Household Energy Efficiency Adoption Behaviour

Integrating Findings from Choice Experiments into Energy and Macro-Economic Models

Structure of WP 5:

WP4: Survey

- Empirical basis for decision making process; how this is influenced by policies
- Decision weights of key factors

Appliances: FORECAST & EMLab-Consumer

WP5: FORECAST (Appliances)

Approach:

- Logit function
- Bottom-up energy demand model
- Simulation of policy effects on investments

WP5: Agent-based modelling (ABM)

(Appliances and Behavior)

- Focus on particular policy design / technology sets
- Role of networks / agents, role of intermediarires and policy acceptance

WP5: INVERT (Buildings)

Approach:

- Nested Logit function
- Weights of decisin criteria
- Definition of investor types
- Simulation of policy effects on investments

Heating: Invert/EE-Lab & EMLab-Consumer

Scenario Definition

- **Current-policy scenario:** Default reference scenario
- **Individual-policy scenario(s):** Assessment of individual policy instruments
- **Policy-package scenario(s):** Bundle of policy instruments, specifically addressing vulnerable groups.

Results from the *FORECAST Residential Appliances* model

Dr. Heike Brugger

Implementation of DCE Results Into the Forecast Residential Model

Directed policy interventions directly addressing external barriers

Barriers to energy efficiency
Split incentives
Transaction costs
Lack of information
Lack of capital
Technological risk
Financial risk

Discrete **C**hoice **E**xperiments (DCE) with Thousands of Interviewees

Empirically identified **utility function** for Label, Size…

Identification of End-User Groups & Their Preferences

Implement utility function based on DCE results

Calculation of Market Shares

Calibration with Energy Balance & Market data

Calculation of Energy Demand, Savings & Effectiveness of Policy Scenarios

Results: Final energy demand in survey countries

Scenarios

BAU	Business-as-usual
REB-LIG	Rebate for low income households
REB-AIG	Rebate for all income households
MEPS+	Enhanced minimum energy performance standards
BAT	Best available technology

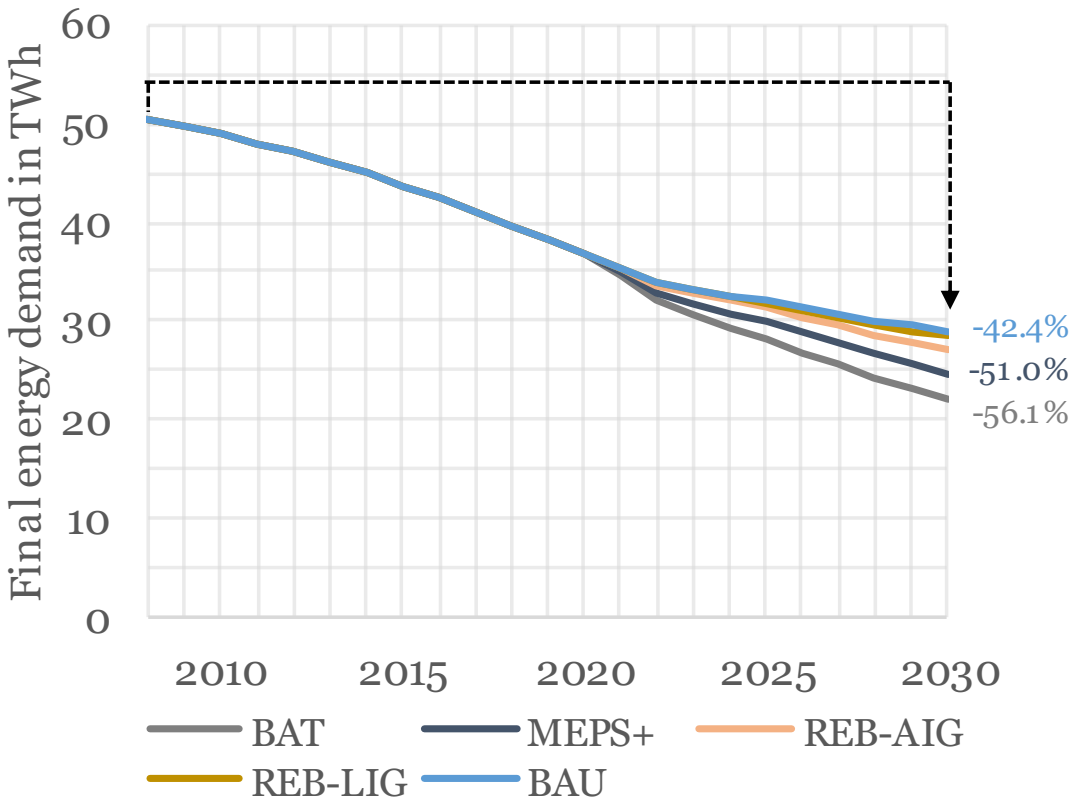


Fig. 2. Final energy demand for refrigerators in the CHEETAH survey countries.
Projections based on the FORECAST model.

Results: Effectiveness

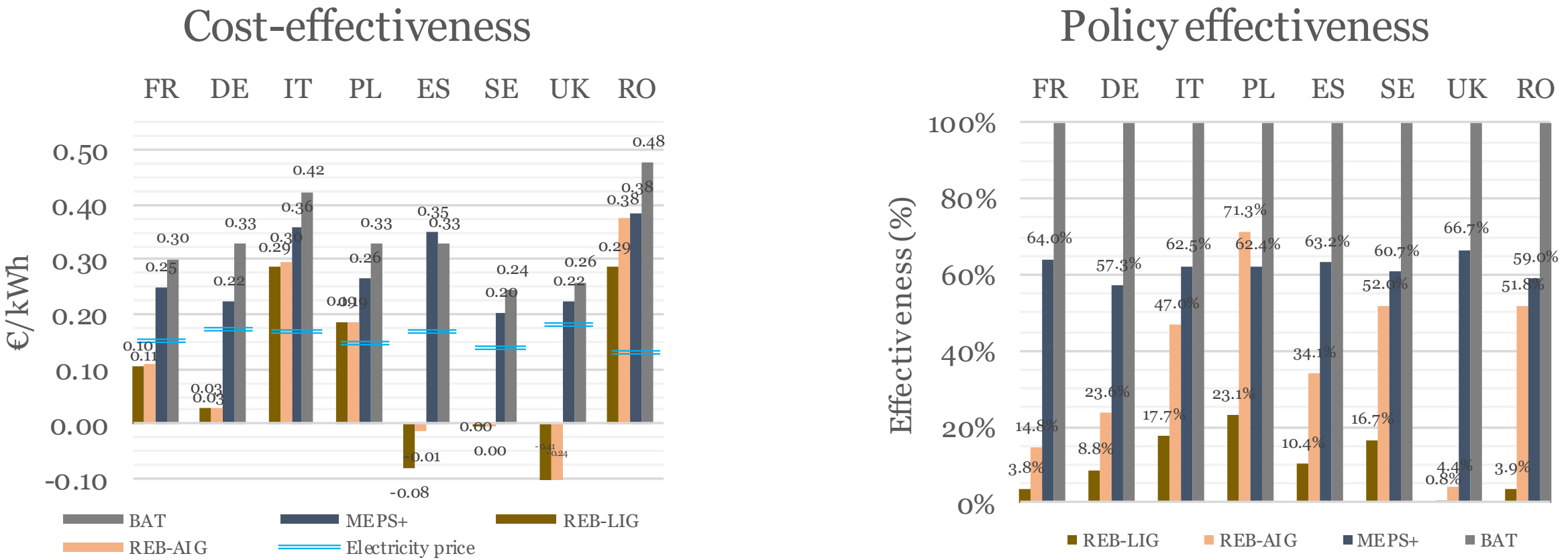


Figure 2. Policy effectiveness for the CHEETAH survey countries.
Target year 2030. Projections based on the FORECAST model.

Summary of Findings

- Countries differ in
  - the effectiveness of the policies from a consumer perspective
  - in their electricity prices, the *greater* the electricity price, the higher is the attractiveness of the policies from a consumer perspective
- Stricter MEPS and BAT have the highest lever, yet, the results suggest that they induce substantial additional costs for households
- Rebates can induce additional savings while presenting lower financial burden to households than regulation

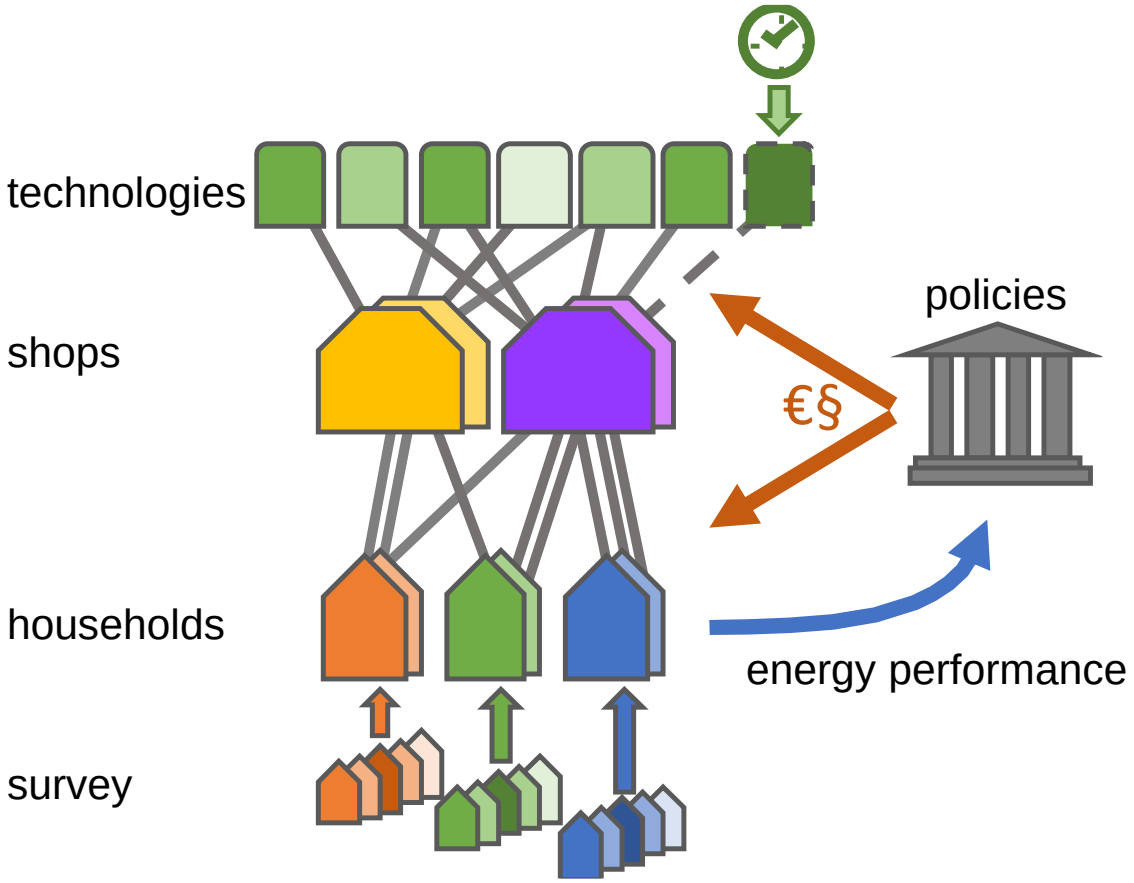
Results from *EMLab-Consumer*

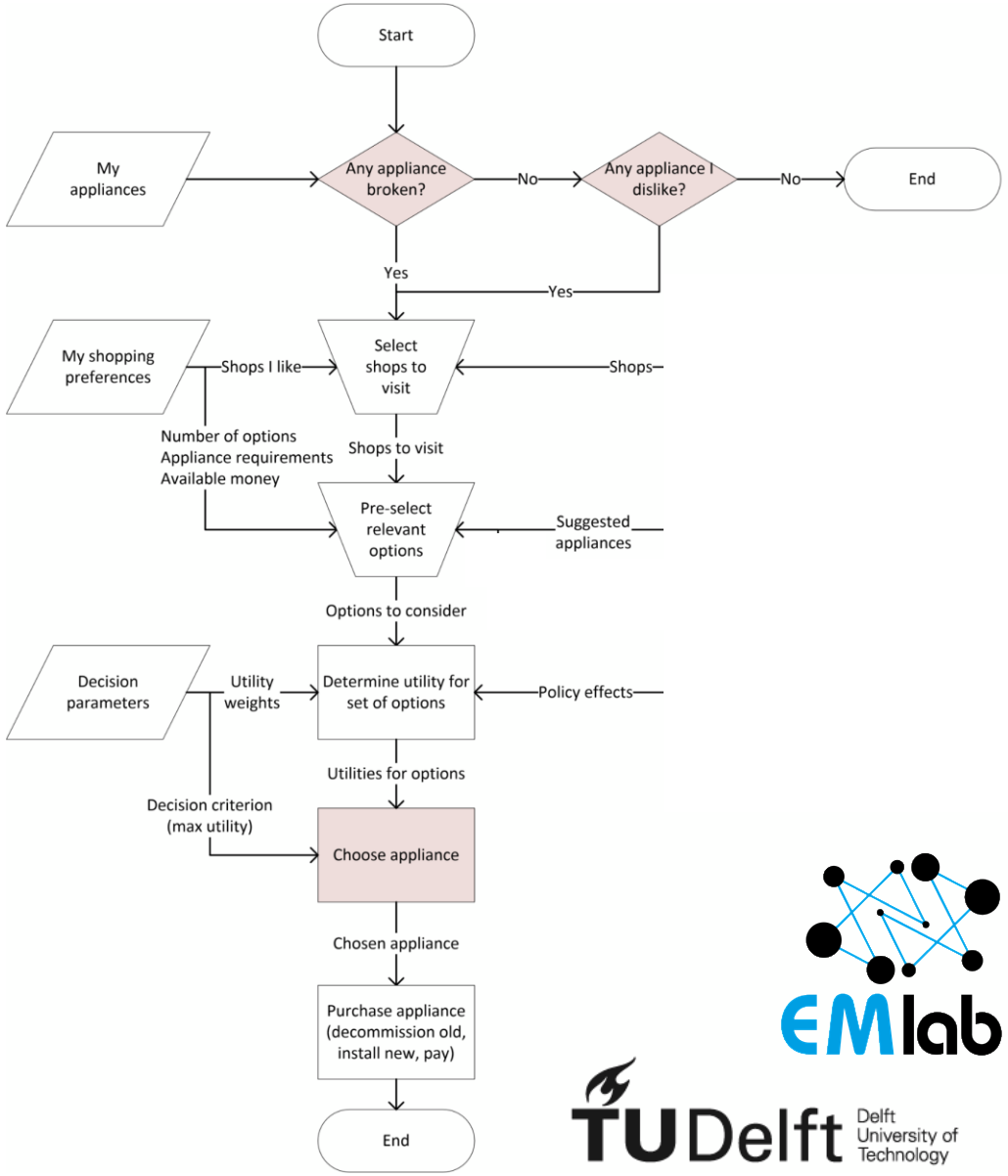
Dr.ir. Emile Chappin

TU Delft Delft University of Technology

EMlab

Agent-based model EMLab-consumer





EMlab

TU Delft Delft University of Technology

CHEETAH

Changing Energy Efficiency Technology Adoption in Households

setup S
reset R
step Q
go G
defaults

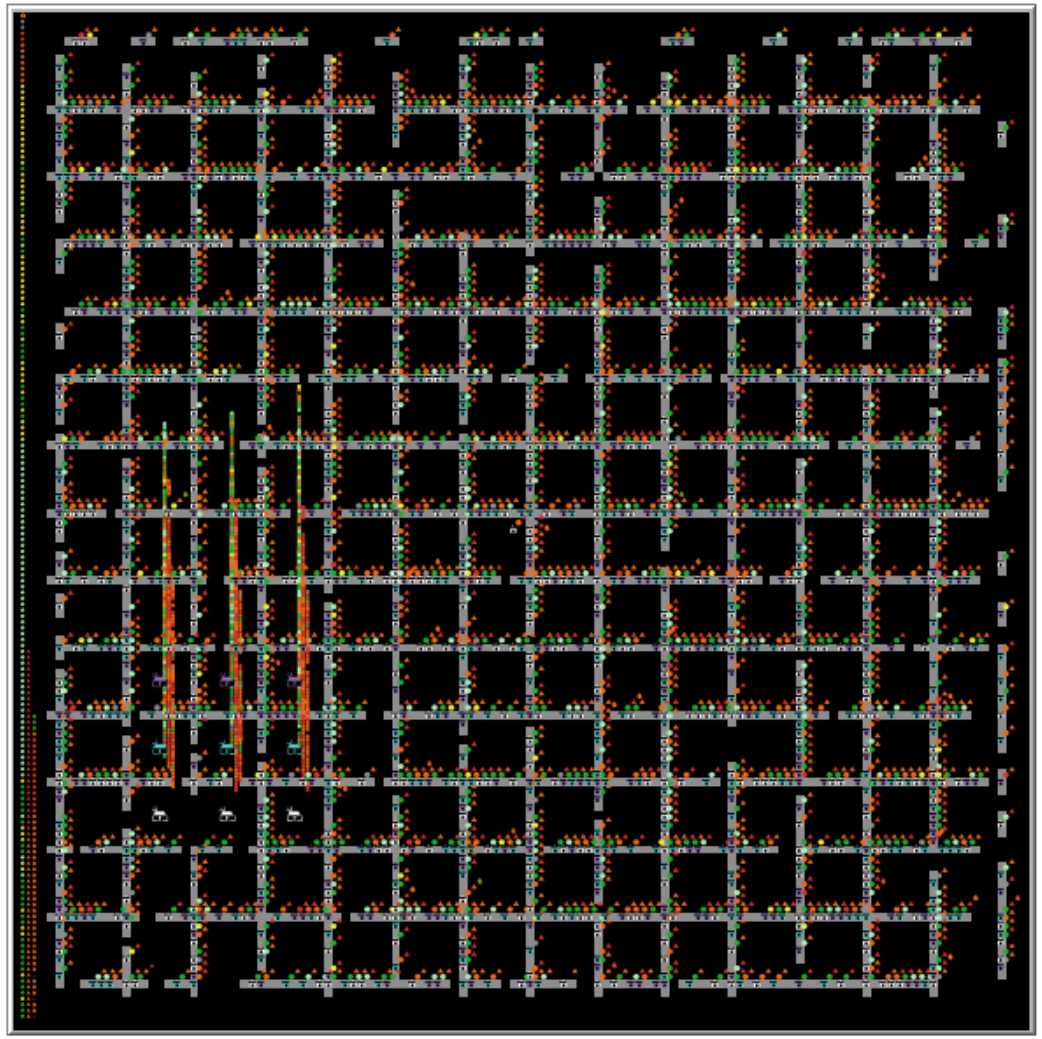
General parameters

country: UK
ticks-per-year 1
simulation-length-in... 20
suppl-max-appls 150
global-alpha 1
percentageSmartTher... 5
frequencyOfImproved... 1
maxAgeOfModelInStore 4

Policies

policy-allowed-labels-tv: slow
policy-allowed-labels-fridge: off
policy-allowed-labels-washmach: off
policy-allowed-labels-heatings...: off
policy-allowed-labels-thermostat: off
first-year-subsidy 4
last-year-subsidy 40

labels-allowed-TV: A++ or higher
labels-allowed-fridge: any label
labels-allowed-washmach: any label
labels-allowed-thermostat: any label
labels-allowed-heatings...: any label
Who-gives-subsidy: Public
Who-to-subsidies: low-income
minimum-label-subsidy: 1



Decision details / parameters

hh-fridge-size-range 25
hh-washmach-volume-per-hh-... 2.5
hh-washmach-volume-range 3.0
supplier-selection: all

subsidylevel-TV: 0
subsidylevel-heatingsyst...: 0
subsidylevel-thermostat: 0
subsidylevel-wasmach: 0
subsidylevel-fridge: 0

Ager
min
num
num
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726
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1

Technolog
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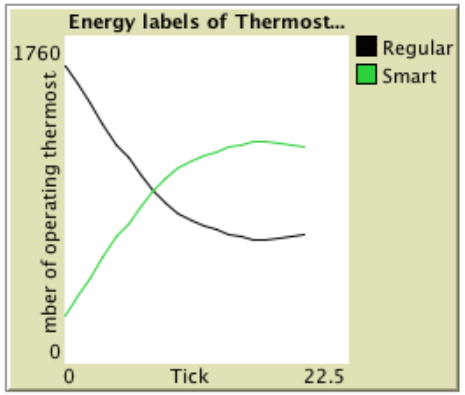
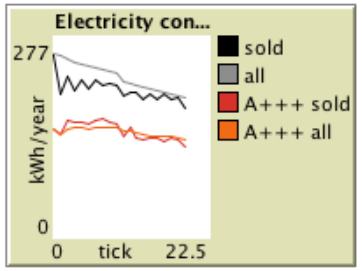
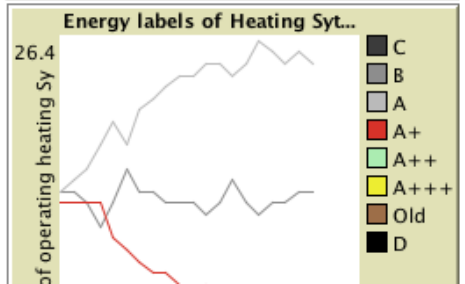
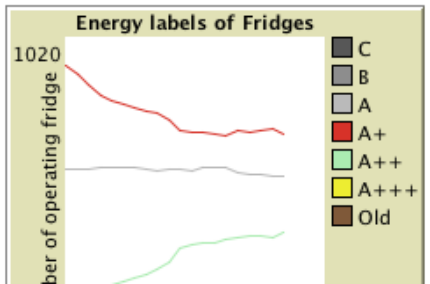
Labels

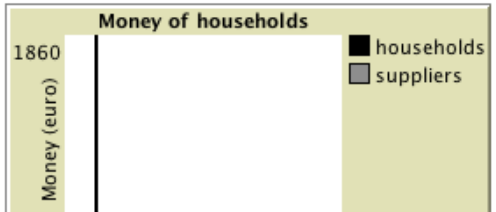




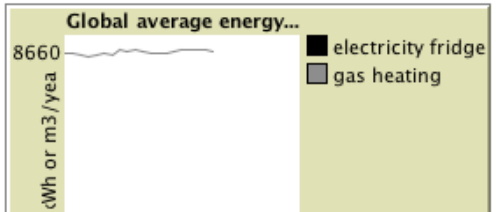




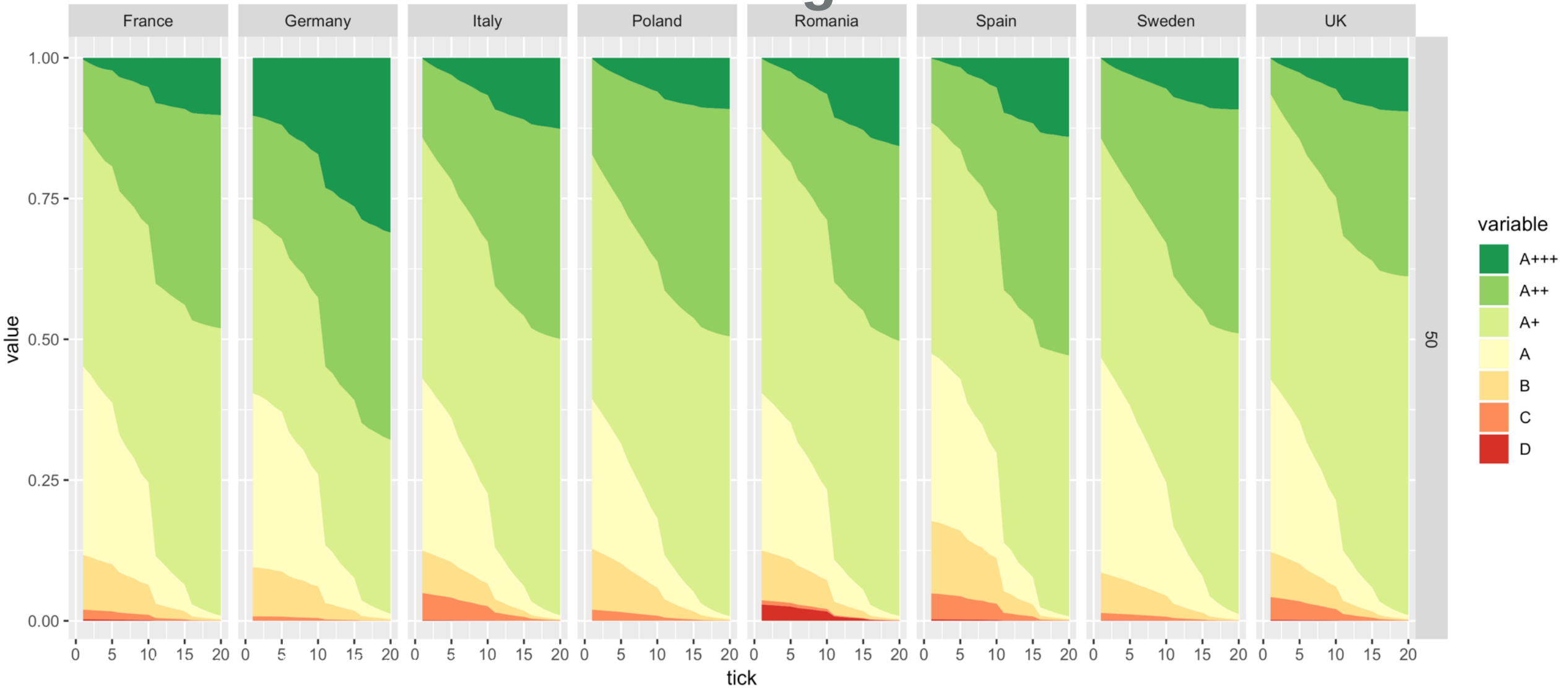
Money



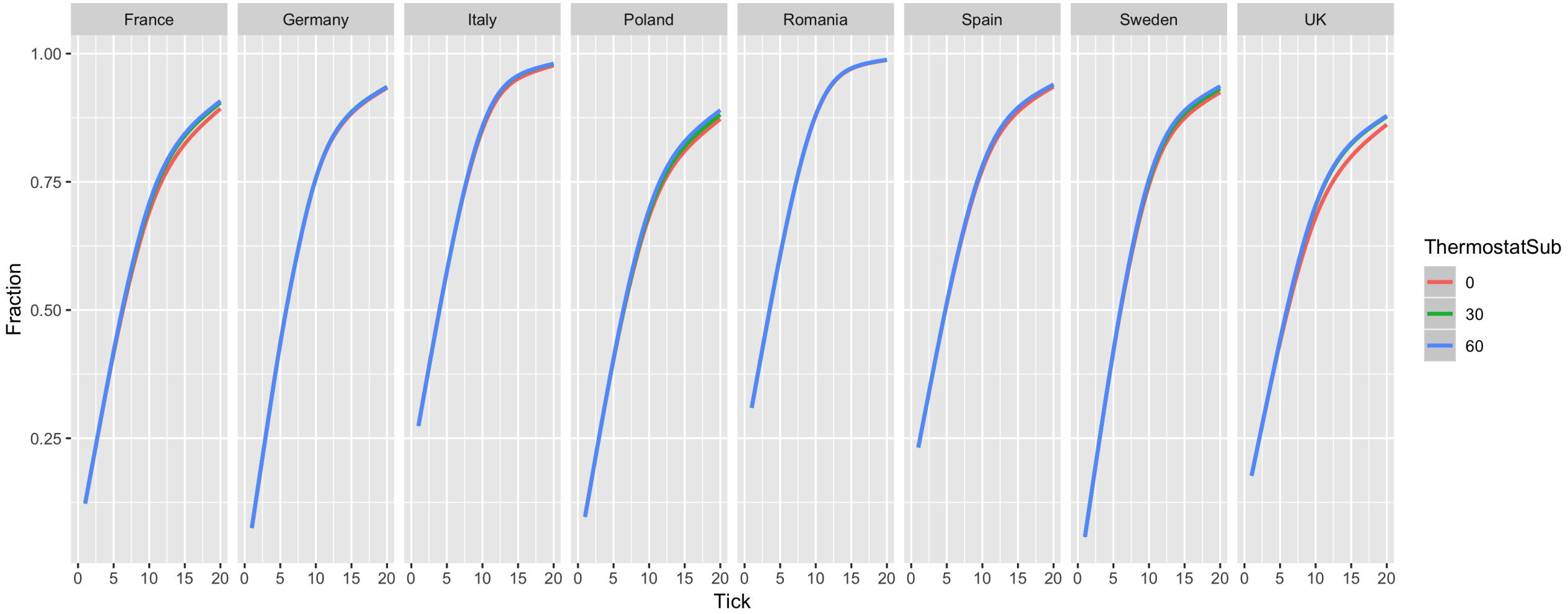
Energy



Simulation results – fridges



Simulation results – smart thermostats



Outcomes

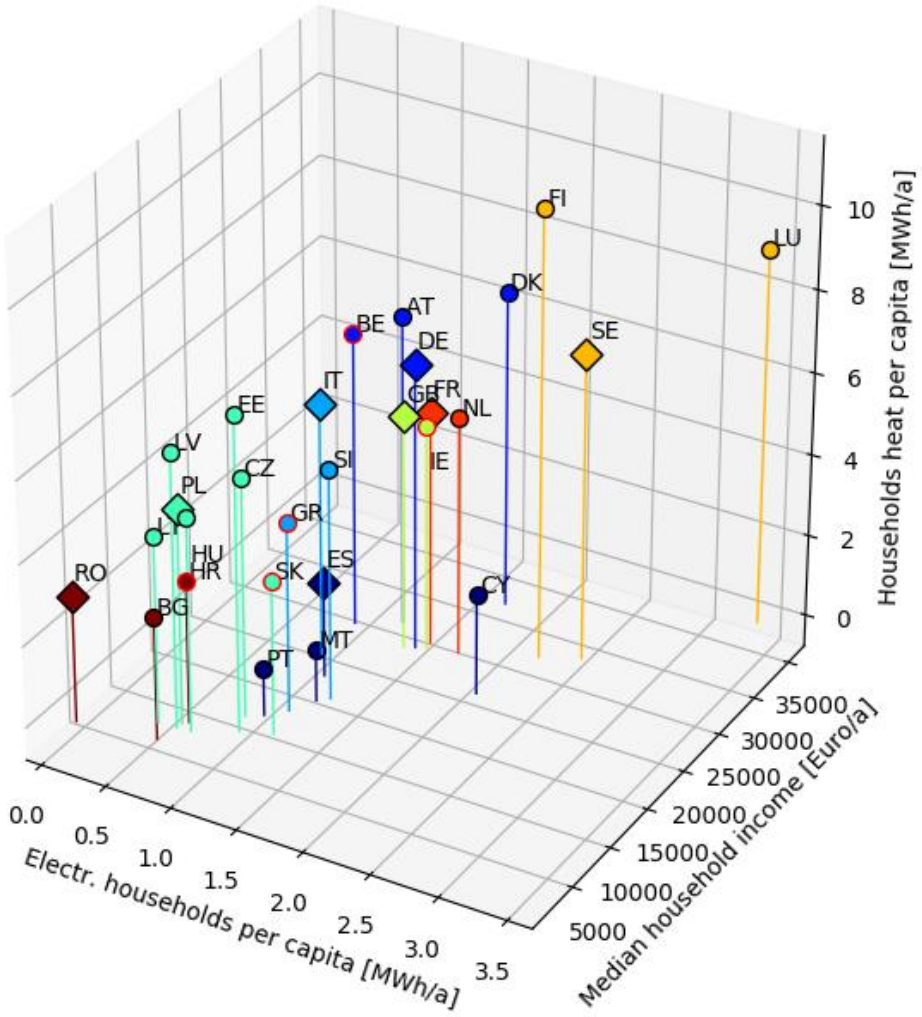
- EMLab-Consumer simulates decisions of households, directly using the 8 country survey, the choice models derived from the same survey. It will be published open source (http://emlab.tudelft.nl)
- Captures investments smart thermostats and fridges
- Studies the effects of subsidies and performance standards. Impact of rebates are limited by appliance models offered to consumers
- Used to inspire the other models
  1) capturing heterogeneity of decision makers
  2) reflection on crucial assumptions (switching away from smart thermostats, averages per energy label)

Results from the *Invert/EE-Lab building stock* model

Dr. Andreas Müller

Implementation of survey results into the Invert/EE-Lab model

- Align decision rules of investors in the Invert/EE-Lab with discrete choice experiment
- Implement household groups based on the EU statistics on income and living conditions (EU-Silc) data
- Apply results for non-survey countries based on similarities regarding household income, residential heat demand and residential electricity consumption

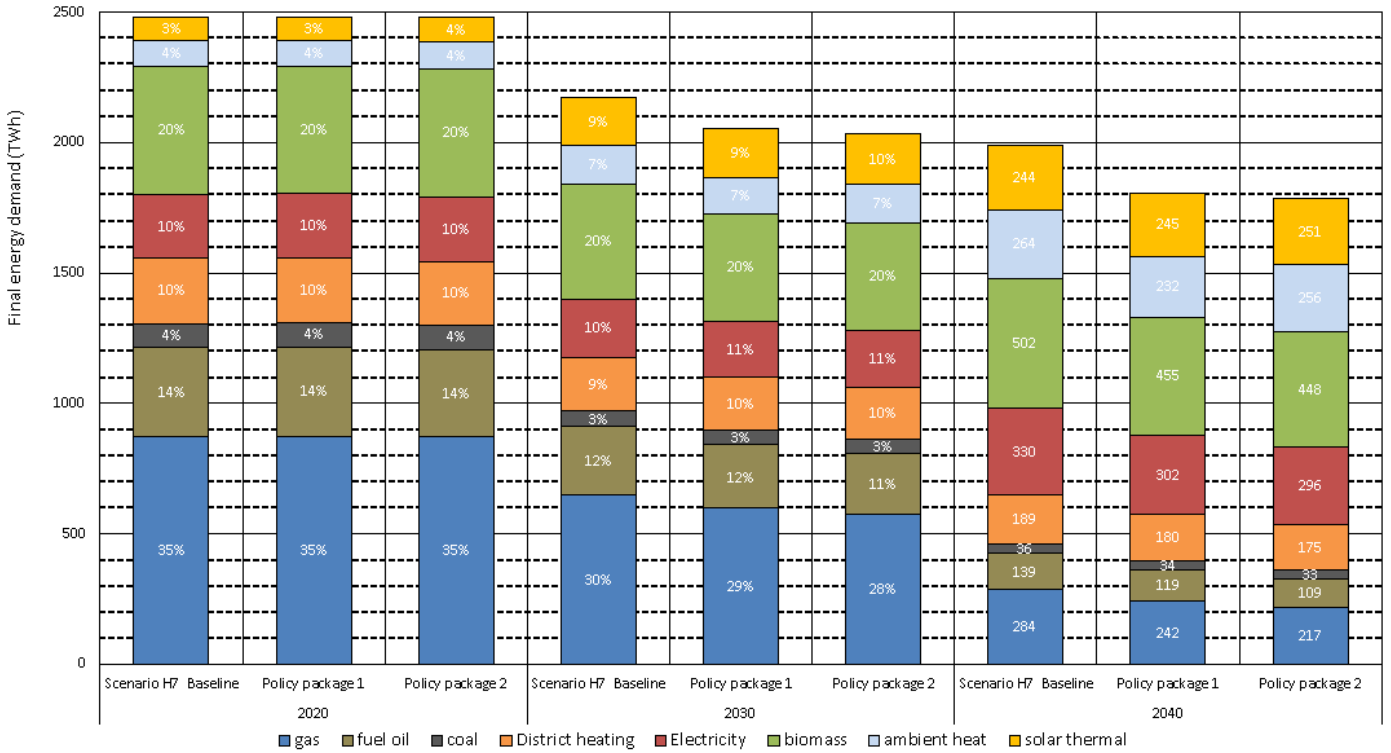


Results: Final energy demand for space heating in the EU-28 countries

- Reference Scenario: Decarbonization and increased mainly based on obligations

- Policy scenarios: Additional financial support (annual budget of 30 €/ inhabitant)
- Increased support for heating control devices: („smart“) thermostats
- Additional soft measures such as recommendation campaigns etc.
- Policy scenario 2: Higher support for Low income households, lower support for other households

Results: Final energy demand for space heating in the EU-28 countries



- Additional policy measures increase the savings by 10 percentage points until 2040
- Shifting subsidies budgets towards low income doesn't adversely affect the energy savings

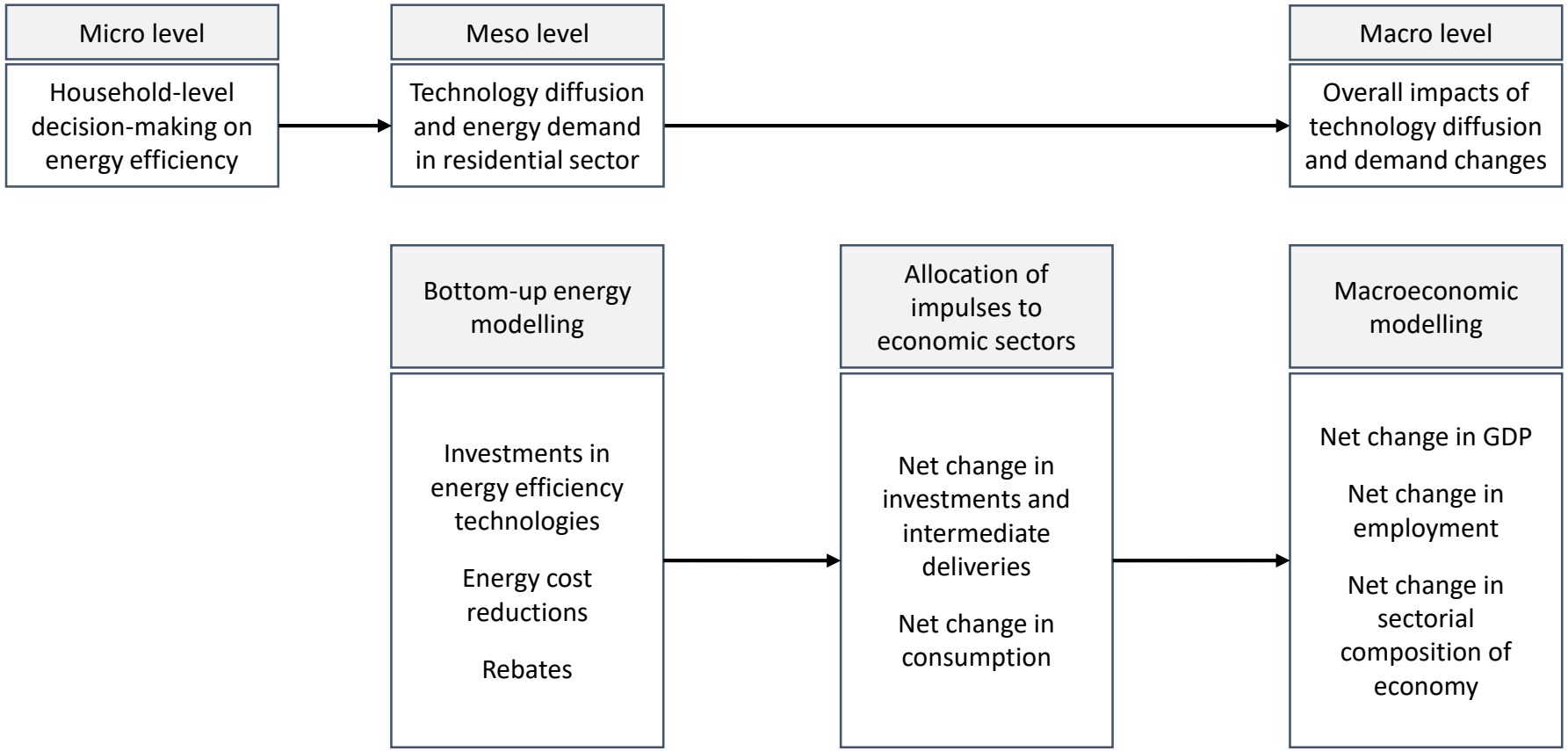
Summary of Findings

- Even financial support is not sufficient to reduce the energy consumption and CO2 emissions needed to achieve the EU-2050 climate targets
- However, decarbonization of built environment requires high investments
- Low income households, especially in countries with lower-than-EU-average income level might not be able to raise the needed capital.
- Shifting financial support partly towards low income household and ensuring efficient access to the capital market is required to enable a decarbonization that leaves no one behind.

Results from *ASTRA-EC*

Matthias Pfaff

Objective of macroeconomic analysis



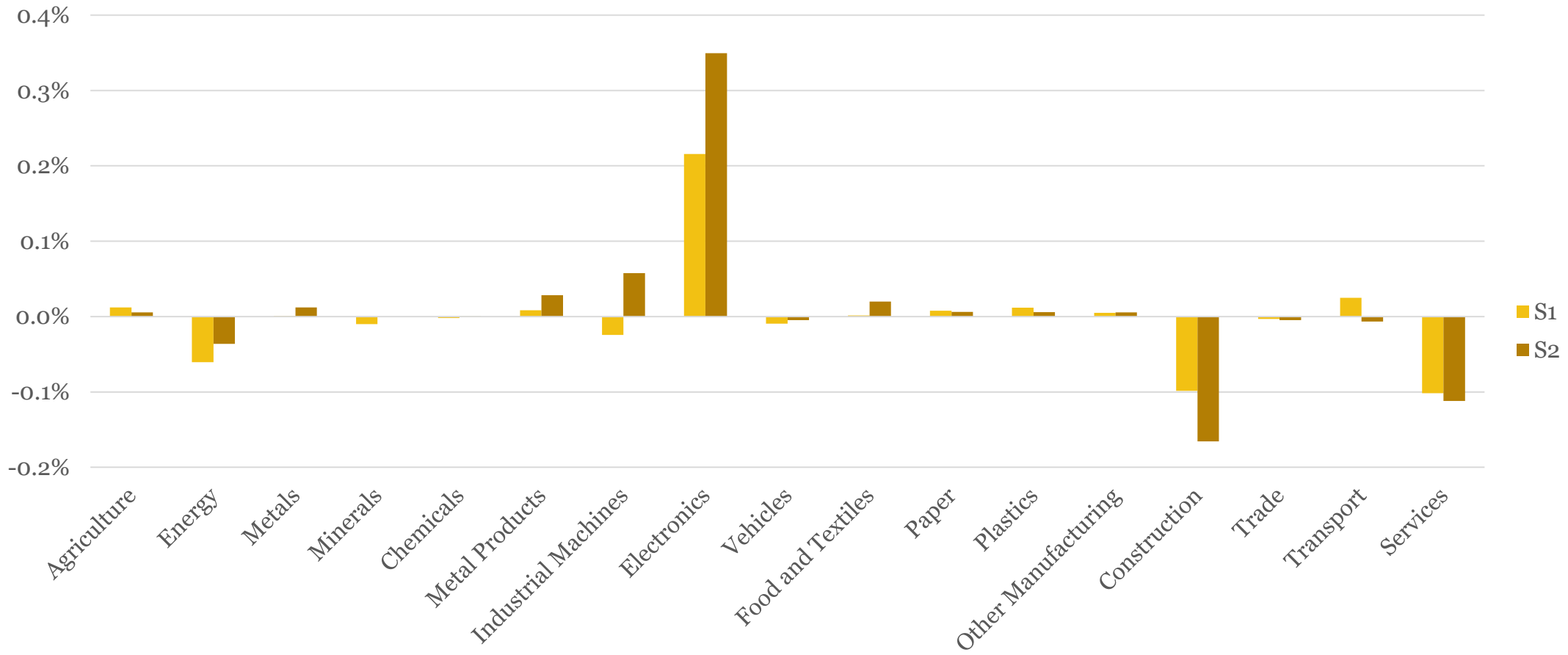
Description of macroeconomic effects

Effect	Description
Effects resulting from investments	Increased demand in sectors providing energy efficiency technologies and services → Increased production and employment in these and upstream sectors
Effects resulting from energy cost reductions	Reduced energy expenditures → Reduced production and employment in energy and upstream sectors
Effects resulting from cost differentials	Differences between investment increases and energy cost reductions affect disposable income → Changes in consumption in economic sectors not related to energy efficiency
Effects resulting from production changes	Changes in production of investment and consumption goods lead to changes in income → Inducement of further multiplier effects
Effects resulting from changes in structural composition	Economic sectors differ with regard to import shares and labour intensity → Structural sectorial change leads to changes in overall import and labour intensity of an economy

Macroeconomic modelling inputs

	2020		2025		2030	
Variable (M€)	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
Investment HVAC	-389	2,653	245	-281	2,853	5,906
Investment building envelope	-52	579	5,077	4,705	3,885	2,067
Investment thermostats	0	0	2,326	2,445	3,981	4,100
Investment appliances	0	0	5,993	7,062	6,933	8,852
Investment total	-441	3,231	13,641	13,932	17,651	20,924
Energy expenditures	-302	-711	-10,545	-12,501	-15,749	-21,288
Rebates	-247	-190	4,053	5,879	4,680	6,925

Relative employment changes EU28 in 2030



Changes in disposable income per quintile