Please answer the brief survey:

https://www.menti.com/al4mocv5cago

Or go to menti.com and enter the code 35 21 76 7

Fossil oil in global and Austrian energy scenarios

Johannes Schmidt (BOKU University)

Research Seminar – Petroleum Engineering / Montanuniversität Leoben – 28.11.2022

About me

Background:
- Graduation in Computer Science at TU Wien
- Doctorate in Energy Systems Analysis at BOKU
- Habilitation in Energy & Resource Economics

Research foci
- Renewable energies, climate & land-use (conflicts)
- Decarbonization scenarios
- Electricity markets & risks
- And most recently, real-time data visualisations on energy crisis: energie.wifo.ac.at

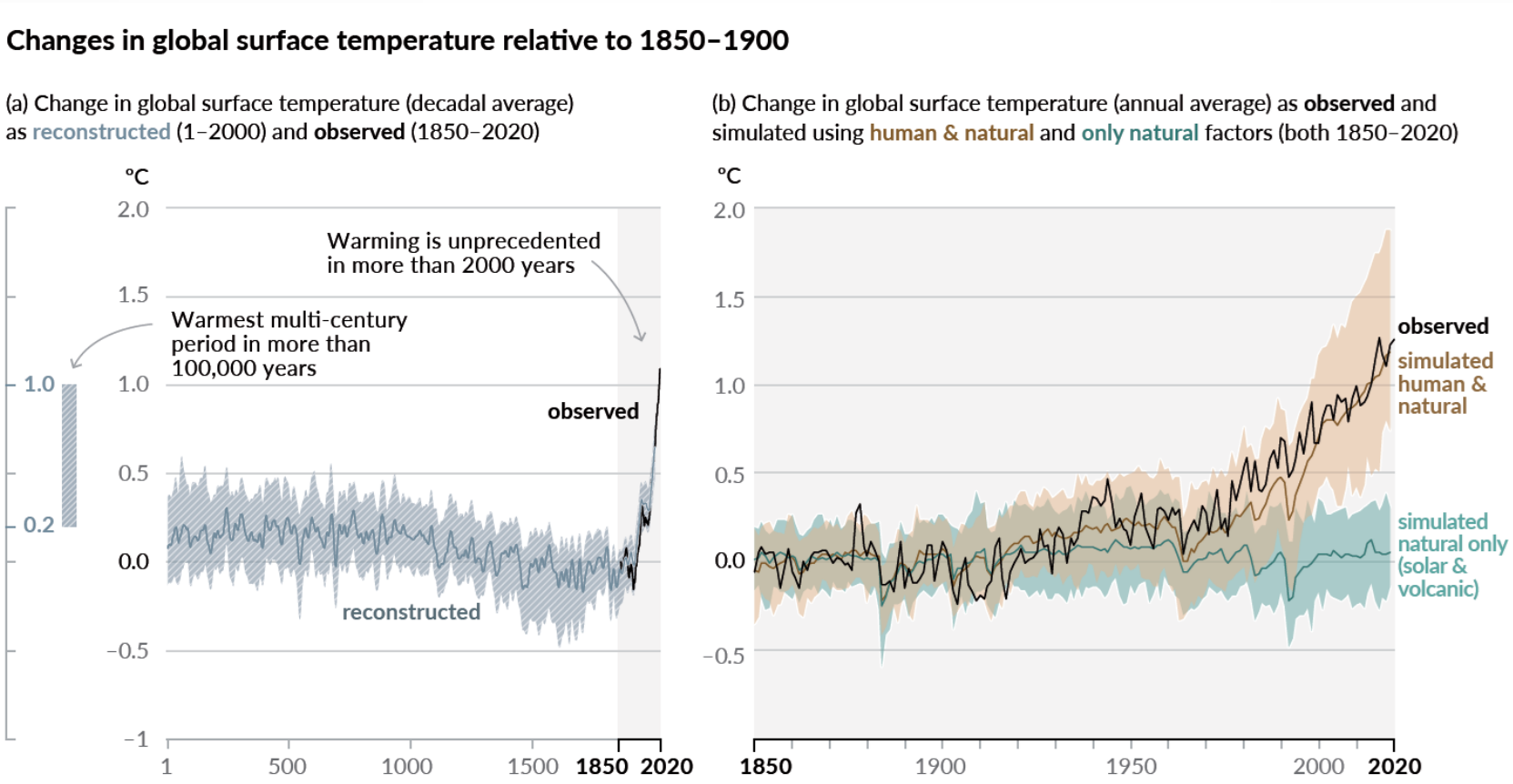
Methods in our group
- Simulation and optimization models, statistical models & spatial /GIS modeling, reinforcement learning
- Qualitative methods in social sciences

Regional focus: Austria, Sweden, Brazil, US

Interdisciplinary Research Group (third-party funding)
- Economists, Computer Scientists, Mathematicians, Human Geographers, Land-use researchers

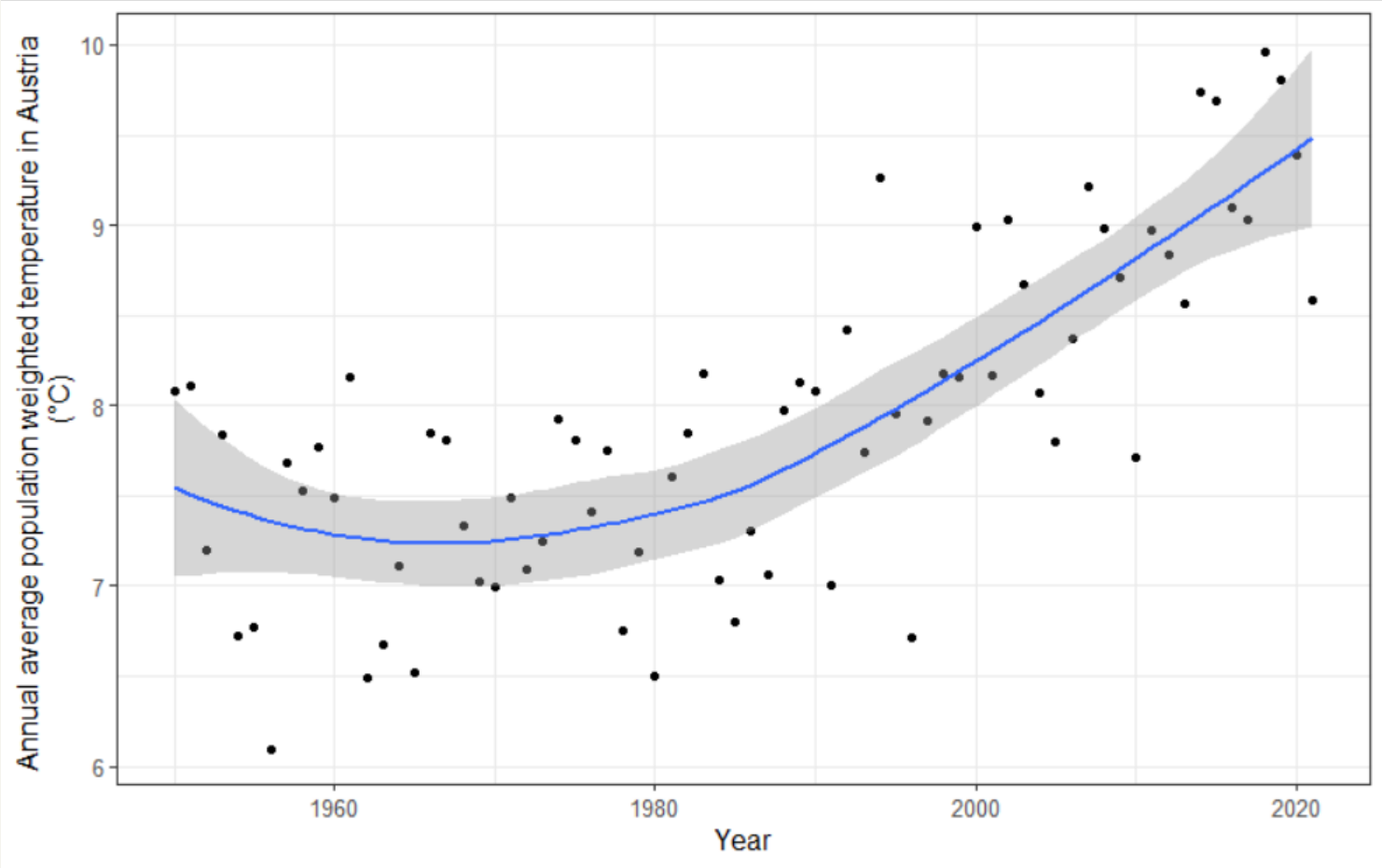
Some basics about climate change

It’s getting warmer.



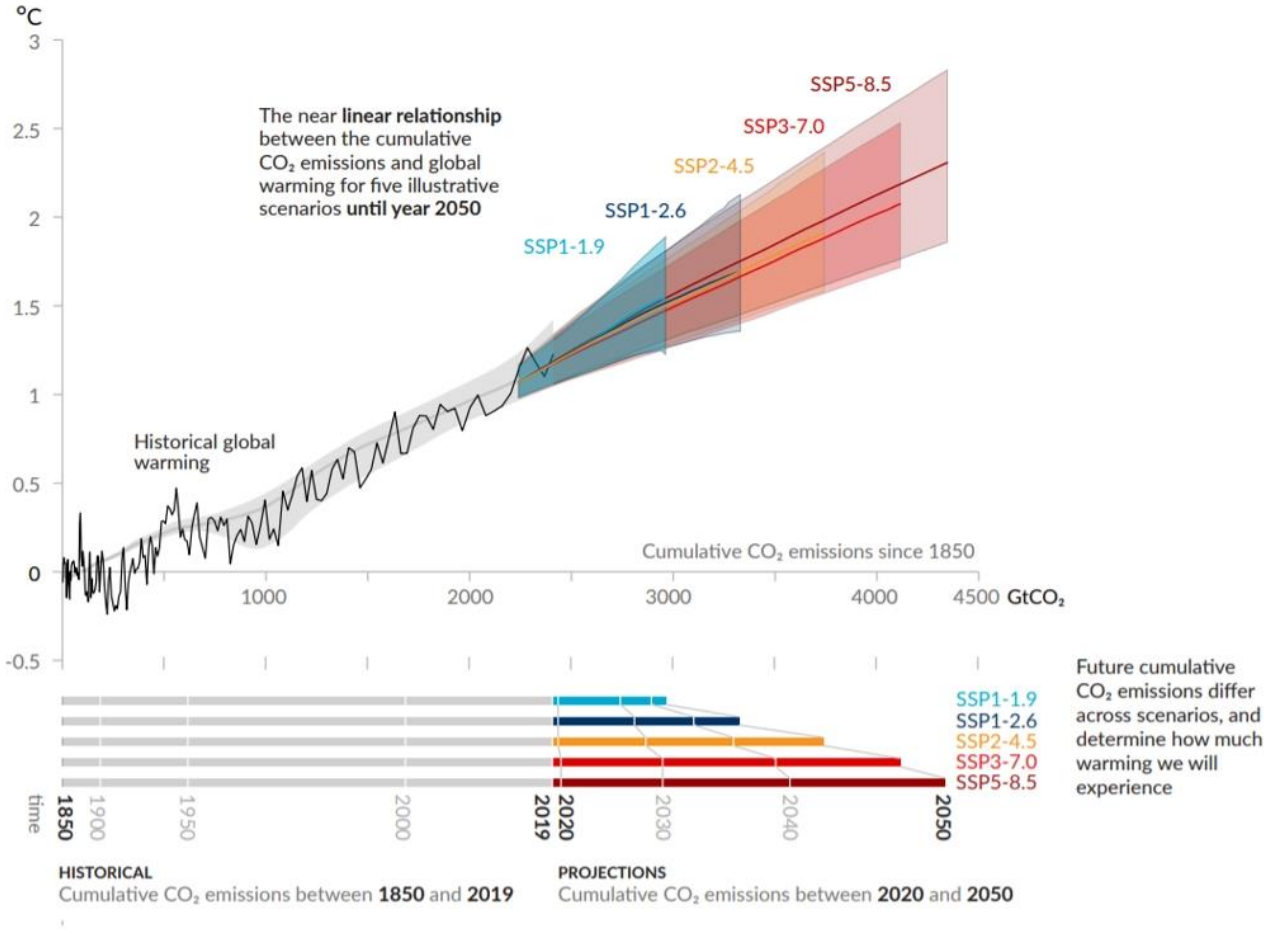
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf

It’s getting warmer. In Austria too.



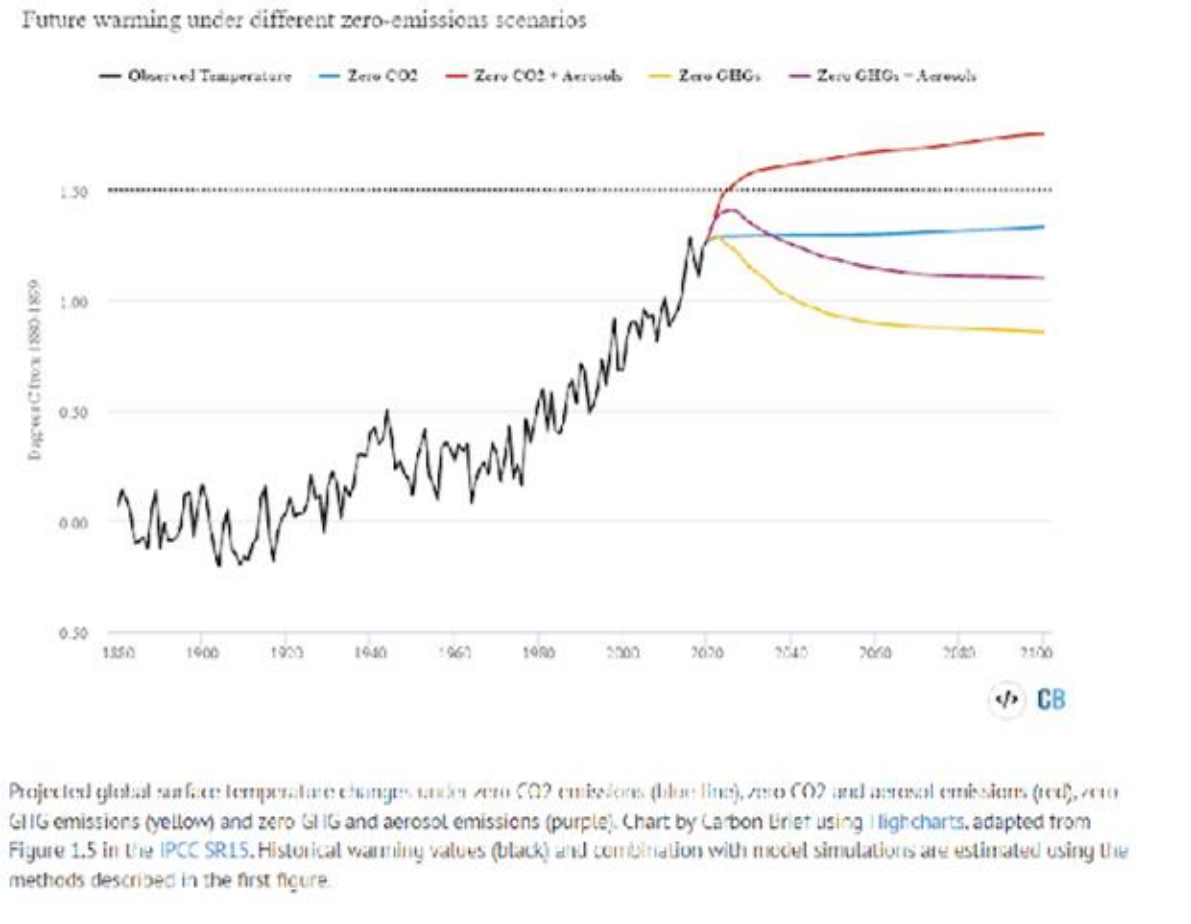
Source: ERA5 – reanalysis data. Analysis: energie.wifo.ac.at

Emissions vs. Temperature: an almost linear relationship



https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf

But: netZERO = temperature increase stops

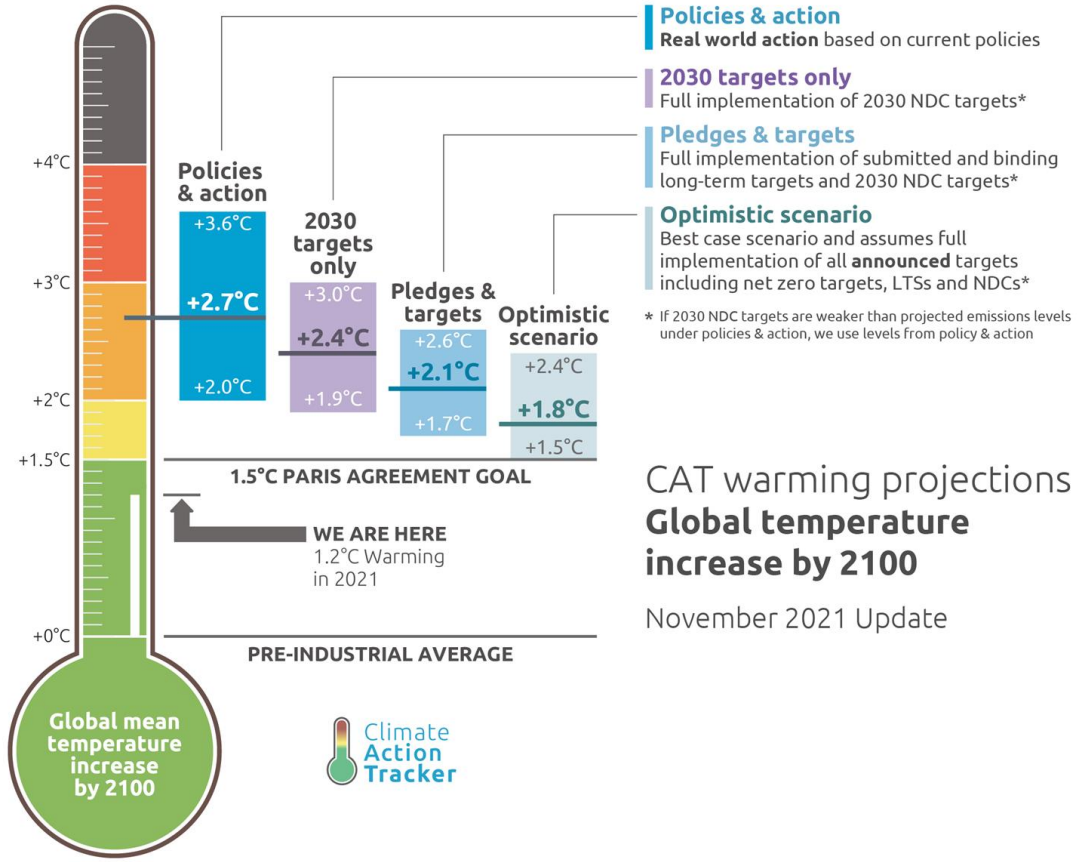


Projected global surface temperature changes under zero CO2 emissions (blue line), zero CO2 and aerosol emissions (red), zero GHG emissions (yellow) and zero GHG and aerosol emissions (purple). Chart by Carbon Brief using Highcharts, adapted from Figure 1.5 in the IPCC SR15. Historical warming values (black) and combination with model simulations are estimated using the methods described in the first figure.

Source: Carbonbrief https://www.carbonbrief.org/explainer-will-global-warming-stop-as-soon-as-net-zero-emissions-are-reached/

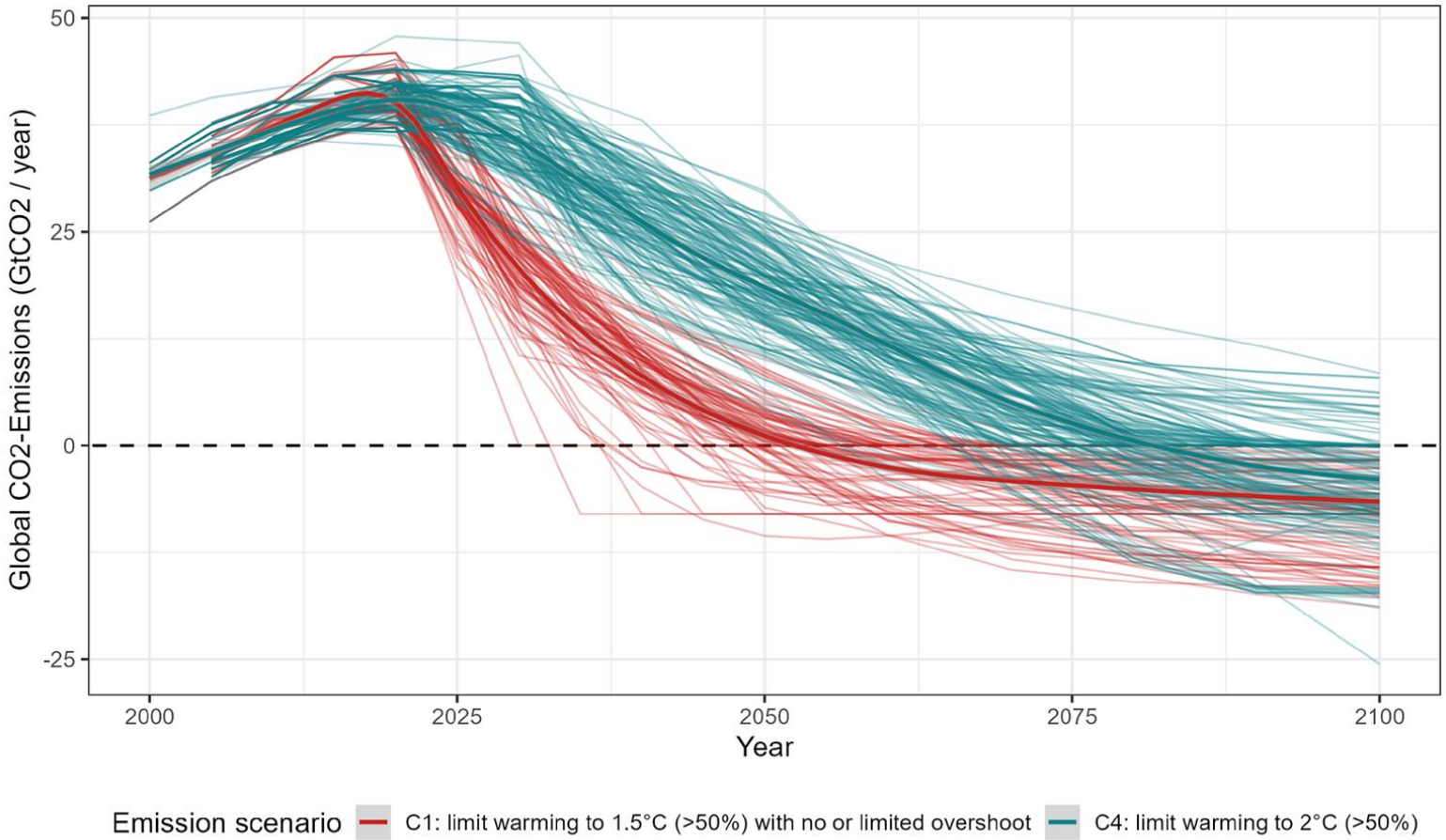
Global scenarios

Where are we headed



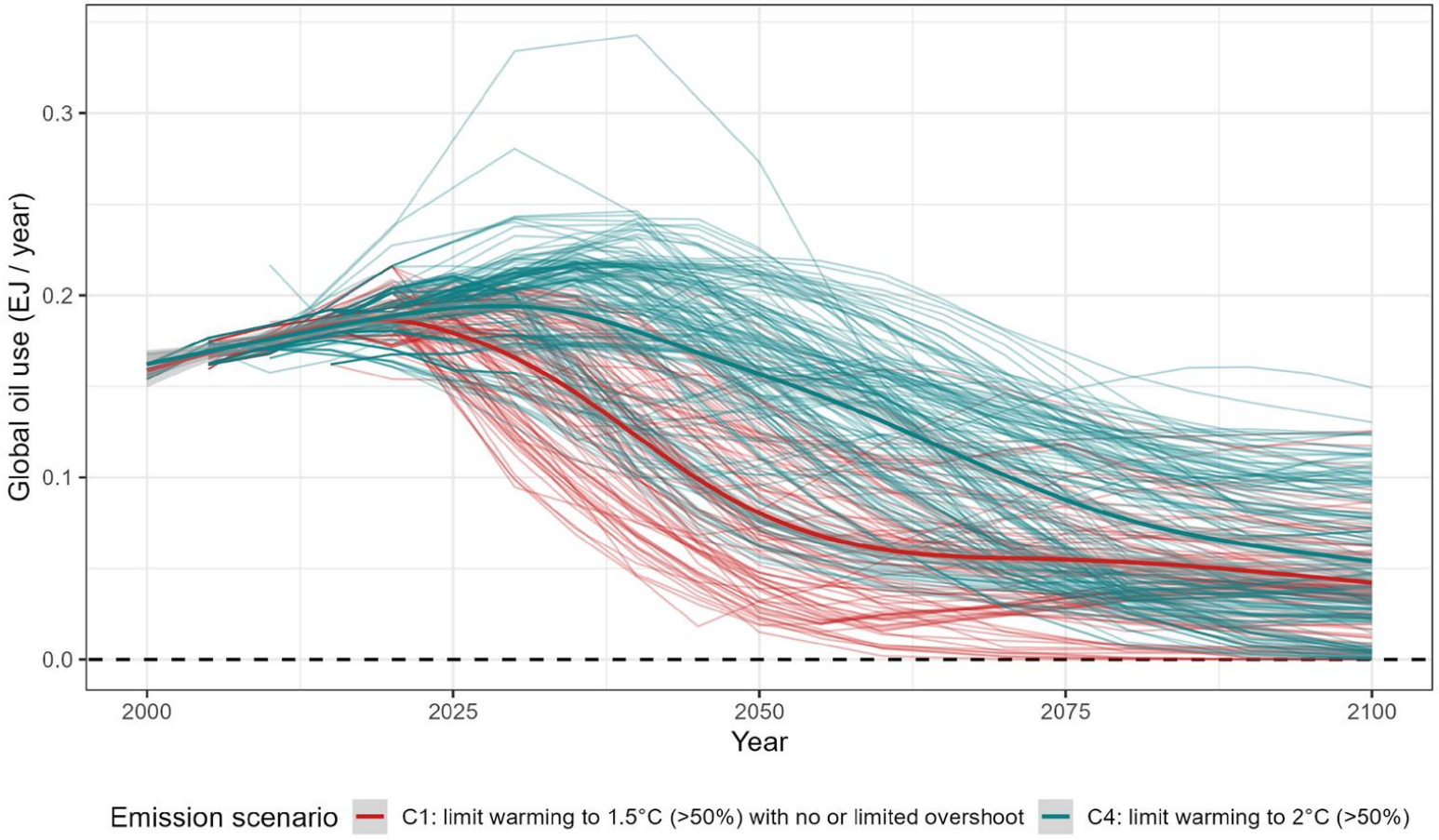
https://climateactiontracker.org/

Falling off a cliff: emission reductions in the 6th Assessment Report



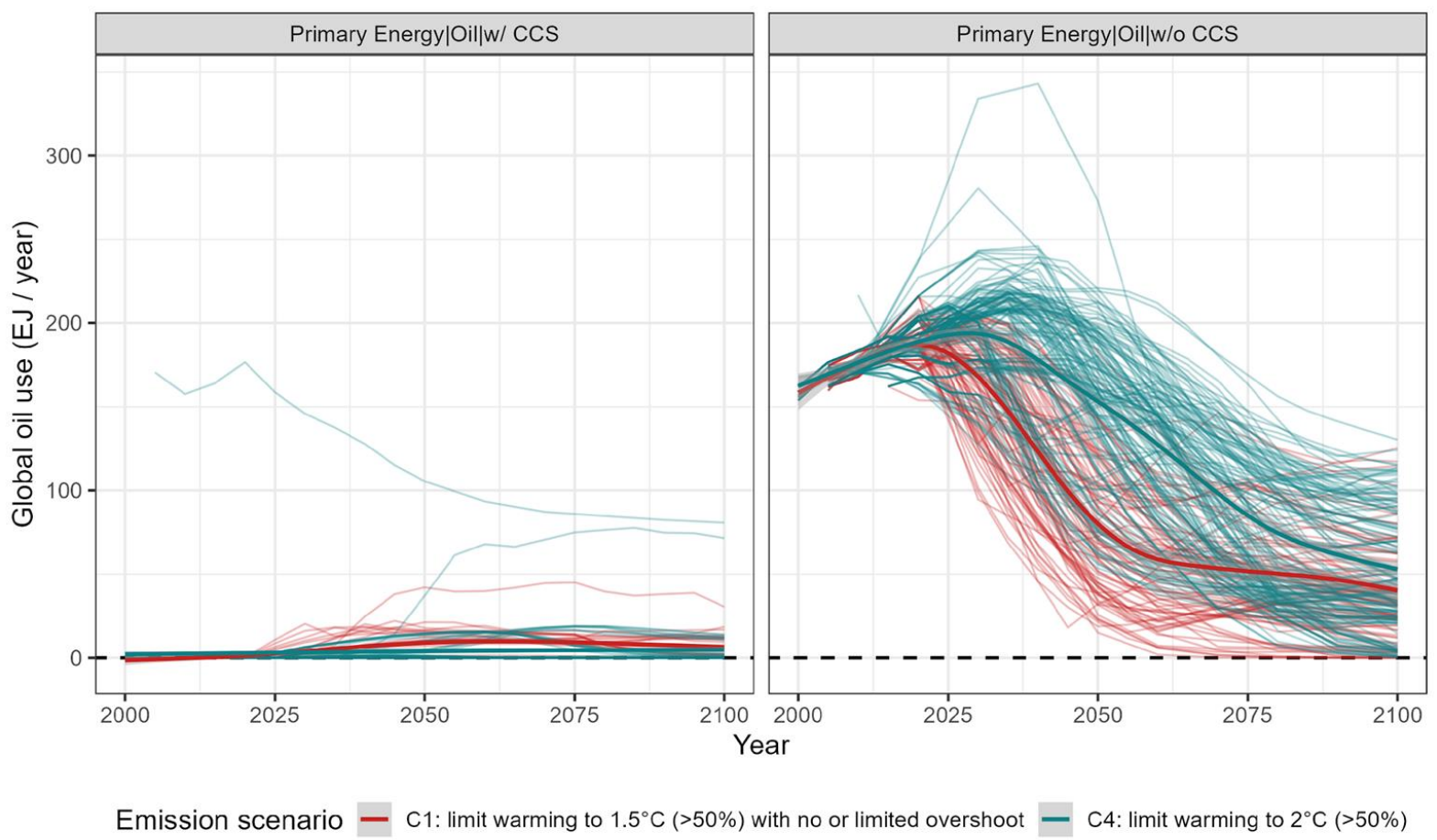
Source: IIASA AR6 Scenario Explorer and Database. https://data.ece.iiasa.ac.at/ar6/

Oil use peaks latest in 2050 (2°C). It peaks latest in 2040 for 1.5°C.



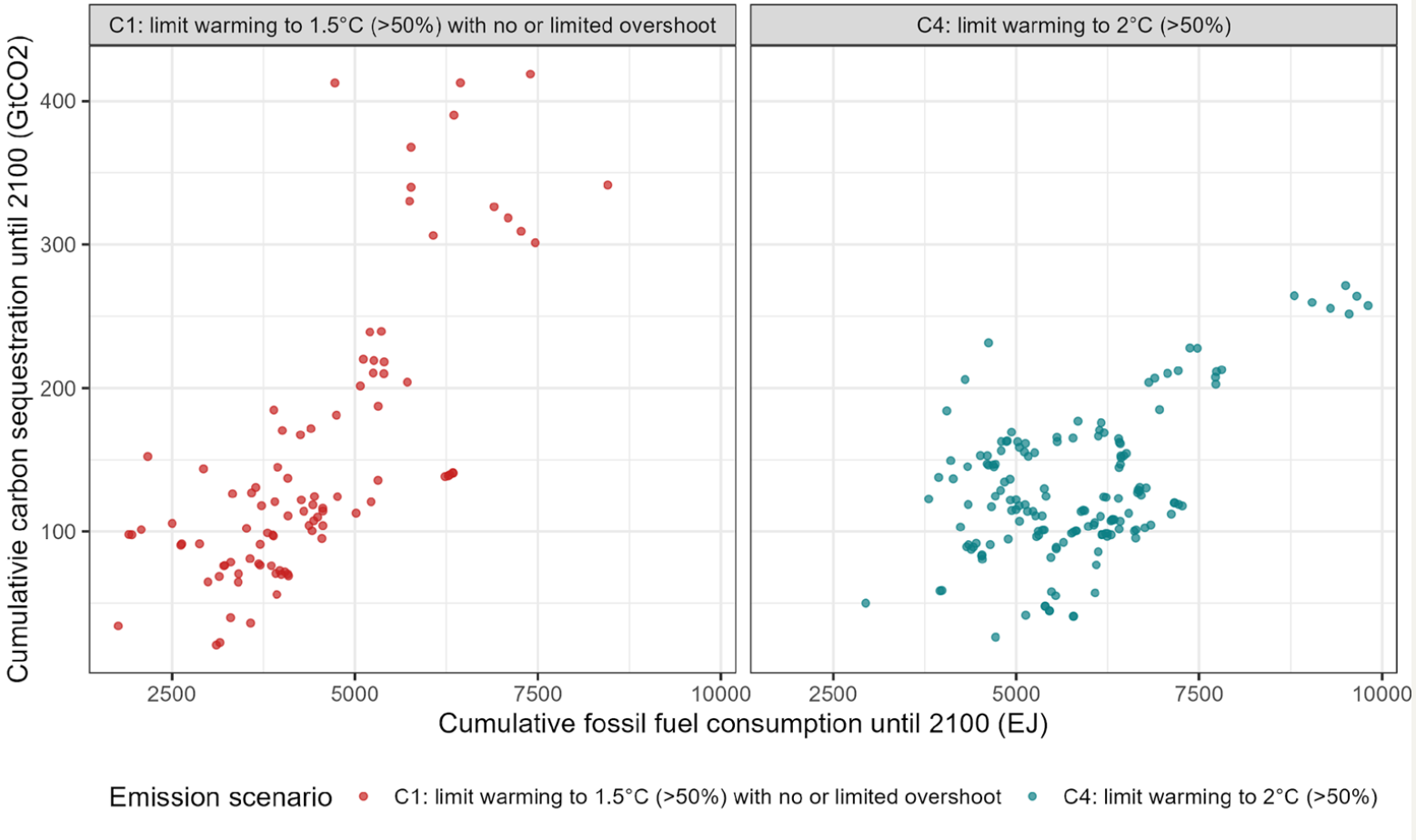
Source: IIASA AR6 Scenario Explorer and Database. https://data.ece.iiasa.ac.at/ar6/

No major use of CCS for oil



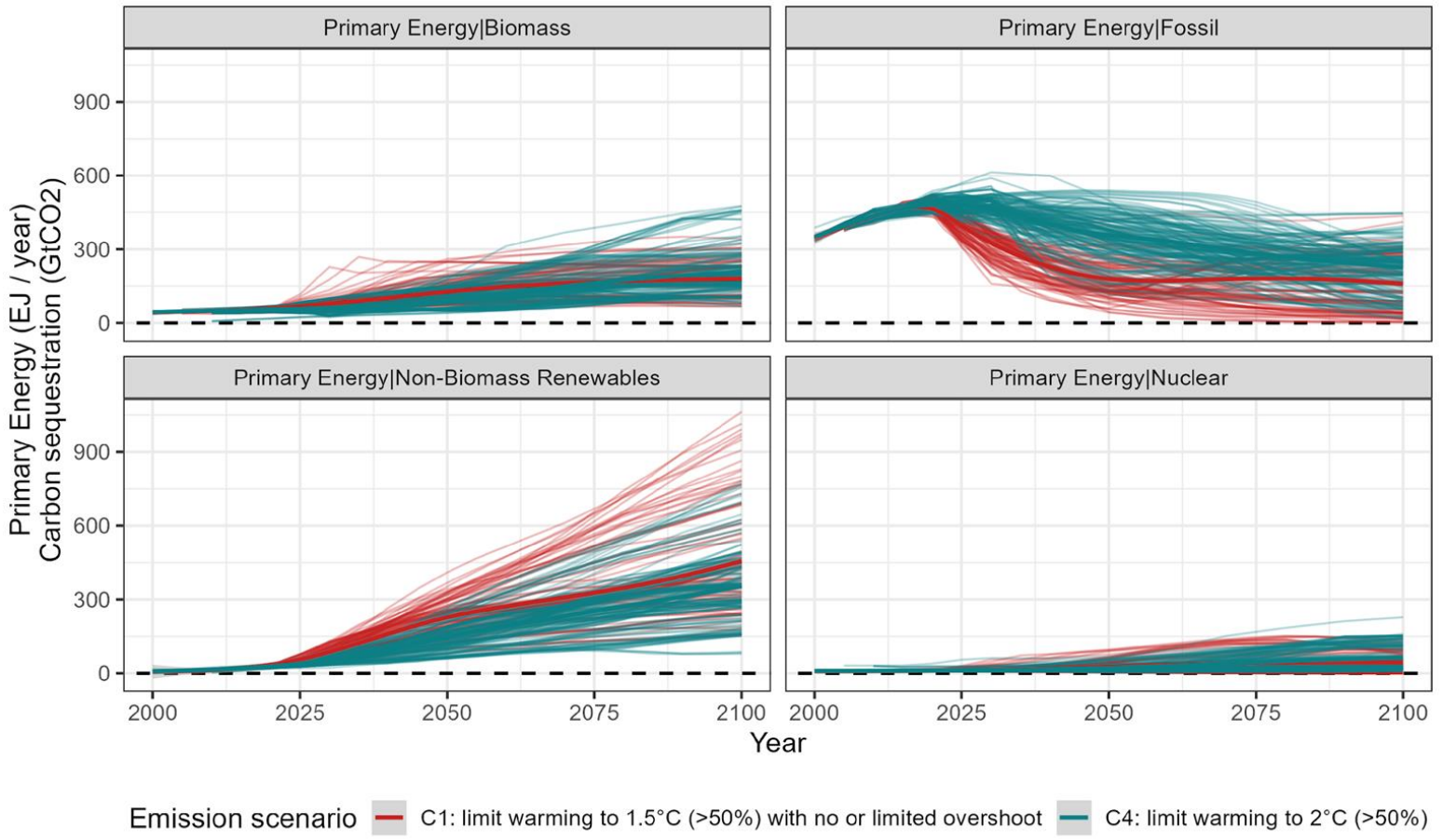
Source: IIASA AR6 Scenario Explorer and Database. https://data.ece.iiasa.ac.at/ar6/

More fossils, more carbon sequestration.



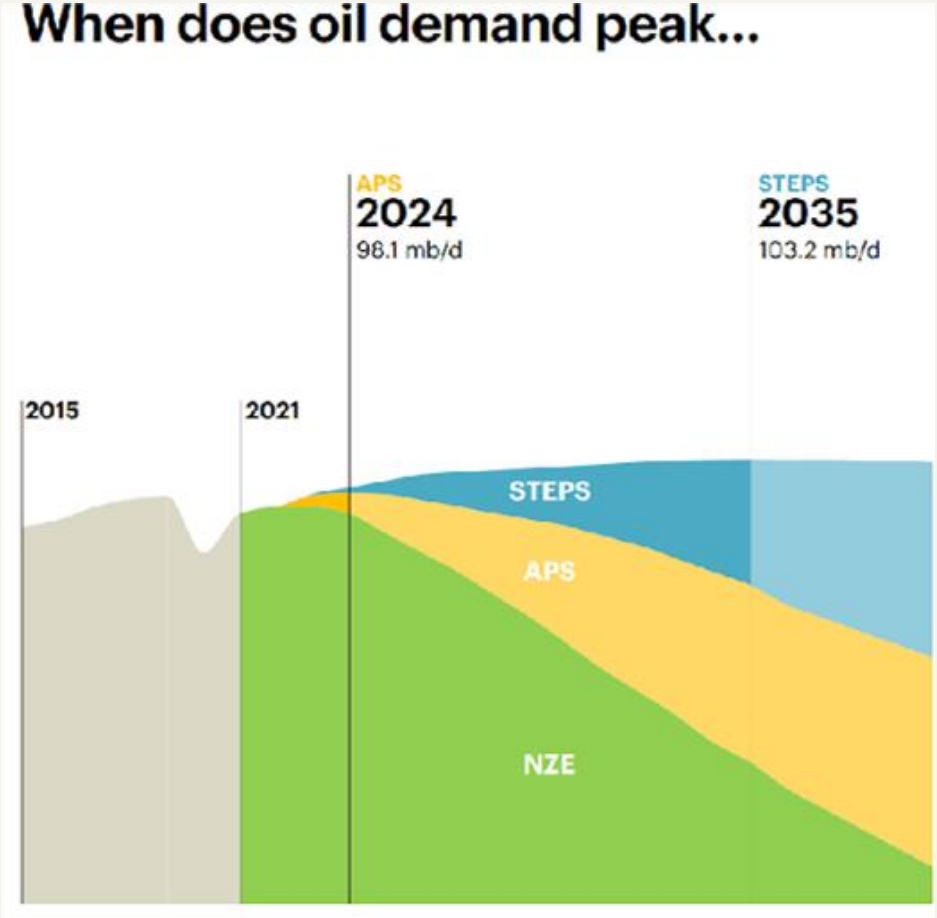
Source: IIASA AR6 Scenario Explorer and Database. https://data.ece.iiasa.ac.at/ar6/

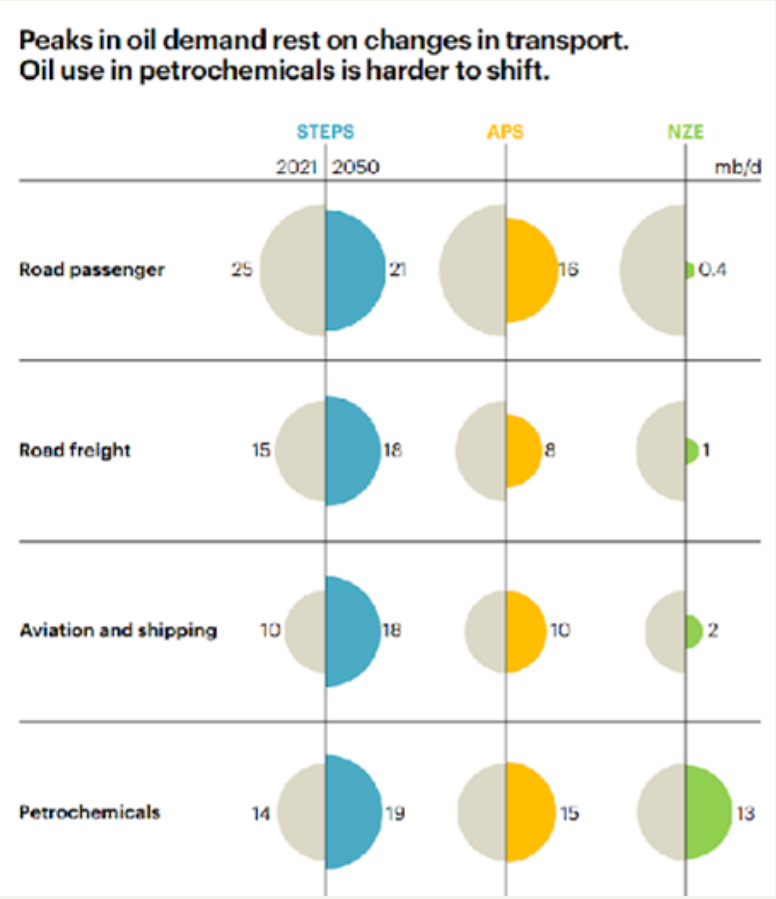
More of everything: substituting fossils.



Source: IIASA AR6 Scenario Explorer and Database. https://data.ece.iiasa.ac.at/ar6/

Ok, these are normative scenarios. What says the IEA?



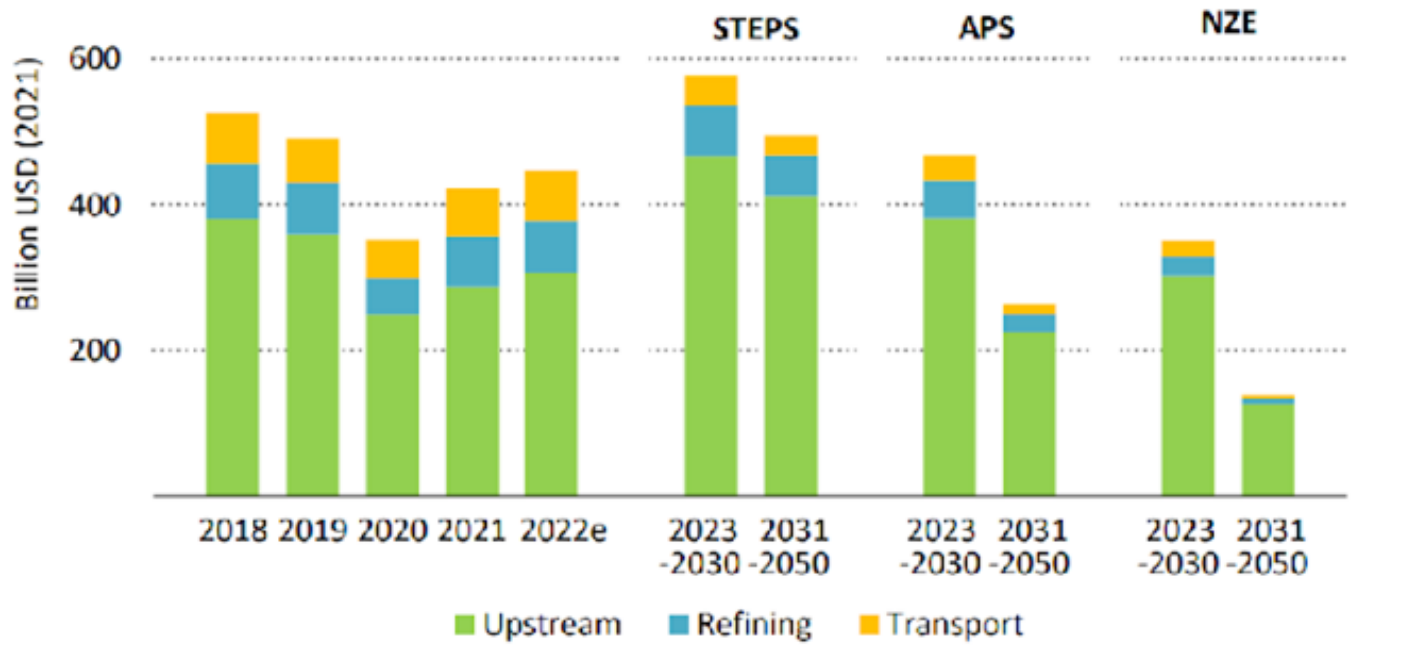


Source: IEA World Energy Outlook. https://www.iea.org/reports/world-energy-outlook-2022

Oil investments are *lower* than required for *stated policies*

7.5 *Oil investment*

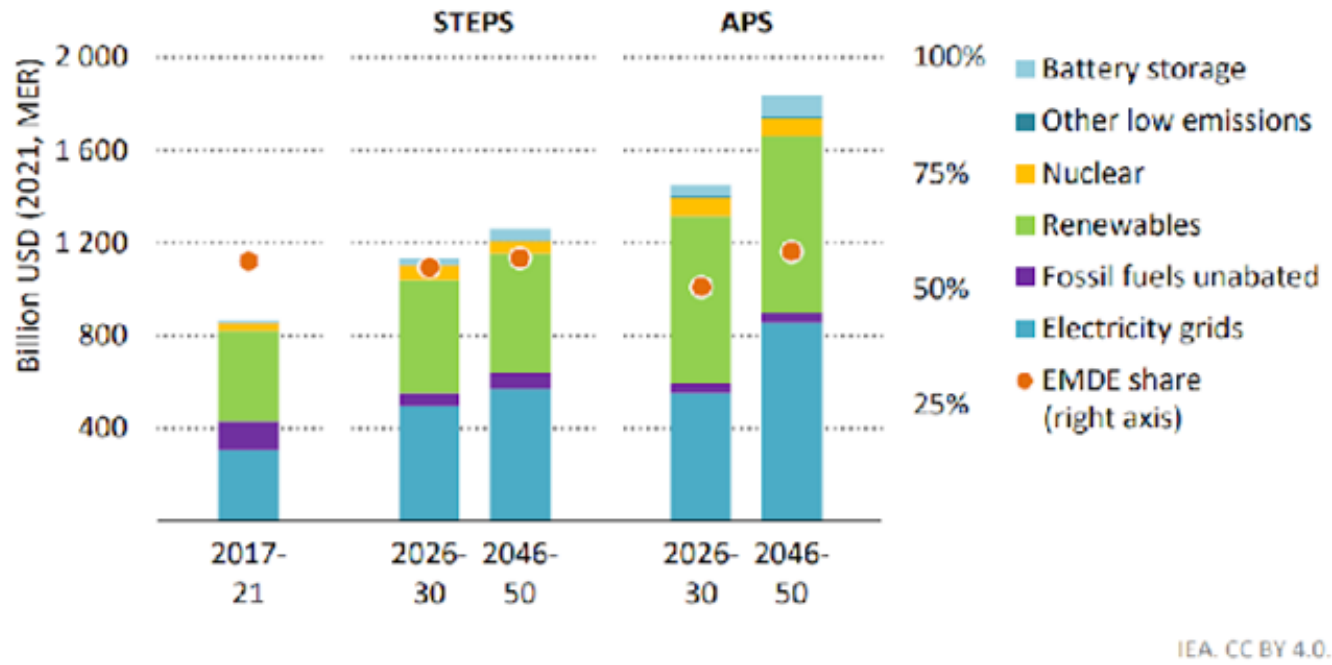
Figure 7.7 ▷ Average annual investment in oil by scenario



Source: IEA World Energy Outlook. https://www.iea.org/reports/world-energy-outlook-2022

On track in terms of alternative investments?

Figure 6.15 ▷ Average annual investment in the power sector by type and scenario, 2017-2050

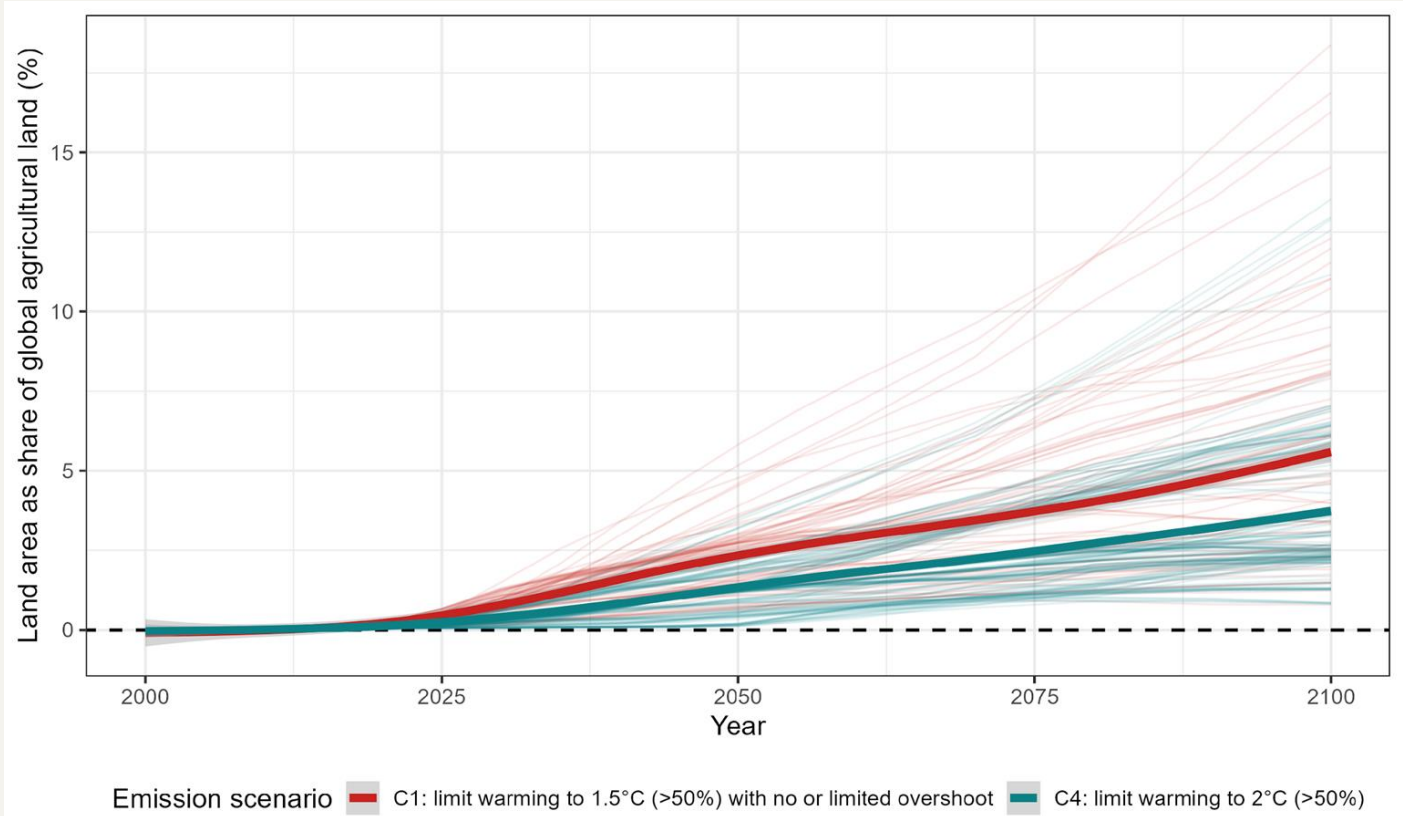


Power sector investment is set to increase; up from an annual average of USD 860 billion in the 2017-21 period, with renewables and grids representing the largest shares

Source: IEA World Energy Outlook. https://www.iea.org/reports/world-energy-outlook-2022

Besides biomass, land no major constraint

Huge problem for biomass, but minor for other technologies, e.g PV:.



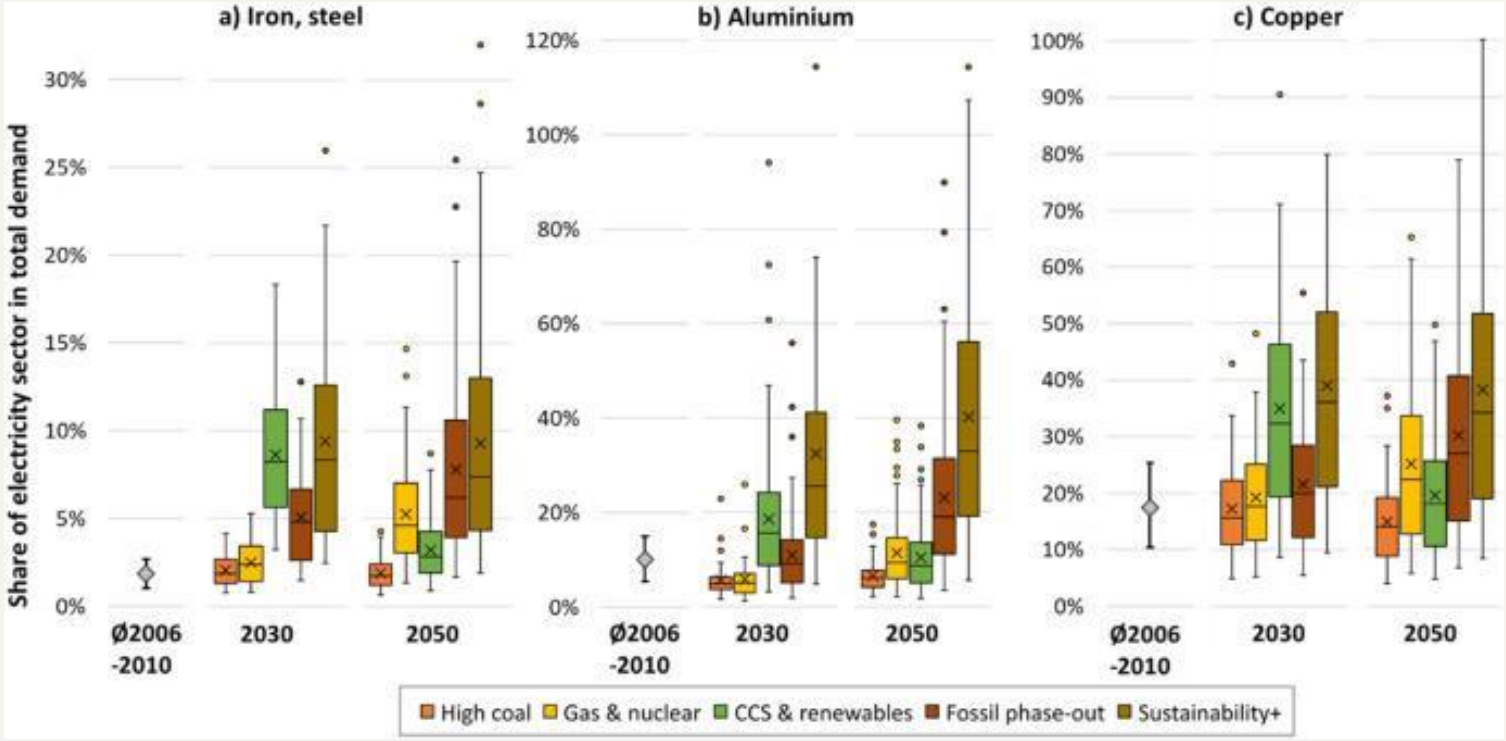
Also see:

Ramirez Camargo, L., Castro, G., Gruber, K. *et al.* Pathway to a land-neutral expansion of Brazilian renewable fuel production. *Nat Commun* **13**, 3157 (2022). https://doi.org/10.1038/s41467-022-30850-2

Schmidt, J., Gruber, K., Klingler, M., *et al.* A new perspective on global renewable energy systems: why trade in energy carriers matters. *Energy & Envirionmental Sciences* 7, 2022 – 2029 (2019). https://doi.org/10.1039/c9ee00223e

Source: IIASA AR6 Scenaro Explorer and Database. https://data.ece.iiasa.ac.at/ar6/
Global agricultural land: 49Mkm2, 1TWh=10km2 of land.

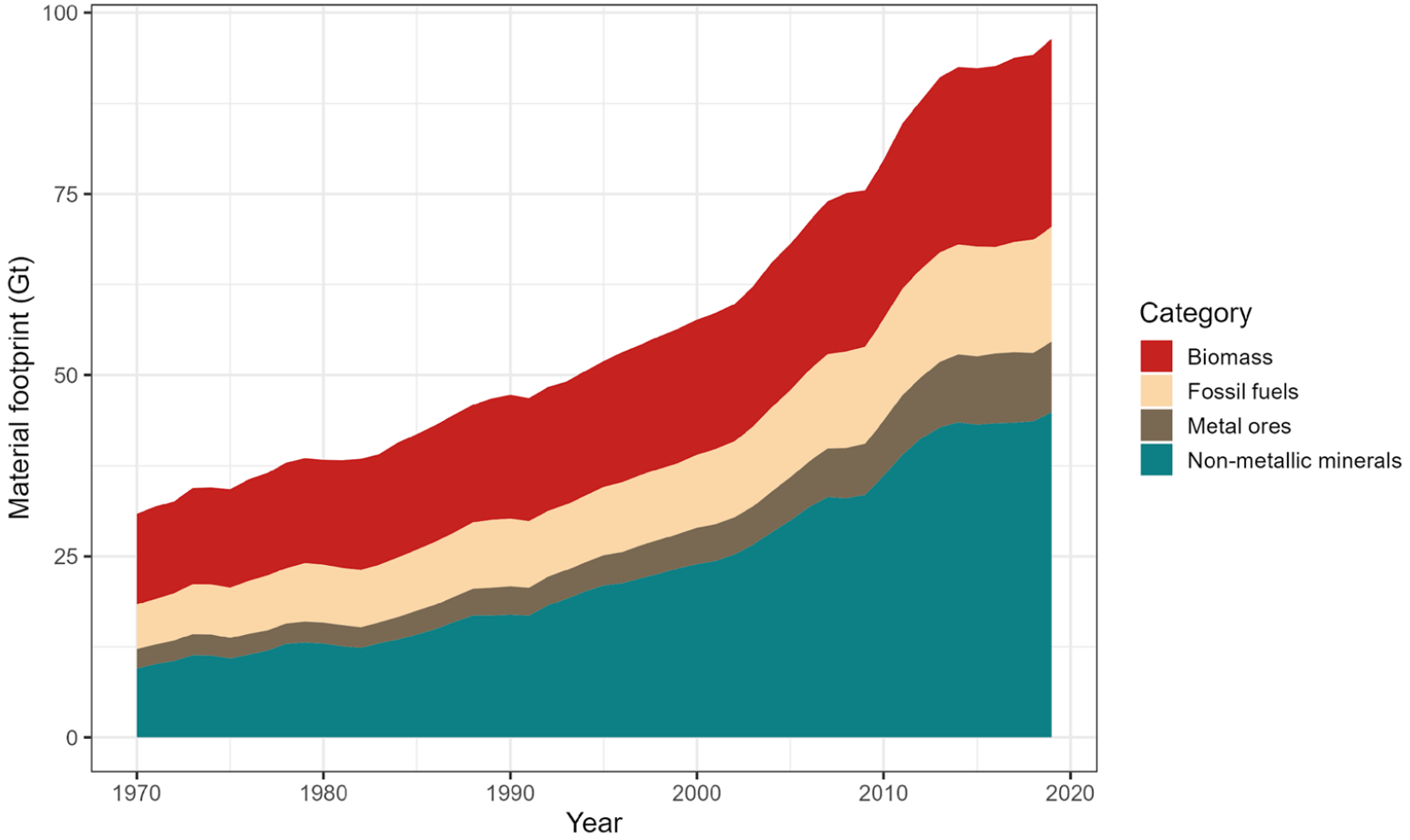
But minerals? Significant, but manageable.



Concrete: substituting all global energy consumption by wind energy (150 PWh) would need ~6% of global annual concrete production.

Kalt, G., Thunshirn, P., Krausmann, F., Haberl, H. (2022.). Material requirements of global electricity sector pathways to 2050 and associated greenhouse gas emissions. Journal of Cleaner Production, Volume 358, 2022.

Extraction of fossils would be reduced!

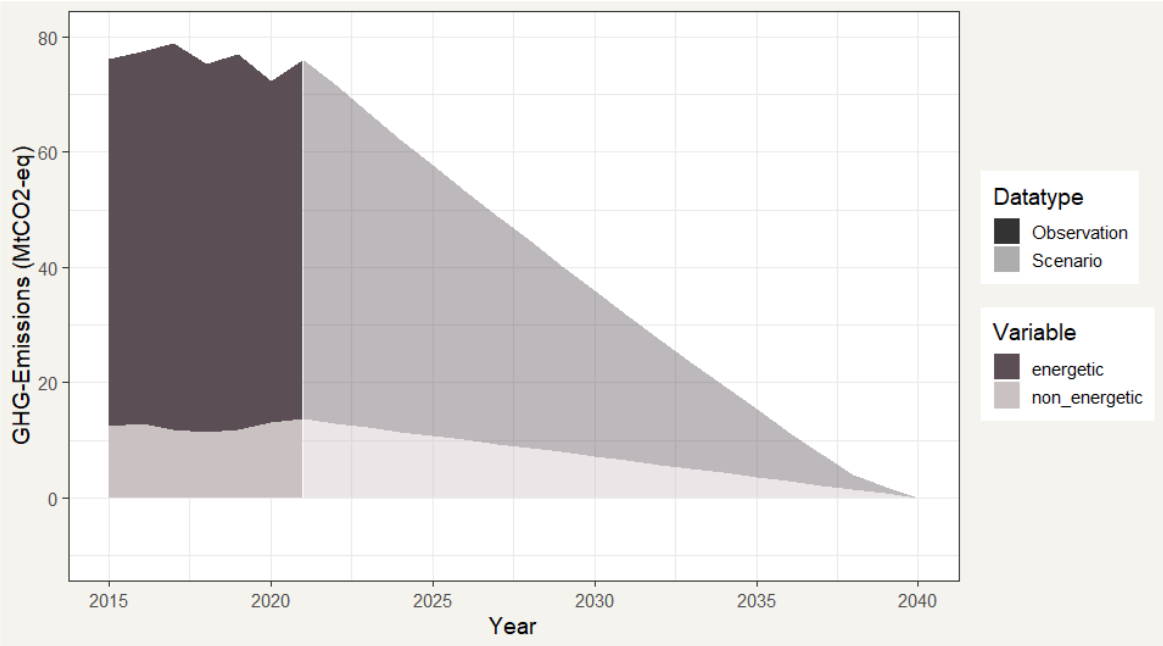


Global material footprint database. https://www.resourcepanel.org/global-material-flows-database

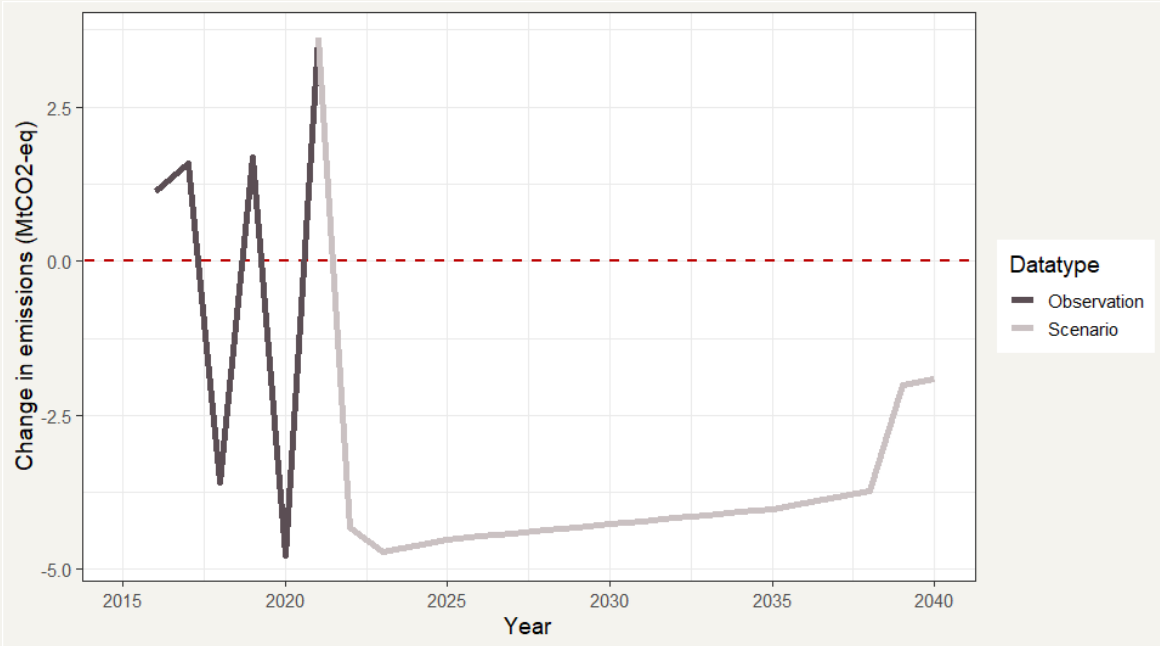
Austrian scenarios

Climate neutrality in Austria in 2040: compliance with the 1.5° limit (50%, with overshoot)

Total emissions

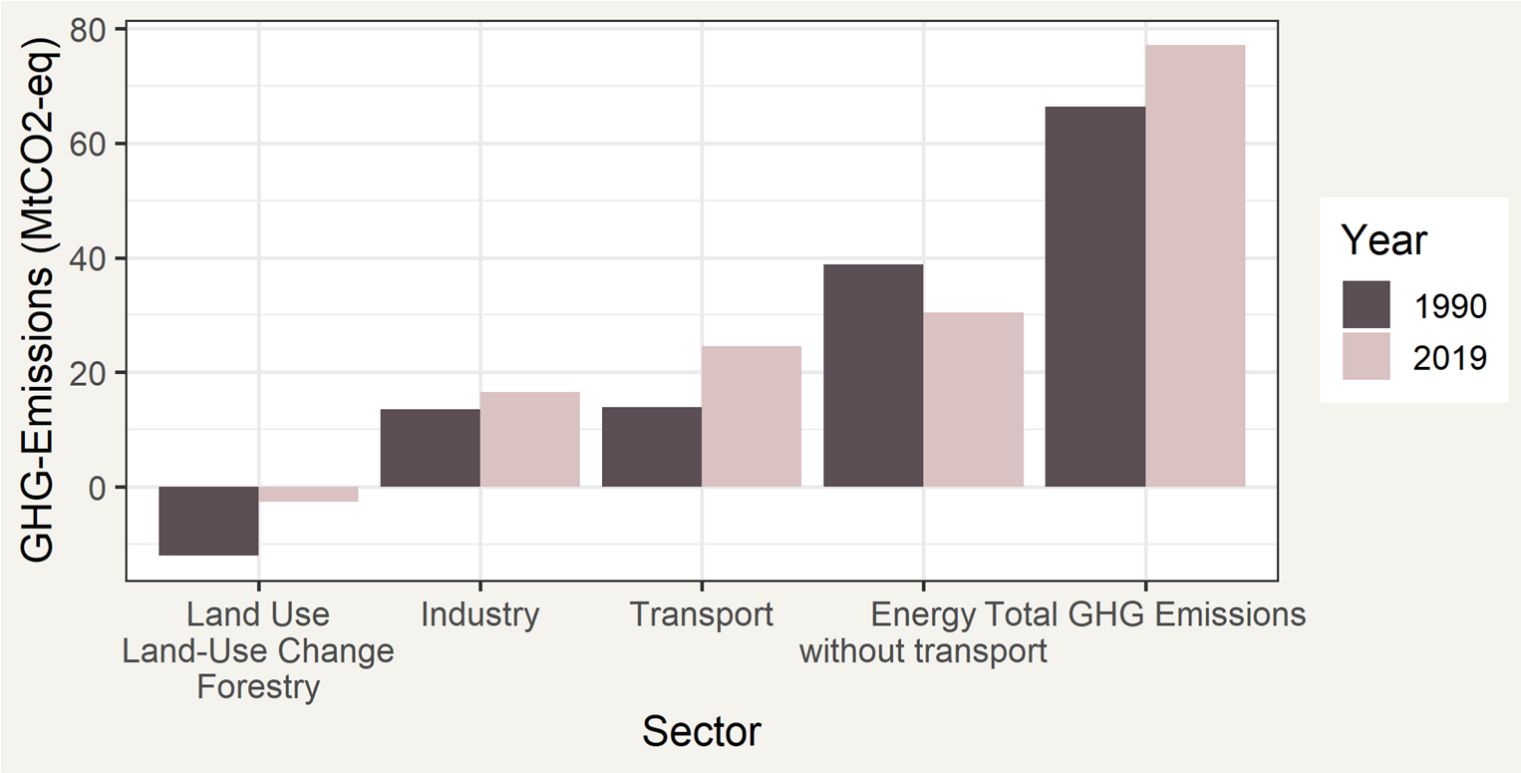


Change in emissions



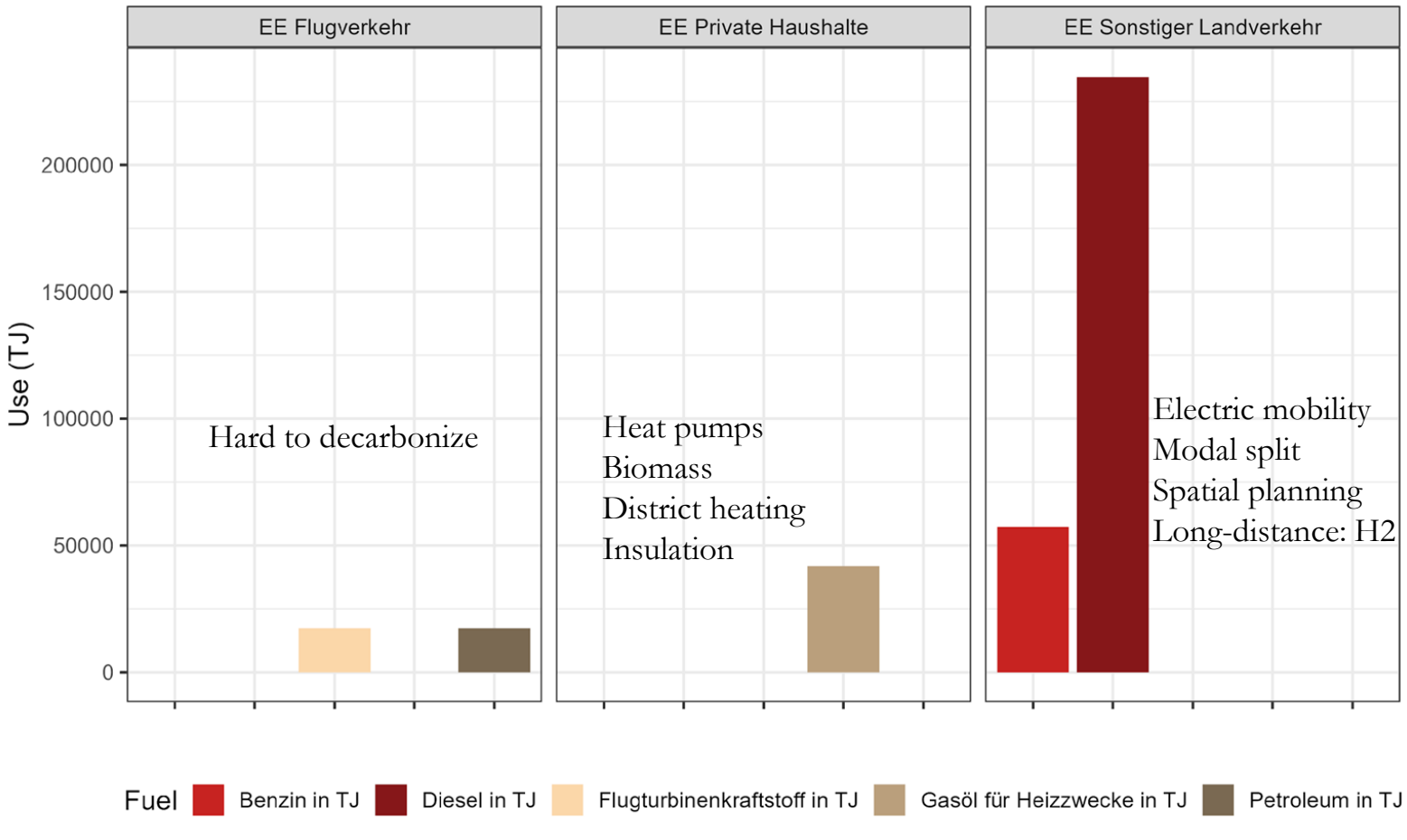
Source: Steininger, Kirchengast (2021).
Treibhausgasbudget für Österreich auf dem Weg zur Klimaneutralität 2040.
https://wegccloud.uni-graz.at/s/ezopLM6ycRk8Txo
+ own analysis

Austrian greenhouse gas emissions by sector



UNFCCC Greenhouse Gas Inventory. https://di.unfccc.int/flex_annex1

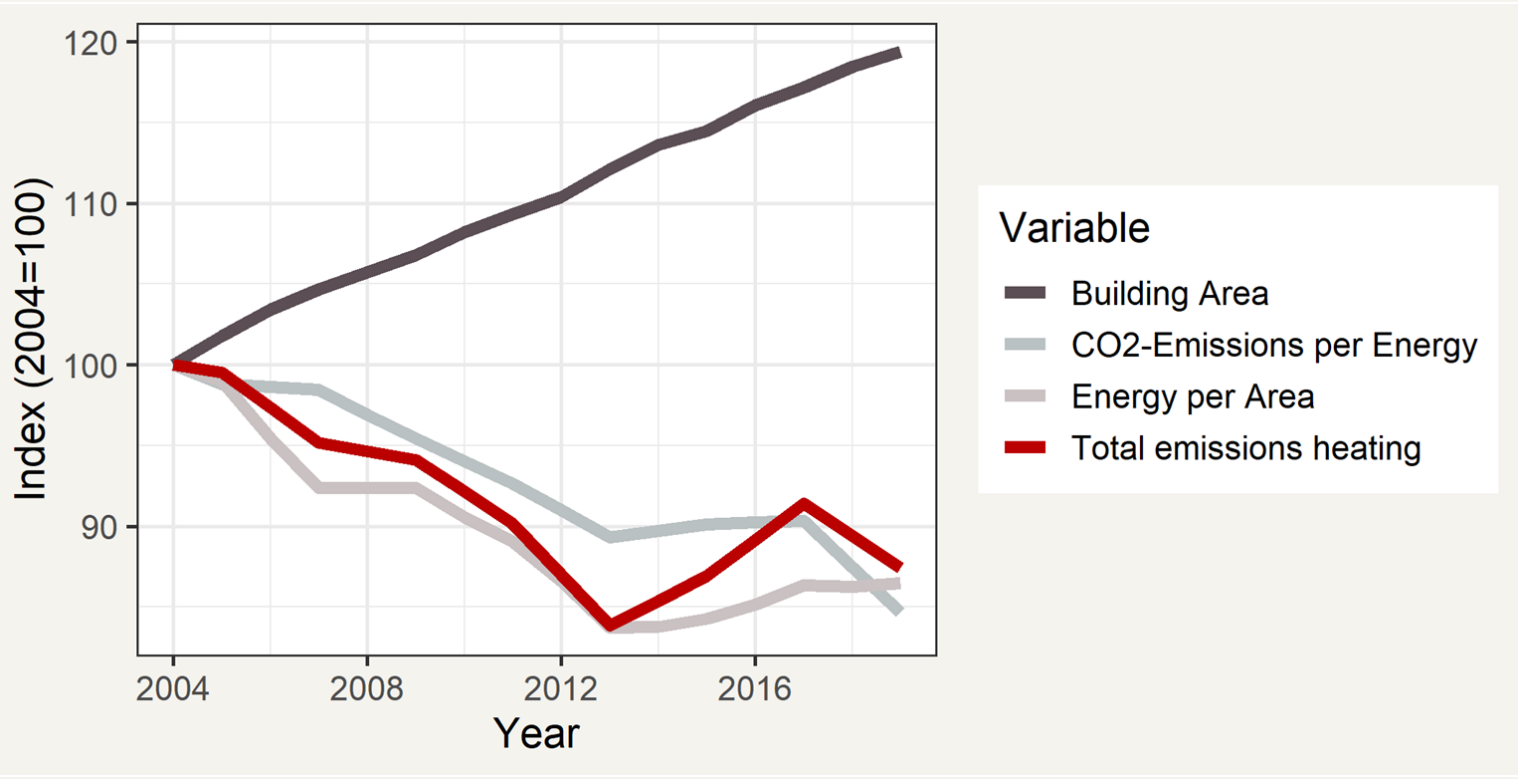
Oil in Austria



Statistik Austria.
Austrian Energy Balance + Own Analysis.

3 options to reduce emissions

Example: private heating sector



Reduce service level: less living area

Increase energy efficiency: e.g. better insulation

Reduce carbon intensity: e.g. heatpumps + renewable energy

Period 2004-2019:

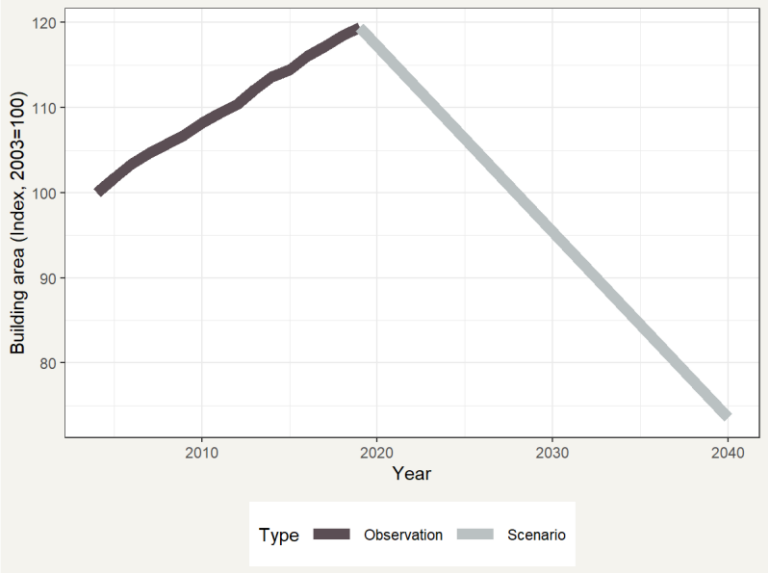
- **Increase in service level (~+13%)**
- **Decrease in energy intensity (~-13%)**
- **Decrease in carbon intensity (~-20%)**
- **Decrease in emissions (~-17%)**

Statistik Austria. Austrian Energy Balance + Own Analysis.

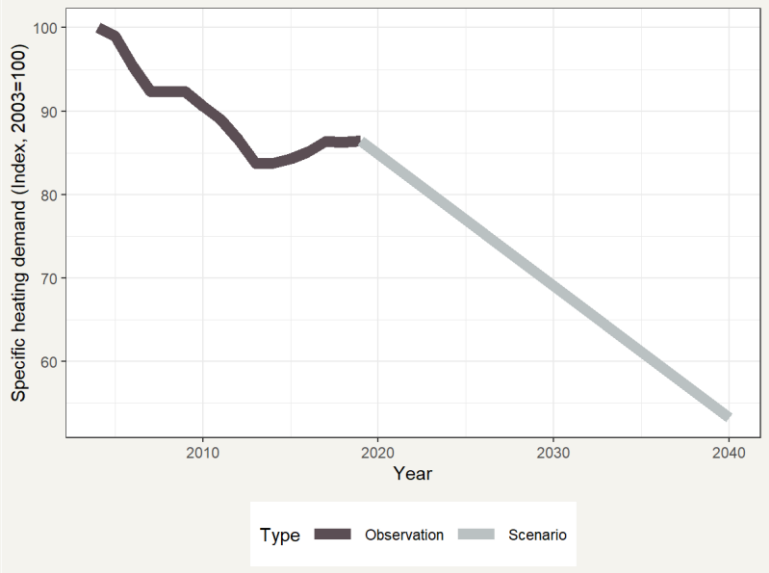
3 ceteris paribus scenarios for getting to 0 emissions by 2040

Example: private heating sector

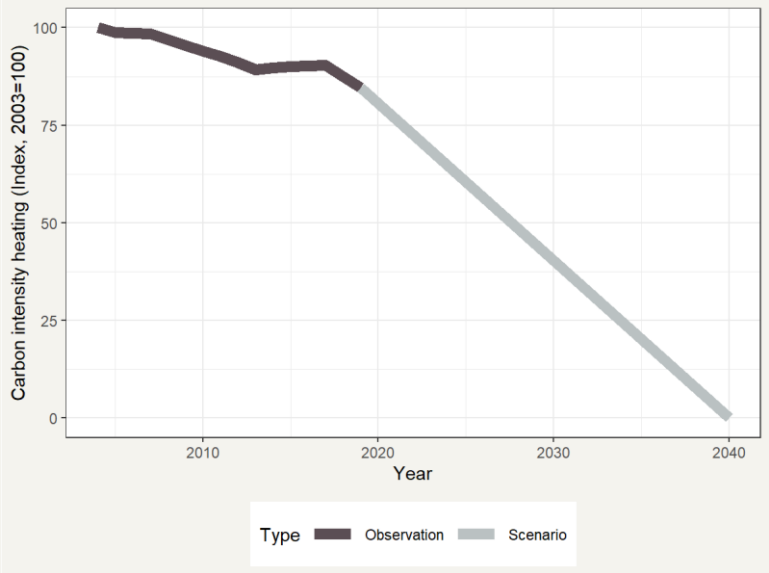
Sufficiency
(from 45m2/capita to 27m2/capita)



Room temperature & Efficiency
(from 134kWh/m2 to 53kWh/m2)



Decarbonization
(from 152gCO2/kWh to 0gCO2/kWh)

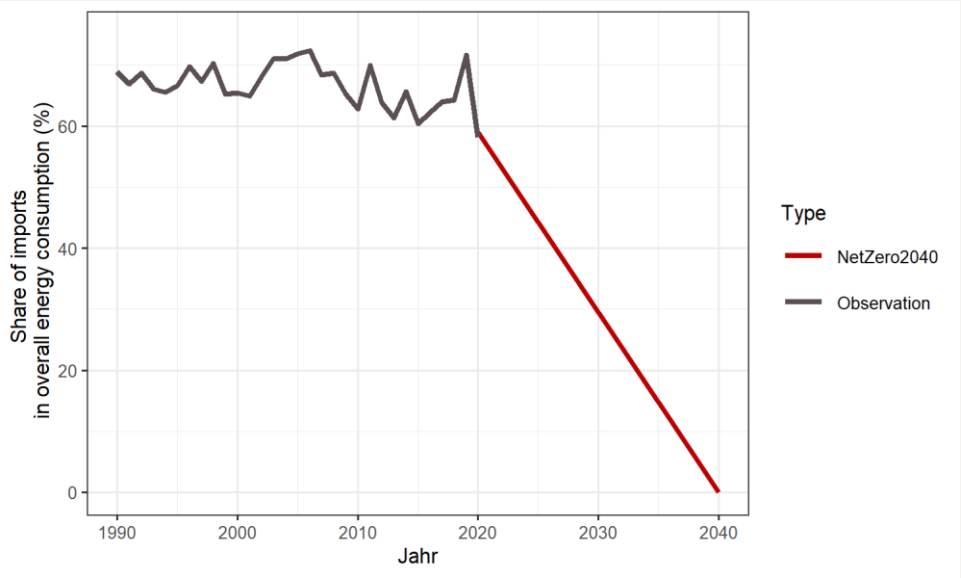


Statistik Austria. Austrian Energy Balance + Own Analysis.

Challenge energy supply

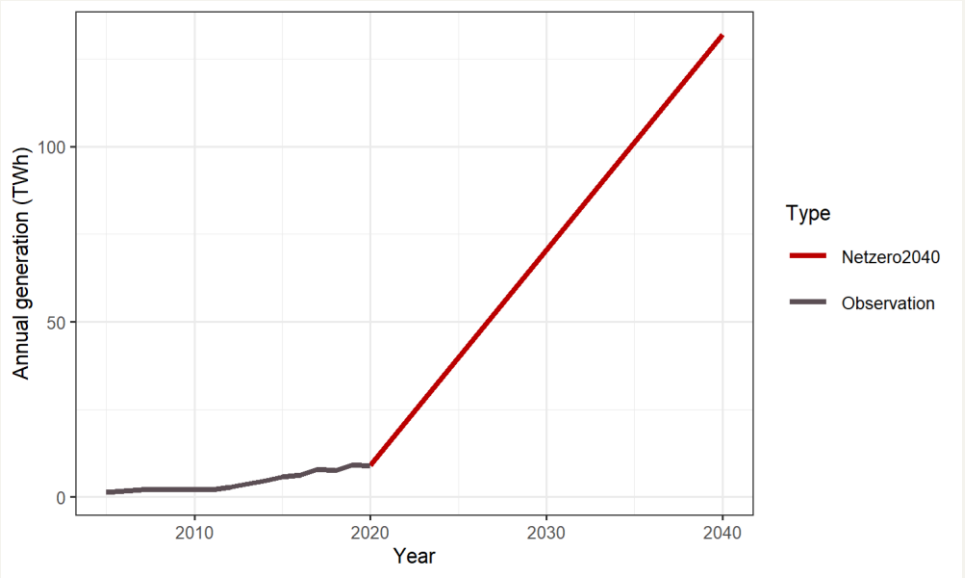
High import shares & very high speed necessary

Import share



Low-carbon fuel carrier imports very limited in coming 2 decades due to **cost, speed of expansion, carbon opportunity cost**

PV + wind power expansion

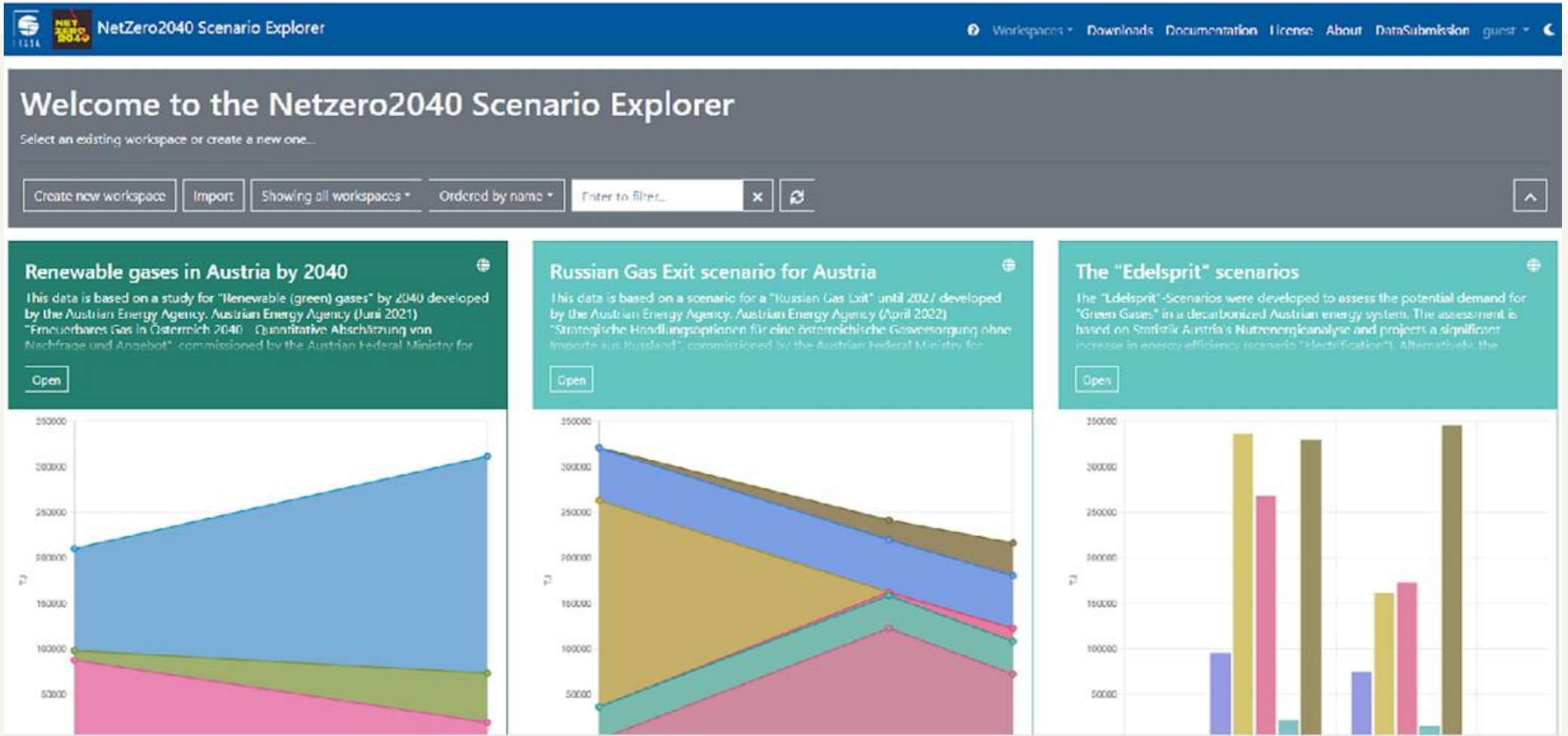


Past trends are **insufficient.** In 2040, renewable electricity generation has to be expanded 4 * the amount currently foreseen until 2030.

Statistik Austria. Austrian Energy Balance + Own Analysis.

NetZero2040 Scenario Explorer

https://data.ece.iiasa.ac.at/netzero2040



Drivers of decarbonization

Renewable & low-carbon energies

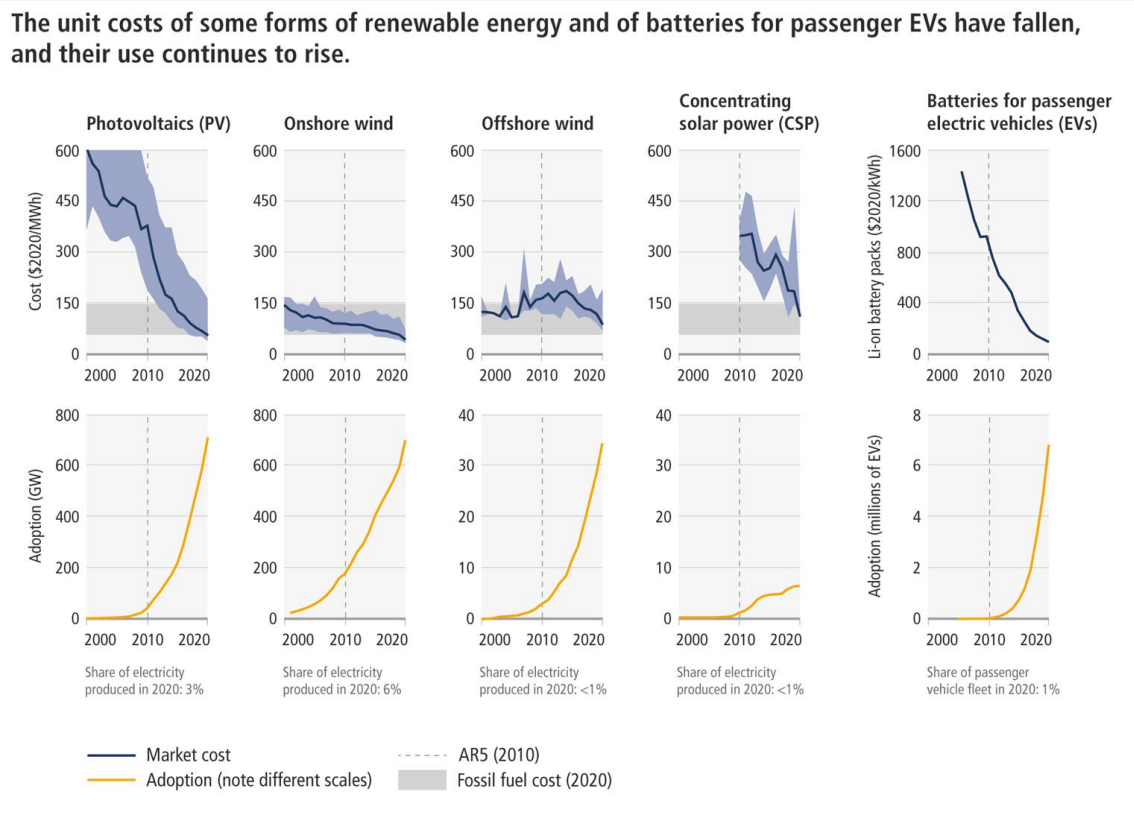
- Massive cost declines of renewables & low carbon technologies
- Innovative technologies
- Most scenarios globally see netzero cheaper or at equal cost level than the fossil fuel counter factual
- But beware: low-carbon energy system costs are increasingly driven by integration cost.

Political agenda

- Commitments to stringent decarbonization goals globally (e.g. China)

Geopolitical situation

- Going low-carbon in Europe also increases security of supply, which is a major concern today



Source: IPCC AR6. WGIII.

Barriers to the transition

Bottlenecks in
- Supply of equipment & of skilled labour
- Resources, efficiency & coordination of municipal, state, and federal administration (Quality of procedures?)
- Infrastructure expansion (particular electric grid)

Acceptance and Just Transition
- Shift in benefits and costs in terms of jobs, income, landscape quality, etc. between households, companies and sectors
- These impacts have to be at the core of policy making (current discussion on energy prices!)

Policy making
- Stringent targets, but much less stringent policies

Lock-in effects: Investment decisions today are very relevant in terms of reaching netzero
- There may be still time to buy a combustion-engine car (10-15 years lifetime), but there is no time left to install a fossil heating system (20-30 years lifetime)

Things we urgently need to know (in Austria) where your expertise may be very helpful

Storing CO2
- Where & how much?
- At which leakage rates & at which cost?

Storing H2
- Where & how much?
- At which leakage rates & at which cost?
- Underground methanation?

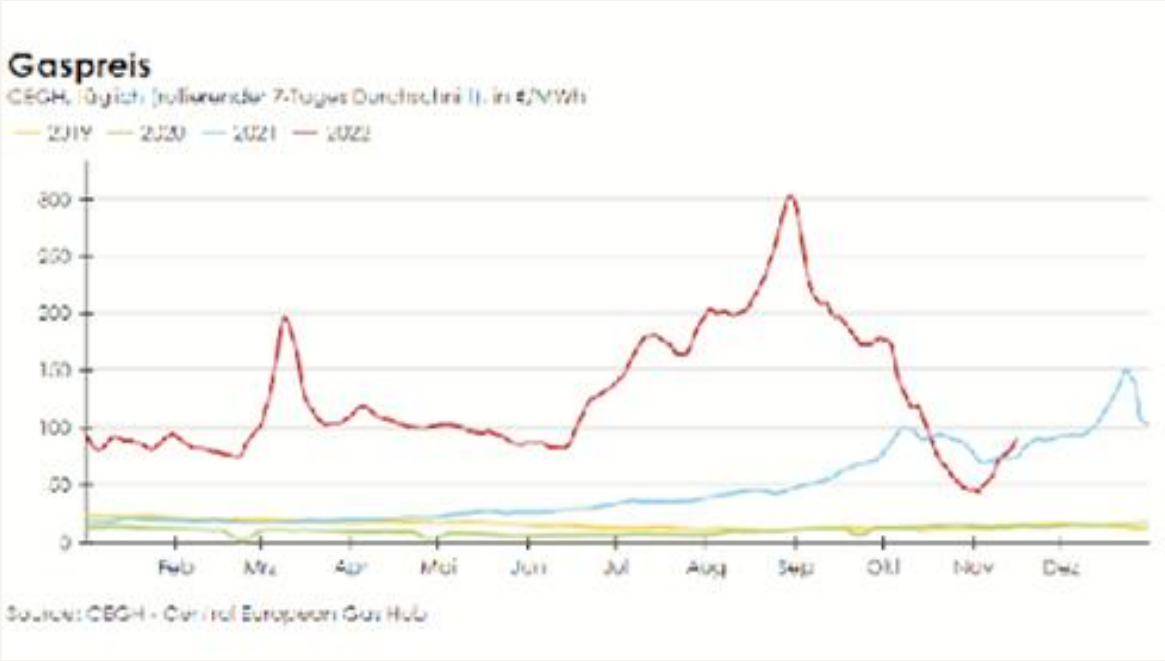
Geothermal energy
- Where & how much?
- At which cost?

The energy crisis & the energy transition

Significant energy price increases (Factor 10)

Short-term consequences for climate policy
- Demand down: Recession (-emissions)
- Coal up (+emissions, but ETS!)
- Electrification more expensive
- Austria: estimate of -2% of emissions in 2022
- Europe: ~0% change in 2022

Long-term consequences for climate policy
- Economics of netzero scenario improved
- Investments: overall investment climate worsening, but sector specific investments increasing (if policy does not intervene wrongly)
- More rapid transition envisioned (EU level, Germany, ...)
- High energy prices & recession: how will this play out politically in European democracies?
- High cost of energy subsidies vs. Investments into low-carbon infrastructure



Source: https://energie.wifo.ac.at

Conclusions

Reaching netzero emissions is economically & technically feasible

The speed of the transition, is however, unprecedented: past trends are only partly sufficient to reach netzero by 2040

Oil consumption is declining in all decarbonization scenarios from at least 2030 on – and in the IEA STEPS scenario from 2035 on. Investments into oil are currently lower than necessary for STEPS.

There are crucial questions in the energy transition that subsurface engineering can answer

Discussion

Climate-neutrality: a threat to your field?

Where do you see your role if the world transitions to climate neutrality?

How do you perceive the employment environment for graduates currently?

The project partners

Funding by the Austrian Klimafonds as part of the 13th Austrian Climate Research Programme (ACRP). Grant number KR20AC0K18182

Thank you!

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@joaoestrangeiro

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