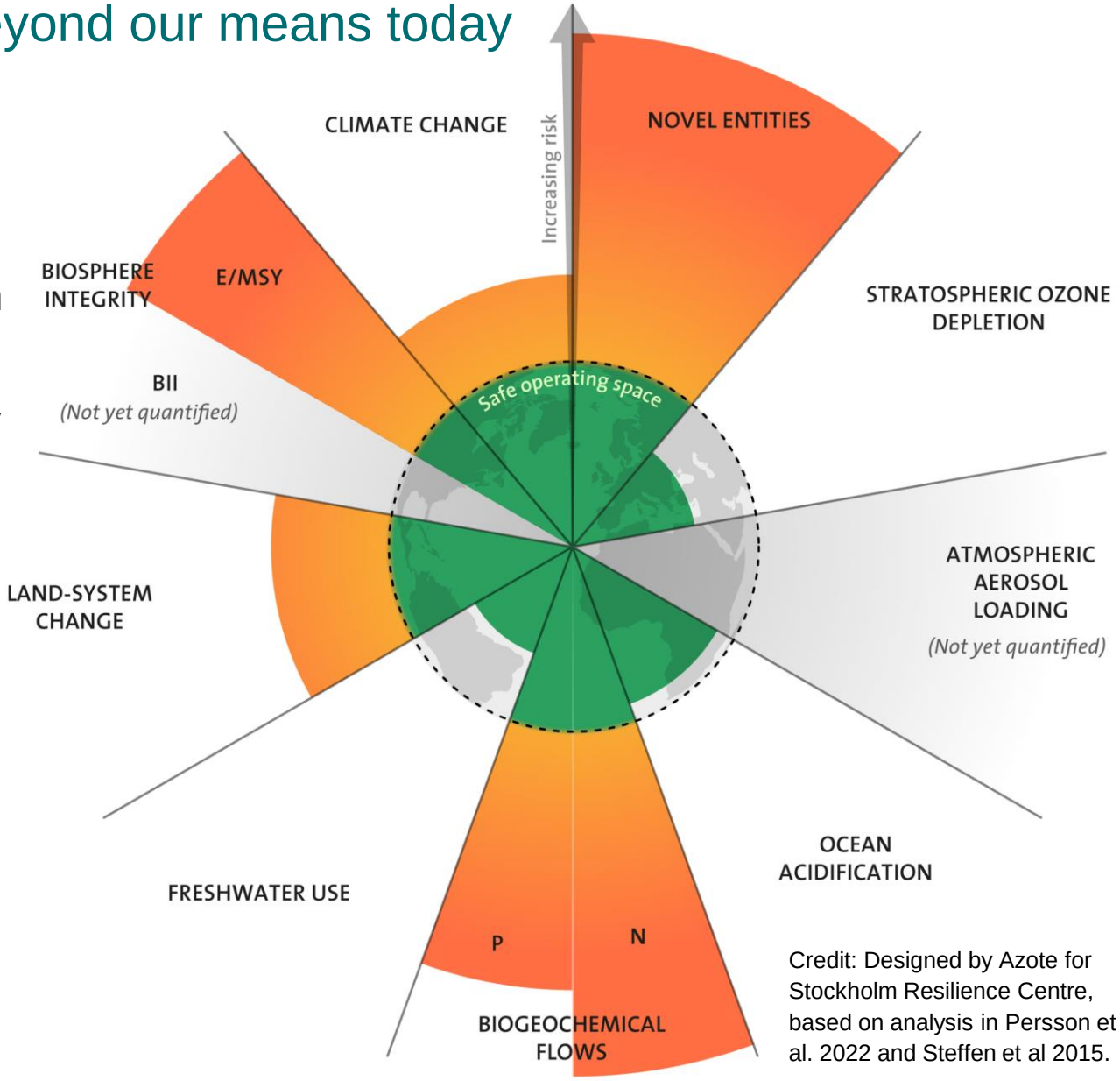
- **Planetary Boundary Concept = set of nine indicators that characterize stability and resilience of the Earth system -> ecological orientation**
- **Concept published in 2009 by Johan Rockström and 28 international scientists**
- Crossing the thresholds (the planetary boundaries) and leaving the safe operating space increases the risk of triggering large-scale abrupt or irreversible changes in our environment that may make it impossible for humanity to live as we know (and do) it today

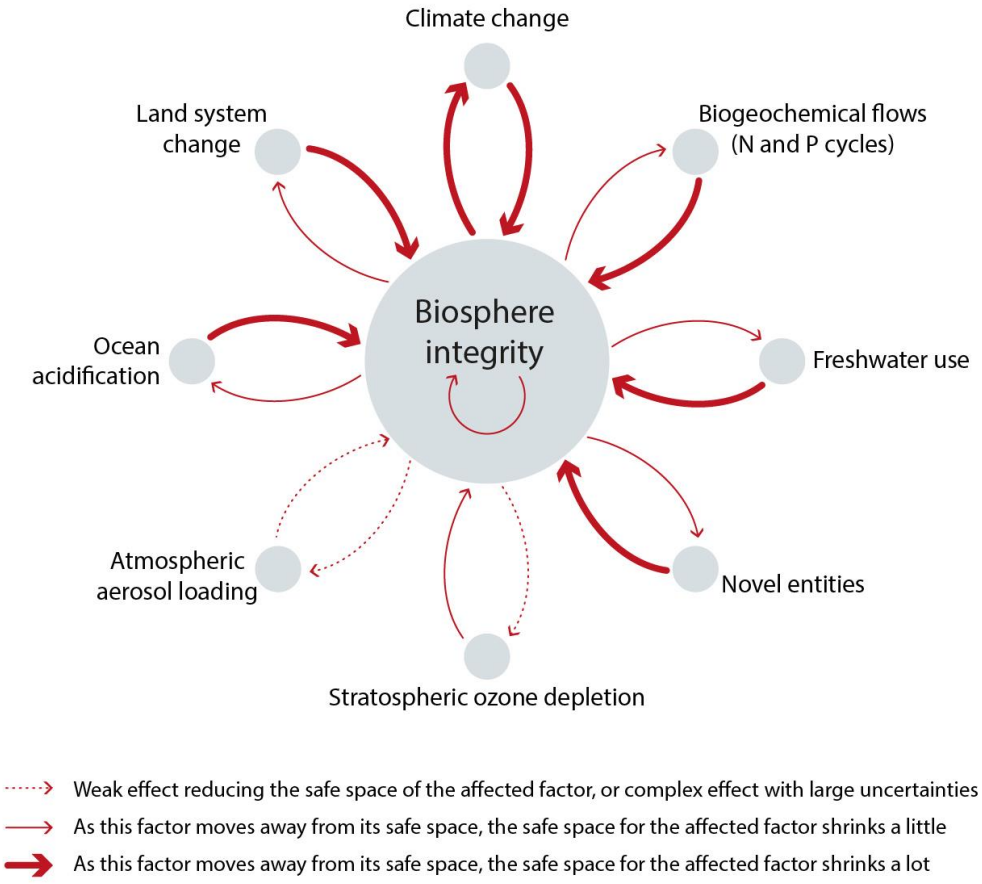


Credit: Designed by Azote for Stockholm Resilience Centre, based on analysis in Persson et al. 2022 and Steffen et al 2015.

Sources: Rockström, J. et al. 2009. Planetary boundaries:exploring the safe operating space for humanity. *Ecology and Society* **14**(2): 32. [online] URL: http://www. ecologyandsociety.org/vol14/iss2/art32/ ;

What determines the challenges of today?
Planetary boundaries make it very vivid and clear where we are already living (clearly) beyond our means today

- **The thresholds are defined by Rockström et al. (2009) as follows:**
  - **Climate change:** CO_2-concentration in the atmosphere
    < 350 ppm and/ or a maximum change of +1 W m^{-2} in radiative forcing
  - **Ocean acidification:** mean surface seawater saturation state with respect to aragonite ≥ 80% of pre-industrial levels
  - **Stratospheric ozone:** <5% reduction in O3 concentration from pre-industrial level of 290 Dobson Units
  - **Biogeochemical flows:** limit industrial and agricultural fixation of N_2 to 35 Tg N yr^{-1} and annual P inflow to oceans not to exceed 10 times the natural background weathering of P
  - **Global freshwater use:** <4000 km^3 yr^{-1} of consumptive use of runoff resources
  - **Land-system change:** <15% of the ice-free land surface under cropland
  - **Biosphere Integrity:** loss of biological diversity - annual rate of <10 extinctions per million species
  - **Chemical pollution:** has not been determined by Rockström et al. (2009) / see next slide
  - **Atmospheric aerosol loading:** not yet quantified



Sources: Rockström, J. et al. 2009. Planetary boundaries:exploring the safe operating space for humanity. *Ecology and Society* **14**(2): 32. [online] URL: http://www. ecologyandsociety.org/vol14/iss2/art32/ ; Steffen, W. et al. 2015. Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, et.al. 2015. Planetary boundaries: Guiding human development on a changing planet. Science 347: 736, 1259855.

What determines the challenges of today?

The ecological dimension is not sufficient to describe the boundaries and has to be combined with an appropriate social foundation -> Doughnut Economics

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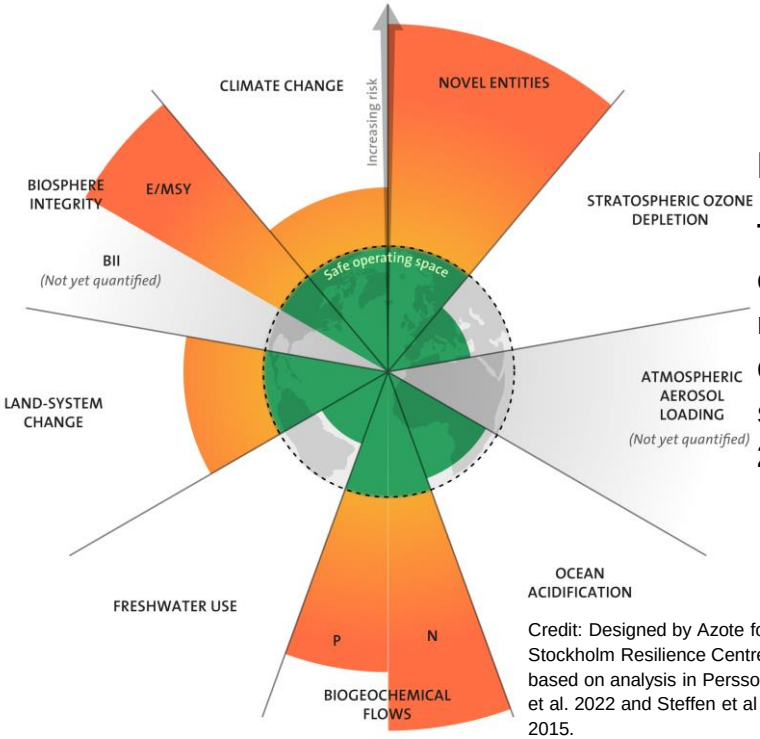
The Doughnut's dimensions (as of 2017)

Social Foundation

The 12 dimensions of the social foundation are derived from the social priorities agreed in the Sustainable Development Goals (UN, 2015)

Ecological Ceiling

The 9 dimensions of the ecological ceiling are the nine planetary boundaries defined by Earth-system scientists (Steffen et al., 2015)



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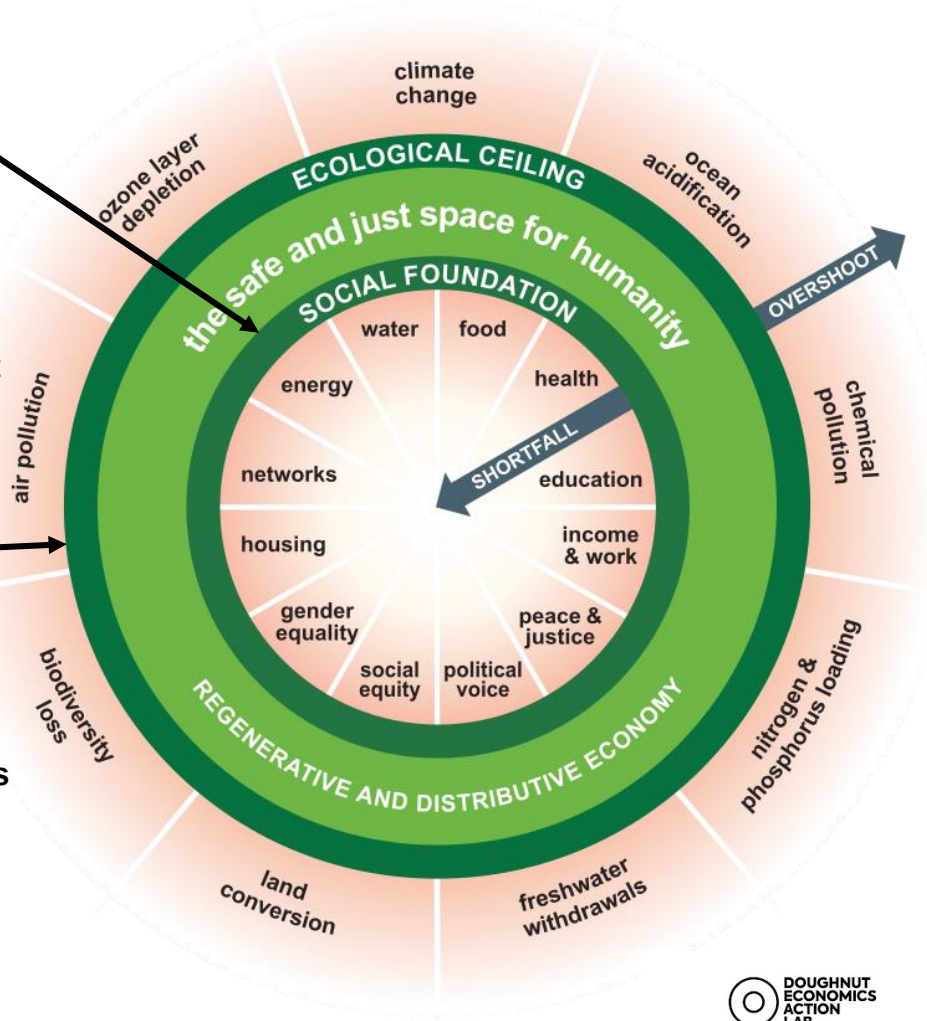


DOUGHNUT ECONOMICS ACTION LAB
doughnuteconomics.org

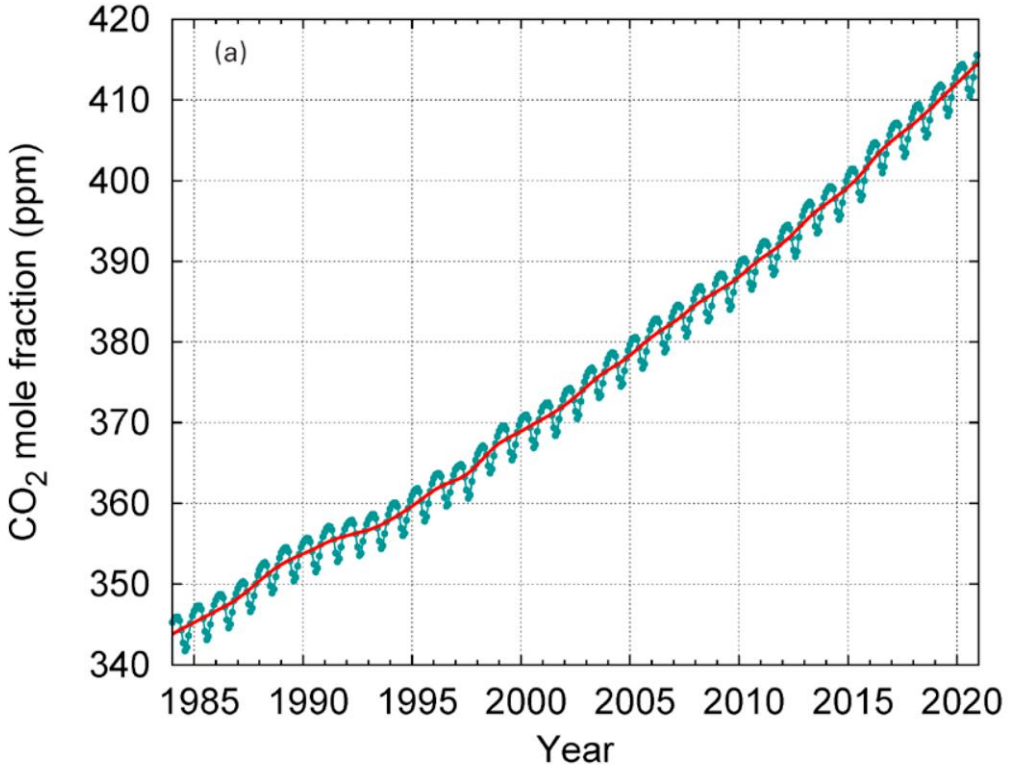
Doughnut symbolizes the balance of good life for mankind and the boundaries within which a safe and just space for humanity exists

Example: Climate Change

- deep dive into a specific challenge that leads to massive transformation needs in the energy and industry system

Challenge Climate Change

Climate science community pretty sure that increasing greenhouse gas concentration in the atmosphere leads to growing global temperature



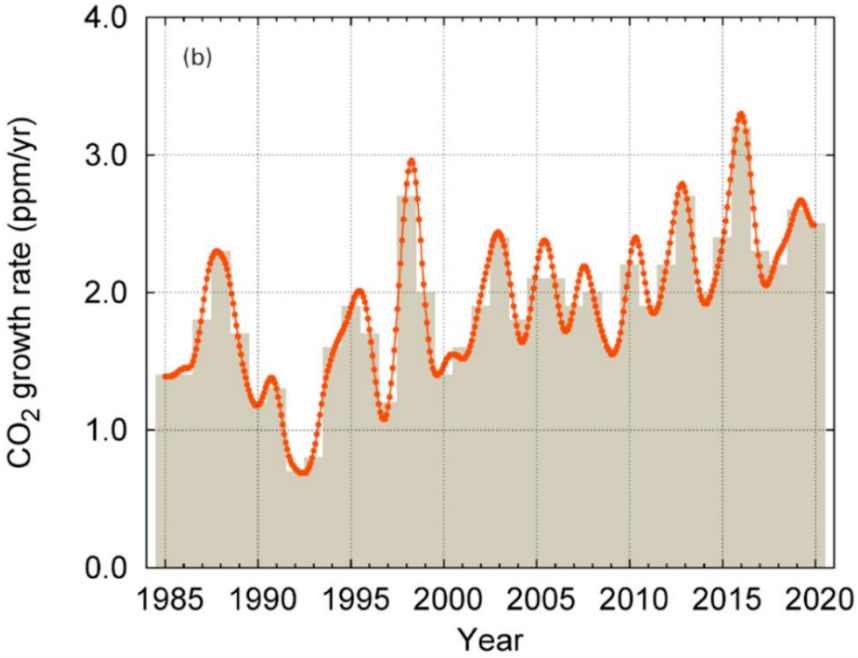


Figure 6. Globally averaged CO_2 mole fraction (a) and its growth rate (b) from 1984 to 2020. Increases in successive annual means are shown as shaded columns in (b). The red line in (a) is the monthly mean with the seasonal variation removed; the blue dots and blue line in (a) depict the monthly averages. Observations from 139 stations were used for this analysis.

Quelle: WMO GREENHOUSE GAS BULLETIN - The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2020. 25 October 2021.
https://library.wmo.int/index.php?lvl=notice_display&id=21975#.YX_MMqAxklI

Bildquelle: dpa.

Weltorganisation für Meteorologie

Mehr Treibhausgas als je zuvor

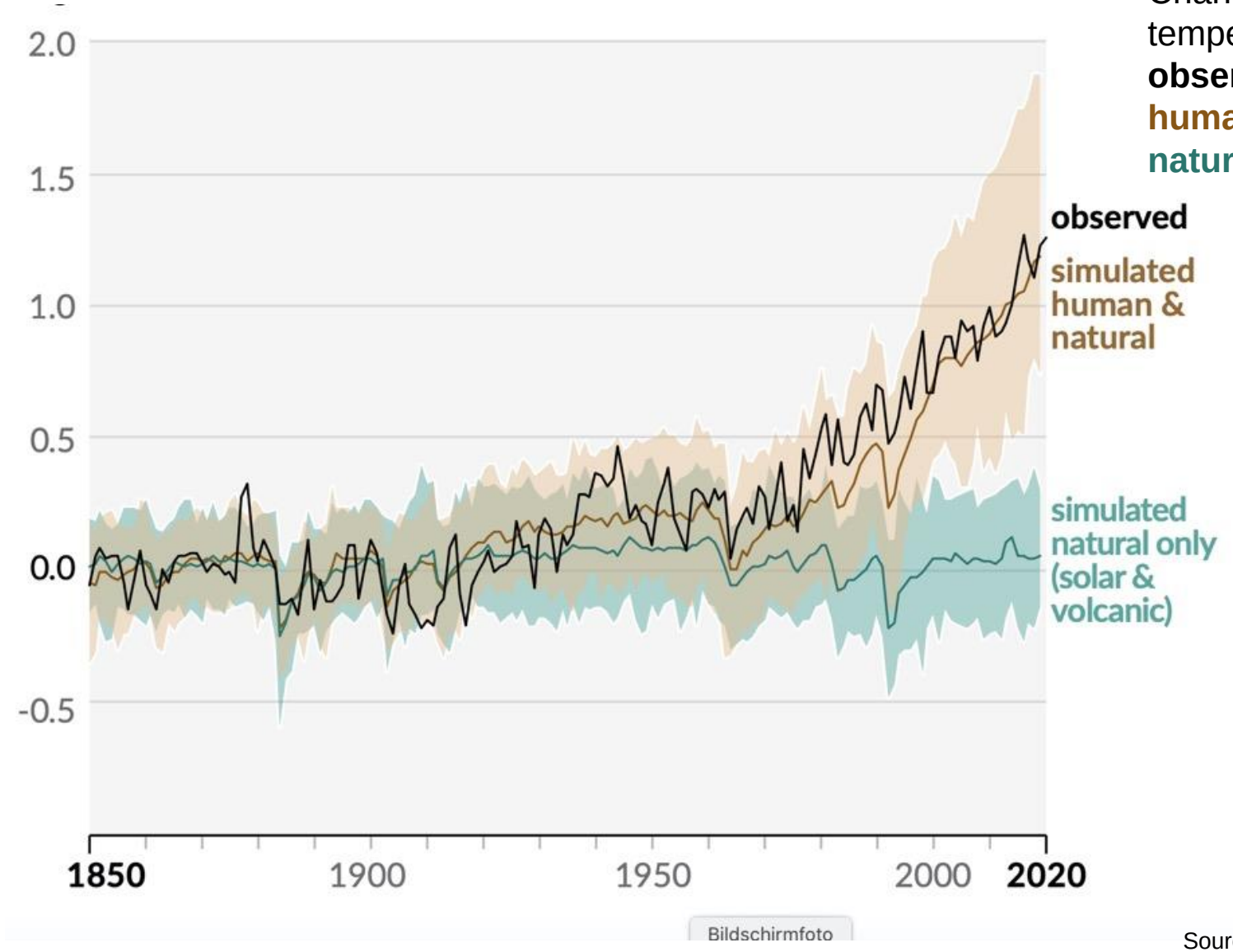
Stand: 25.10.2021 12:19 Uhr

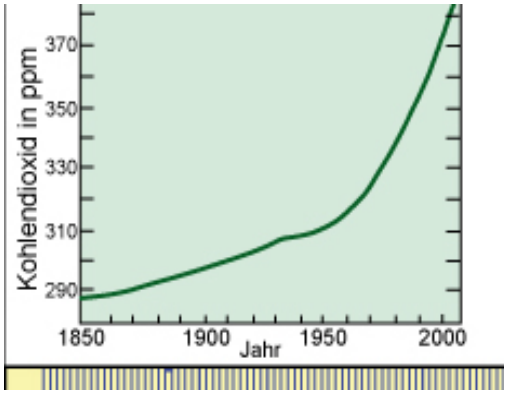
Die Treibhausgaskonzentration in der Atmosphäre hat 2020 einen neuen Höchststand erreicht. Auch die Corona-Pandemie konnte den Anstieg nicht stoppen. Die Hoffnungen ruhen nun auf der anstehenden Weltklimakonferenz.

Challenge Climate Change

Global mean surface temperature increases significantly since beginning of industrialisation and can be associated to human activities (anthropogenic origin)

Change in global surface temperature (annual average) as **observed** and simulated using **human & natural** and **only natural** factors (both 1850-2020)

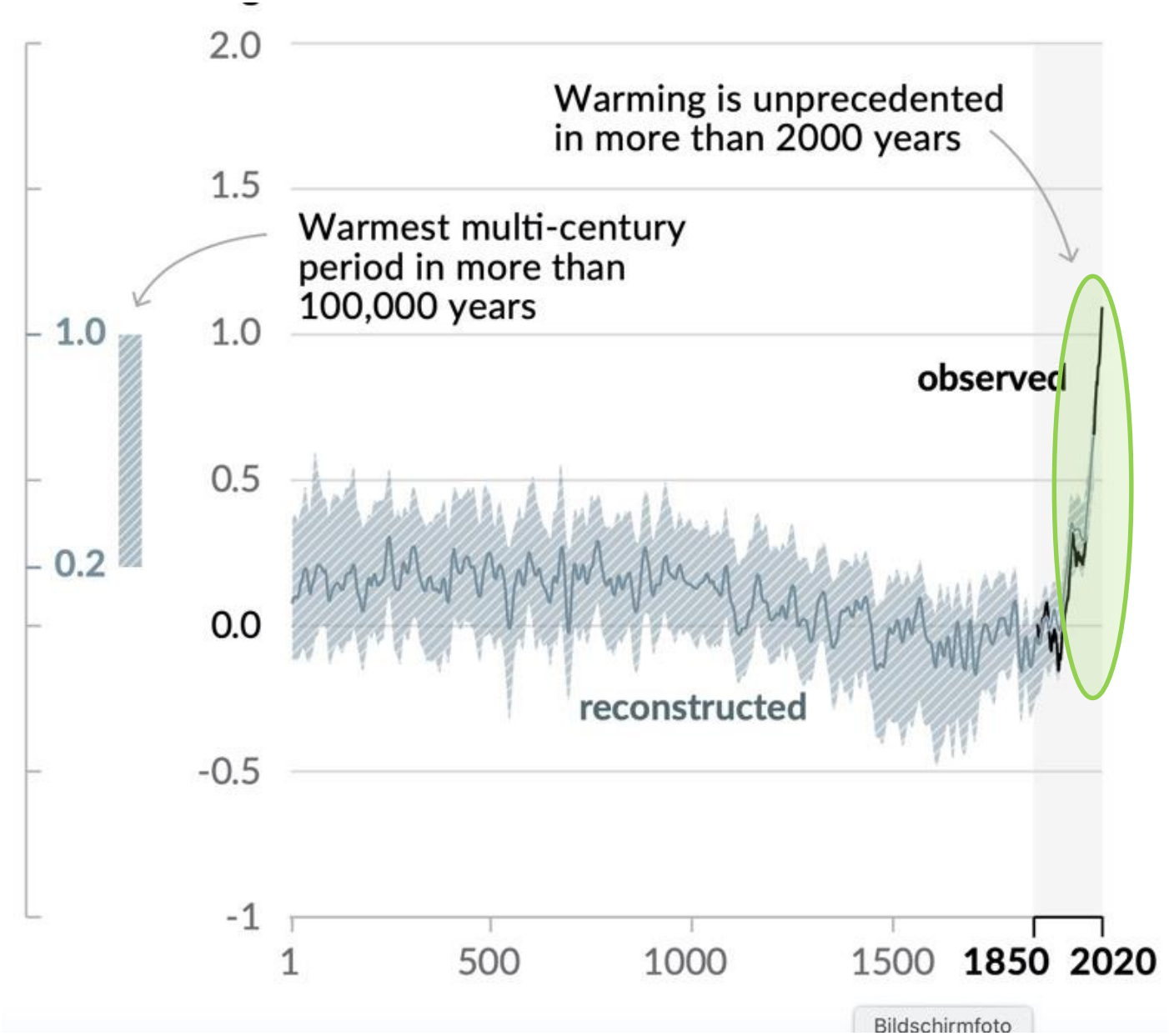




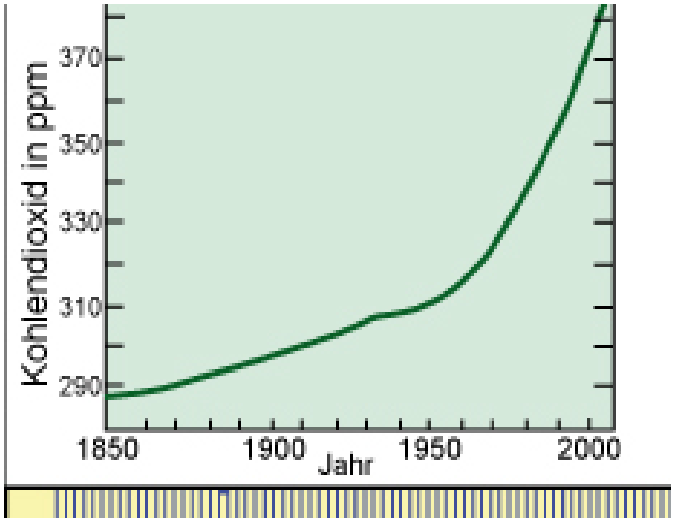
Source: IPCC WG I Assessment Report 2021

Challenge Climate Change

Long term temperature observation shows the fast increase and why the situation is so specific (hockey stick curve)



Change in global surface temperature (decadal average) as **reconstructed** (1-2000) and **observed** (1850-2020)

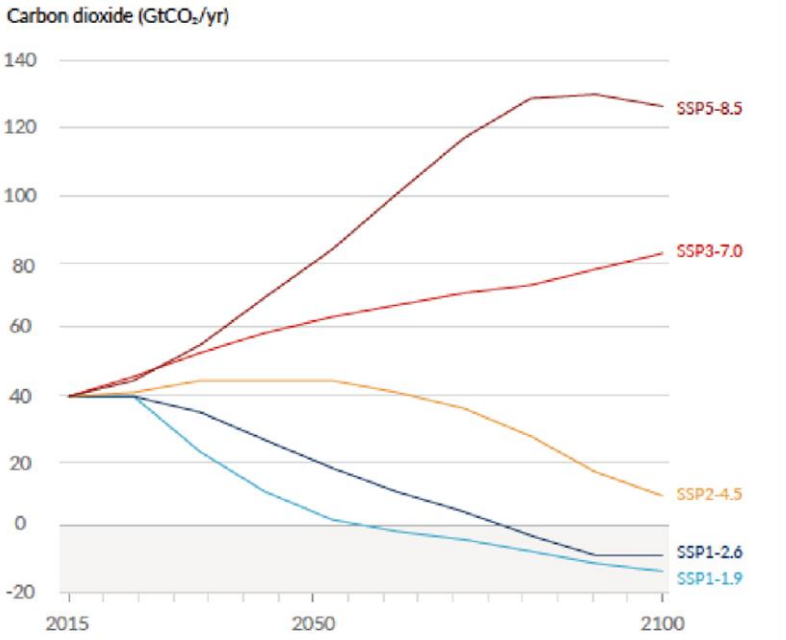


Source: IPCC WG I Assessment Report 2021

Challenge Climate Change

Intergovernmental Panel on Climate Chance (IPCC) report 2021 confirms mankind origin and expect further (significant temperature increase)

- **There is a great consensus amongst climate scientists that**
  - Climate change is („unequivocal“) anthropogenic origin
  - Further increase of global mean temperature by 1.5°C until 2040 (compared to pre-industrial level) can hardly be avoided
  - Assuming a continuous increase of GHG emissions (SSP3-7.0) temperature increase could be 2.6° in 2060
  - Tipping points (“Kippelemente”) have not been taken into consideration in this calculation (e.g. melting of Sibirian permafrost soil), but could further speed up temperature increase
  - As a consequence weather extremes will increase by number and intensity – adaptation measures become crucial



Scenario	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change[Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press

Climate change challenge

International Climate Protection conference 2015 in Paris marks a cornerstone and determines level of ambition

Rio 1992

Kyoto 1997

Copenhagen 2009

Paris 2015

- For the first time since 25 years international negotiations ended with a treaty which comprises climate protection commitments of more than 190 countries – almost the entire world (based on voluntary agreements - INDC: intended national determined contribution)
- **Major goal: limiting temperature increase in comparison to pre-industrial level to well below (!) 2°C and if even possible to 1,5°C**

Jubel nach der Annahme des Entwurfes: UN-Klimachefin Christiana Figueres, UN-Generalsekretär Ban Ki-Moon, der französische Außenminister Laurent Fabius und der französische Präsident Francois Hollande (von links)

Climate Change challenge

Setting the scene for action and how to go forward

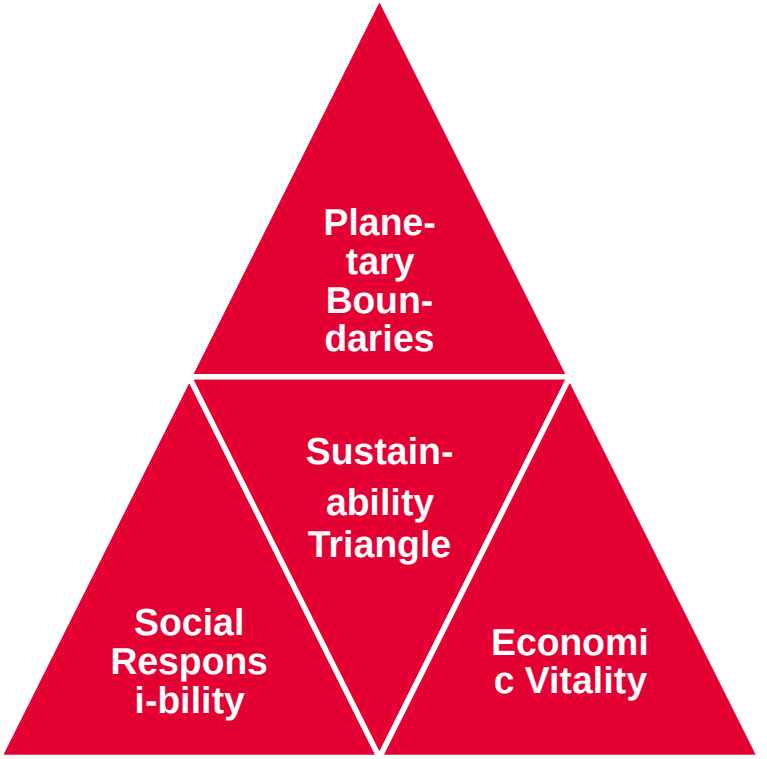
- **Paris climate agreement (COP 21), Glasgow results (COP 26)** and related policy decisions at Global, European and German level set the scene for action (GHG neutrality by 2050), but climate targets **have to be seen in the broader sustainability context of UN Sustainability Goals**

- **Further and massive market penetration of renewable energies** is absolutely crucial. In addition **direct electrification and indirect electrification** (via hydrogen or hydrogen based energy carriers/feedstocks for industry) play a major role for all relevant sectors
- **No blueprint available for GHG neutrality strategy** - keeping the balance between fast action (key for limiting climate change), reliability (key for investment security) and flexibility (key for reflection of uncertainties and dynamics) required

Climate change challenge

What are alongside clmate change the major challenges for the energy system of the future

- Safeguarding competitiveness (industry) and socially acceptability (society)
- Security of energy supply
- Environmental and climate friendliness **(**e.g. greenhouse gas neutrality 2050)
- Social acceptance (overcoming NIMBY effect) and openness for participation
- **Just transition - careful handling of induced structural changes (intended as well as not intended changes)**
- **Transparent and open discussion between stakeholders (sociopolitical discourse)**



Climate change challenge

Paris and Post-Paris phase created a big momentum for international climate policy and as a consequence market development of climate protection technologies

Future markets have to be „paris-compatible“

More and more ambitious mitigation targets at international level result in more engagement in terms of technology development and market penetration (also at companies level)

- results in higher implementation dynamic and possibility of joining forces to overcome common (technology/infrastructure) challenges
- results in more competition: the race is open; open question – who will have the best chances to become a world champion in the growing global climate technology markets

Todays energy and climate policy is an important pillar of economic policy and can help to secure competitiveness and the standing of the country as attractive location for business and technology exporter

Climate Change

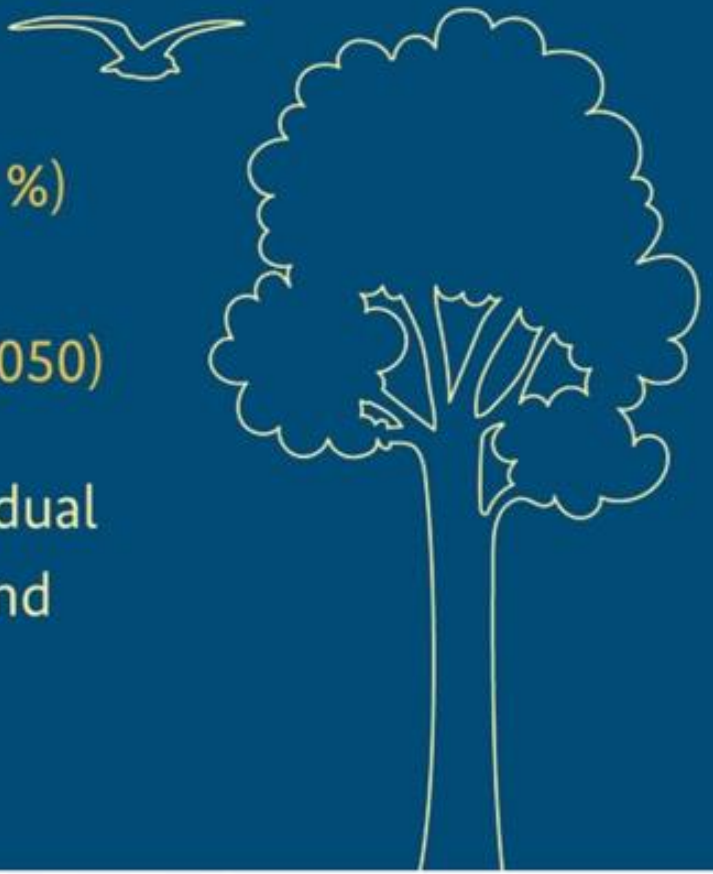
National German target and how GHG neutrality could be achieved

German climate policy goals

Climate Protection Law from July 2021 defines GHG neutrality by 2045 as national target following a groundbreaking judgement of the Federal Constitutional Court (-> requested a better protection of youth)

Germany to achieve climate neutrality earlier

- Greenhouse gas emissions
  - → By 2030: 65% less CO2 (current target 55 %)
  - → By 2040: 88% less CO2
  - → 2045: Climate neutrality (current target 2050)
- Permissible annual CO2 emissions for individual sectors such as energy, industry, transport and buildings to be reduced.



German climate policy goals

GHG neutrality by 2045 – even more ambitious as EU – resulting challenge: Where do we stand today and what can we expect for the near future

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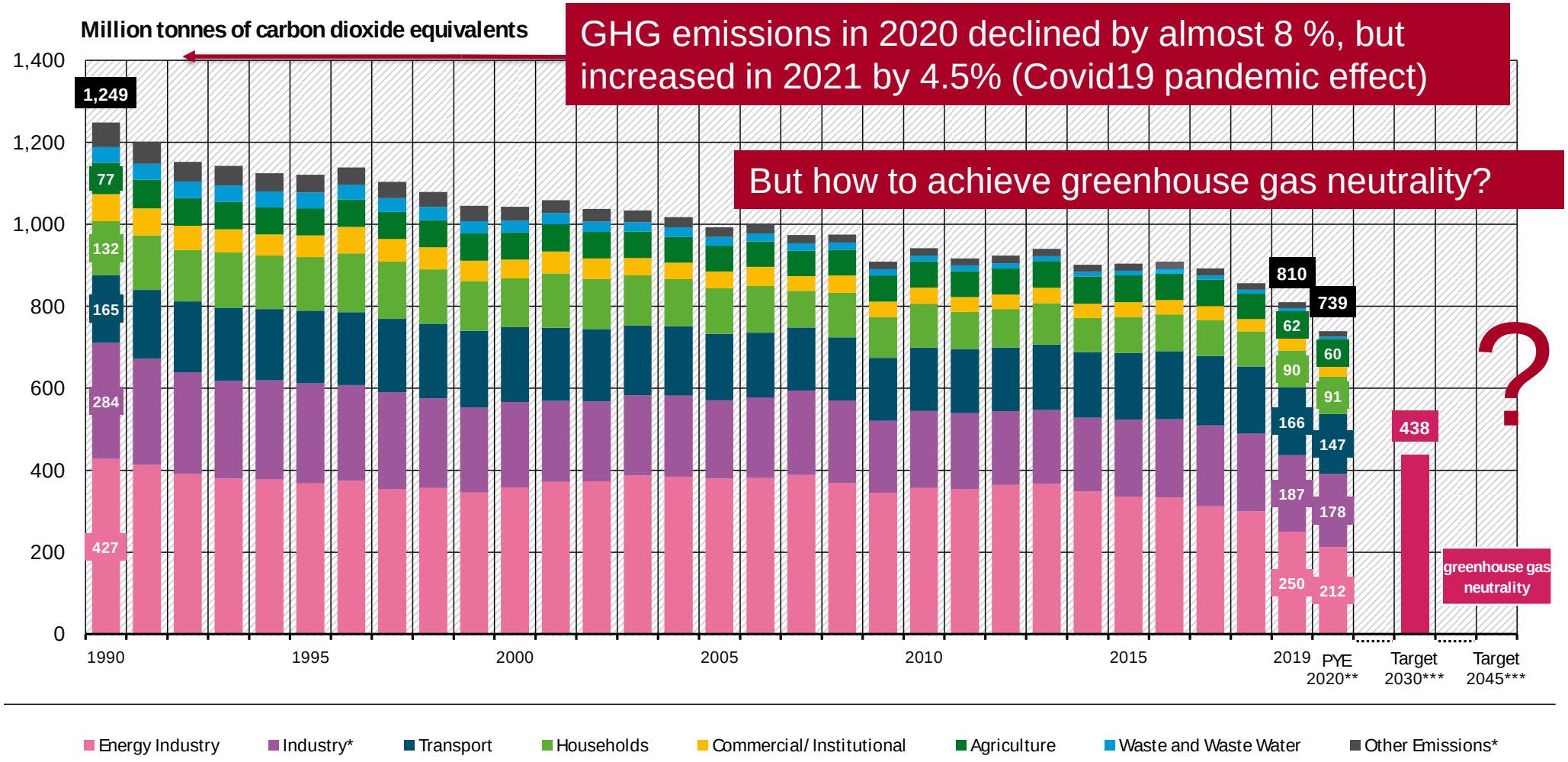
reduction 35.7% (1990 -2019) and 41% (1990 - 2020)

Emission of greenhouse gases covered by the UN Framework Convention on Climate



How GHG neutrality could be achieved

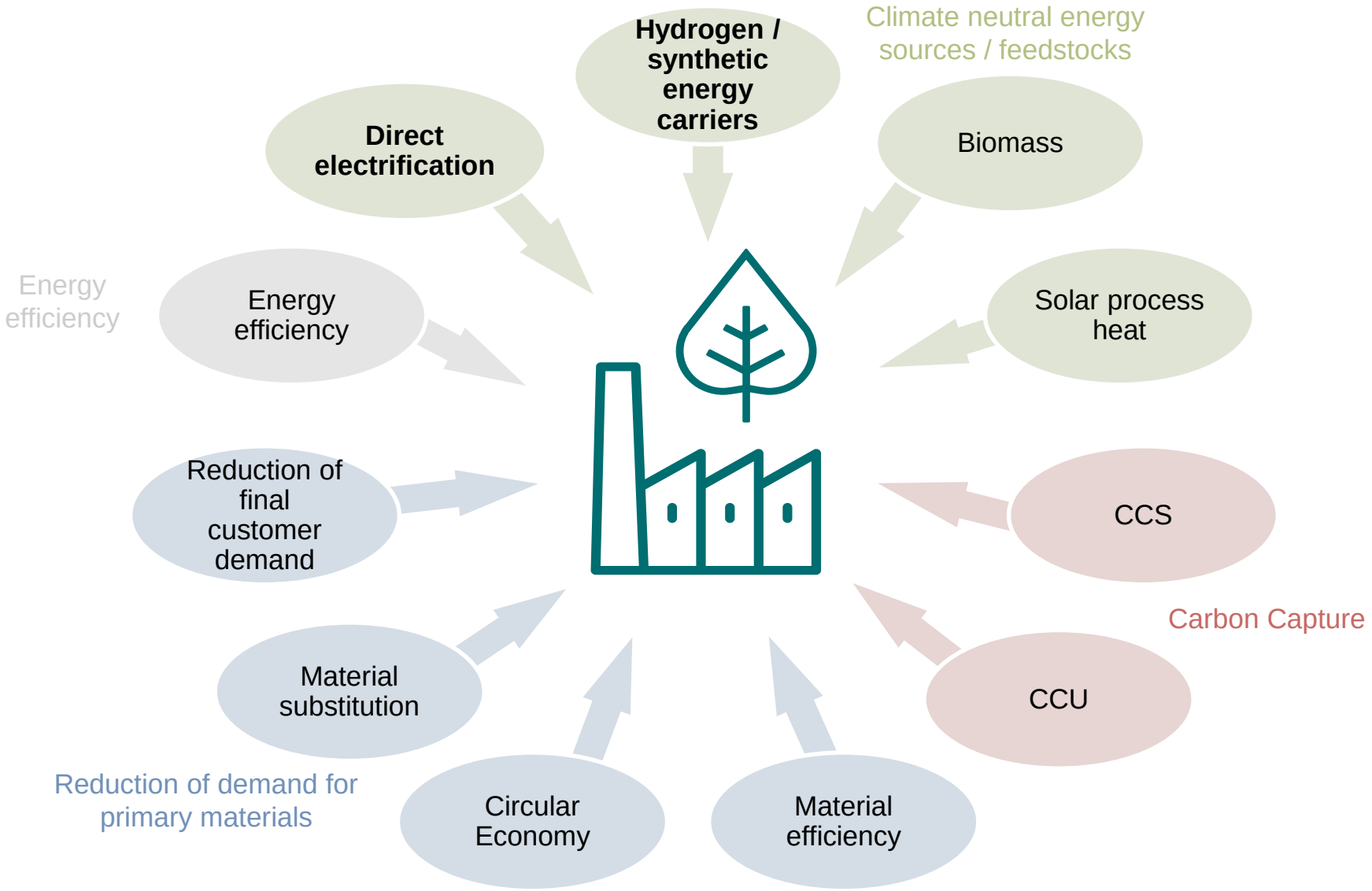
Wuppertal Institute study on behalf of Agora Energiewende shows potential way along three major phases

- → **Study „Towards a Climate-Neutral Germany“, jointly initiated by Agora Energiewende, Agora Verkehrswende and Stiftung Klimaneutralität**
- → **Conducted by Prognos/ Öko-Institut/ Wuppertal Institut**
- → **Mission: Addressing the official German government long-term target (climate neutrality by 2045) but assumes 65% reduction by 2030 as a consequence of the higher EU-2030 target**
- → **Goal: Present a path towards climate neutrality taking into account cost efficiency and social acceptance.**

Note: The extended version of the study is currently available in German, the executive summary is published in English.

How GHG neutrality could be achieved

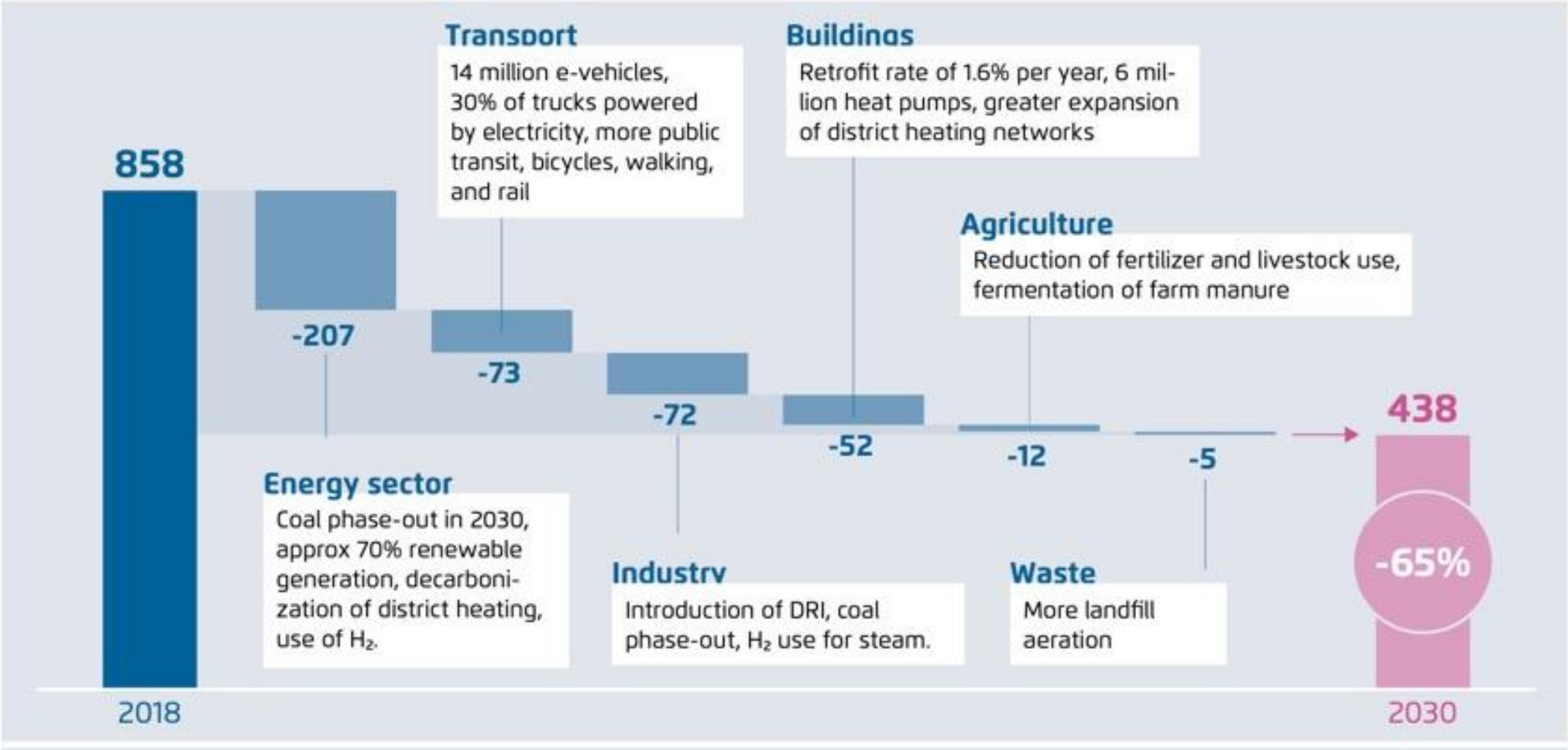
There is no silver bullet technology/strategy for GHG mitigation – broad portfolio of options needed



How GHG neutrality could be achieved

Mix of options is needed in each sector for the three major phases of transformation

Step 1



Prognos, Öko-Institut, Wuppertal Institut 2021

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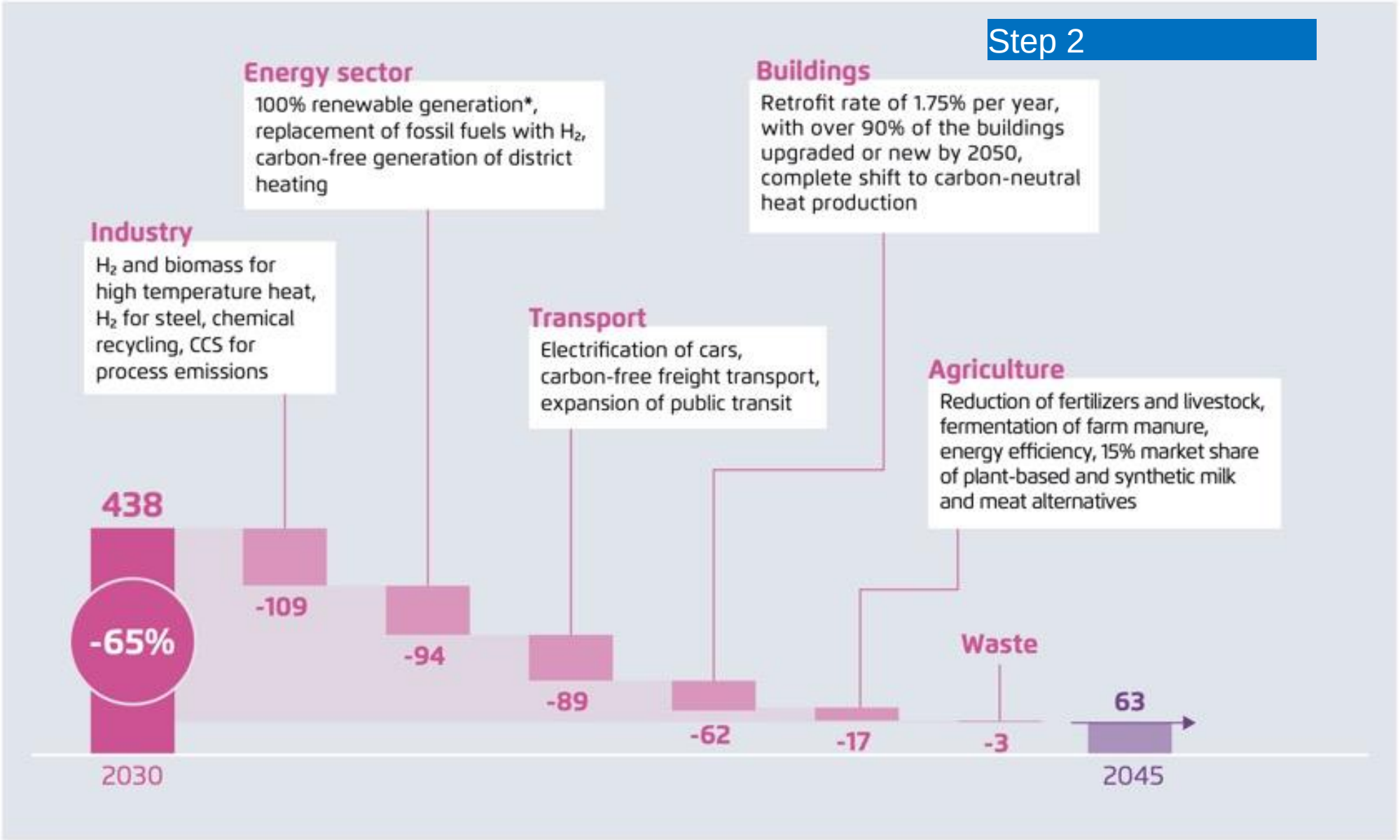

How GHG neutrality could be achieved

Mix of options is needed in each sector for the three major phases of transformation

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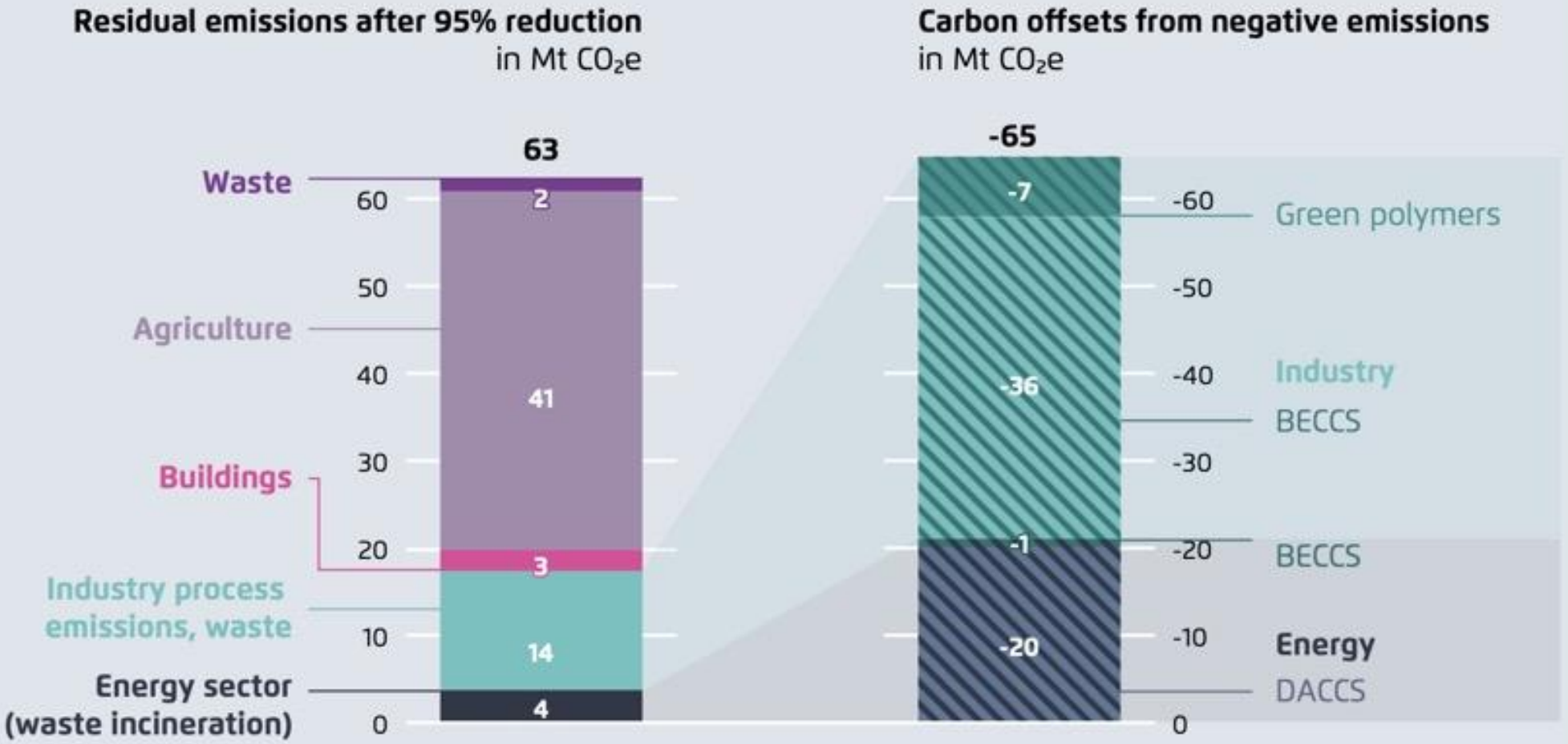
Step 3 in detail – residual GHG emissions and their offsetting in 2045

Step 3



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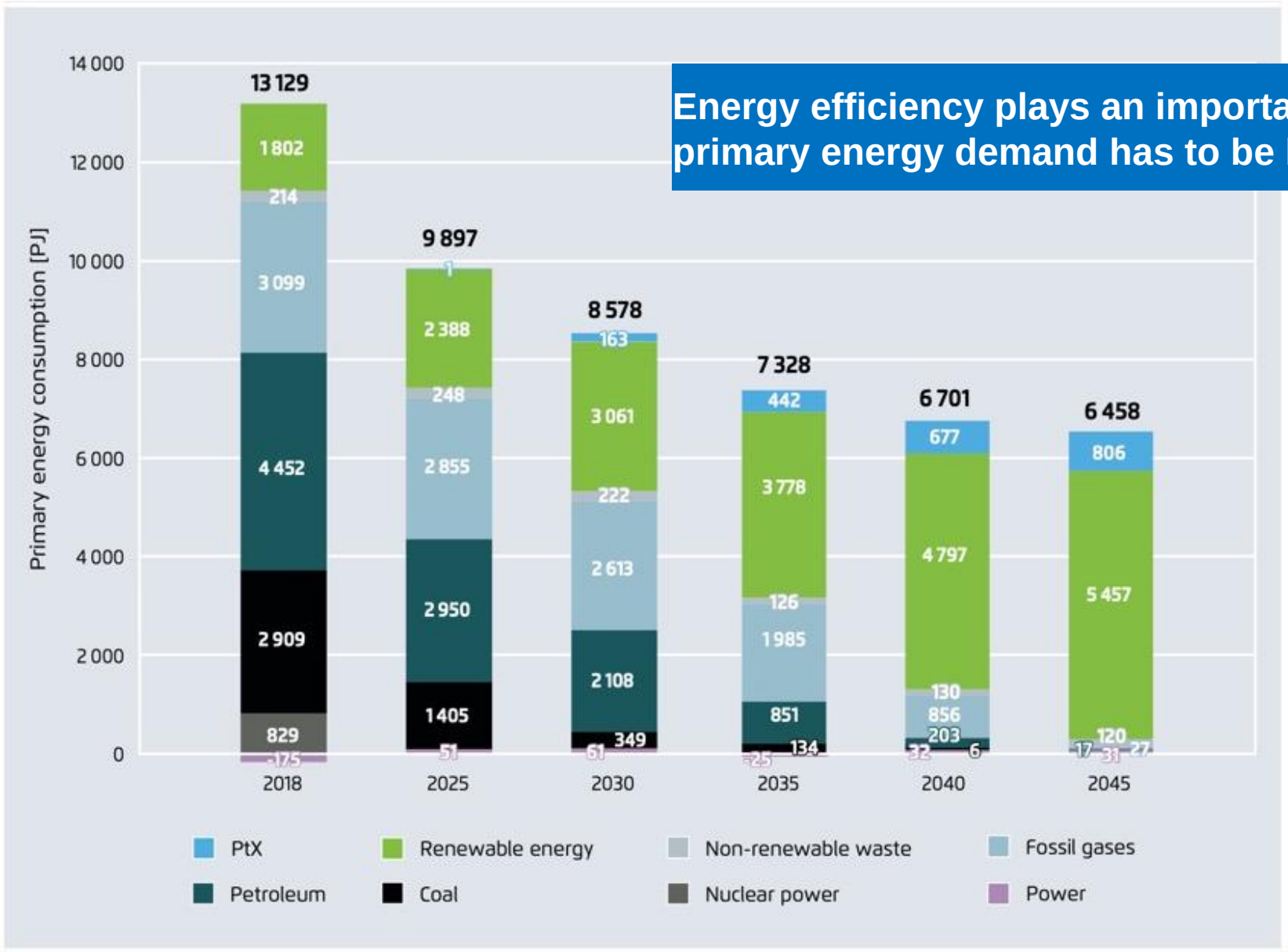

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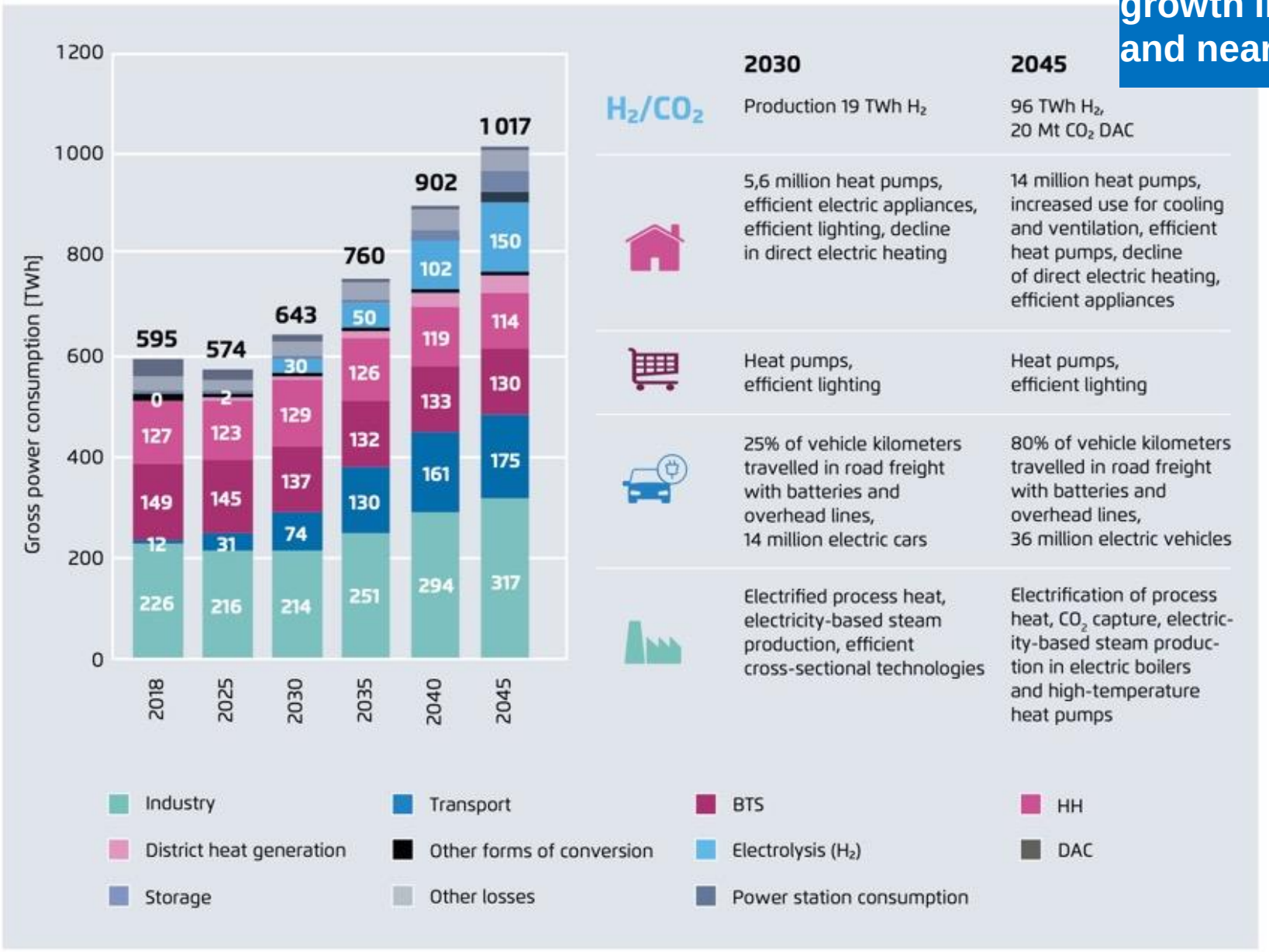
How GHG neutrality could be achieved

Mix of options is needed in each sector for the three major phases of transformation

Electricity demand growth in all sectors and nearly doubles



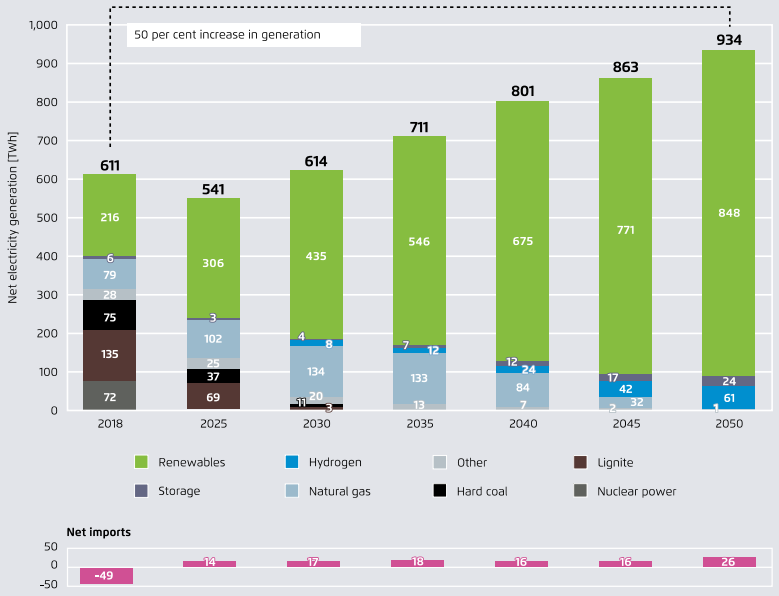
Prognos, Öko-Institut, Wuppertal Institut 2021

How GHG neutrality could be achieved

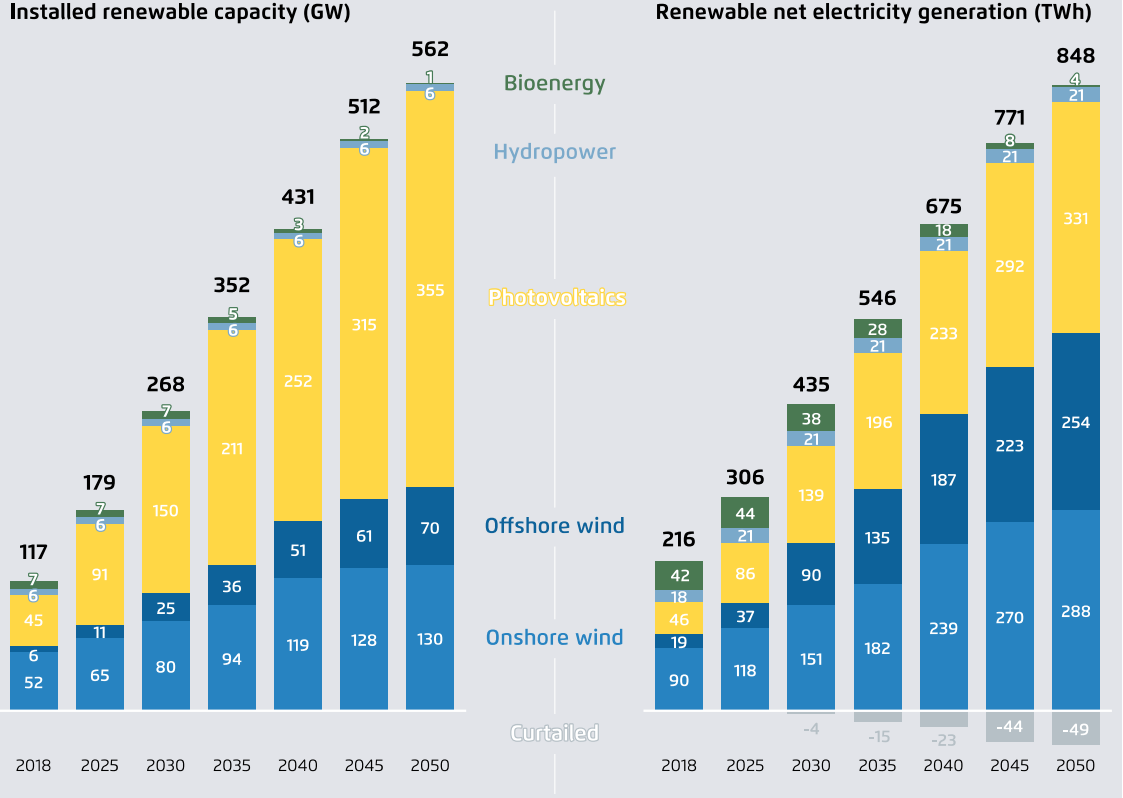
Renewable energy market penetration have to be accelerated significantly

Annual renewable energy capacity addition have to be doubled or even tripled in comparison to 2018-2020 average

Net electricity generation and net imports — Figure 8



Other energy sources for electricity generation: blast furnace gases, waste incineration, petroleum, other sources. Storage: generation from battery storage and pump storage
Prognos (2020)



Needed average added capacity per year
Gross increase, for life spans of 25 years

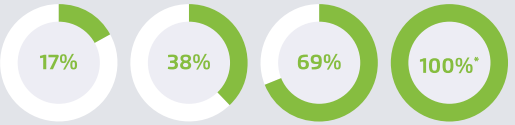
2021–2030

- 10 GW photovoltaics
- 1,7 GW offshore wind
- 4,5 GW onshore wind

Past years with greatest added capacity:
Photovoltaics: 8 GW (2010, 2012)
Offshore wind: 2 GW (2015)
Onshore wind: 5 GW (2014, 2017)

Cumulative gross increase from 2021 to 2030:
Photovoltaics: 98 GW
Offshore wind: 17 GW
Onshore wind: 44 GW

Share of renewable energy in gross electricity consumption

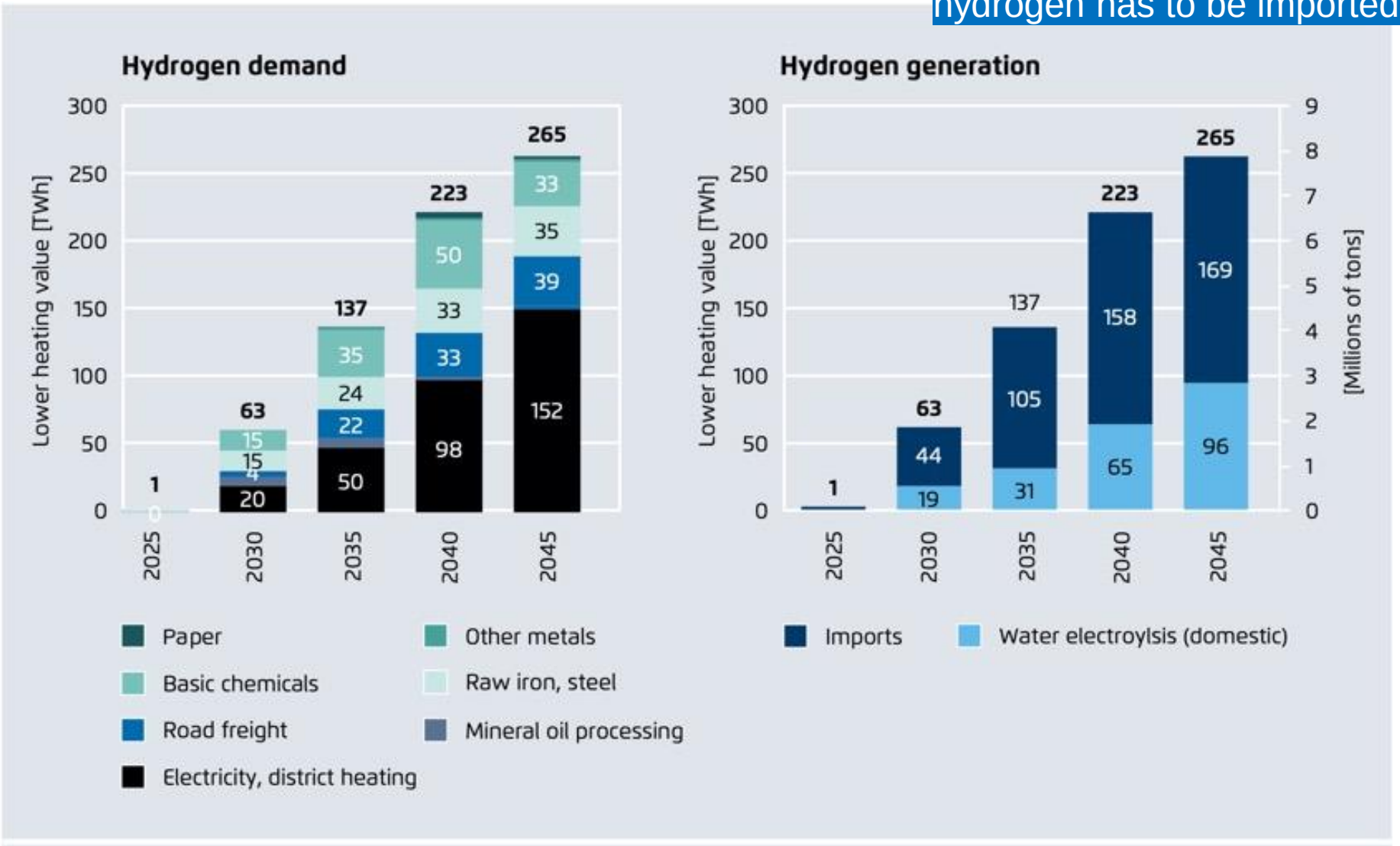


* Includes electricity generation from renewable hydrogen together with stored and imported renewable electricity.
Prognos (2020)

How GHG neutrality could be achieved

Hydrogen economy as central strategy element gaining more and more relevance after 2030

Due to limited national renewable energy resources majority of hydrogen has to be imported



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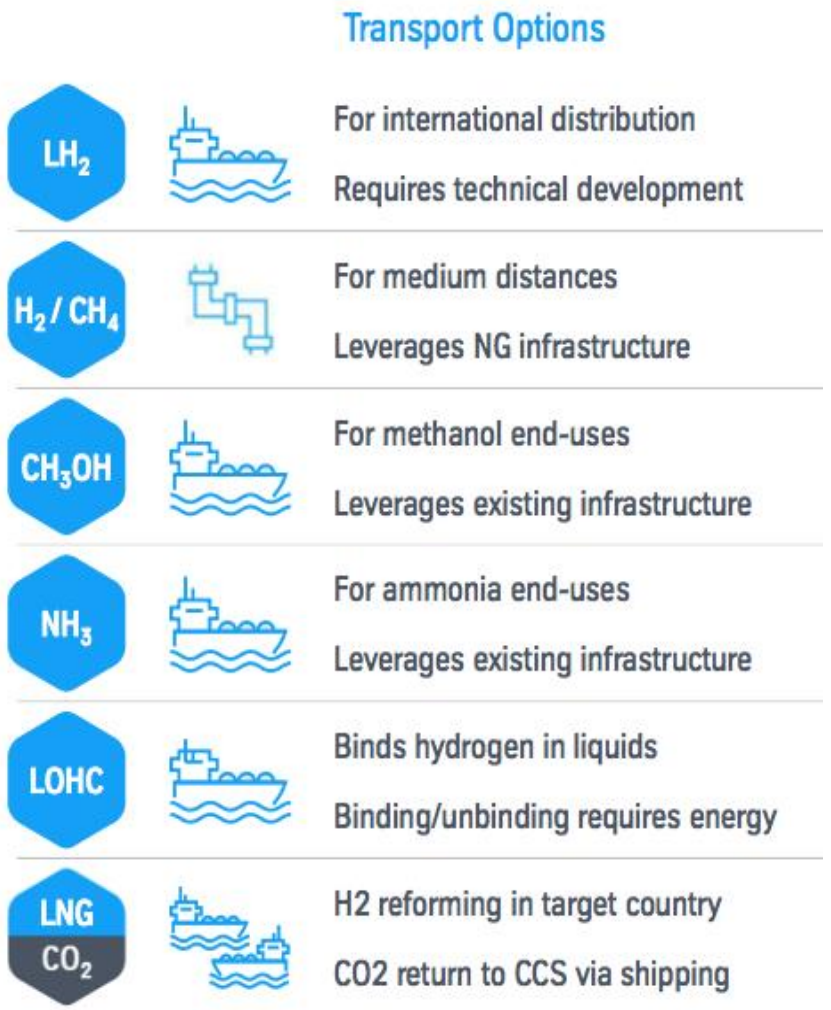
How GHG neutrality could be achieved

Germany will rely massively on hydrogen import – lesson learned from Russia's aggression in Ukraine requires from the very beginning a diversifies import mix



Source: BloombergNEF (2020)

Outlook and remaining challenges

Outlook

Implementation of transformation pathways to GHG neutrality is associated with manifold challenges but also substantial chances

- **Technological challenges** (e.g. system integration of volatile renewable energy sources)
- **Infrastructure challenge** (further development of existing and build up of new infrastructures: H_2, CO_2)
- **Market challenge** (further development of market design and incentive structures)
- **Resource challenge** (substitution and/or recycling from critical/rare resources)
- **Stakeholder challenge** (overcoming of persistant forces)
- **Policy and institutional challenge** (integrative policy approach in the multi-level system)
- **Societal challenge** (social acceptance, participation, fair burden sharing, just transition, empowerment of „all“ consumers) -> sociopolitical discourse and positive, motivating narrative necessary)
- **Innovation challenge** (combination of technical and (!) social innovations to system solutions)
- **Temporal challenge** (consequent and durable shaping of transformation processes over decades – how to keep track for decades)

Outlook

Implementation of transformation pathways linked to clear win-win potentials for national economy and could create advantages for positioning of companies on growing future marktes

- McKinsey expects substantial additional investment needs for implementation of transformation path
- Total investment (for the period 2020 to 2045) are supposed to be around 5 Bill. EUR for a conventional path (including necessary retrofits and replacement investments) and around 6 Bill. EUR for a climate protection pathway
- Annual additional investments associated with climate protection sum up to 40 Mrd. EUR (ca. 1 % of GDP)
- **Positive national economic impacts expected due to triggering an innovation and investment dynamic -> enables leadership chance in growing climate technology markets**

Quelle: Mc Kinsey 2021

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Thank you for your attention!