Material stocks as drivers of global greenhouse gas emissions: Results from a scenario analysis for 2050

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Why material stocks are important

- They transform resources into services such as shelter, mobility or supply and discharge.
- Building up and maintaining stocks requires large amounts of materials and energy.
- Providing services from stocks requires energy
- Stocks shape social practices (including production and consumption), thereby creating path dependencies and legacies for future resource use

Quantifying stocks of artifacts using the MISO model, an input driven, dynamic stock-flow model, integrated in ew-MFA

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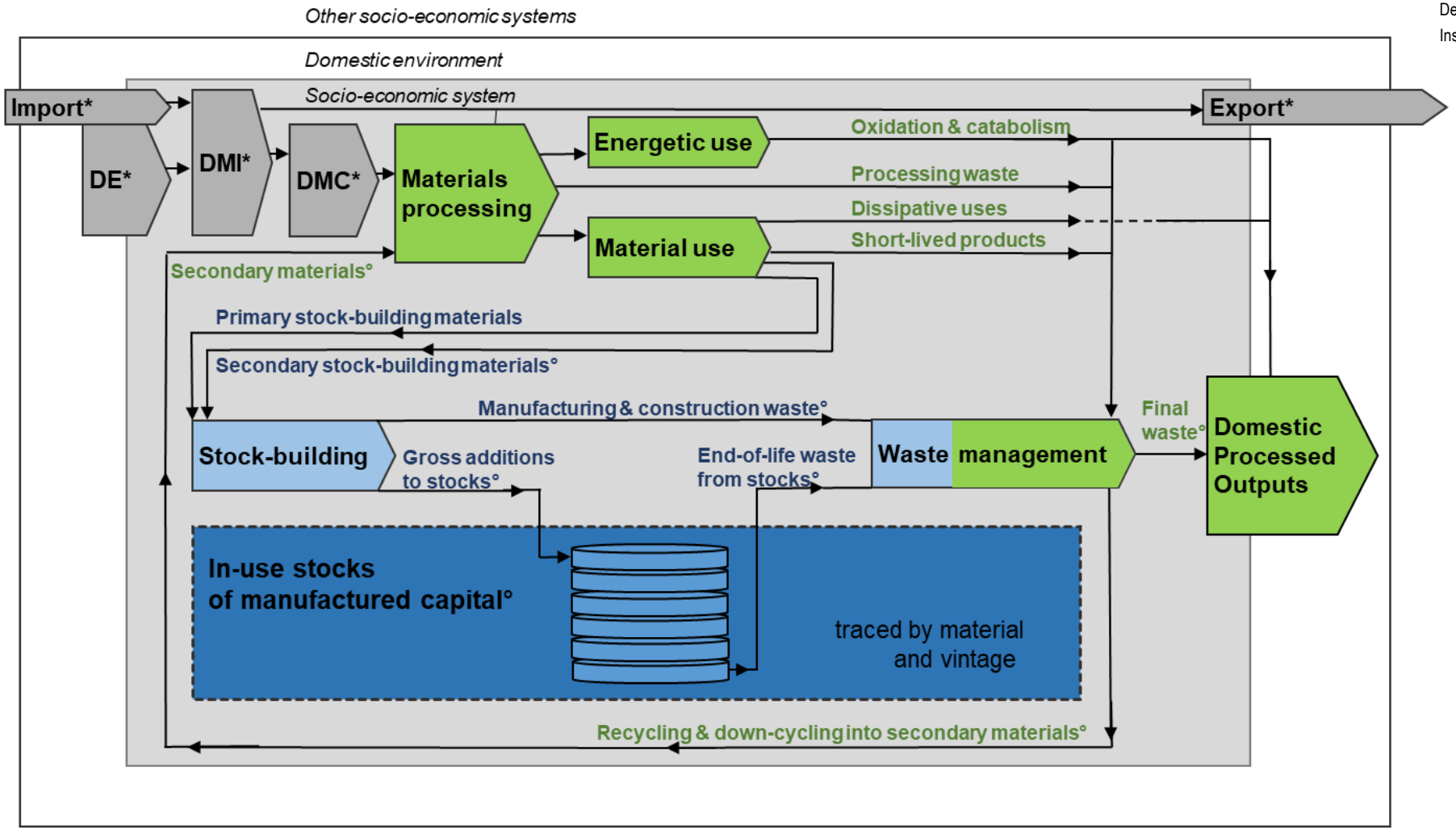

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Wiedenhofer, D., Fishman, T., Haas, W., Haas, W., Krausmann, F., (2019). Integrating material stock dynamics into economy-wide material flow accounting: concepts, modelling, and global application for 1900-2050.
10.1016/j.ecolecon.2018.09.010

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Share of stock-building materials increased from 20% to 50% Stocks increased 27 fold to nearly 1000 Gt; large differences in per capita stocks between countries prevail.

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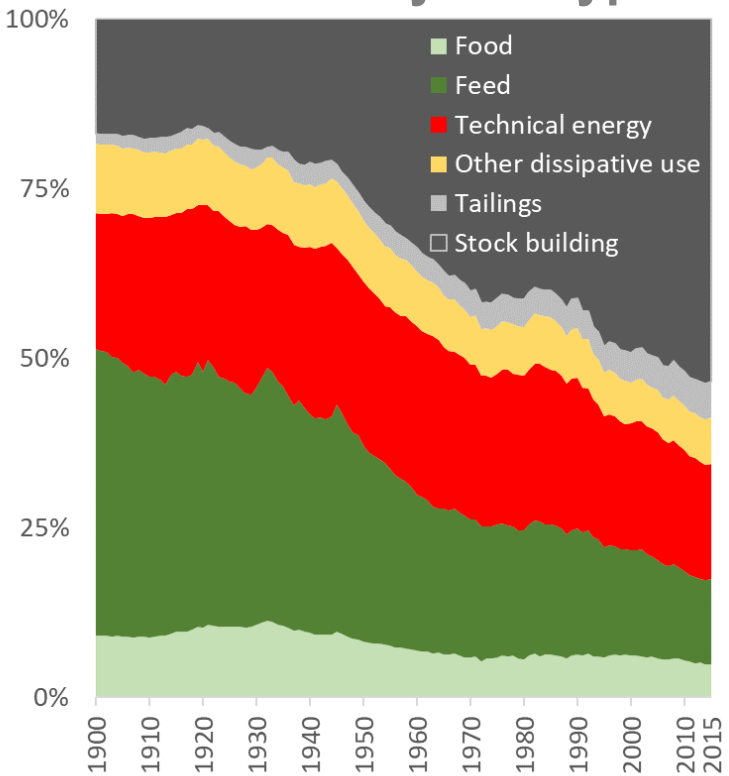
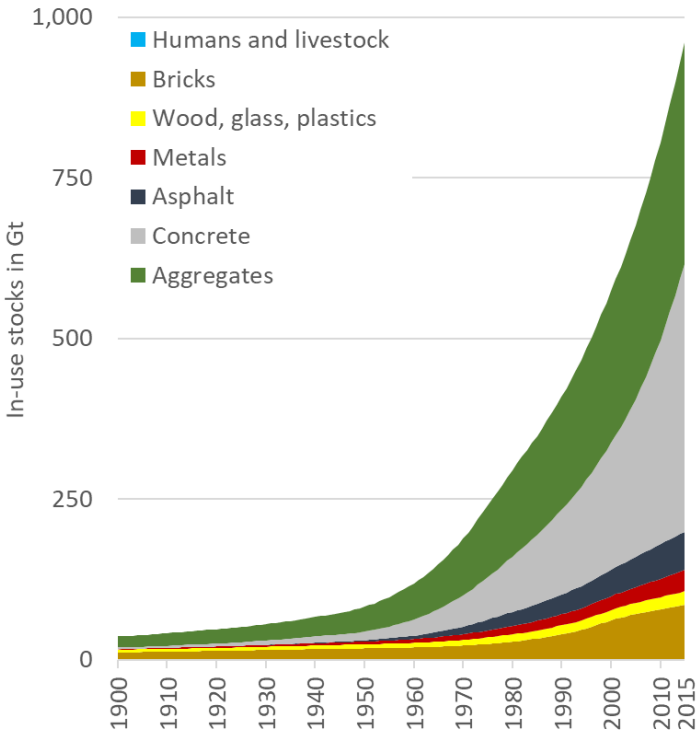
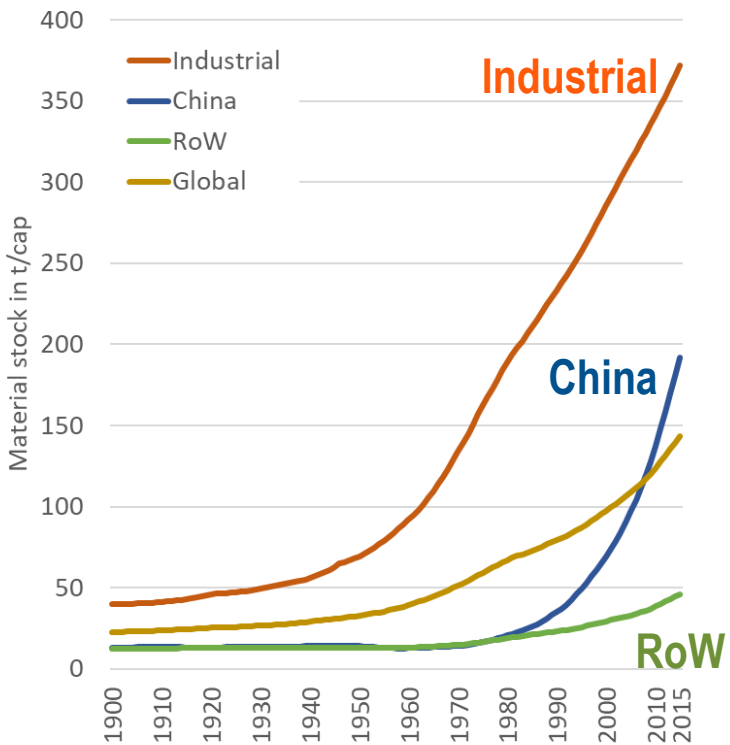
Extraction by use type



In-use stocks of materials



Stock per capita



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Krausmann, F., Lauk, C., Haas, W., and Wiedenhofer, D.. (2018). From Resource Extraction to Outflows of Wastes and Emissions: The Socioeconomic Metabolism of the Global Economy, 1900–2015'. *Global Environmental Change*. https://doi.org/10.1016/j.gloenvcha.2018.07.003.

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Modelling GHG emissions from fossil fuels & cement production based on material stock – energy relations.

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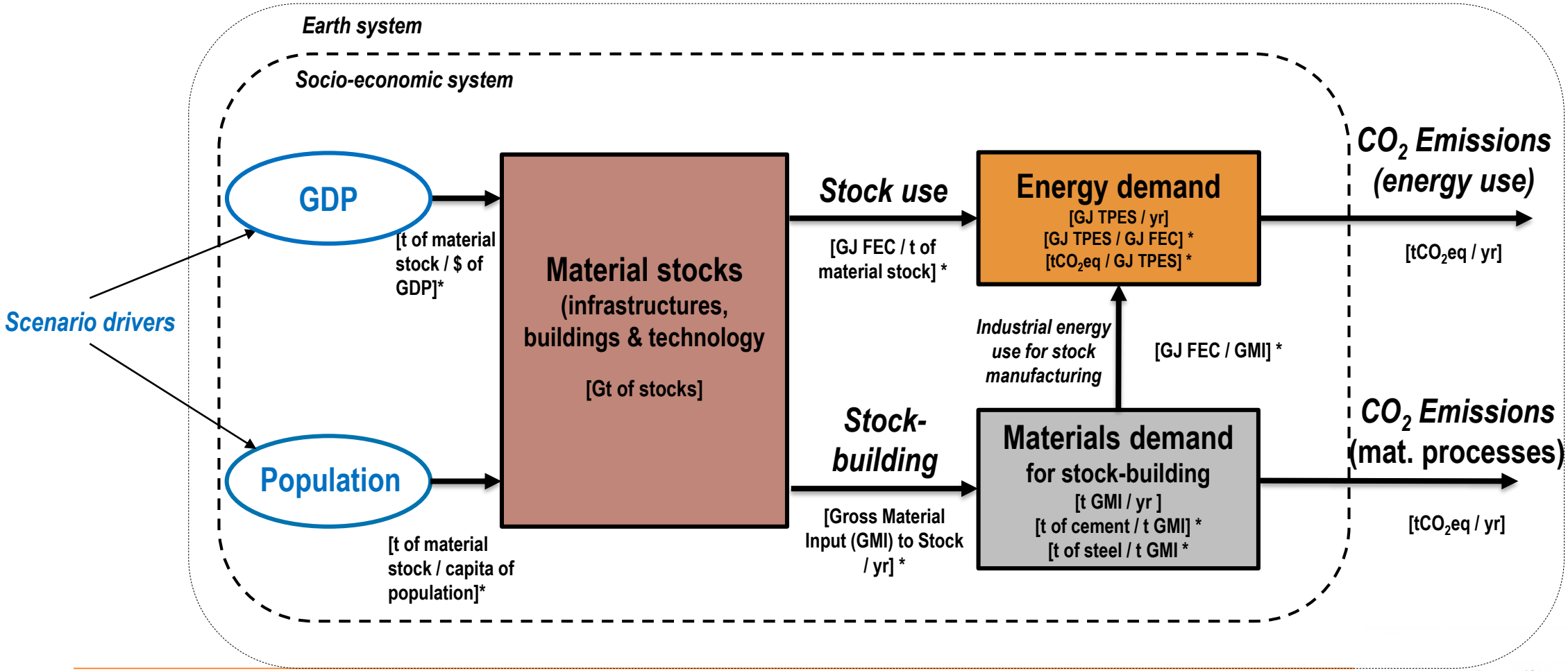

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* Scenario variables historically calibrated

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Scenarios for stock development and GHG emissions 2050

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- **GDP-driven scenarios:** GDP development in SSP2, assumptions on GDP per unit of stock ratio.
  - A GDP-driven high: Constant GDP/stock ratio
  - [B GDP-driven low: Trend GDP/stock ratio], not shown here.
- **Population-driven scenarios:** Population development (UN median) and assumptions on per capita stocks in 2050.
  - C Convergence1970: Contraction-convergence of global per capita stocks at industrial level of 1970
  - D Convergence2015: Convergence of global per capita stocks at industrial level of 2015
- **Decarbonisation pathways**:
  - Trend: low or no improvements in CO_2 intensity of TPES
  - Full decarbonisation of energy system in 2070, 2060, 2050, 2040 & 2030
  - Estimated C emissions from cement production (calcination) and coke use in blast furnaces (hard to decarbonise)

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Selected scenario assumptions and model parameters, 1980-2015-2050

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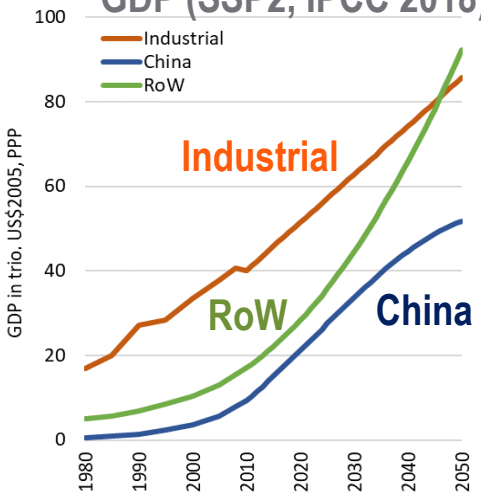
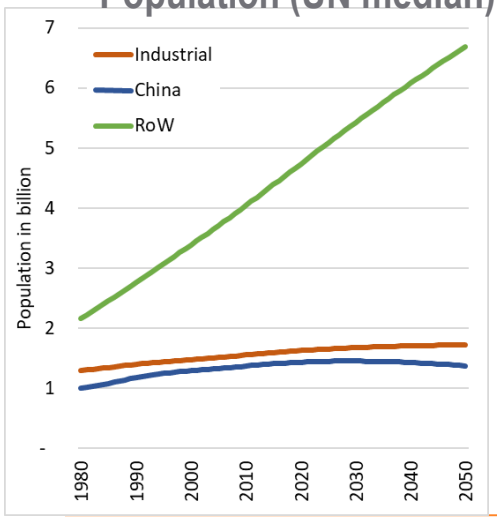
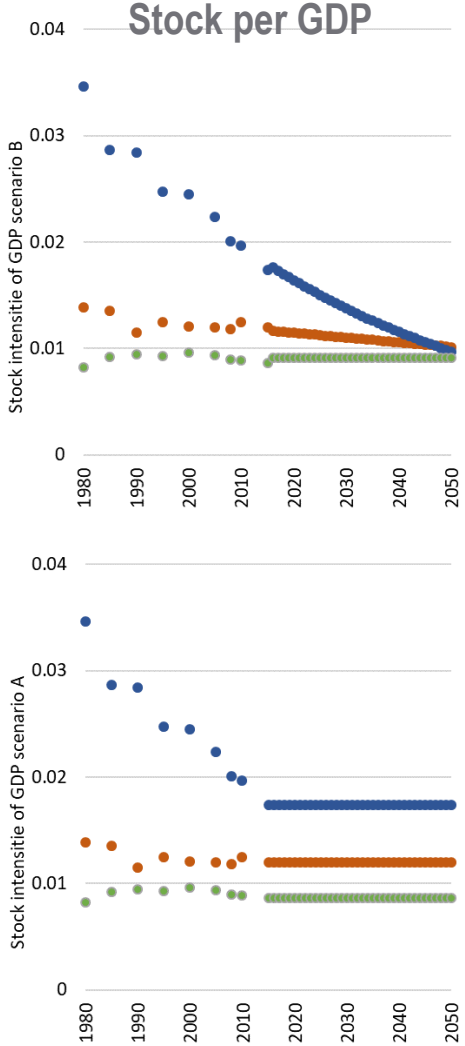
GDP (SSP2, IPCC 2018)



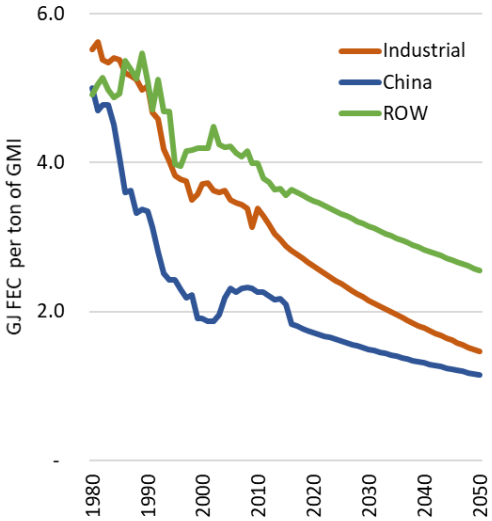
Population (UN median)



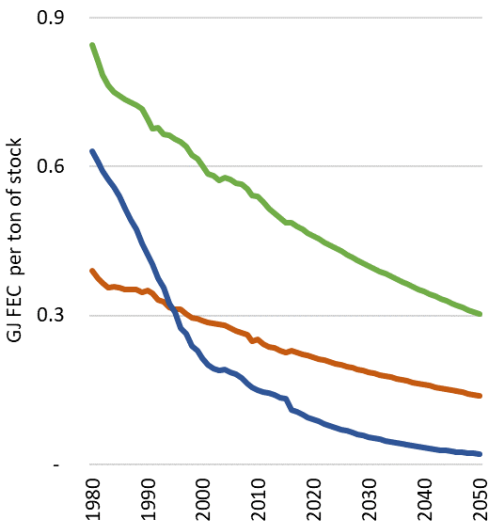
Stock per GDP



Energy intensity: Stock manufacturing



Energy intensity: Stock use



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Scenario results:
Development of stocks 1970-2050 in Gt

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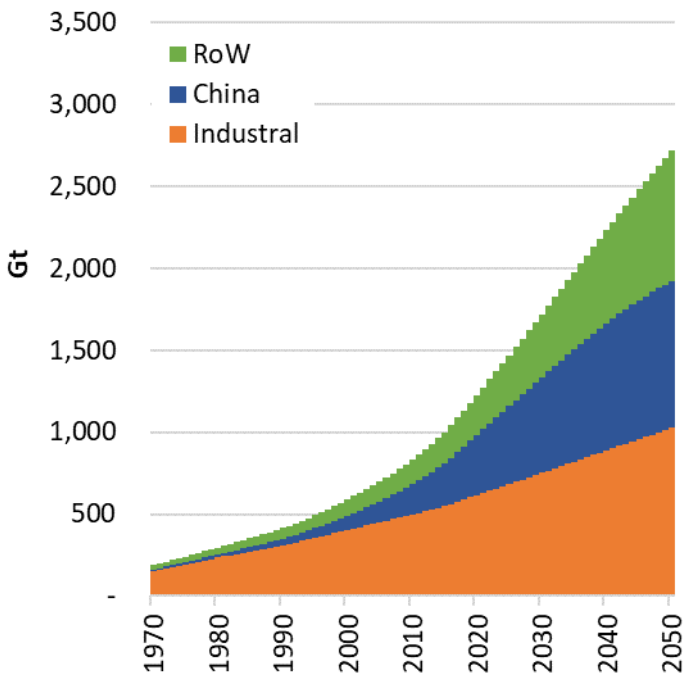
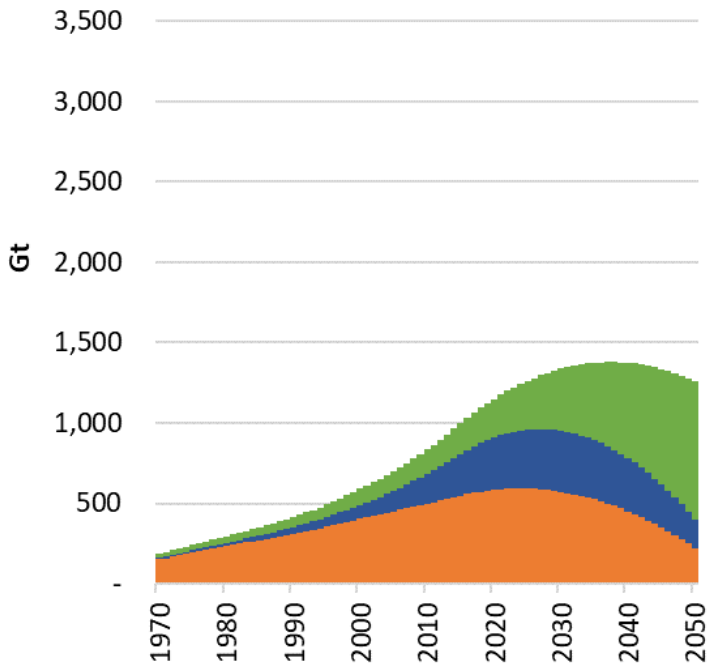
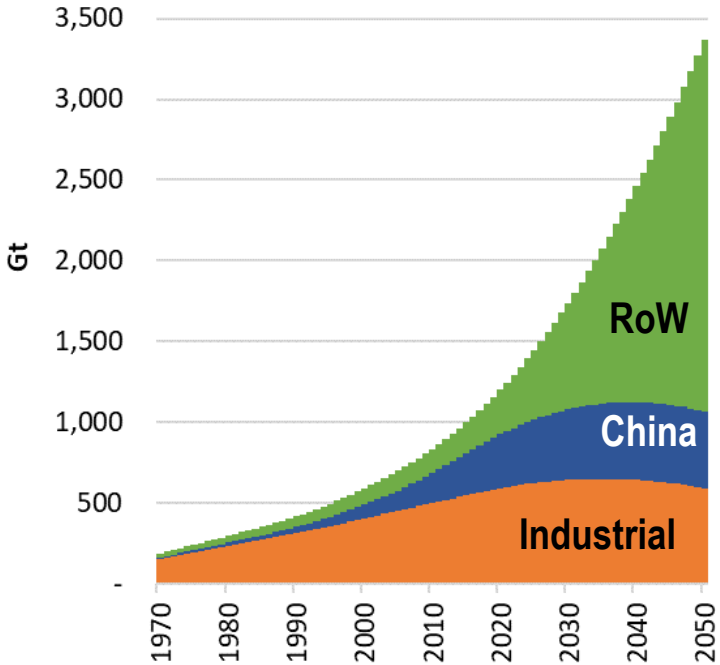
B GDP-driven high



C convergence1970



D convergence2015



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Per capita stock in 2050:
Large differences across groups and scenarios

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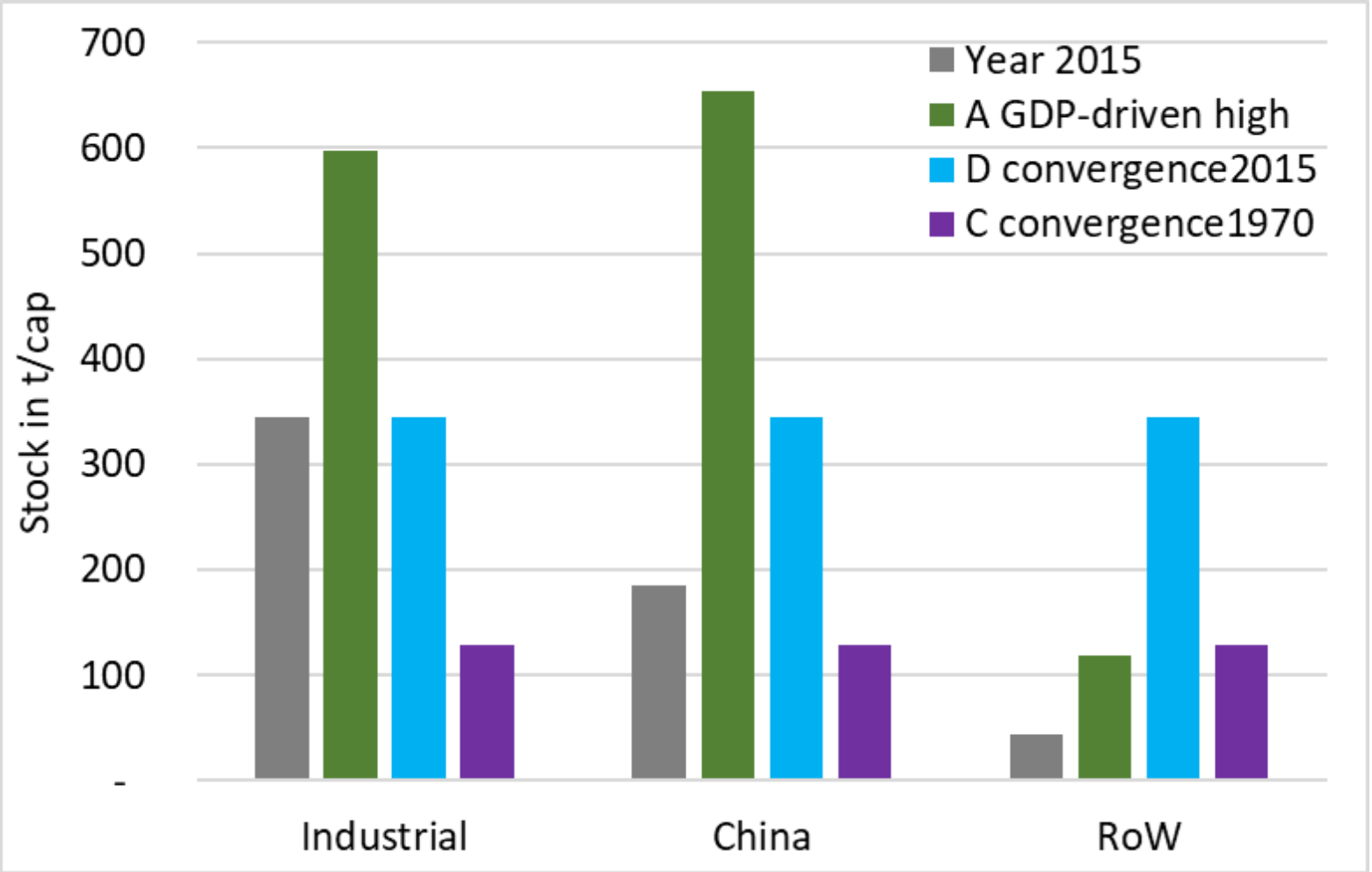

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Scenario results:
Yearly CO_2 emissions 1970-2050 (trend pathway)

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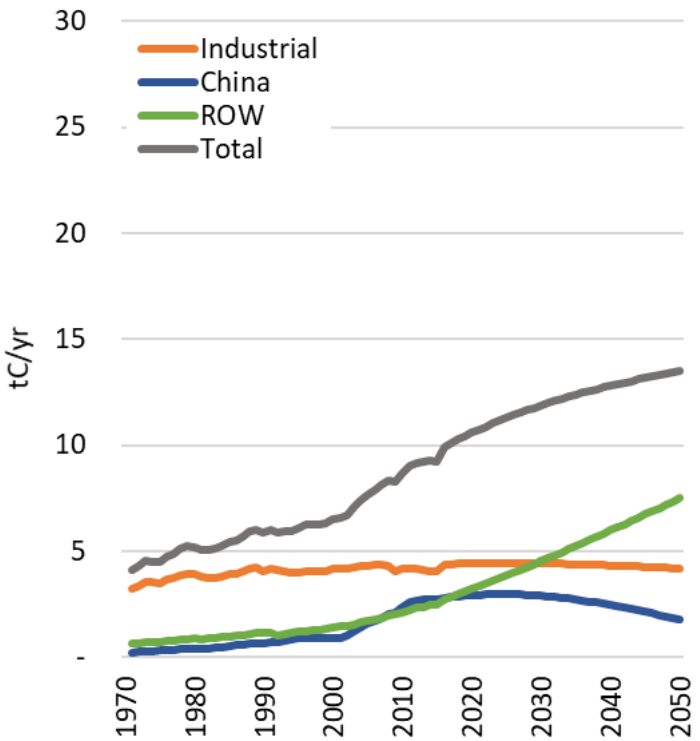
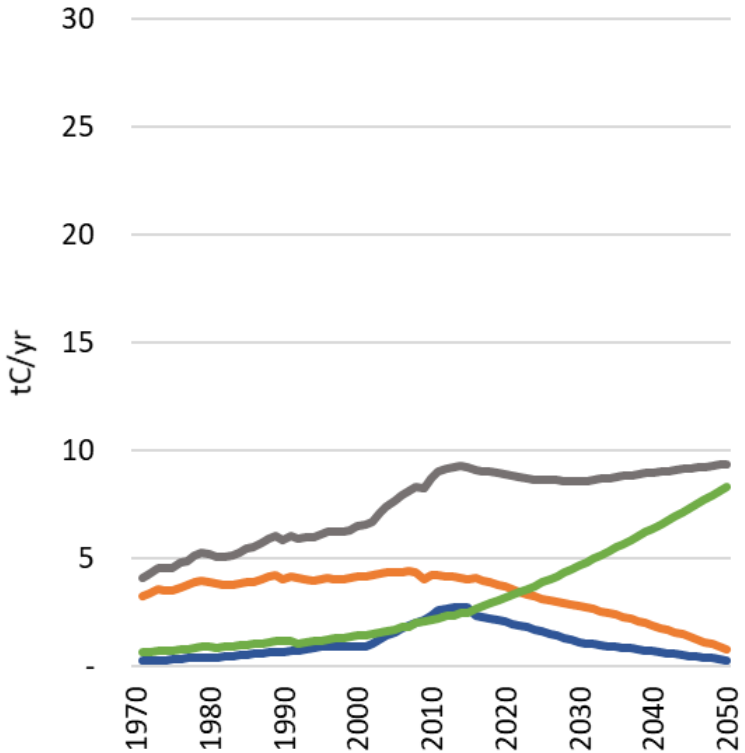
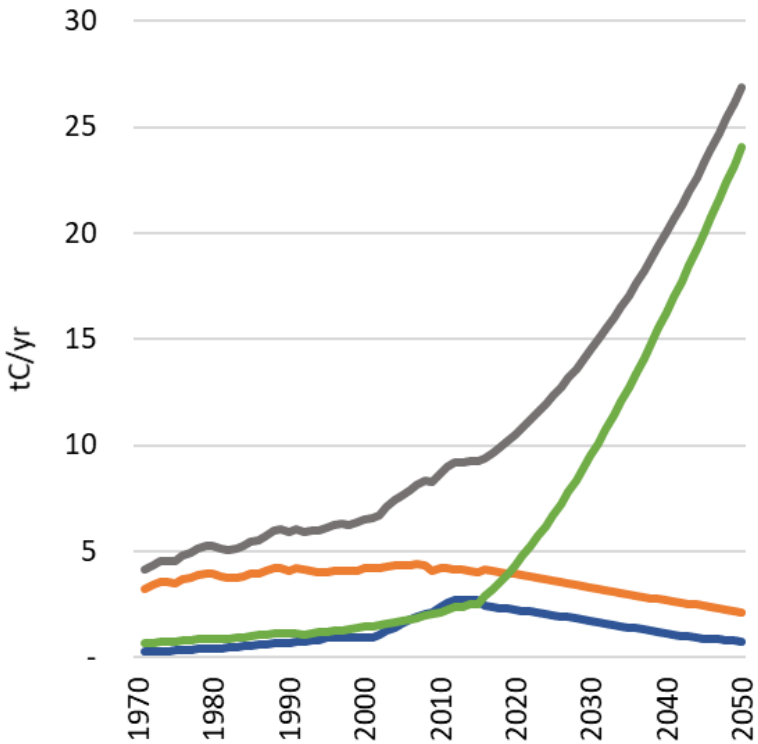
B GDP-driven high



C convergence1970



D convergence2015



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Scenario results:
CO_2 emissions from stock manufacturing and stock use

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	Average yearly TPES (2016-2050) [EJ/yr]	Share of manufacturing in TPES [%]	Cumulative CO_2 emissions (2018-2050) [GtC/yr]	Share of manufacturing in CO_2 emissions [%]
2015	554	37%		44%
A GDP-driven high	724	35%	401	42%
B GDP-driven low	673	31%	361	38%
C convergence1970	567	29%	293	35%
D convergence2015	1066	37%	568	42%

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Remaining carbon budget in 2050 (1.5°C goal): Decarbonication pathways

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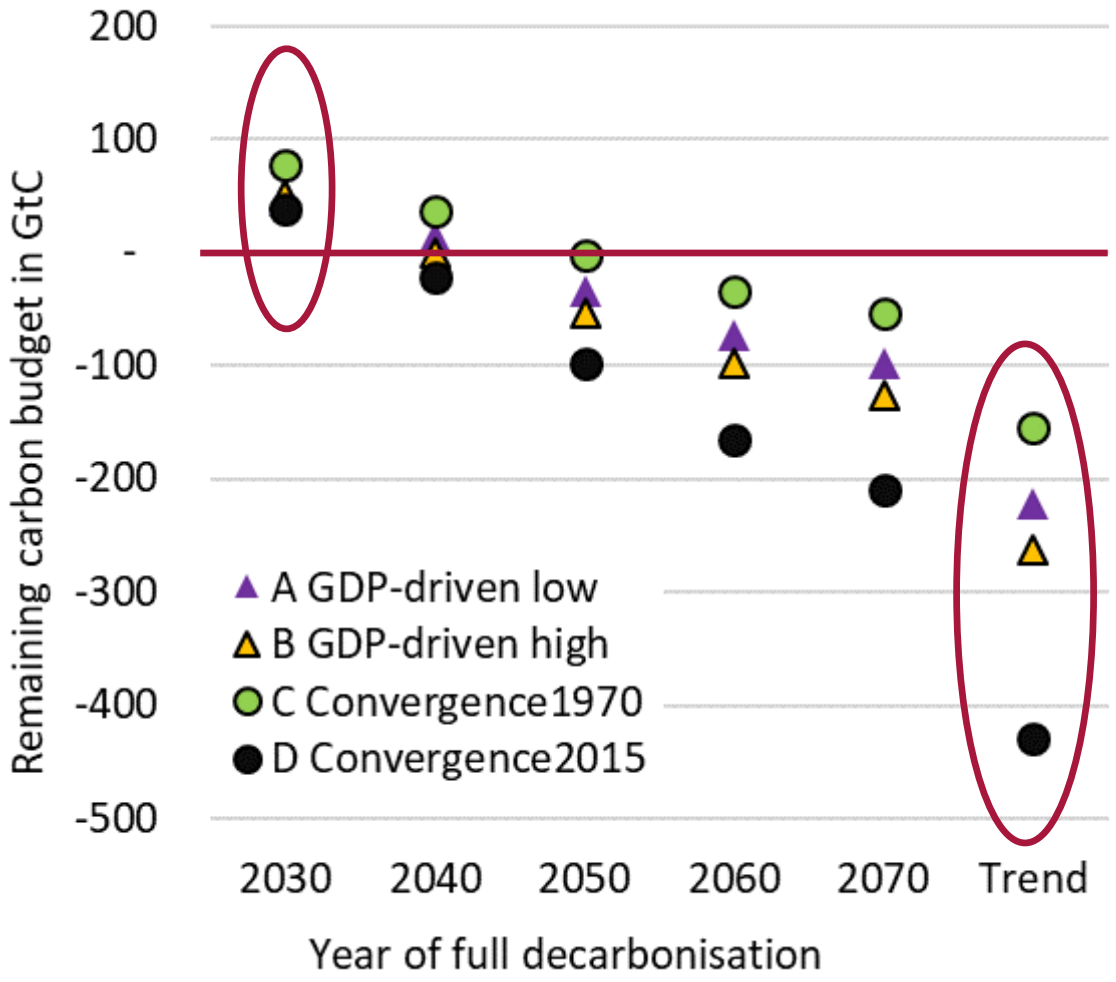

Source: Own calculations, IPCC 2018)

Negative values: Cumulative emissions exceed the available budget of 150 GtC.

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Conclusions

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- Exploratory results of simple but transparent scenarios that fully comply with laws of thermodynamics: Indicates high potential of socio-metabolic approaches complementary to prevailing IAMs.
- The scenarios point towards the importance of inequalities in per capita stocks and population growth for future emissions.
- Stock expansion in the industrial countries needs to slow down; radically more efficient stocks in the Global South are required.
- More elaborate scenarios: Exploring the link between stocks, economic development and human well-being: What level of stocks is sufficient to meet human needs and to ensure human well-being?

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