Structure of WP 5:

WP4: Survey

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

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 intermediaries and policy acceptance

WP5: INVERT (Buildings)
Approach:
- Nested Logit function
- Weights of decision criteria
- Definition of investor types
- Simulation of policy effects on investments

Appliances: FORECAST & EMLab-Consumer

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 Choice Experiments (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

Empirically identified utility function for Label, Size...

Implement utility function based on DCE results

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.

2019-11-26  Forecast Appliances - Dr. Heike Brugger – Fraunhofer ISI
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
Agent-based model
EMLab-consumer

- technologies
- shops
- households
- survey

€§

policies

energy performance

Changing Energy Efficiency Technology Adoption in Households

2019-11-26
EMLab-Consumer results, Emile Chappin, Delft University of Technology
Simulation results – fridges

<table>
<thead>
<tr>
<th>Country</th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Poland</th>
<th>Romania</th>
<th>Spain</th>
<th>Sweden</th>
<th>UK</th>
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Variable:
- A++:
- A+:
- A:
- B:
- C:
- D:

Tick:
- 0
- 5
- 10
- 15
- 20

Value:
- 0.00
- 0.25
- 0.50
- 0.75
- 1.00
Simulation results – smart thermostats

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<thead>
<tr>
<th>Country</th>
<th>ThermostatSub</th>
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<tbody>
<tr>
<td>France</td>
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<tr>
<td>Germany</td>
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<tr>
<td>Italy</td>
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<td>Poland</td>
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<tr>
<td>Romania</td>
<td>30</td>
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</tr>
<tr>
<td>Sweden</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>30</td>
</tr>
</tbody>
</table>

2019-11-26   EMLab-Consumer results, Emile Chappin, Delft University of Technology
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

- **Micro level**: Household-level decision-making on energy efficiency
- **Meso level**: Technology diffusion and energy demand in residential sector
- **Macro level**: Overall impacts of technology diffusion and demand changes

**Bottom-up energy modelling**
- Investments in energy efficiency technologies
- Energy cost reductions
- Rebates

**Allocation of impulses to economic sectors**
- Net change in investments and intermediate deliveries
- Net change in consumption

**Macroeconomic modelling**
- Net change in GDP
- Net change in employment
- Net change in sectorial composition of economy

2019-11-26  Macroeconomic results from ASTRA-EC
## Description of macroeconomic effects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Description</th>
</tr>
</thead>
</table>
| 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

<table>
<thead>
<tr>
<th>Variable (M€)</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
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<tbody>
<tr>
<td></td>
<td>S1</td>
<td>S2</td>
<td>S1</td>
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<tr>
<td>Investment HVAC</td>
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<td>2,653</td>
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<td>Investment building envelope</td>
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<td>Investment thermostats</td>
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<tr>
<td>Investment appliances</td>
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<td>Energy expenditures</td>
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<td>-711</td>
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<tr>
<td>Rebates</td>
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<td>-190</td>
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</tbody>
</table>
Relative employment changes EU28 in 2030
Changes in disposable income per quintile

Quintile 1
Quintile 2
Quintile 3
Quintile 4
Quintile 5