Demand-side CO_2 mitigation potential in the UK heating and transport sectors

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cambridge econometrics

clarity from complexity

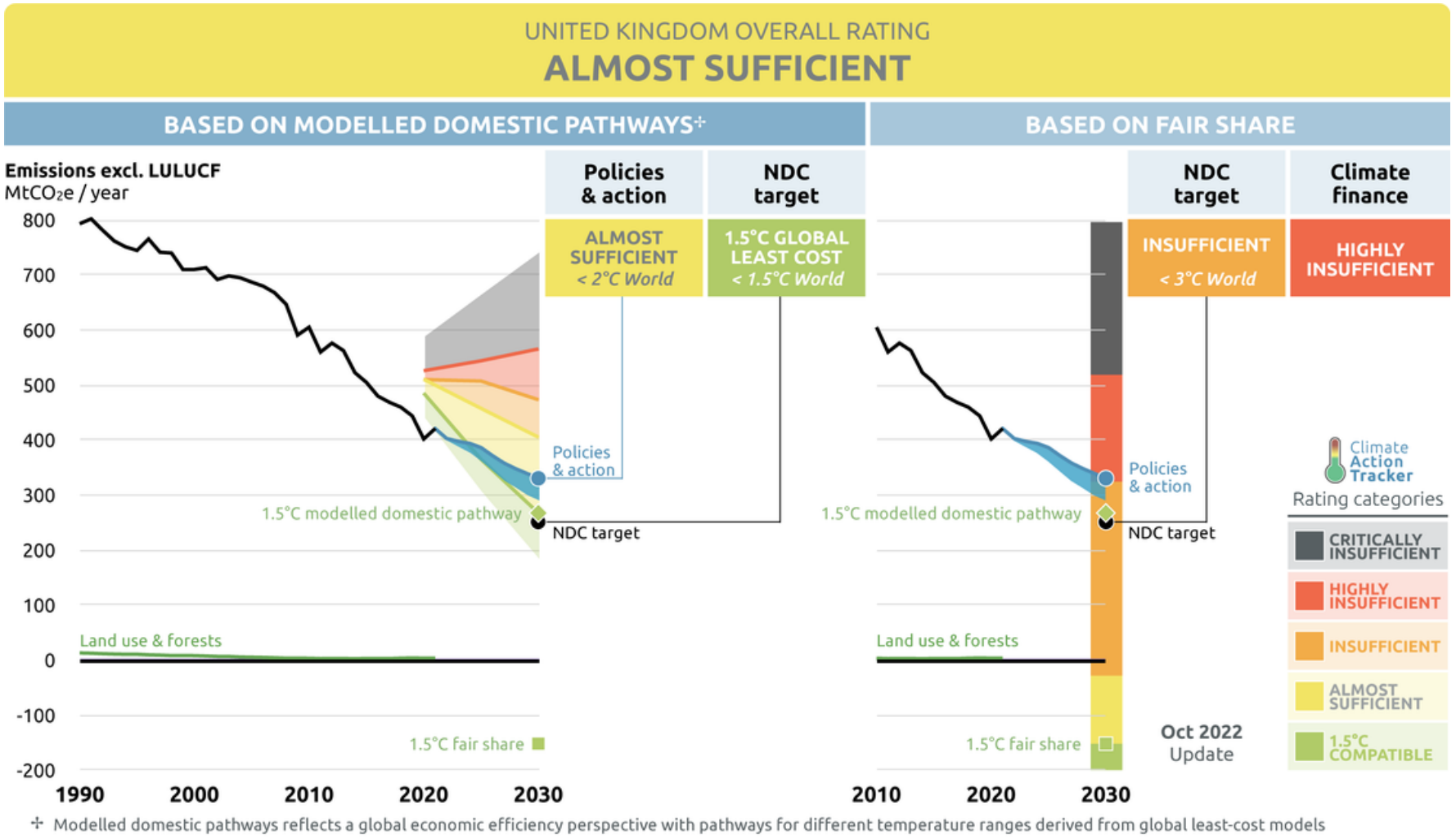
Agenda

1 **Economics of sufficient consumption**
Rebound effects, savings, etc.

2 **E3ME – post-Keynesian, demand-led integrated model**
Introduction to E3ME and its modules

3 **Demand scenario: Sufficiency in heating and transport**
Scenario inputs, assumptions and modelling results

UK emissions pathways



✣ Modelled domestic pathways reflects a global economic efficiency perspective with pathways for different temperature ranges derived from global least-cost models

Climate Action Tracker, 2023

- The UK's climate action is **not consistent with the Paris Agreement**
- NDC and long-term targets are broadly aligned with cost-effective domestic pathways
- BUT **do not represent a fair share** of the global effort (*Climate Action Tracker, 2023*)

New measures are required

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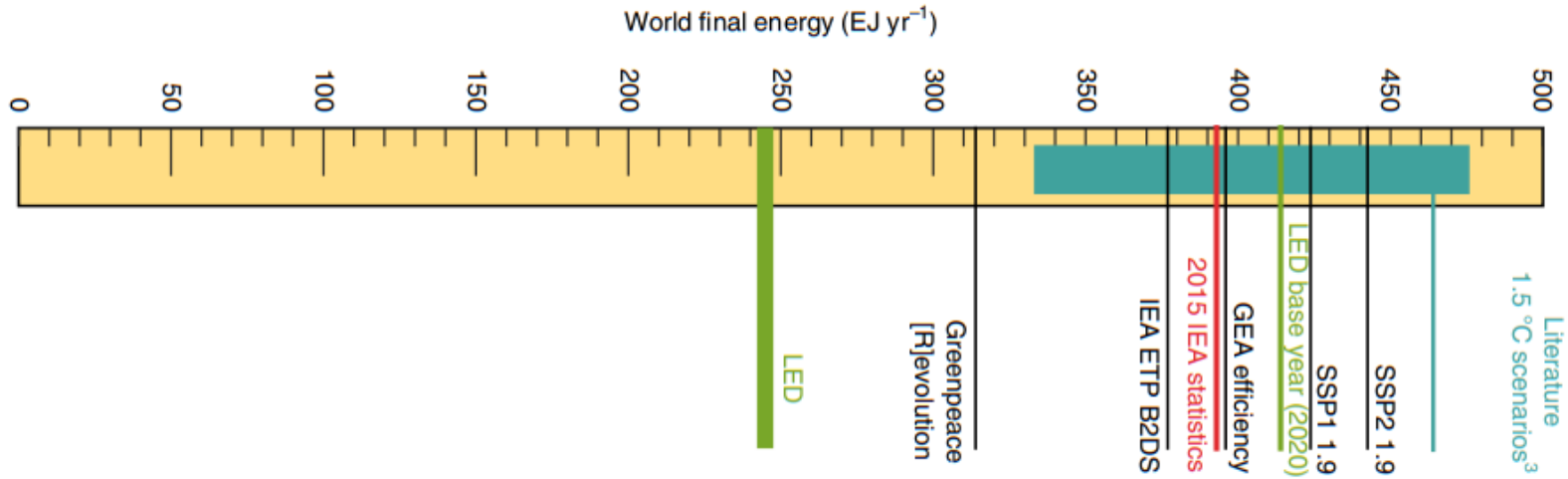
Demand-side approaches

The emergence of demand-side approaches are necessary

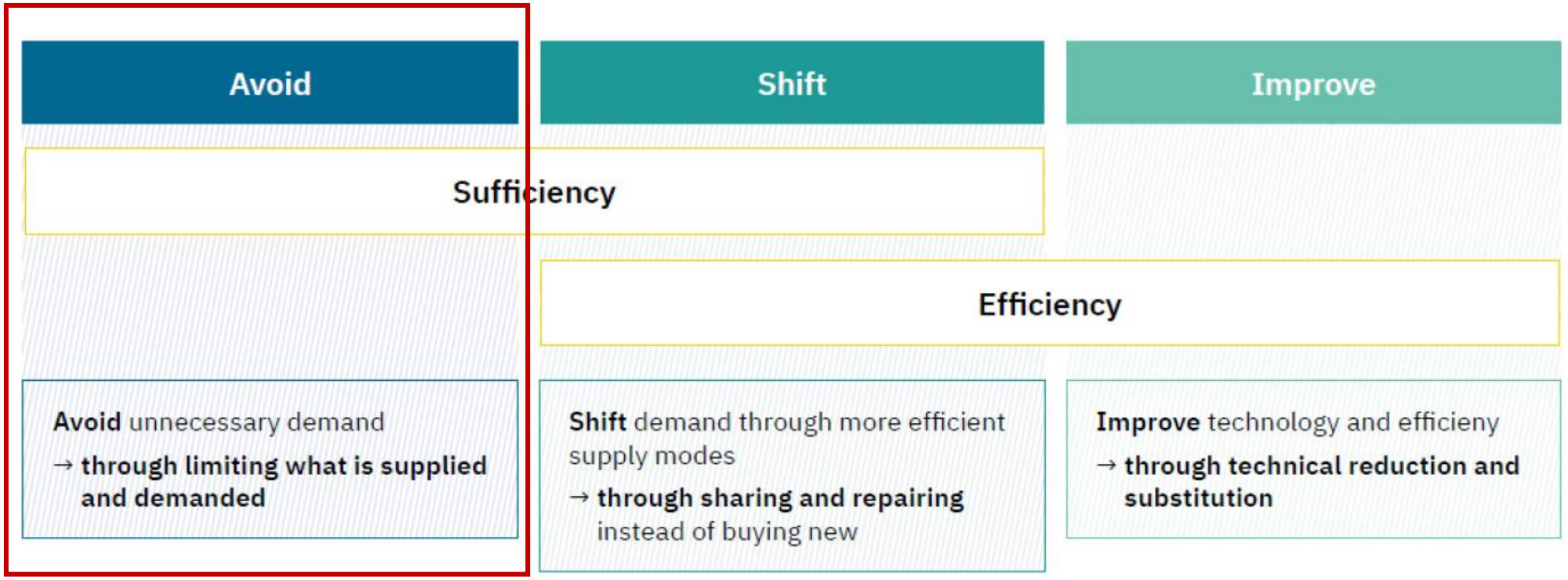


- IPCC
  AR6 WGIII Chapter 5
- Mitigation **without** high reliance on CCUS technologies
- Seminal work by Grubler et al. (2018) low energy demand scenario
- **Most exercises work with exogenously defined GDP assumptions**

Source: Grubler, A., Wilson, C., Bento, N. et al. A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies. Nat Energy 3, 515–527 (2018). https://doi.org/10.1038/s41560-018-0172-6

Sufficient consumption
Avoidance from the ASI framework is generally less studied

Figure 3 – Schematic overview of ASI framework, source: Lorek et al. [11]

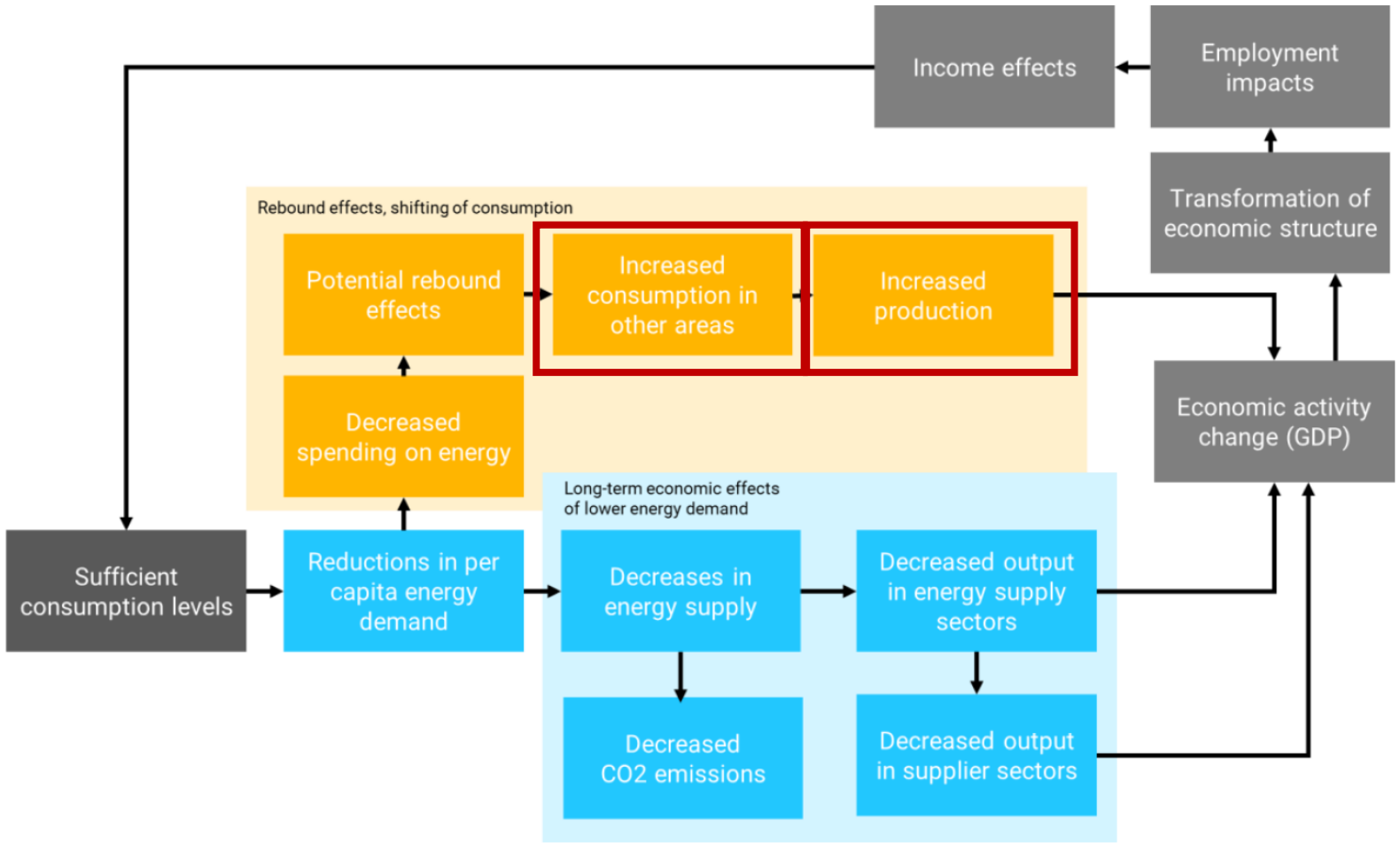


Source: S. Lorek, C. Gran, J. Barth, B. Kiss-Dobronyi, S. Tomany, and L. Weber, '1.5 Degree Policy Mix. Demand-side solutions to carbon-neutrality in the EU: introducing the concept of sufficiency', ZOE-Institute for future-fit economies, #5, 2021.

Macroeconomics

Rebound effects are likely to come in, the effects are not well understood

Figure 2 – Overview of relevant E3ME model linkages, including endogenous modelling of rebound effects and economic impacts of decreased energy supply



- It is likely that there are **rebound consumption effects**
- **Modelling can help understood impacts stemming from this: trade, induced emissions, structural effects**
- An alternative assumption is that decreased consumption leads to higher savings and thus increased investment

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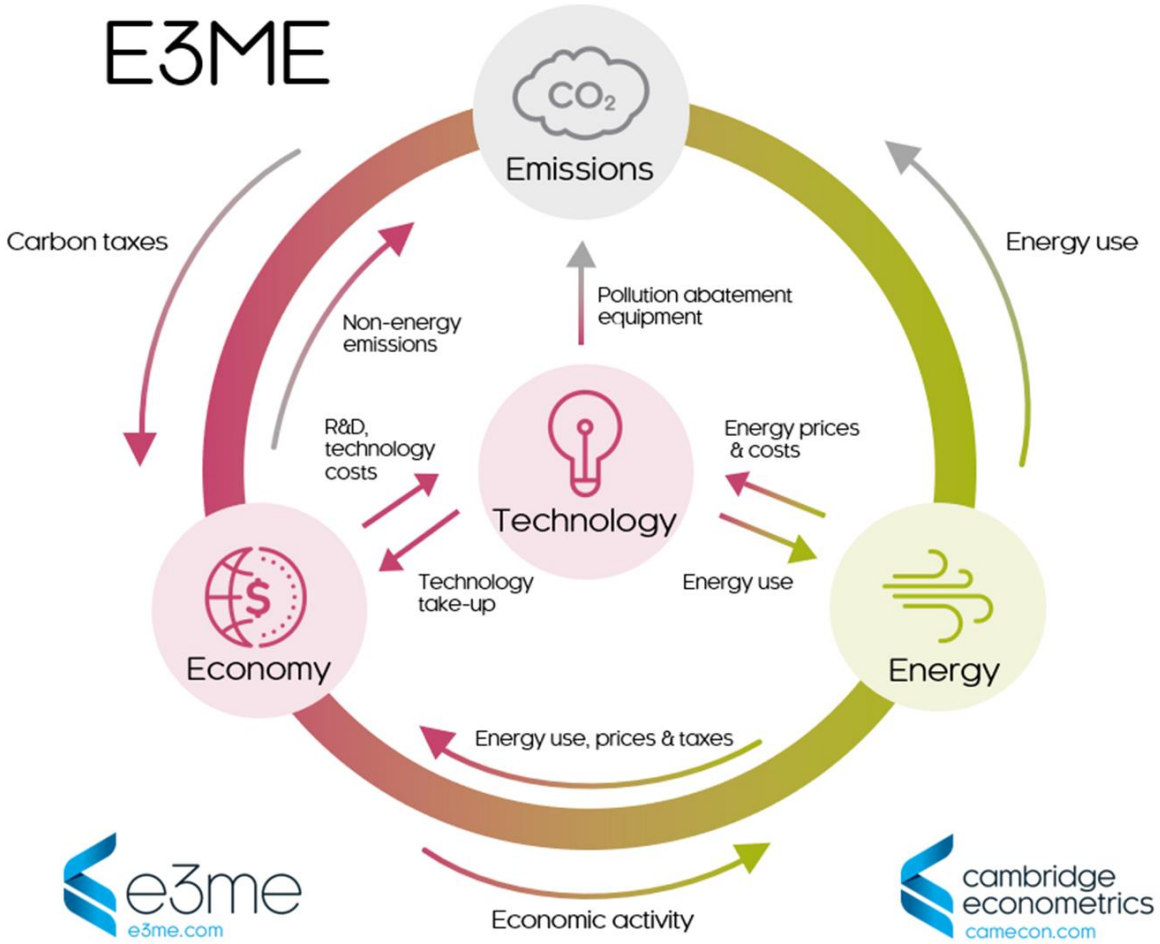
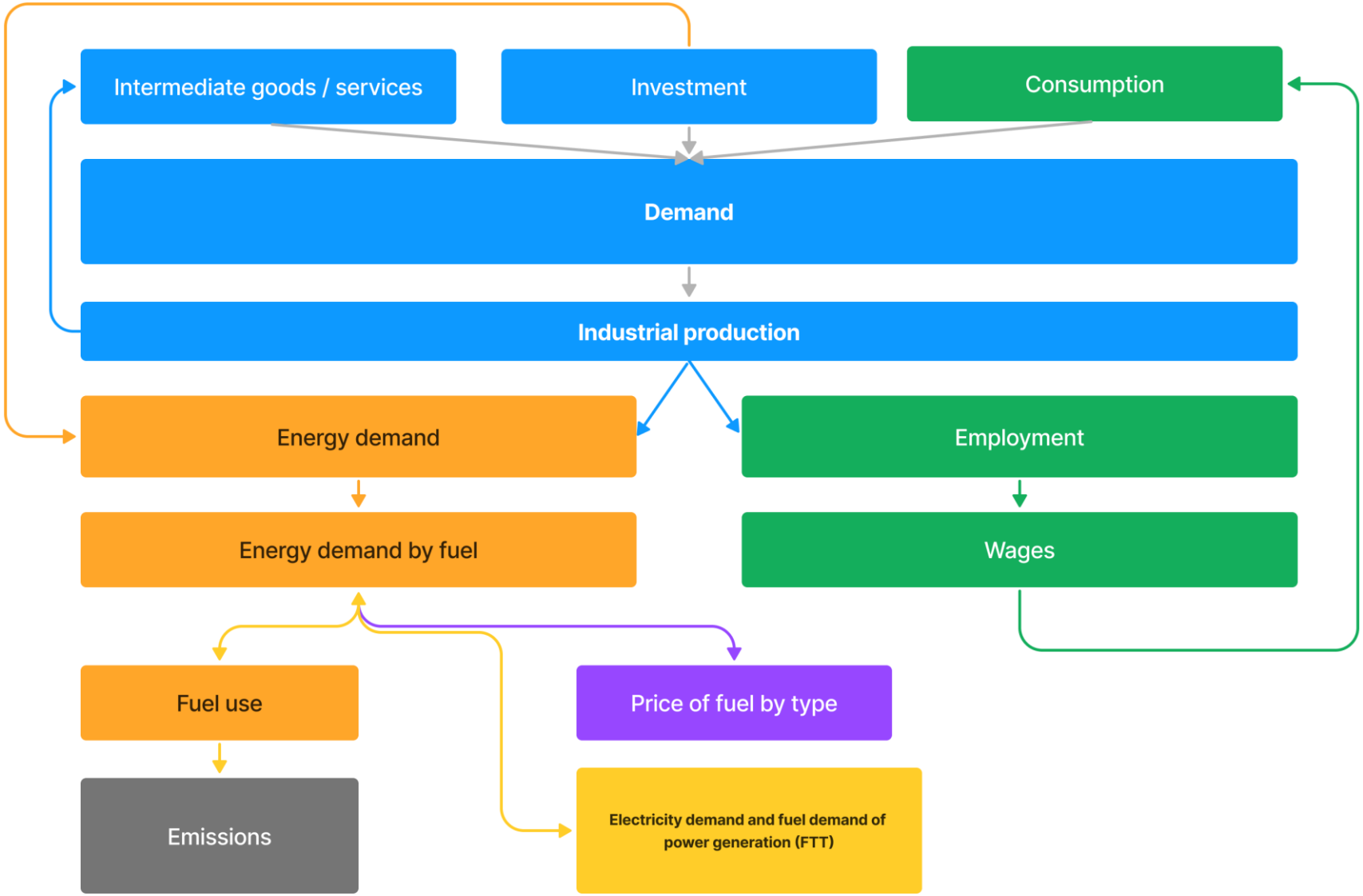
E3ME
Macroeconometric simulation model

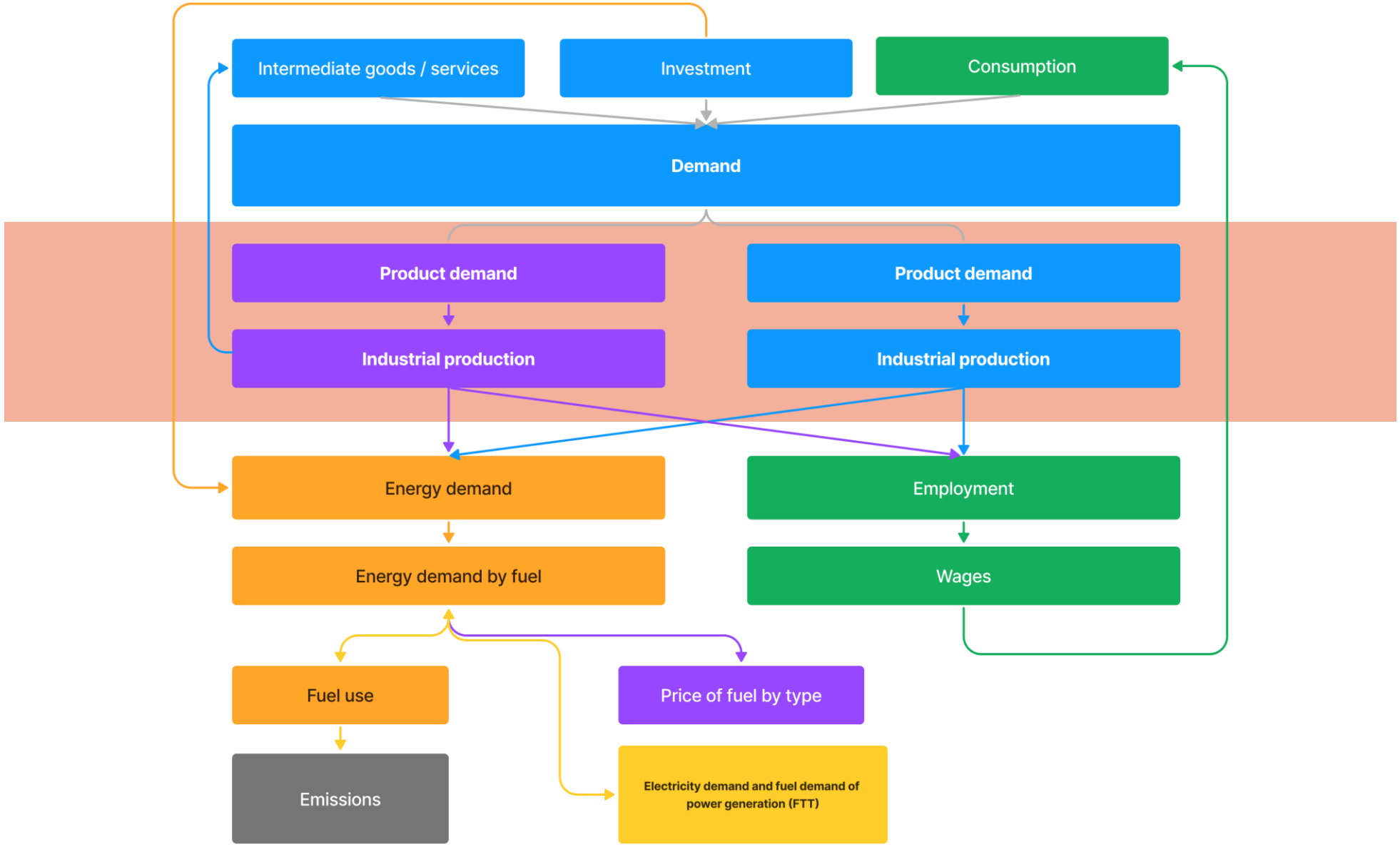


- Highly disaggregated model with endogenous technology
- 71 regions, with different economic, labour, energy system characteristics and different behavioural parameters
- 42 industry sectors within those regions, with own behavioural equations
- 27 consumption categories

Flow of E3ME



Disaggregated consumption is a main feature used here

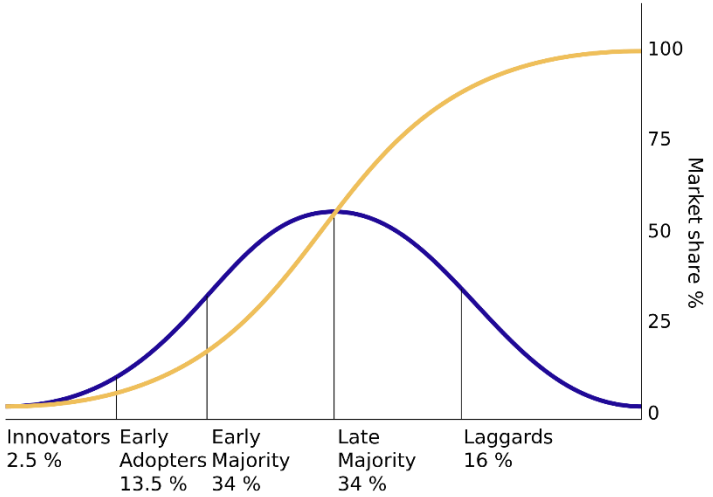


FTT models

Diffusion model for new technologies

Why?

- **Bottom-up model**; econometric approach is lacking (1) small number of large capacity plants, (2) emerging new technologies (no historical evidence on take-up)
- "Best" method is question of purpose: Planning vs Forecasting
- Optimisation (planning) is not the best method, when the market and individual decisions are involved



Based on Rogers (1962)

FTT:Power

- J.-F. Mercure (Mercure 2012) developed the framework at the University of Cambridge
- **Technology diffusion** follows a *S-shaped curve*, but depends on existing technologies and their lifetime
- FTT:Power models new capacities from the perspective of **investor decisions**, where the distribution of **levelised cost (LCOE)** is the deciding factor
- Costs decrease in line with global investments (learning-by-doing) in renewables and move along supply-demand curves for fossil fuels
- Adaptation decisions have spill-over effects and influence further decisions, therefore scenarios often **path-dependent**

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Approach to sufficient consumption modelling

Finding the sufficient level of consumption empirically

Heating

- Empirical connection between final residential heating and outside temperature from EU countries
- Separating the minimum energy consumption which is necessary due to outside temperature changes and additional energy consumption for comfort
- Sufficient consumption is defined based on the historical levels of comfort energy consumption
- Two scenario settings for the UK:
  - Decreasing energy consumption to median comfort level
  - Decreasing energy consumption to 25th percentile comfort level

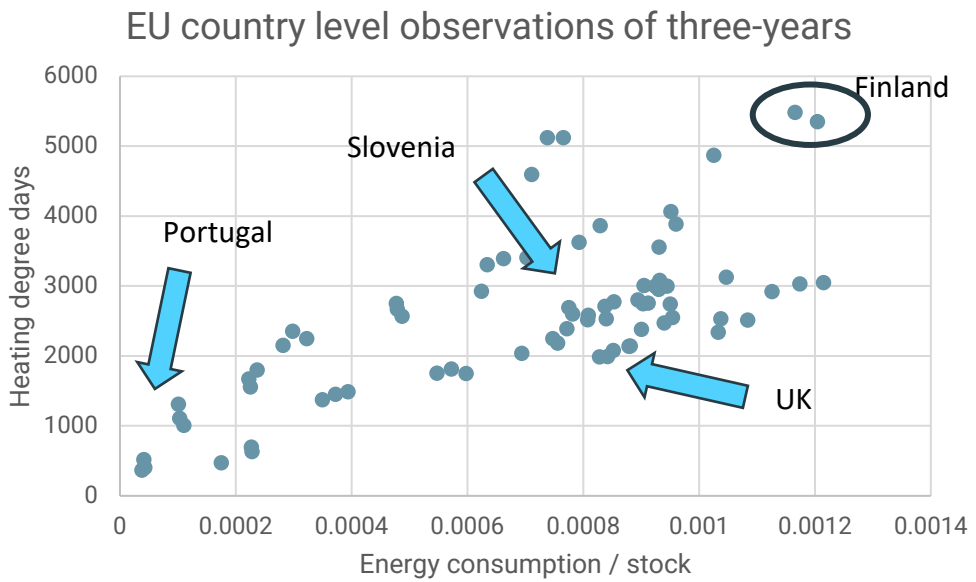
Travel

- Two main variables to define transport consumption:
  - PKM: passenger kilometre demand per car
  - Cars per person
- Derived distribution of global PKM demand from 2018
- Two scenario settings for the UK:
  - Median target for both variables: 16% reduction in PKM / slight increase allowed for car ownership
  - 25th percentile: 30% reduction in PKM / 6% reduction in car-ownership

The aim of the analysis is not to determine the sufficient level of consumption but to assess the socioeconomic impacts of the different level of ambition in demand reduction.

Approach to sufficient consumption modelling - heating
Possible approach 1: separate comfort and base energy use

Energy consumption & temperature data



- We test how much of the variance in energy consumption can be explained by the variance in outside temperature levels
- The UK consumes less energy in absolute terms than most of the other European countries
- The residual distribution of residuals is used to determine the comfort consumption of each country
- The UK consumes approximately 20% more energy for comfort than the median European country and approximately 40% more than the 25th percentile

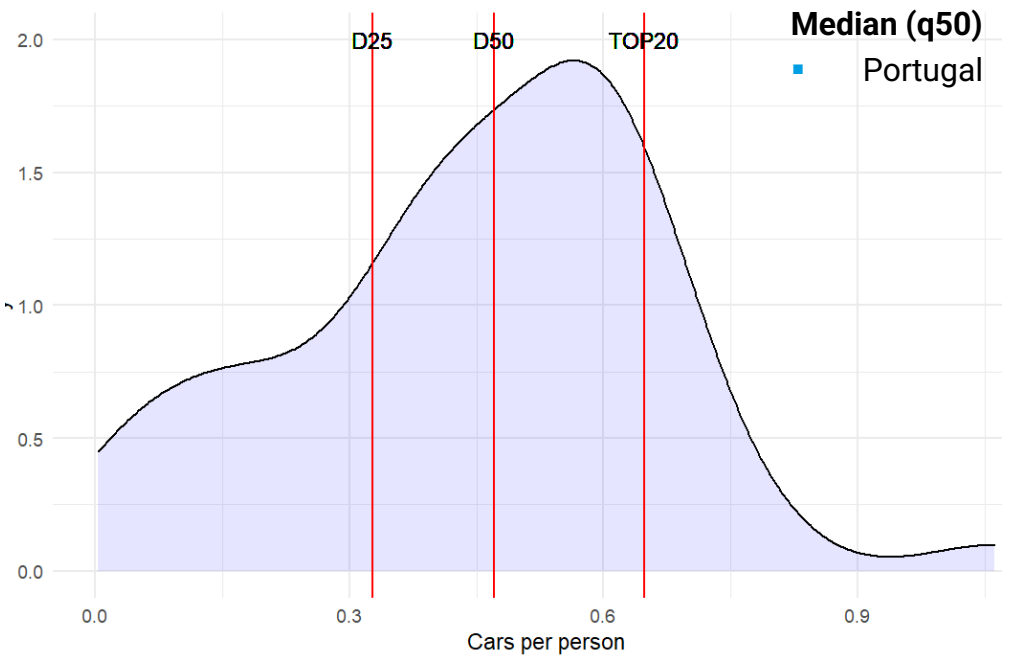
The distribution of comfort consumption represents how much of the demand could be decreased and still be considered as a sufficient level of consumption.

Approach to sufficient consumption modelling - transport

Possible approach 2: assume stagnant consumption levels

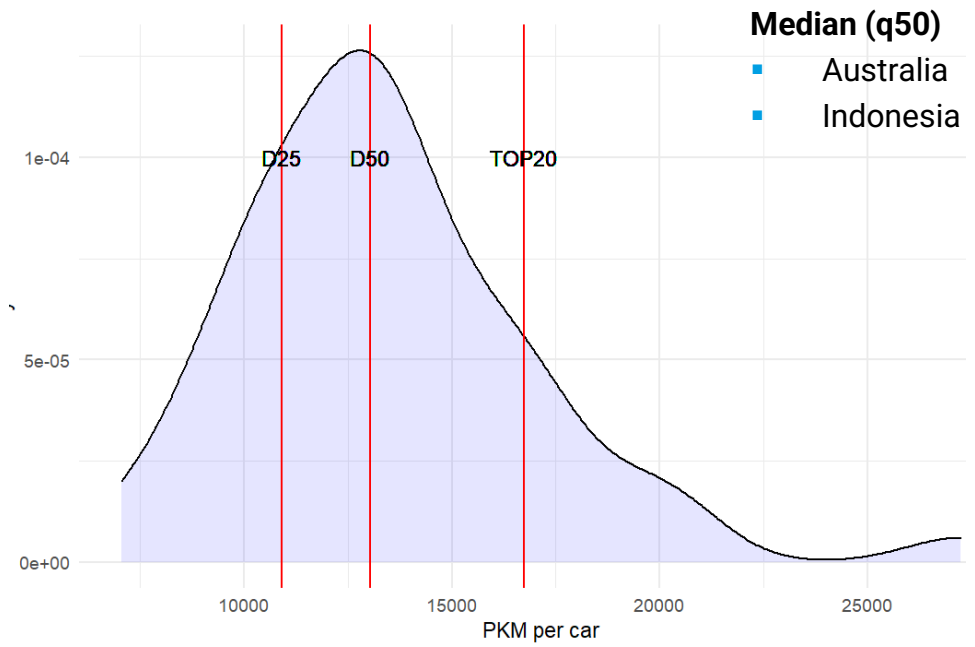
Cars per person

Global distribution, 2018



PKM demand

Global distribution, 2018



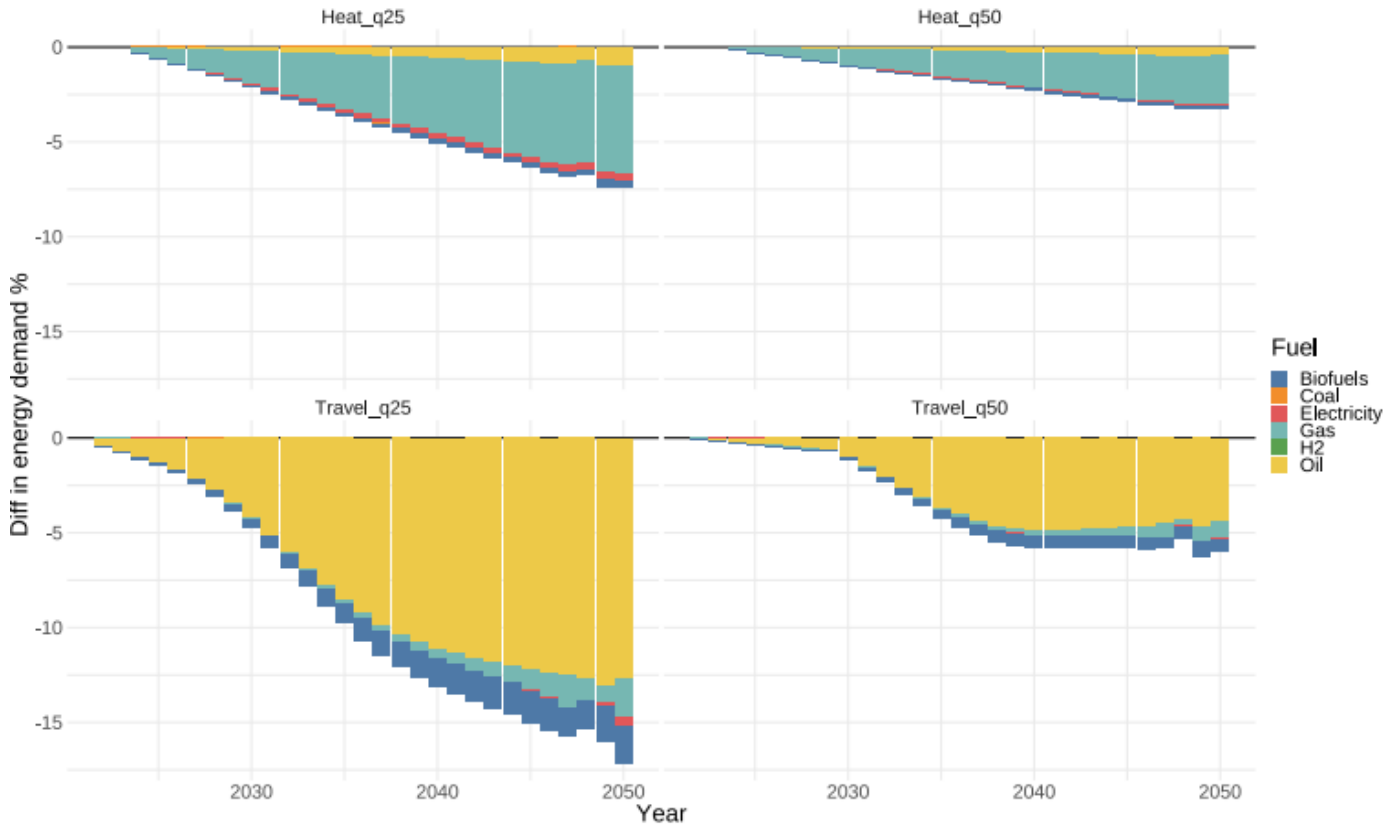
Limit consumption of key products (vehicles and fuel) to key momentums of 2018 distributions

Economic output across sectors

Demand for all fuel types decreases

Final Energy Demand %

relative difference from reference



- Energy demand significantly decreases for all fuel types

- In the heating sector gas is the most important reduced fuel, while in transport it is oil

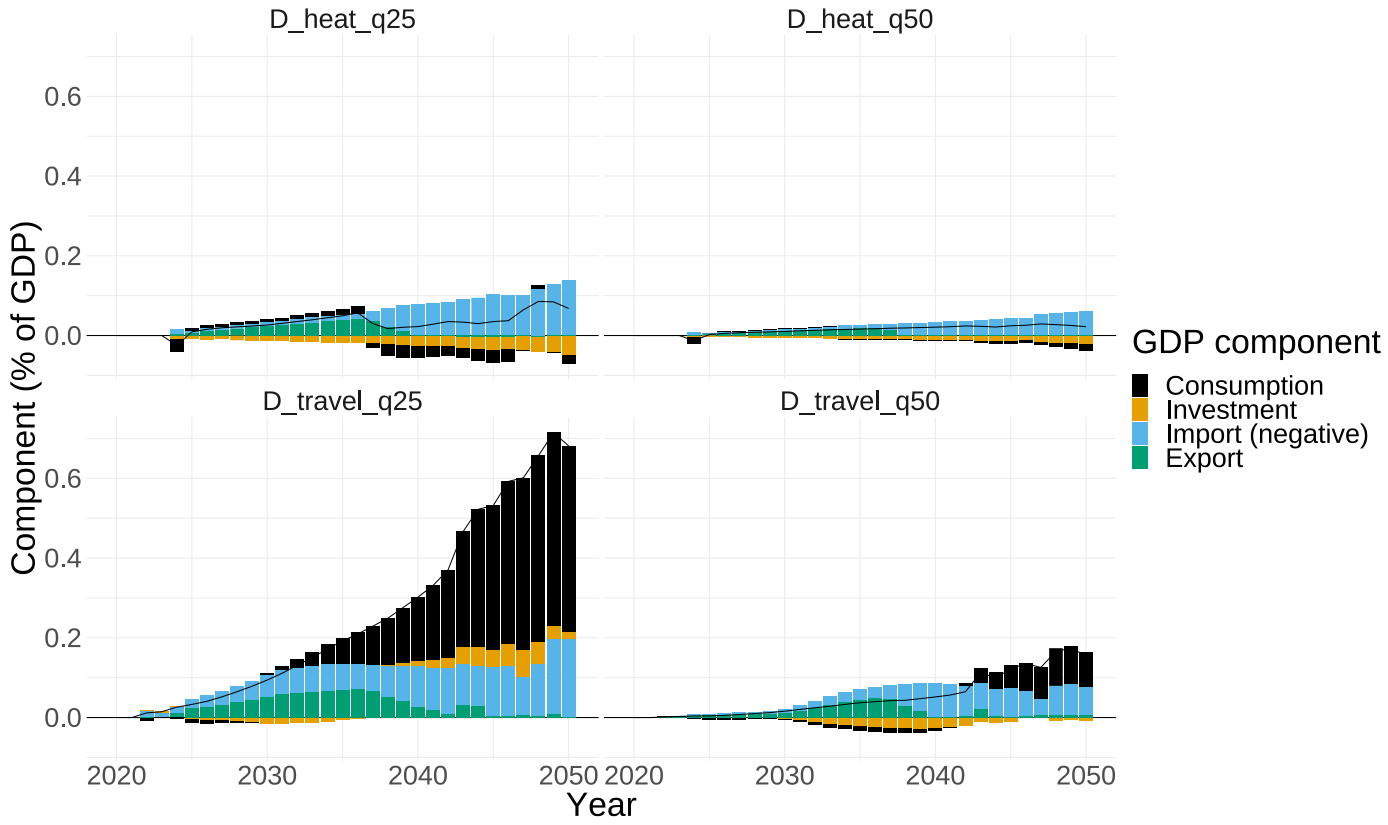
Source: E3ME modelling August 2023

Economic output across sectors

GDP shows slight growth, due to increased consumption

GDP %

Global Gross Domestic Product, Travel q(25)
relative difference from reference



- Small but positive GDP impact in all scenarios
- Travel has a significantly higher impact compared to heating

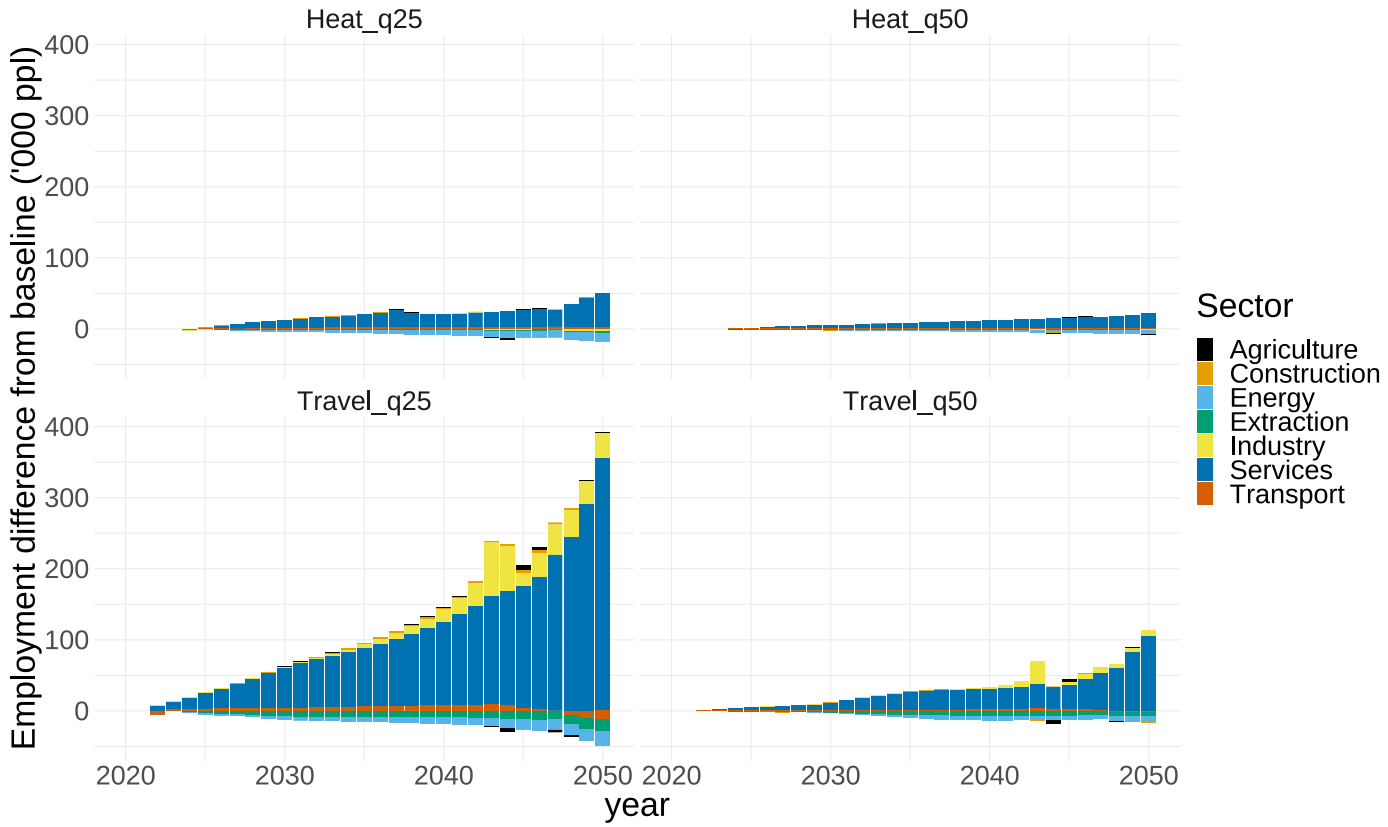
Source: E3ME modelling August 2023

Economic output across sectors

Shift towards services has a positive impact on employment

Employment across sectors

Absolute difference from reference



- Considerable employment effect, potentially influencing thousands of people

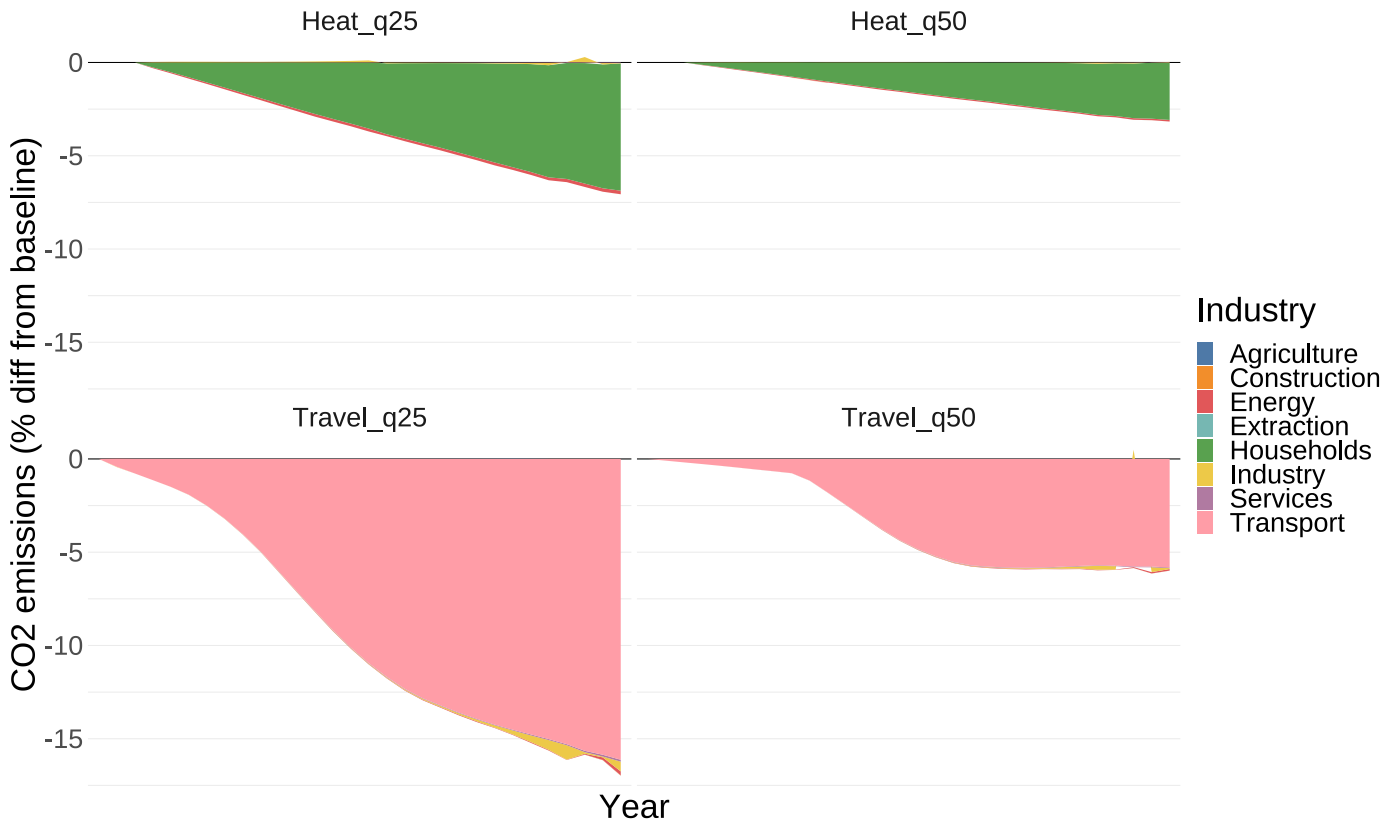
- Most affected is the services sector, because of a demand shock due to rebound effects

Source: E3ME modelling August 2023

Emission reduction
Fancy title

CO_2 emissions

Global annual CO_2 emissions
absolute difference from reference



- All scenarios show the expected decrease in final emissions
- CO_2 emissions are less connected across demand-side mitigation options. The decrease in demand turns into effect almost fully in the original sector.

Source: E3ME modelling August 2023

Conclusions

Positive economic impacts correlated with the ambition of the energy demand reduction

Decreased consumption

- Sufficient consumption is defined based on historical relative levels of energy use

Economic rebound effects

- Saved energy consumption translates into consuming higher levels of the services sector

Overall impact

- Besides the significantly lower CO_2 emissions, the decreased consumption is projected to create many jobs over the years

Added value

- Potential definitions for sufficient consumption pathways
- Use of an integrated assessment macroeconomic-model (IAM) to uncover the effects of decreased consumption

Further potential

- Extending the described methodology to a wider range of datasets and thereby uncover more of the dynamics of sufficient consumption
- Further interpretation of sectoral changes, with the goal of finding practical and feasible policy tools to achieve sufficient consumption

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