Climate Recon 2050:
Dialogues on Pathways and Policy

Lukas Emele, Öko-Institute
Yves Marignac, Association négaWatt
Stefan Petrovic, DTU

Modelling net zero emissions

Introduction, definition and implication

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1. Introduction: *"reaching net zero emissions"*

- Paris Agreement (article 4 no. 1):
  "In order to achieve the long-term temperature goal […], Parties aim […] ***to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases*** *in the second half of this century […]."*

- EU Governance Regulation (Regulation (EU) 2018/1999, Article 15, No 2 (a)):
  "[…] the Commission shall […] adopt a proposal for a Union long-term strategy for greenhouse gas emissions reduction in accordance with the Paris Agreement […]. The long-term strategy referred to in this paragraph shall include an analysis covering [….] inter alia a scenario on ***achieving net zero greenhouse gas emissions within the Union by 2050*** *and negative emissions thereafter […]"*

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2. Concept of net zero emissions

- The concept of “net zero emissions” is based on the fact that radiative forcing is due to “net emissions”, which is the balance between raw emissions of greenhouse gas (GHG) and removal by sinks, or so-called “negative emissions”.
- Reaching net zero anthropogenic emissions → balance of
  - Gross anthropogenic GHG emissions
  - Carbon removals (“negative emissions”): Reinforcing the role of natural sinks or by creating artificial ones (carbon capture and storage (CCS) and bio-energy with carbon capture and storage (BECCS) technologies)
- Needs a comprehensive and holistic approach
  - All emissions in all sectors
  - Potential for increasing natural sinks or developing artificial ones
  - Crossed effects between these
  - Not only technological solutions but also changes of life-style, urban planning, land use or circular economics
- More difficult to model than the traditional sectorial approach

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3. Carbon neutral versus climate neutral

- **Carbon neutral:** All activities lead to net zero CO_2 emissions
  - Either: Reduce CO_2 emissions to zero
  - Or: Compensate remaining CO_2 emissions
  - **Decarbonisation:** Process of reducing CO_2 emissions and aiming for carbon neutrality
- **Climate neutral:** Covers not only CO_2 emissions but all greenhouse gases
  → Sum of all greenhouse gas emissions (applying global warming potentials) = 0

- Many energy models only calculate CO_2 emissions → effects of energy-related non-CO_2 emissions are neglected!
- Global life-cycles are not included in most energy models

Source: Tim Butler Tim; Birgit Lode, Andy Parker, Kathleen Mar, Falk Schmidt, and Mark G. Lawrence (2015): *Long-term climate goals – Decarbonisation, carbon neutrality, and climate neutrality*. Institute for Advanced Sustainability Studies (IASS) Potsdam, November 2015, https://www.iass-potsdam.de/sites/default/files/files/policy_brief_decarbonisation.pdf

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4. Domestic emissions versus carbon footprints

- **Domestic emissions:** All emissions are released from a specific territory

- But: No country is living in autarchy
  → Exchanges of materials, goods, services and possibly people with other entities
  → Exchanges themselves generate emissions (e.g. international transport)

- **Carbon/climate footprint emissions:** compensation for exchanges
  → Domestic emissions + import-related emissions – export-related emissions

- Challenge of reaching net-zero emissions differs between countries due to national circumstances (history, level of development, geographical situation, population density…)
  → Potential for mutualization, especially relevant on EU level

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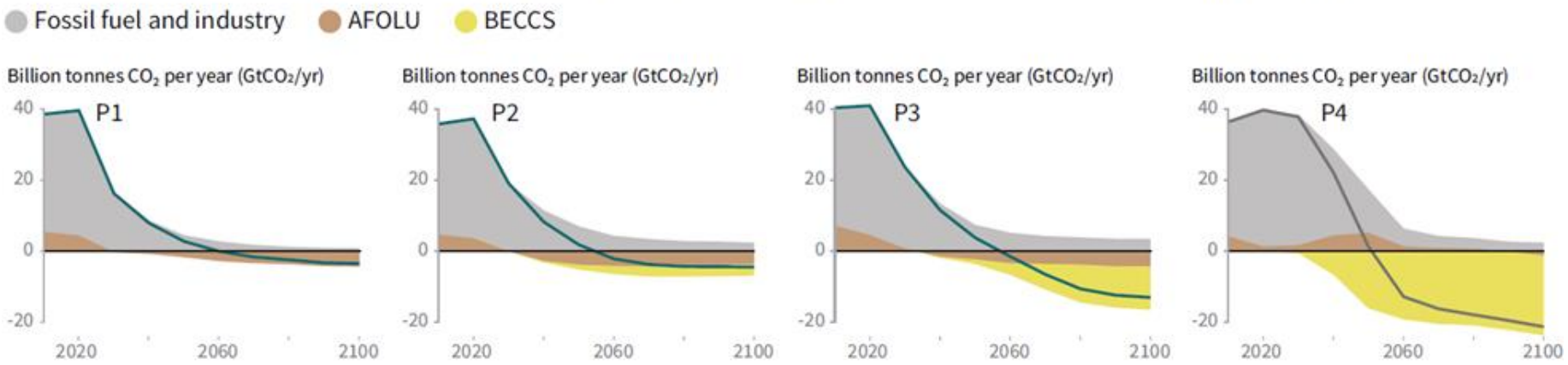
5. Net zero emissions and emission budgets

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

IPCC (2018): *Summary for Policymakers*. In: *Global warming of 1.5˚ C*. https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_High_Res.pdf