Towards Decarbonizing the European Building Stock: Policies and their Impact on Vulnerable Household Groups

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Motivation

- The EU area has declared the goal of decarbonising the energy supplied to building until 2050. Such a decarbonisation comes along with high investment needs
- In contrast to other sectors such as the electricity production and distribution sector, such investments need to be taken by millions of different individual investors, each with their own set of drivers and barriers
- An important barrier is the individual lack of available investment capital or barriers to access the capital market

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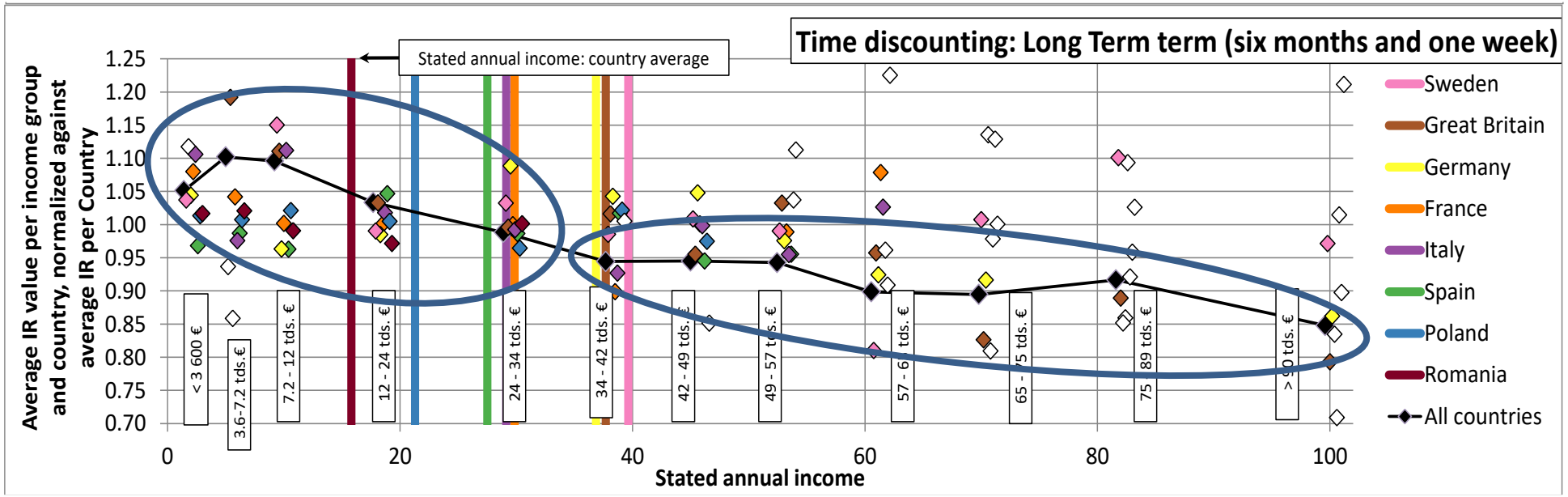
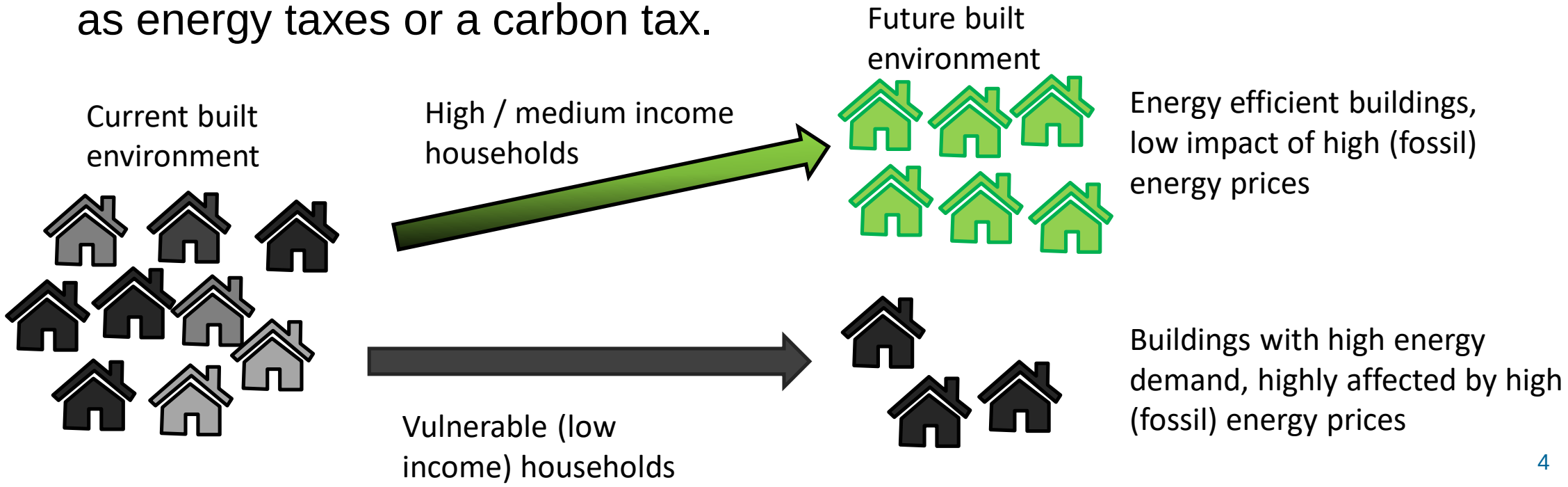
Motivation

- Results from a previously finished project (BRISKEE project) indicate that low income households (below 34 tds. €/a) demand an higher interest rate when evaluating different investment opportunities



Research question (1)

- Is there strong evidence that vulnerable household groups (low income households and elderly people) will end up in buildings with a low energy performance and high running energy costs and thus especially exposed to policy measures that aim to increase the price of fossil energy carriers such as energy taxes or a carbon tax.



Research question (2)

- What is the impact of different (financial) policy measures on the investment burden for different household groups

  - Only / higher subsidies for vulnerable groups

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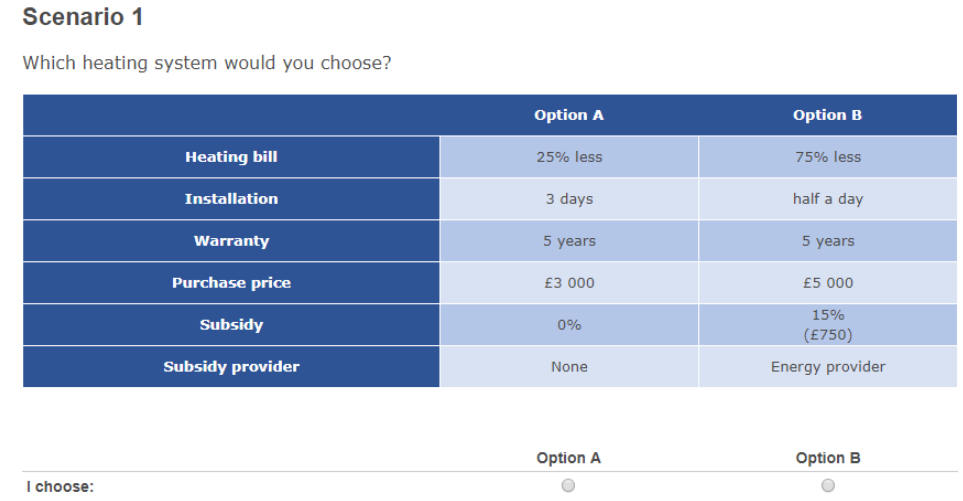
Methodological approach

- **Use Micro-econometric analysis data** derived from a household survey in 8 EU member states (online, ~2000 participants per country, representative samples) using discrete choice experiments

France
Germany
Italy
Poland
Romania
Spain
Sweden
UK



Scenario 1

Which heating system would you choose?

	Option A	Option B
Heating bill	25% less	75% less
Installation	3 days	half a day
Warranty	5 years	5 years
Purchase price	£3 000	£5 000
Subsidy	0%	15% (£750)
Subsidy provider	None	Energy provider

	Option A	Option B
I choose:	○	○

Done by **Grenoble Ecole de Management (GEM)** within in the CHEETAH project

- **Implement** the results derived from the survey **as close as possible in a techno-economic building stock model** (Invert/EE-Lab model)
- Derive scenarios for the EU-28 countries

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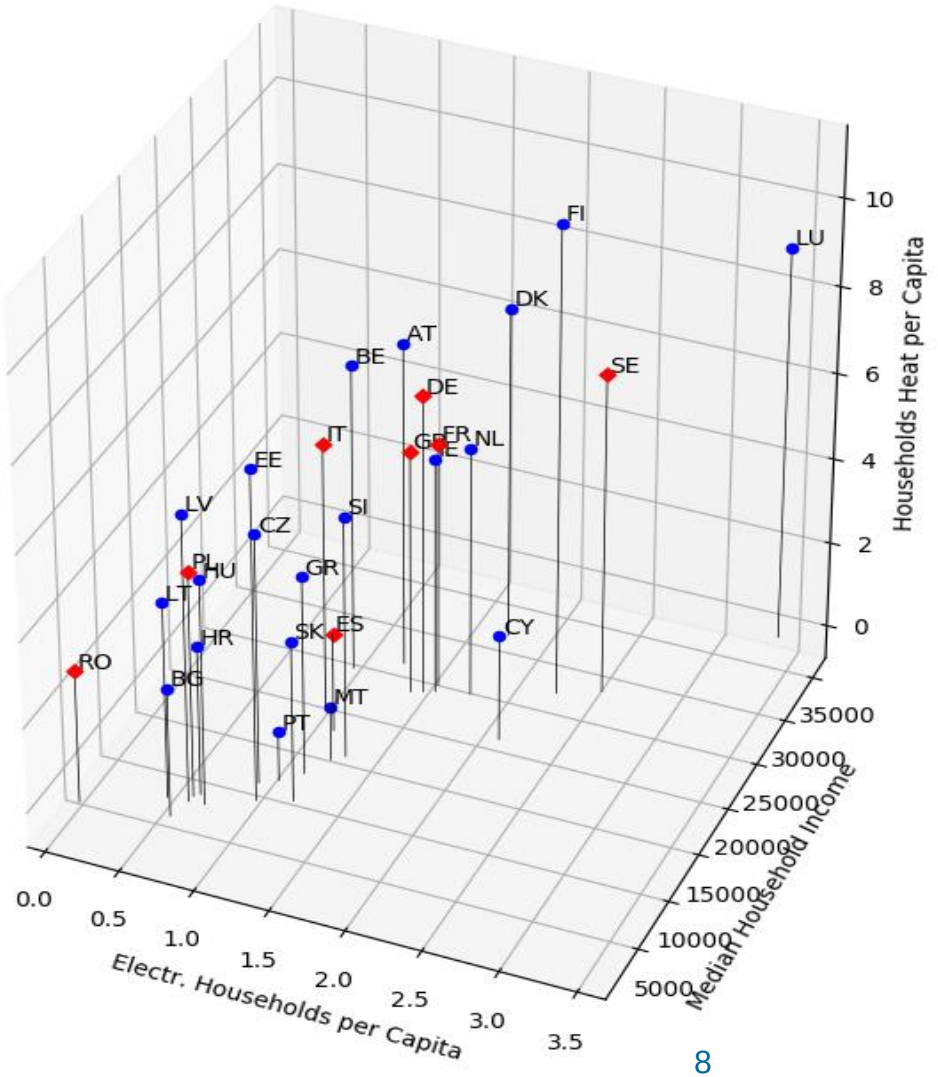
Transfer the survey results to EU-28 countries

- We considered the following parameters as proxies:
  - **Residential heat demand per capita**
  - **Median household income**
  - **Electricity consumption per capita,**
- calculated normalized (N(0,1)) distances between the different countries
- and in addition considered the following aspects:
  - Each survey country has at least one „follower” country
  - Geographic location

Country cluster

- Important to keep in mind that the cluster are formed only based on proxies for similarity indicators.
- Using these indicators, the survey countries: Germany, France and UK are very similar, nonetheless we got substantially different results from the econometric analysis



Utility function

- The applied Invert/EE-Lab building stock model uses a nested logit utility function to derive the future market shares of different technology option
- Based on the decision parameters implemented in the survey, the utility function for heating systems / building refurbishments considers
  - Investment costs
  - Energy costs
  - Warranty
  - Installation time
  - Subsidies

$$Utility\ u = (\boldsymbol{\beta_{price}} * (price - sub\ (€)) + \boldsymbol{\beta_{ene\_sav}} * energy\ costs\ saving\ (\frac{€}{yr}) + \boldsymbol{\beta_{sub}} * sub\ (€) + \boldsymbol{\beta_{warranty}} * (W) + \boldsymbol{\beta_{install\_time}} * (T))$$

- Furthermore: Existing heating system, availability of technology options

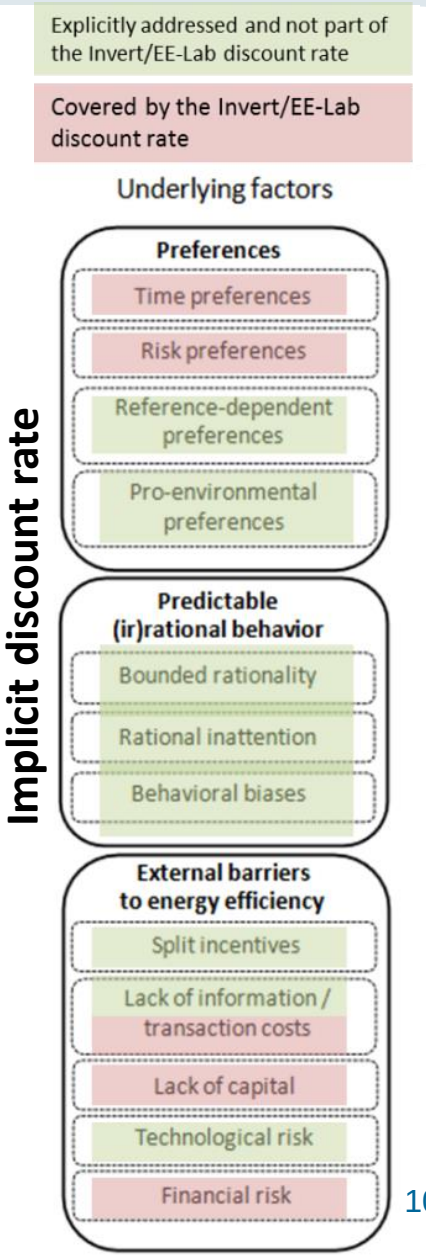
Discount rate

- Using the survey results we calculated the discount rate (excluding financing costs) based on

$$price * CRF * \beta_{price} + en_{costs} * \beta_{ene\_sav} = (price + X * WTPsav) * CRF * \beta_{price} + (en_{costs} - X) * \beta_{ene\_sav}$$

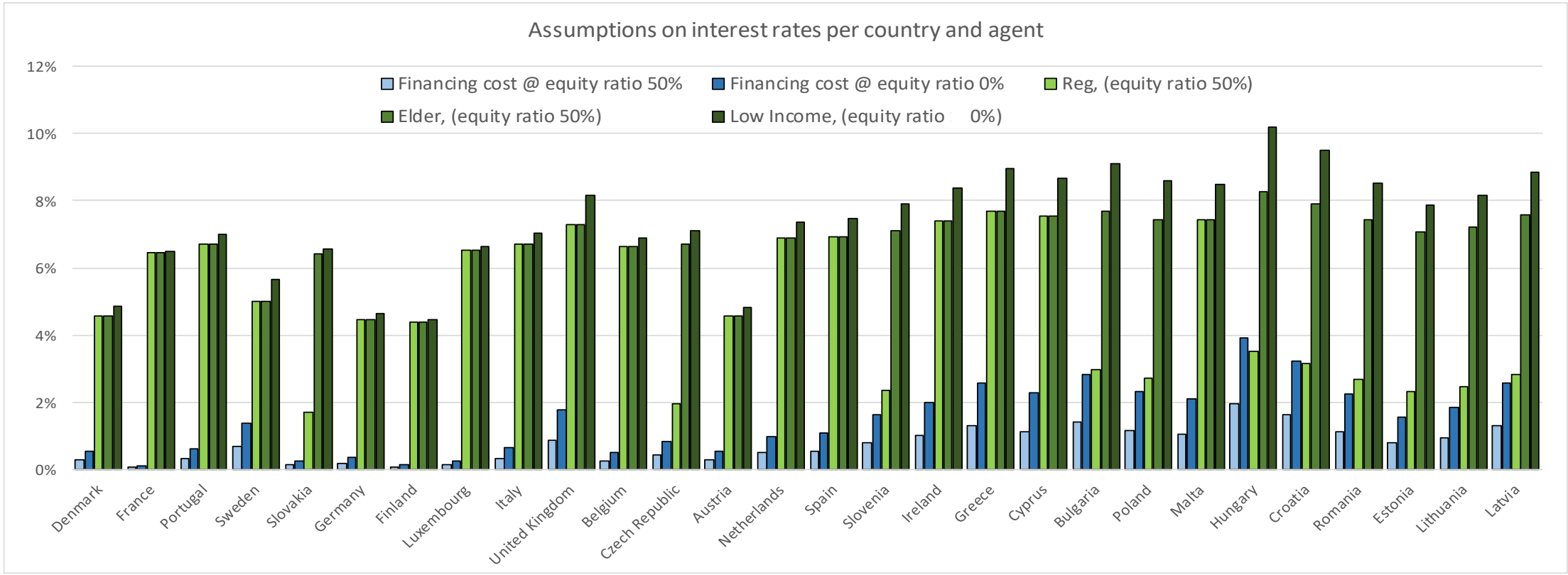
price = investment costs of technology as seen by the investor
en_{costs} = energy costs
CRF = capital recovery factor, $CRF = (1+i)^{15} * i/((1+i)^{15} - 1)$
i = discount rate used in the techno-economic bottom-up model
WTPsav = Willingness-to-pay (additional investment costs) to save one unit of energy costs
β_{price} , β_{ene_sav} = logit parameters

} Derived from the survey



Discount rate

- We furthermore considered country-specific interest rates for housing-specific loans as well agent-specific assumptions on the equity ratio



Vulnerable (to (fuel)poverty) households groups

Based on EU-SILC survey results, most vulnerable are households with

- a single adult person and
- households with dependent children

- Households with adults over 65 years are among the least vulnerable households

➢ **Low income households in this study:**
less than 60% of the country specific median income

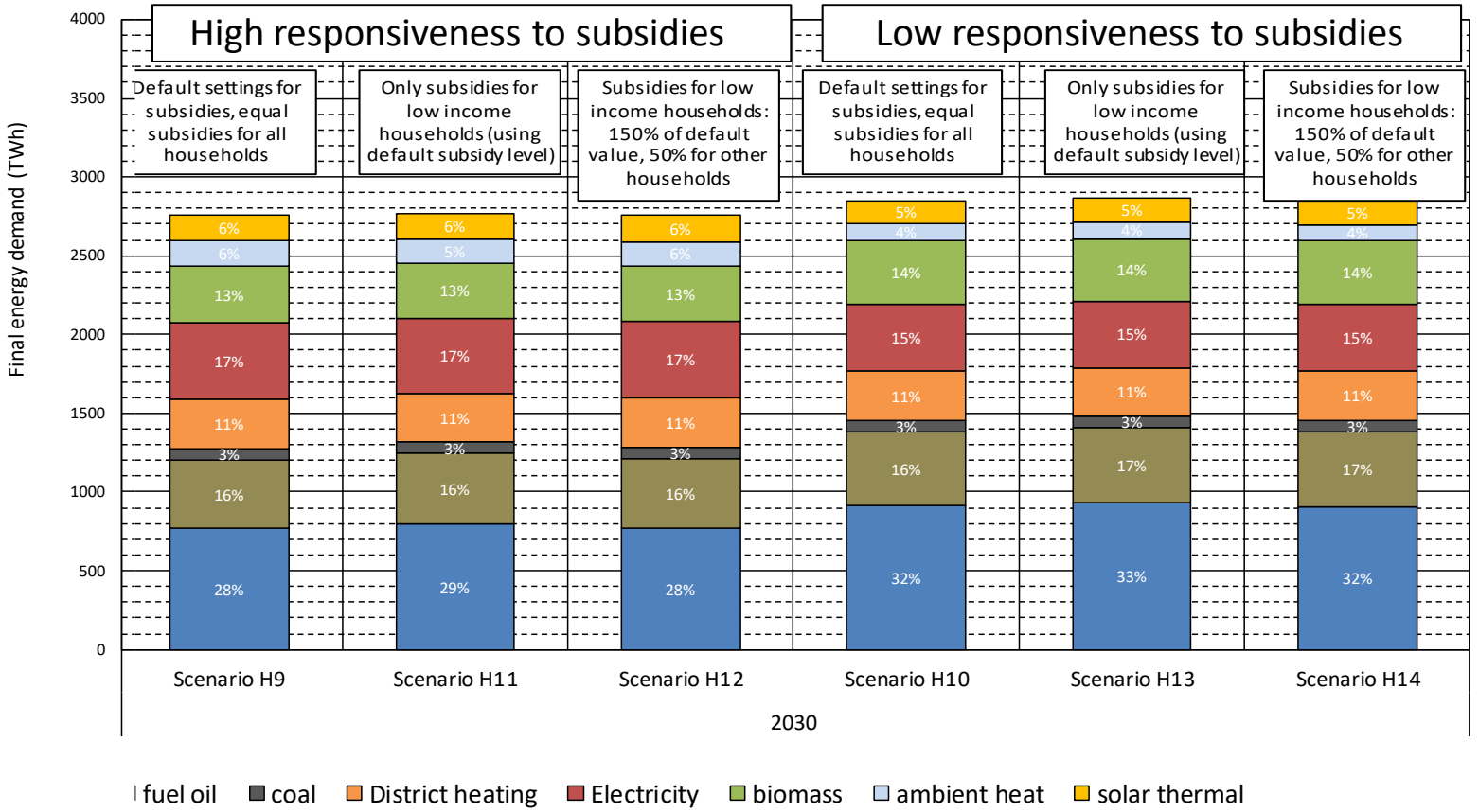
Impact subsidy schema on total energy demand in 2030

Considering the for investment subsidies into **current national budget restrictions** building refurbishments and renewable heating in buildings

(1) Equal subsidies for all households

(2) Subsidies for low income house-holds only

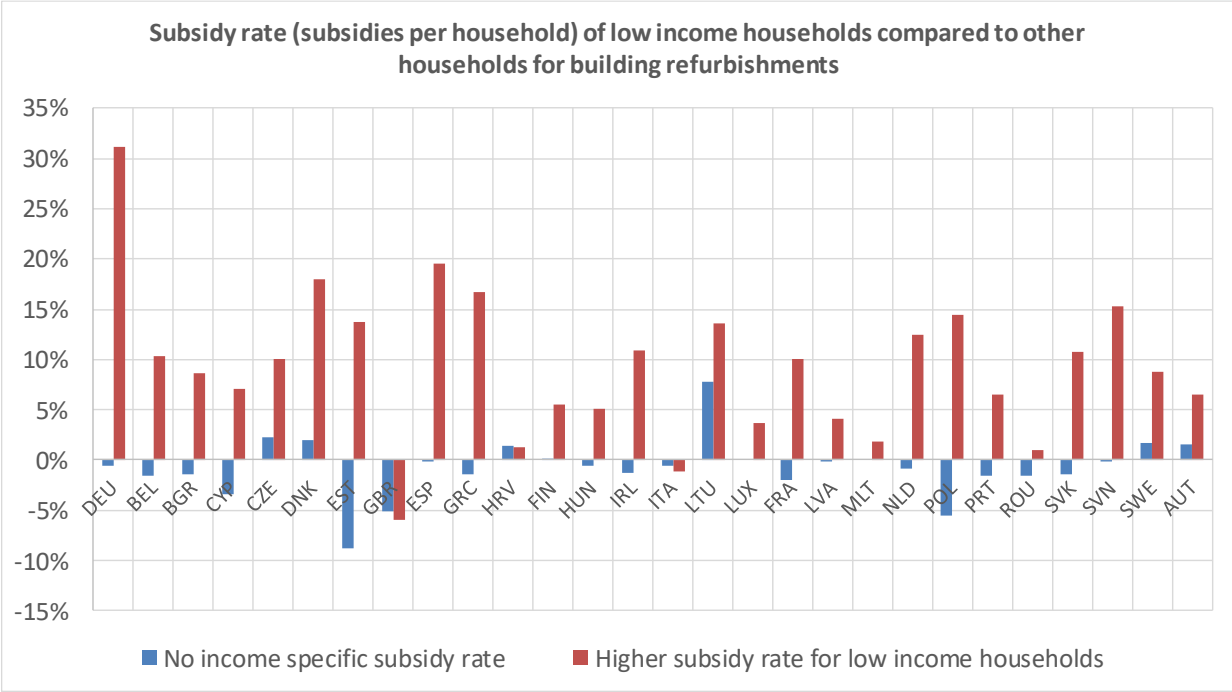
(3) Increase subsidies for low income households by 50%, decrease for other households by 50% - as compared to (1)



➢ **Subsidies are distributed differently among household types, but low/no impact final energy consumption (for heating and DHW) on EU-28 level**

Impact of higher subsidies levels (+50%) for low income households (building owners) on the average subsidies per household until 2040

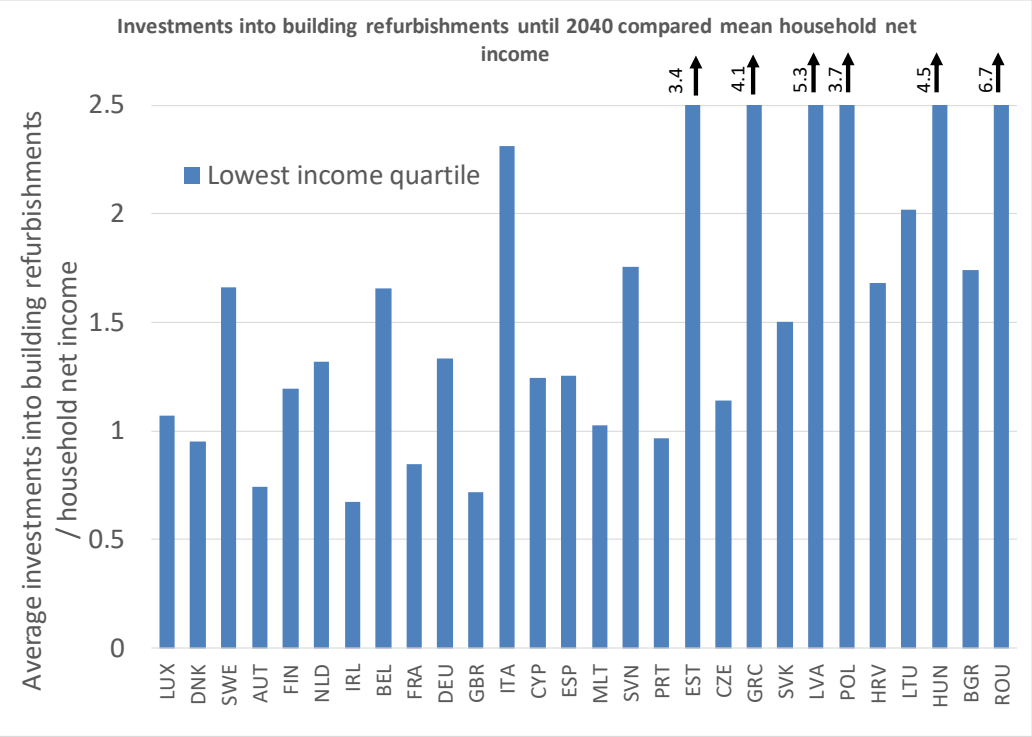
considering an annual subsidy budget constrain of 25€/m2

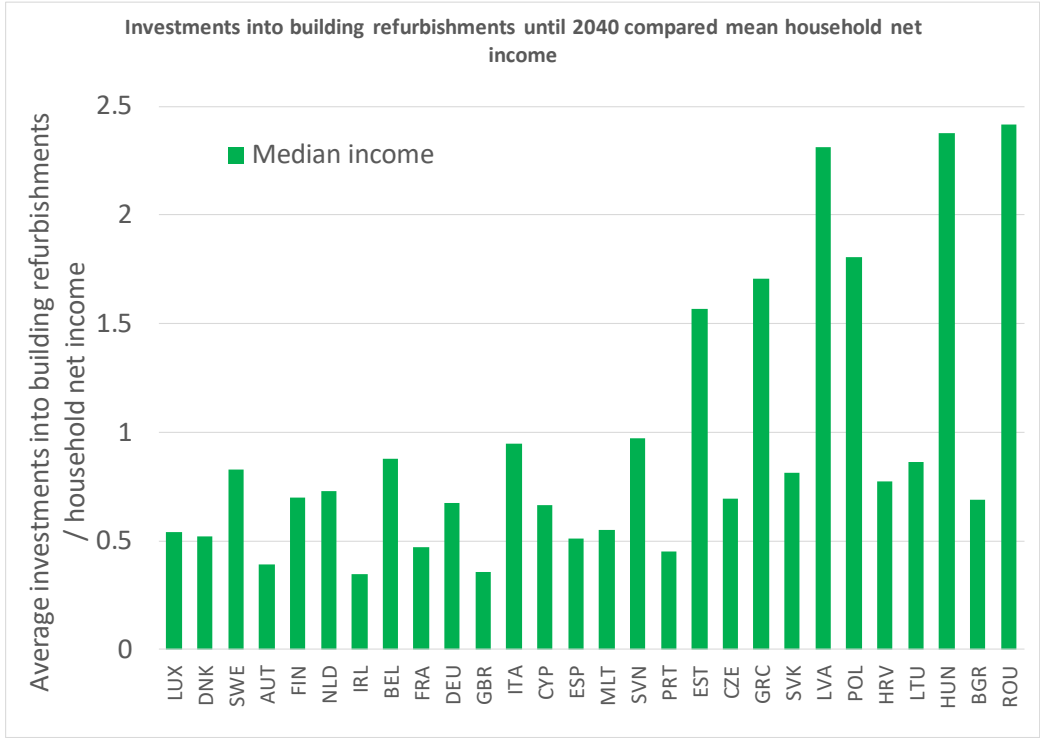


- If subsidy rates are not income-specific, low income households receive slightly lower subsidies per households than the average households

- Although, we increased the subsidy rate for low income households by 50%, in the end subsidies for low income households are only ~10% higher than the average rates
  (Subsidies are given to the building/apartment and not the owner, turn over rate of agents type per apartment 1/30 year)

Average investments into building refurbishments per households (refurbished + unrefurbished) against household income





- The lowest household income quantile need to spend on average about one annual net household income on building refurbishment investments until 2040
- Households with median income need to spend only half of that.

- By using the results of the survey in the applied building stock model, our results don't support the hypothesis that decarbonisation of the building stock will lead to a highly segregated built environment.
- But we also see that low income households need to investment very high amounts of their household income on building refurbishment. Compared to the median income group, the lowest income quantile (mean income of that quantile) need to spend twice the share of their annual income.
- Although the consider scenario is less ambitious as the 2050 targets for the considered sector, it is questionable if low income households (< 40% of the median income) are able to cope with the required investment needs.

- Investment subsidies, specifically addressing low income households can lower the burden, however in order to have an significant effect it would be necessary to substantially increase the current national budget restrictions.

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For more information on the CHEETAH project visit:

www.briskee-cheetah.eu

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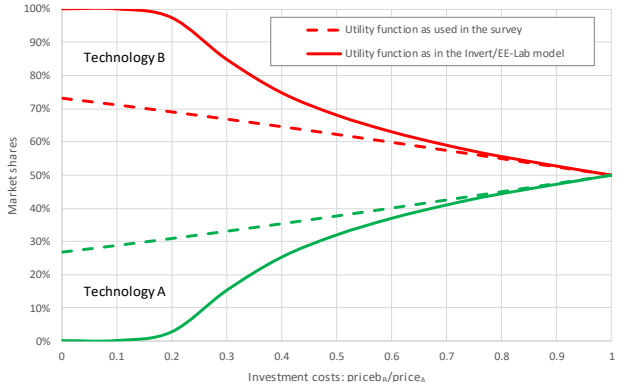
Orig. Photo: Patrick Stargardt

The results of the logit model based on the utility function derived from the survey depends on the absolute order of magnitude of the utility

	Utility U_A	Utility U_B	Market share of technology A s_A
Case 1	1	0.8	55%
Case 2	10	8	88%
Case 3	100	80	100%

In order to cover the whole range of buildings in Europe, we need to implement a utility function that considers cost ratios instead of absolute costs. This leads to a more selective utility function at larger (relative) cost differences



The empirical research:
Large representative household surveys

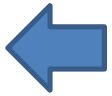
France 
Germany 
Italy 
Poland 
Romania 
Spain 
Sweden 
UK 


75% of EU energy consumption


76% of EU population

BRISKEE (predecessor project) survey:
- Sample of 15,000 households
- Focus on time and risk preferences and stated past adoption of technologies

CHEETAH survey
- Sample of 18,000 households
- Main focus on policy items and hypothetical adoption in choice experiments



Both surveys provide data on socio-demographics, housing, environmental attitudes and technology-specific items

Transfer the survey results to EU-28 countries

- We considered the following parameters as proxies:
  - **Residential heat demand per capita**
  - **Median household income**
  - **Electricity consumption per capita**
- Calculated normalized (N(0,1)) distances between the different countries
- and subsequently considered the following aspects:
  - Each survey country has at least one „follower" country
  - Geographic location

Similarity indicator based on chosen parameters

	France	Germany	Italy	Poland	Romania	Spain	Sweden	UK
Austria	0.46	0.71						0.48
Belgium	0.37	0.54	0.60					0.45
Bulgaria				0.56	0.63	0.30		
Croatia				0.62	0.48	0.33		
Cyprus	0.25	0.04				0.35		0.23
Czech Republic			0.39	0.64				
Denmark	0.44	0.53	0.15				0.44	0.37
Estonia		0.12	0.34	0.42				0.07
Finland	0.21	0.34	0.08				0.51	0.17
France	1.00							
Germany		1.00						
Greece	0.04		0.32	0.38		0.27		0.16
Hungary				0.92				
Ireland	0.91							0.83
Italy			1.00					
Latvia				0.70				
Lithuania				0.82				
Luxembourg	0.19	0.21					0.57	
Malta						0.74		
Netherlands	0.78	0.57						0.65
Poland				1.00				
Portugal						0.64		
Romania					1.00			
Slovakia			0.14	0.40		0.41		0.04
Slovenia	0.25	0.22	0.49	0.09				0.38
Spain						1.00		
Sweden							1.00	
UK								1.00

Vulnerable (to poverty) households groups

		EU-28	Belgium	Bulgaria	Czechia	Denmark	Germany	Estonia	Ireland	Greece	Spain	France	Croatia	Italy	Cyprus	Latvia	Lithuania	Luxembourg	Hungary	Malta	Netherlands	Austria	Poland	Portugal	Romania	Slovenia	Slovakia	Finland	Sweden	United Kingdom
Single person	with dependent children	2.0	2.4	1.6	3.5	1.7	2.0	1.8	2.4	1.5	1.7	2.7	1.7	1.9	1.6	1.7	2.1	2.9	2.5	2.8	2.6	2.1	1.9	1.8	1.6	2.3	2.4	1.4	2.2	1.8
One adult younger than 65 years		1.6	1.5	1.1	2.1	2.7	2.1	1.6	2.4	1.3	1.3	1.6	1.8	1.1	1.4	1.4	1.6	1.5	1.6	1.6	2.1	1.6	1.5	1.2	1.0	2.3	1.7	2.5	1.9	1.5
Two adults	with 3/3+ depend. children	1.6	1.4	3.0	2.6	0.8	0.9	1.2	1.1	1.4	2.0	1.6	1.7	2.0	1.2	1.5	2.0	1.6	1.9	2.4	1.4	1.7	1.9	1.9	2.7	1.1	2.7	0.8	1.6	1.7
Single male		1.5	1.4	1.2	1.6	2.5	2.0	2.1	2.4	1.1	1.1	1.4	1.7	1.0	1.5	1.9	1.8	1.4	1.5	1.5	1.8	1.5	1.6	1.3	1.1	2.0	1.7	2.6	1.8	1.3
Single person		1.5	1.4	1.9	2.0	2.2	2.0	2.4	2.1	1.1	0.9	1.3	1.9	1.2	1.6	2.3	1.8	1.2	1.0	1.4	1.6	1.6	1.3	1.3	1.2	2.5	1.2	2.4	1.9	1.4
Single female		1.2	1.5	2.3	2.2	1.9	1.9	2.6	2.0	1.1	0.7	1.2	2.1	1.3	1.7	2.5	1.8	1.1	0.8	1.4	1.5	1.6	1.2	1.3	1.2	2.8	1.0	2.3	2.0	1.5
Three or more adults	with dependent children	1.3	0.9	1.1	0.5	0.6	0.4	0.5	0.8	1.4	1.4	1.4	0.7	1.4	0.8	0.7	0.7	1.4	1.2	0.8	0.4	1.0	1.3	1.3	1.3	0.7	1.1	1.3	0.9	1.2
One adult 65 years or over		1.3	1.2	2.4	1.8	1.1	1.7	3.4	1.8	0.9	0.4	0.9	2.0	1.2	2.1	3.0	2.0	0.7	0.4	1.3	0.6	1.4	1.1	1.4	1.3	2.6	0.8	2.3	1.9	1.3
Households	with dependent children	1.1	1.1	1.0	1.2	0.7	0.8	0.8	1.0	1.2	1.2	1.2	0.9	1.2	0.9	0.9	1.0	1.3	1.3	1.1	1.1	1.1	1.2	1.1	1.3	0.9	1.3	0.7	1.0	1.1
Two or more adults	with dependent children	1.0	0.9	1.0	1.0	0.5	0.6	0.8	0.9	1.2	1.2	1.0	0.9	1.2	0.9	0.8	0.9	1.1	1.2	1.0	0.9	1.0	1.2	1.1	1.2	0.8	1.2	0.6	0.7	1.0
Total		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Households	**without depend. children**	0.9	0.9	1.0	0.8	1.3	1.1	1.2	0.9	0.8	0.8	0.8	1.1	0.8	1.1	1.1	1.0	0.7	0.7	0.9	0.9	0.9	0.8	0.9	0.7	1.1	0.6	1.2	1.0	0.9
Two adults	with two dependent children	0.9	0.6	0.7	0.9	0.5	0.5	0.6	0.8	1.1	1.2	0.7	0.8	1.1	0.7	0.7	0.9	1.0	1.0	1.0	0.7	0.9	1.0	1.0	1.0	0.7	1.2	0.4	0.4	0.8
Two adults	with one dependent child	0.7	0.6	0.6	0.6	0.4	0.6	0.9	0.8	0.9	0.8	0.8	0.8	0.8	1.0	0.7	0.8	0.9	0.9	0.8	1.0	0.7	0.7	0.7	0.6	0.9	0.7	0.6	0.6	0.7
Two adults younger than 65 years		0.7	0.6	0.7	0.8	0.7	0.8	0.6	0.6	0.8	0.8	0.6	1.0	0.8	1.1	0.8	0.7	0.5	0.9	0.8	0.9	0.8	0.8	0.9	0.6	1.0	0.7	0.7	0.6	0.6
Three or more adults		0.7	0.6	0.6	0.3	0.0	0.5	0.5	0.7	0.9	0.8	0.6	0.8	0.6	0.9	0.5	0.4	0.4	0.6	0.3	0.2	0.3	0.6	0.7	0.5	0.5	0.5	0.4	0.6	0.8
Two or more adults	**without depend. children**	0.7	0.7	0.7	0.5	0.5	0.7	0.6	0.6	0.8	0.7	0.5	0.9	0.6	1.0	0.7	0.5	0.4	0.6	0.7	0.6	0.6	0.6	0.8	0.5	0.7	0.5	0.6	0.5	0.7
Two adults		0.7	0.7	0.8	0.6	0.6	0.7	0.6	0.6	0.7	0.7	0.5	1.1	0.6	1.0	0.9	0.6	0.4	0.6	1.2	0.7	0.8	0.6	0.8	0.5	0.7	0.6	0.6	0.5	0.7
Two adults, at least one 65 years or over		0.6	0.8	1.0	0.4	0.5	0.7	0.6	0.5	0.5	0.6	0.4	1.2	0.6	1.0	0.9	0.5	0.4	0.3	1.5	0.4	0.7	0.4	0.7	0.4	0.5	0.4	0.3	0.4	0.8
Standard deviation		0.4	0.5	0.7	0.9	0.8	0.6	0.9	0.7	0.3	0.4	0.6	0.5	0.4	0.4	0.7	0.6	0.6	0.5	0.6	0.6	0.5	0.4	0.4	0.5	0.8	0.6	0.8	0.6	0.4
		EU-28	Belgium	Bulgaria	Czechia	Denmark	Germany	Estonia	Ireland	Greece	Spain	France	Croatia	Italy	Cyprus	Latvia	Lithuania	Luxembourg	Hungary	Malta	Netherlands	Austria	Poland	Portugal	Romania	Slovenia	Slovakia	Finland	Sweden	United Kingdom

Data source: Eurostat, EU-SILC survey, ilc_li03