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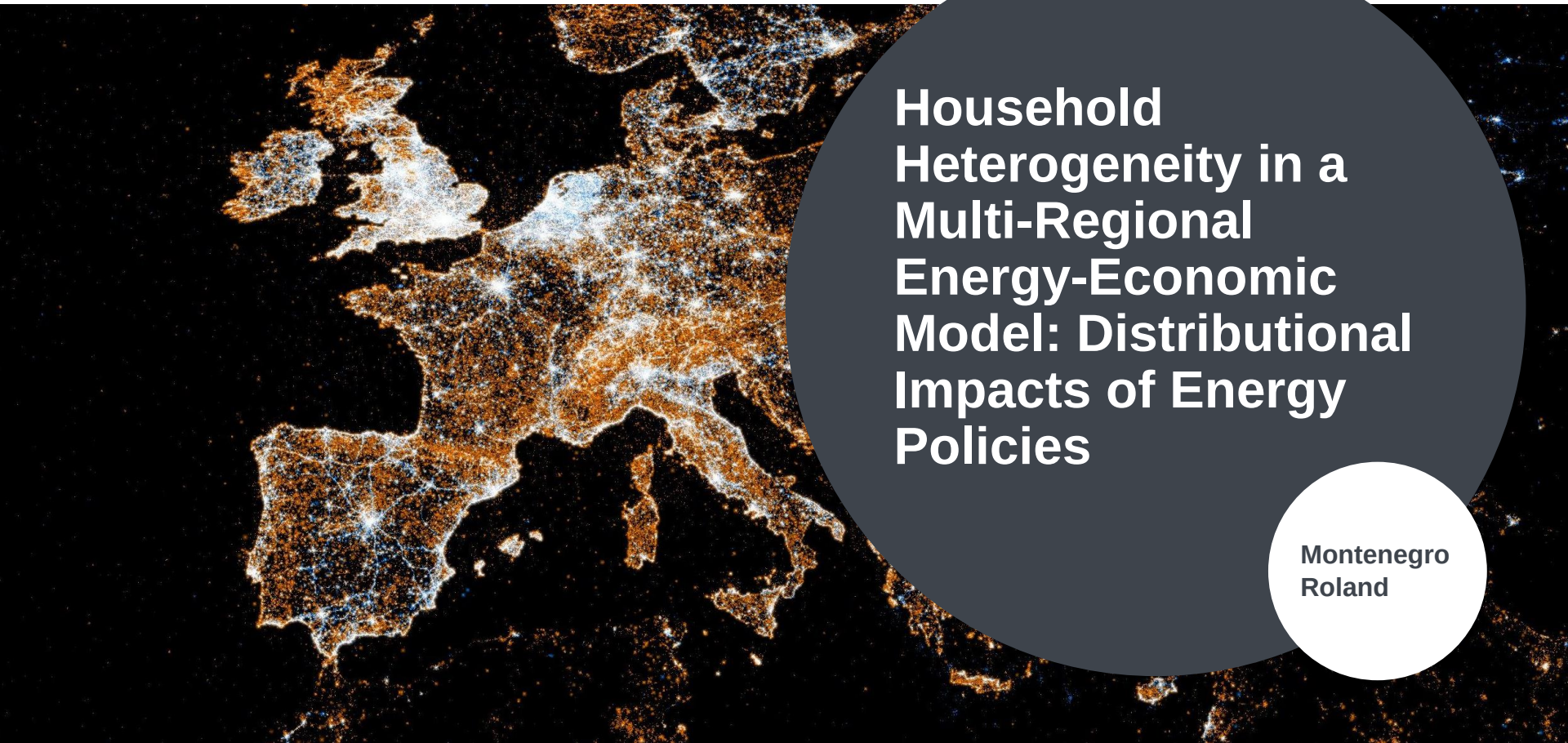


Household Heterogeneity in a Multi-Regional Energy-Economic Model: Distributional Impacts of Energy Policies

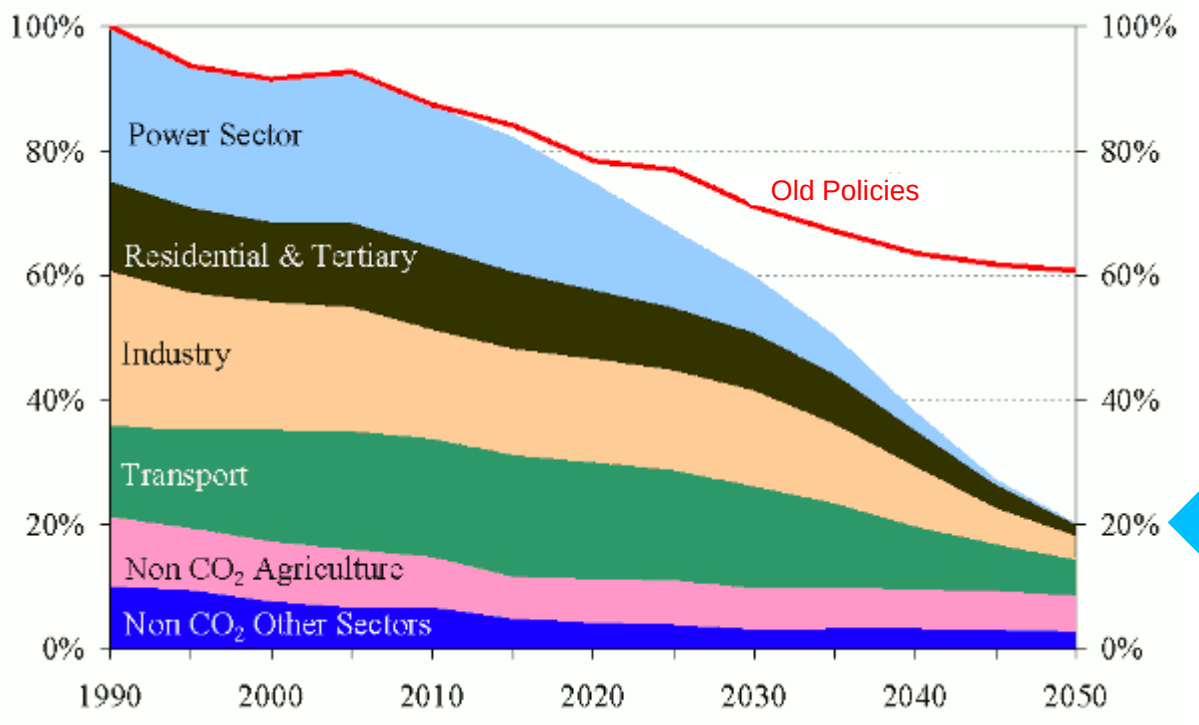
Montenegro
Roland

Agenda

- Introduction
- Methodological implementations
  - Household consumption
  - Elasticity of substitution between energy and housing services
- Environmental tax reform (ETR)
- Scenarios
- Results
- Limitations and insights
- Next steps

Introduction

European Emission target



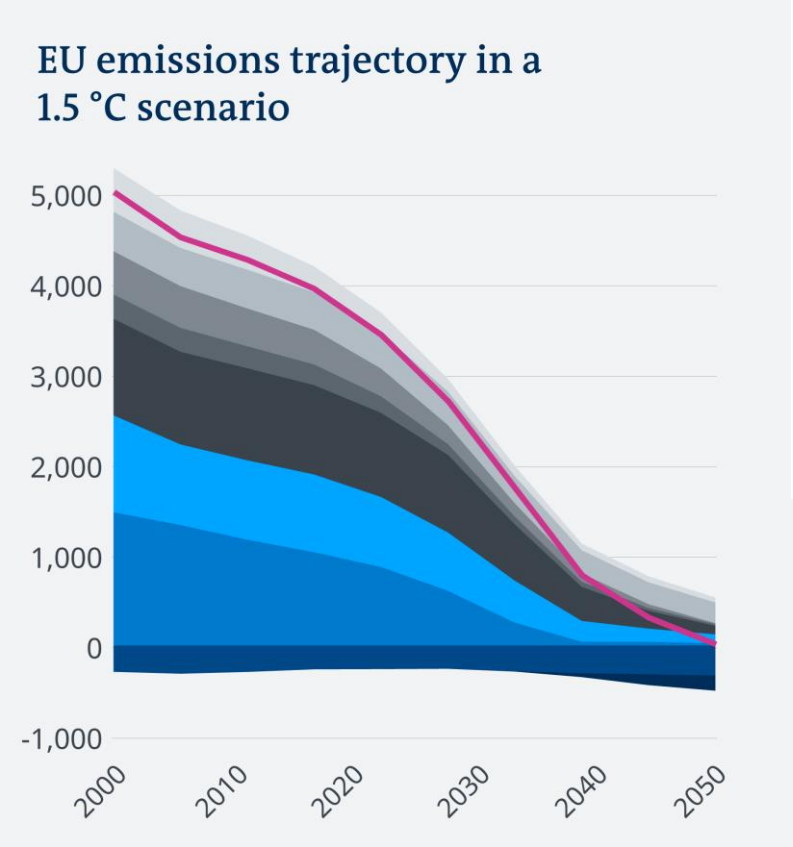
Source: EC
https://ec.europa.eu/clima/policies/strategies/2050_en

- The **burden has to be distributed** among all the sectors in the economy.

Current targets

Introduction

European Emission target



- New targets increase the European ambition to reduce the emissions by 55% in 2030, compared to 1990 levels.
- **Reach carbon neutrality by 2050.**
- **EU Green Deal**

Group of policies in several areas to ensure sustainable economic growth

Introduction

Distributional impacts

What are they?

- Distributional impacts refer to the case when different household groups or individuals are affected by a policy to a different degree.
- Commonly associated with inequality
  - Differences in environmental burden
  - Distribution of income
  - Distribution of welfare
  - Access to energy (and carbon)

Introduction

Distributional impacts – Growing attention

2030 Agenda for Sustainable Development by the United Nations

- 17 Social Development Goals (SDGs)
- 3 of which are directly connected to either energy or inequality

https://sdgs.un.org/goals

Introduction

Distributional impacts – Growing attention

Yellow vest movement

- Originally, the yellow vest protesters were **people from rural areas who have to drive long distances** as part of their daily life.
- Their initial demand was to **repeal the green tax on diesel**. Now, others want the current minimum wage (about $1,350 per month after taxes) to be raised.

https://www.npr.org/2018/12/03/672862353/who-are-frances-yellow-vest-protesters-and-what-do-they-want?t=1607006502419

Introduction

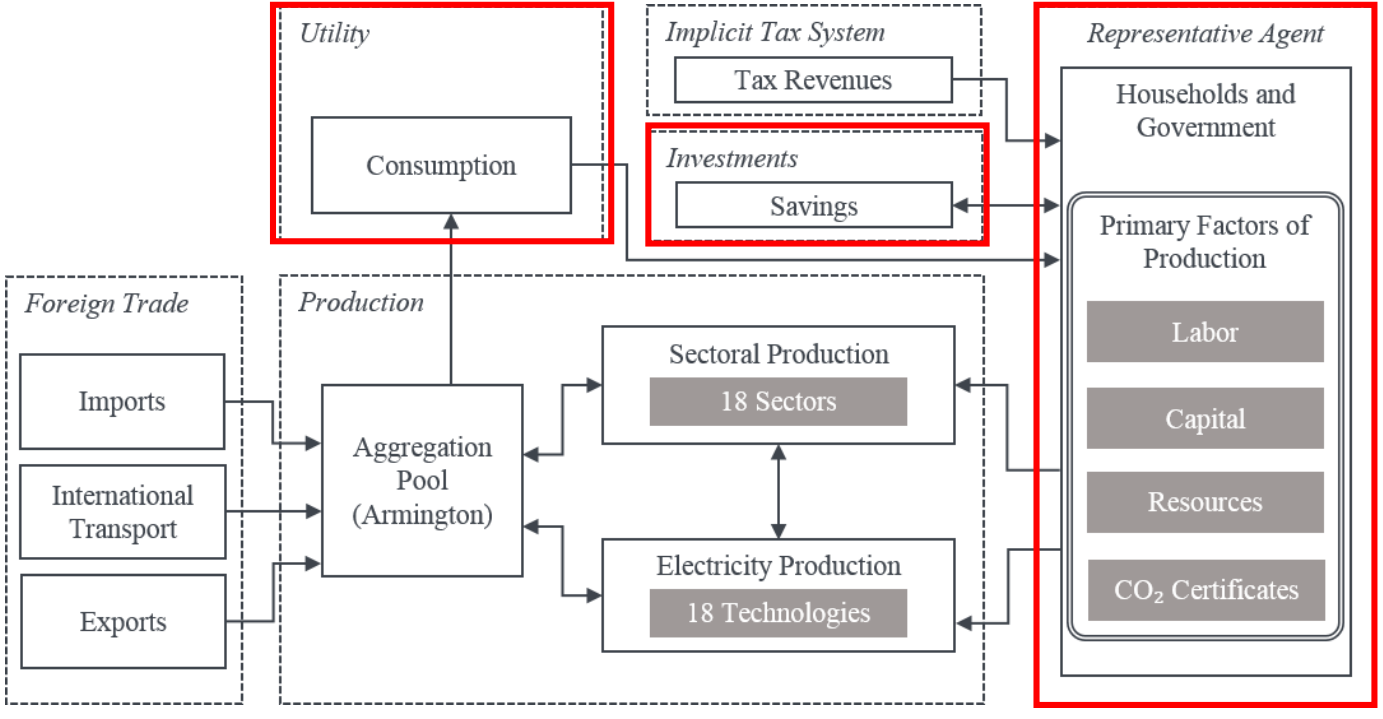
Objective

In light of the side effects of energy and climate policies in terms of income distribution and burden sharing, my main objectives are:

- Development of a technically based method to represent distributional impacts in the household sector.
- Analyze policy alternatives that aim on mitigating negative distributional effects of energy and climate policies

Methodology

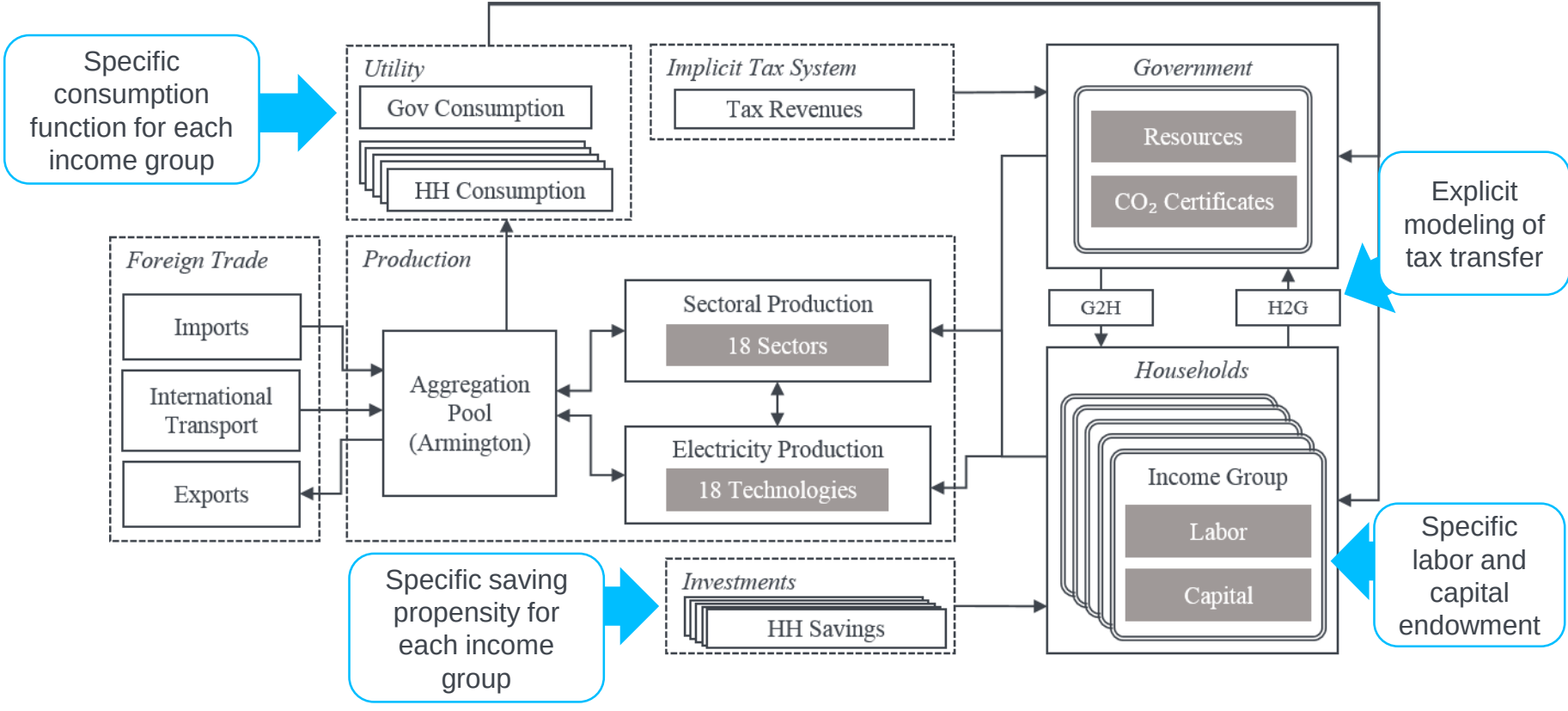
NEWAGE



- NEWAGE was not able to display distributional impacts on a household level because **it represented the households as one homogenous actor**.
- In order to display them, **the first step was to disaggregate the representative agent** into income quintiles and the government.

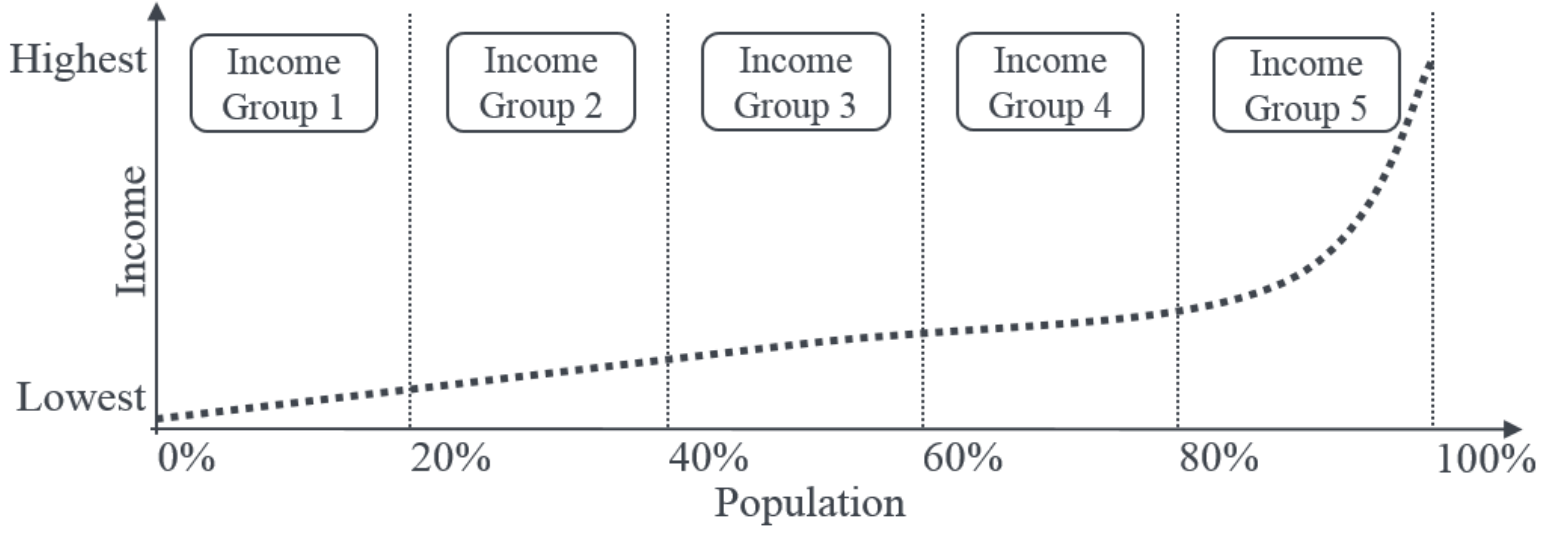
Methodology

NEWAGE – Multiple households



Methodology

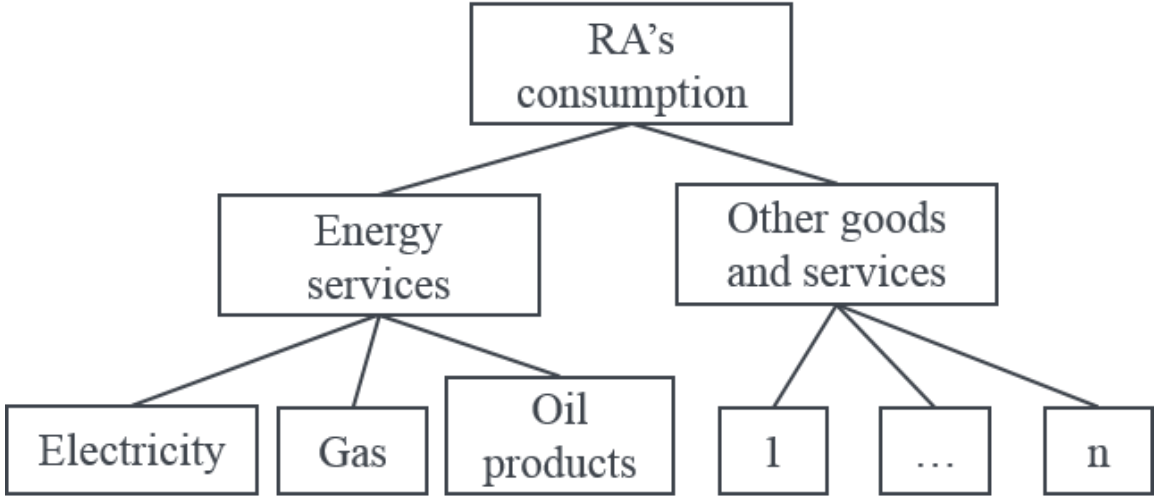
NEWAGE – Multiple households



- Households are divided in income quintiles.
- Households are ordered according to their income and divided into 5 groups of equal size.
- Each quintile contains 20% of the population.

Methodology

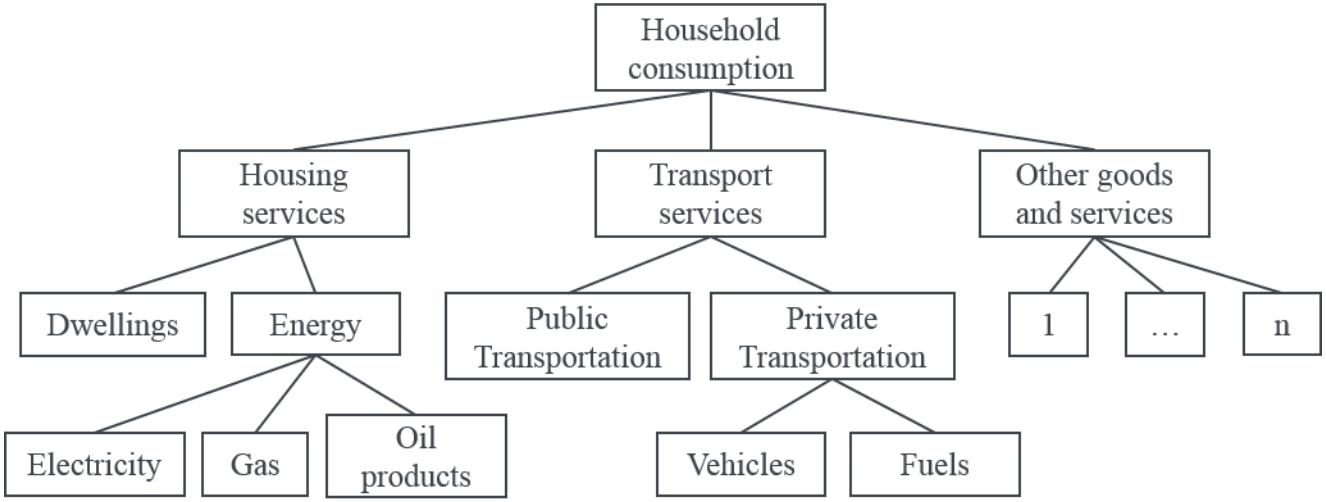
NEWAGE – Households energy consumption



- The original nesting for household consumption grouped energy services separated from all other sectors.
- This representation captures only rudimentary the substitution between energy goods and housing improvement.

Methodology

NEWAGE – Households energy consumption



- The new representation, based on Bye et al. 2017* , allows for a better representation of the consumption of energy goods and direct substitutes.
- Energy for heating can be substituted by consumption of dwelling services, which can represent either improving thermal isolation or the payment of higher rent for a more efficient housing.

* https://doi.org/10.1016/j.energy.2017.10.103

Methodology

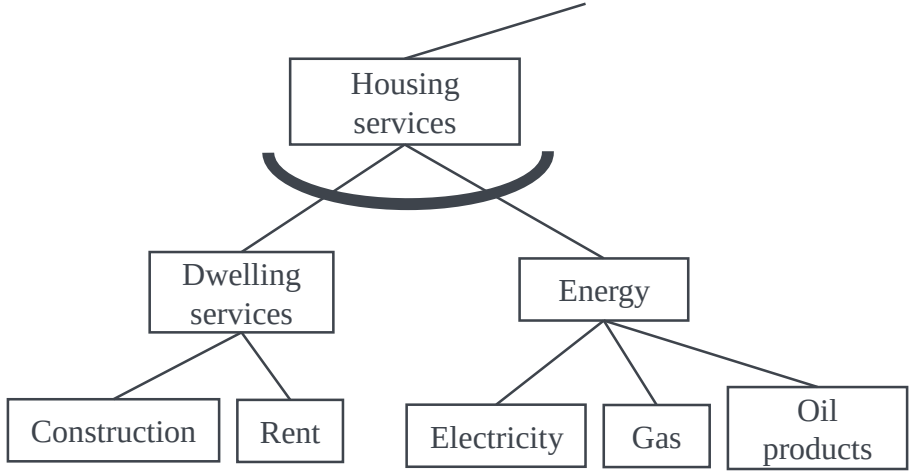
Households energy consumption – Elasticity of substitution

$$\sigma \rightarrow elasticity\ of\ substitution$$
$$0 \leq \sigma \leq \infty$$

Constant **E**lasticity of **S**ubstitution (CES) Function

$$Q = A\ [\ (\alpha\ X_1)^{-\rho} + (\ (\alpha - 1)X_2)^{-\rho}]^{\frac{-1}{\rho}}$$

$$\rho = \frac{(1-\sigma)}{\sigma}$$

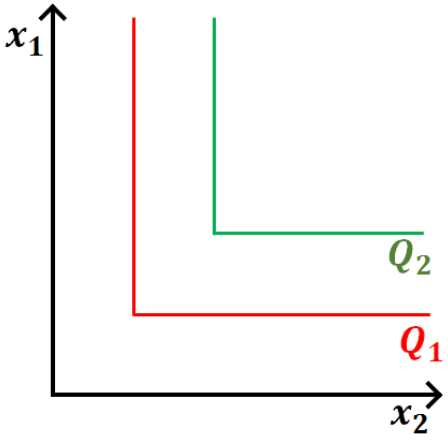


Methodology

Households energy consumption – Elasticity of substitution

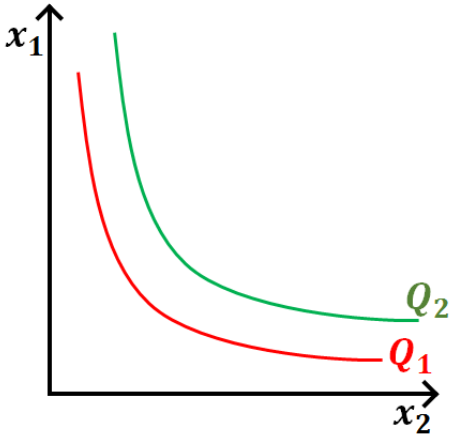
Leontief

$\sigma = 0$



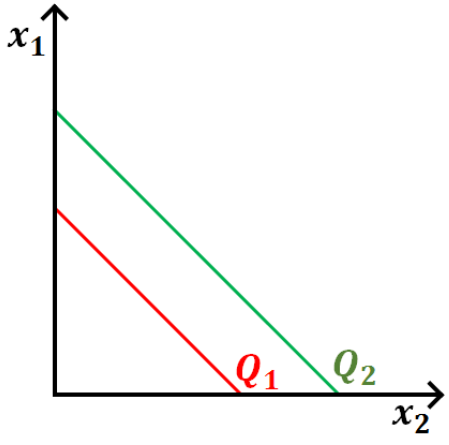
Cobb-Douglas

$\sigma = 1$



Perfect substitution

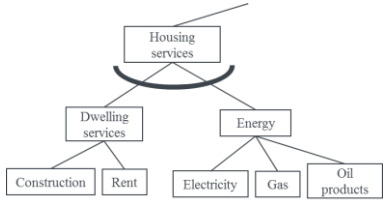
$\sigma = \infty$



Where “Q” represents the level of production

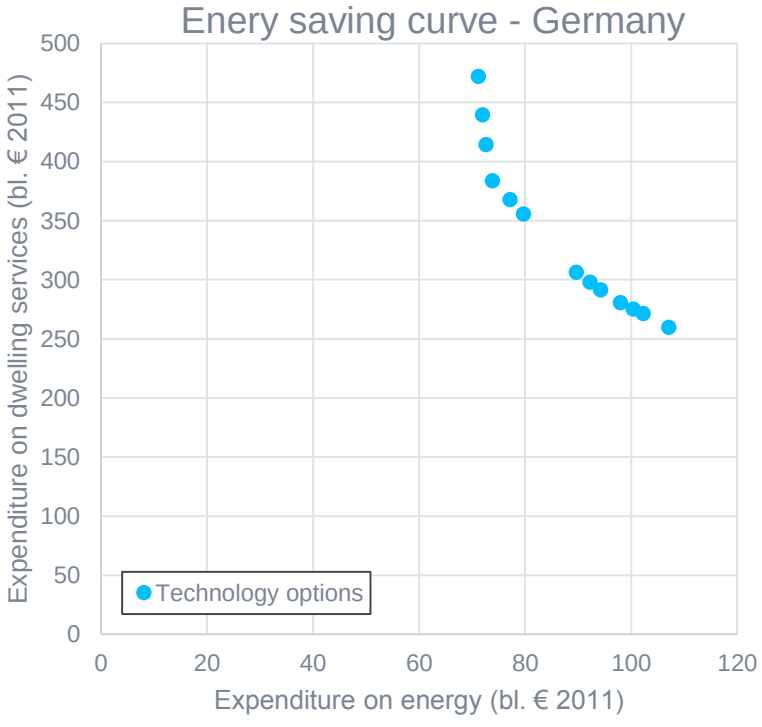
Methodology

Households energy consumption – Elasticity of substitution



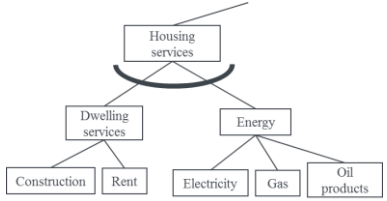
Aggregate investment options for thermal isolation

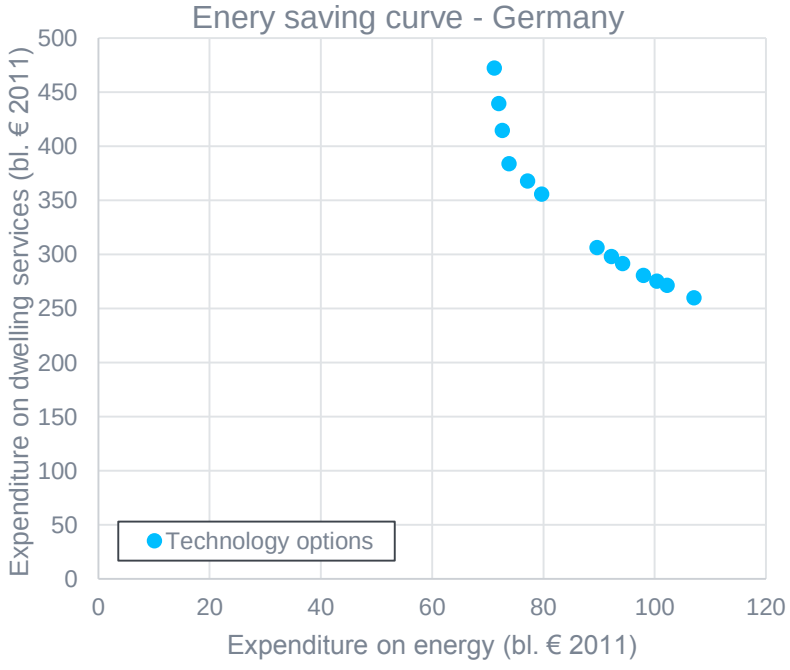
id	Attribu	Year	Pset_P	Step	Region	Value
1	CAP_BND	2020	RESMSBA	P1	DE	73.49886
5	CAP_BND	2020	RESSFBU	P1	DE	36.5645
9	CAP_BND	2020	RESSFBR	P1	DE	27.93269
13	CAP_BND	2050	RESMSBA	P1	DE	40.03519
17	CAP_BND	2050	RESSFBU	P1	DE	20.46651
21	CAP_BND	2050	RESSFBR	P1	DE	16.00389
37	INVCOST	2020	RESMSBA	P1	DE	1.58E+08
41	INVCOST	2020	RESSFBU	P1	DE	1.43E+08
45	INVCOST	2020	RESSFBR	P1	DE	1.43E+08



Methodology

Households energy consumption – Elasticity of substitution





Fit

$$Q = A\ [(\alpha\ X_1)^{-\rho} + ((\alpha - 1)X_2)^{-\rho}]^{\frac{-1}{\rho}}$$

$$\rho = \frac{(1-\sigma)}{\sigma}$$

$$\sigma_{Germany} = 0.352$$

Repeat the process for each of the 8 remaining EU regions

Environmental Tax Reform

Double dividend hypothesis

Concept

- It refers to the notion that environmental taxes can both **reduce pollution (the first dividend)** and **reduce the overall economic costs** associated with the (suboptimal) tax system by using the revenue generated to **displace other more distortionary taxes** that slow economic growth at the same time **(the second dividend)**.

1. Lower emissions

2. Better economic output

https://www.eea.europa.eu/help/glossary/eea-glossary/double-dividend#:~:text=with%20javascript%20off.-,Term,time%20(the%20second%20dividend).

Environmental Tax Reform

What researchers say?

Authors agree that in addition to the economic dividend, there can be other benefits (other dividends) from ETRs:

- Employment increase
- Fair income distribution
- Progressive taxation

However, these dividends do not always happen and ETR options have to be investigated in a case by case basis in order to assess which dividends appear for each policy option.

https://www.eea.europa.eu/help/glossary/eea-glossary/double-dividend#:~:text=with%20javascript%20off.-,Term,time%20(the%20second%20dividend).

Scenarios

Reduction of overall energy-related CO2 emissions

Reference scenario **[REF]**

- Considers the economic effect of Covid in 2020
- Reduction in ESD sectors only through technology development

Reduction Scenario **[CME]**

- Also known as “Current mechanisms” from ARIADNE project
- Overall emissions reduction of 53% in 2030 compared to 2005 levels
- 62% reduction in ETS sectors and 44% reduction in ESD sectors

Scenarios

Environmental Tax Reform Scenarios

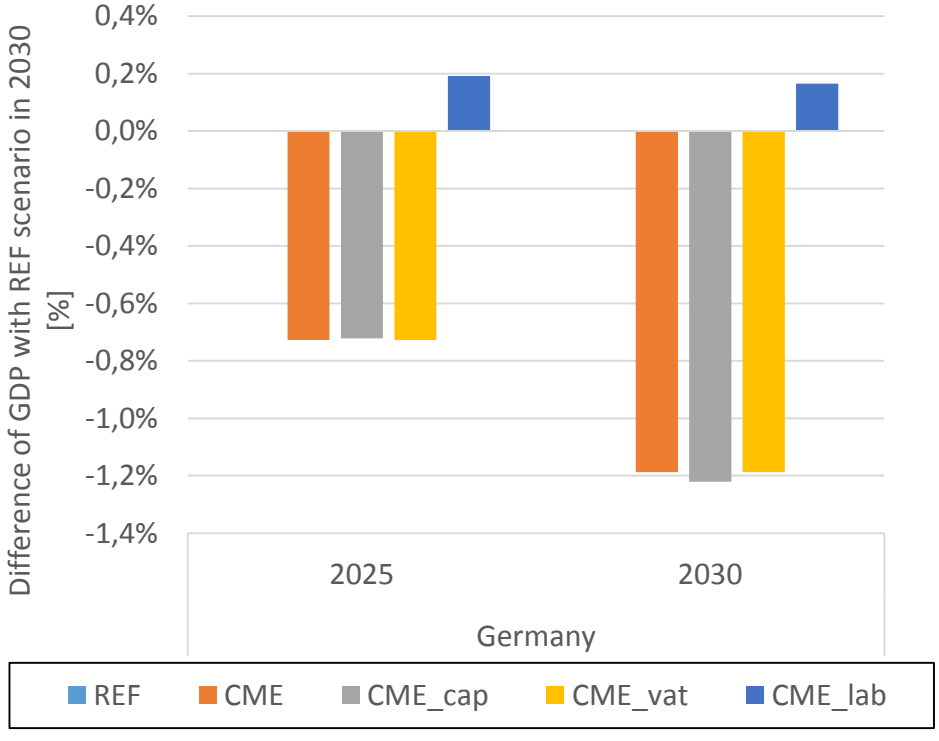
The Environmental tax reform scenarios consider that the emission targets in the ESD sectors are reached through a national cap-and-trade system and the revenues are used in one of the four schemes:

1. No revenue recycling – Status Quo **[CME]**
2. Per capita redistribution **[CME_cap]**
3. Reduction of Labor tax **[CME_lab]**
4. Reduction of Value added tax (VAT) **[CME_vat]**

Results

GDP - Germany

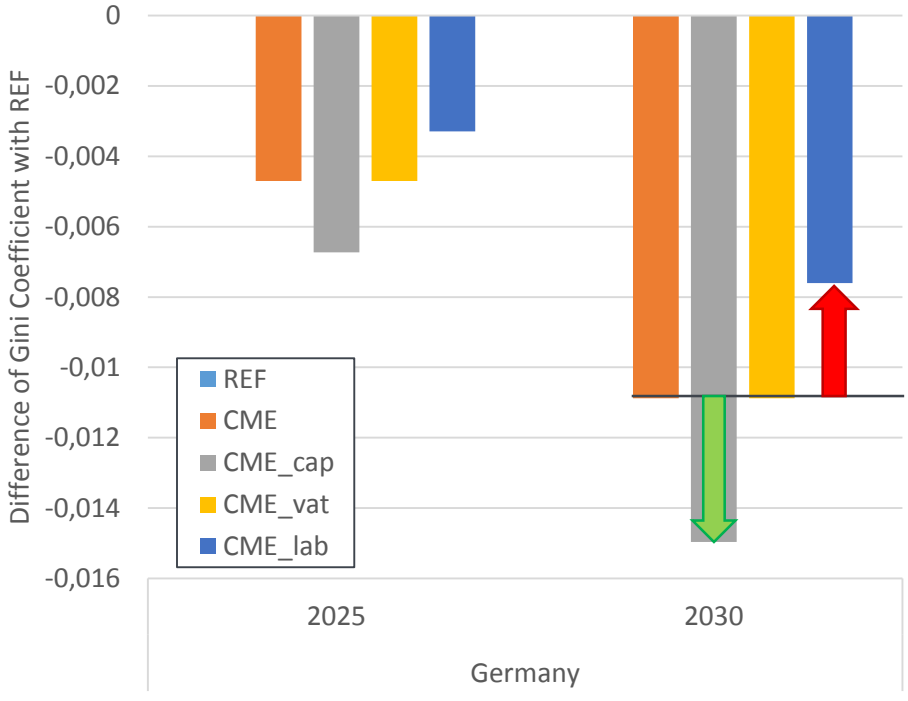
Average yearly growth per scenario					
Years	**REF**	**CME**	**CME_cap**	**CME_vat**	**CME_lab**
2011-2020			0.515%		
2020-2030	1.935%	1.814%	1.810%	1.814%	1.952%



- In terms of GDP development, only scenario CME_lab presents the economic dividend.
- The remaining scenarios all present a GDP loss of around 0.7% and 1.2% compared to REF in 2025 and 2030 respectively.

Results

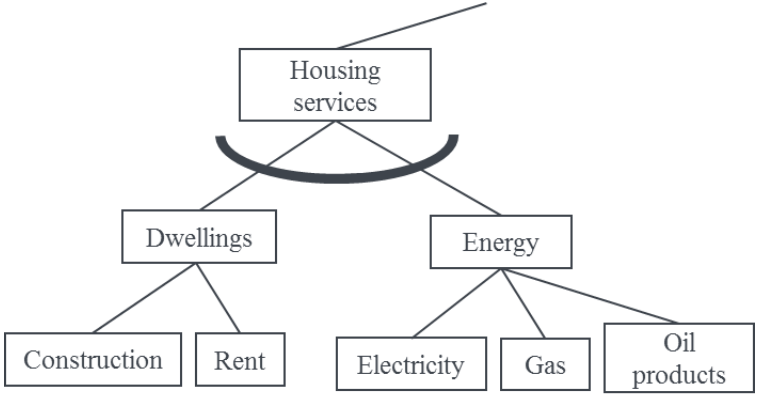
Income distribution – Gini Index



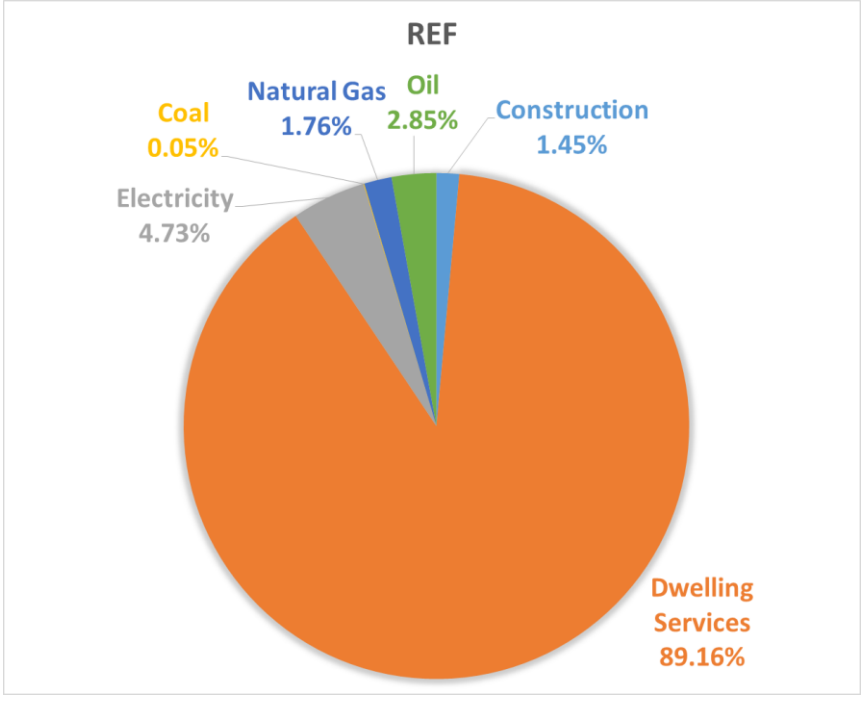
- All scenario present better Gini Coefficients than REF.
- On the other hand, CME_lab present a lower value than CME
- CME_cap has the best results in terms of income distribution

Results

Energy substitution

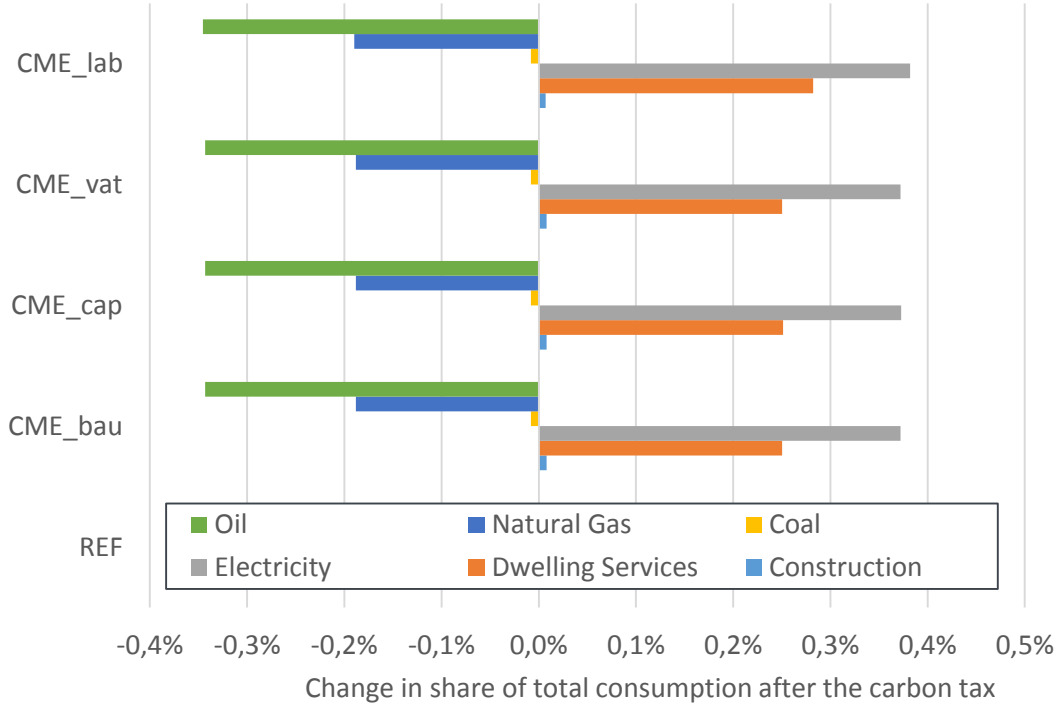


Consumption of housing services in 2030
Sum over all households



Results

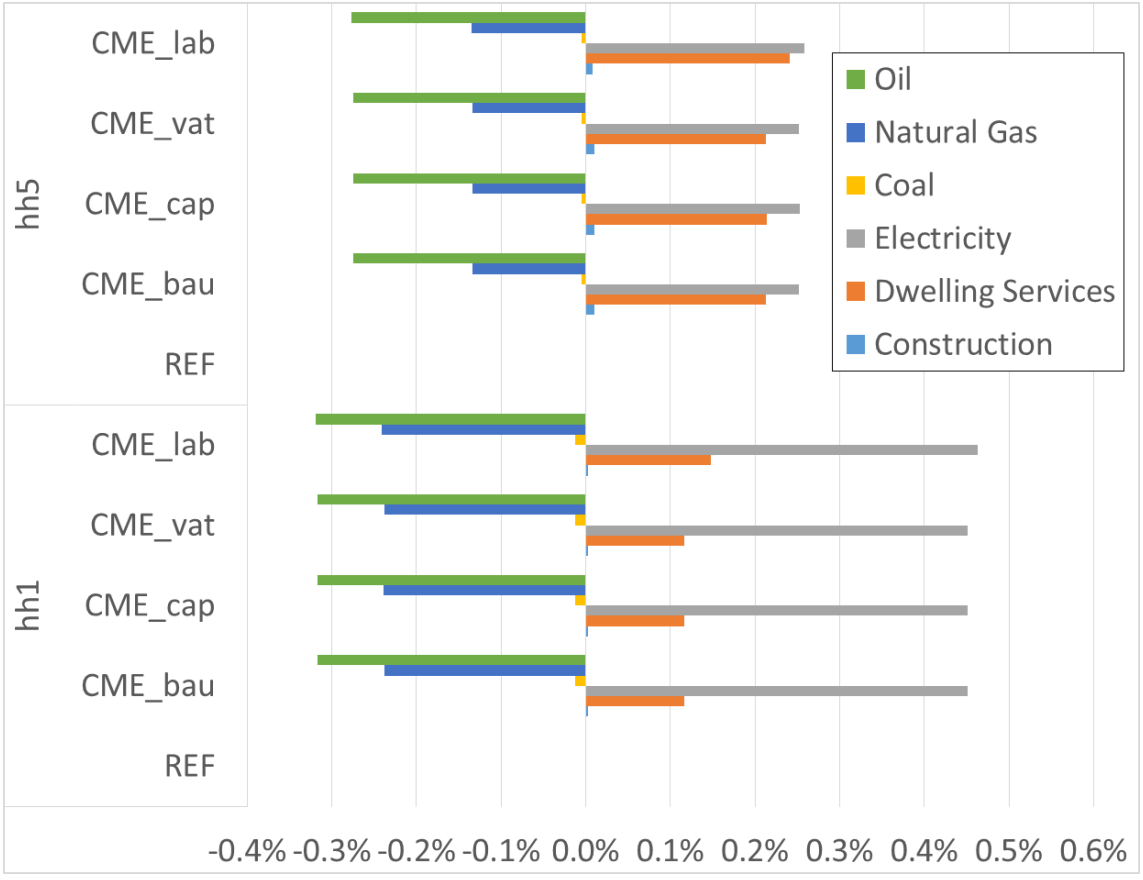
Energy substitution



- In all scenarios we see higher consumption share of dwelling services, electricity and a small increase in construction
- The fossil fuels, as expected, all reduce their consumption

Results

Energy substitution



- When looking at the difference in consumption according to income group, it is possible to see that low-income households are more prone to use electricity.
- High-income households still can afford carbon taxation and are less pressured to substitute their fossil-fuel consumption

Limitations

- Heating technologies, such as heat pumps, are not explicitly modeled.
- Instead, technology development is represented by:
  1. Autonomous Energy Efficiency Index
  2. Higher consumption of electricity
- Access to data regarding energy consumption per household is limited.
  - Knowing the distribution of electricity usage for transportation per income group could help plan better policies for EV adoption in low-income households

Insights and impacts

- Including distributional impacts in policy analyses helps identifying winners and losers of different policy packages.
- CME_lab leads to higher GDP growth, but higher inequality
- CME_cap leads to GDP stagnation compared to CME, but lower inequality
- These results can help policy makers decide what kind of economic growth to prioritize in the coming years
- Although not the case in these results, high changes in energy demand from different recycling schemes can be fed to energy system models, which sometimes lack the feedback between income and energy demand.

Next steps

- Modeling:
  - Calibration of the model to account for the household disaggregation
  - Calculation of final scenarios
- Text:
  - Introduction and literature review: making corrections
  - Methodology: 50%
  - Missing: Results and Conclusion

Next steps

- Publications:
  - Carbon leakage and competitiveness: Socio-economic impacts of greenhouse gas emissions decrease on the European area until 2050 (2017 – Main author)
  - Long-Term Distributional Impacts of European Cap-and-Trade Climate Policies: A CGE Multi-Regional Analysis (2019 – Main author)
  - On the Way to a Sustainable European Energy System: Setting Up an Integrated Assessment Toolbox with TIMES PanEU as the Key Component (2020)
  - Beyond the Energy System: Modeling Frameworks Depicting Distributional Impacts for Interdisciplinary Policy Analysis (2020 – Main author – review article)

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Thank you!

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Questions?