Methodology for identifying household electricity consumption patterns and their role in flexibility

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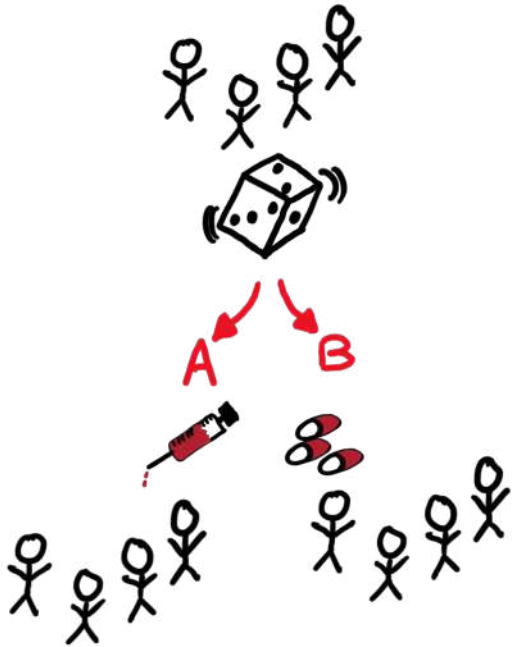
CLIMBING THE CAUSALITY LADDER TO UNDERSTAND
THE ENERGY DEMAND ON THE RESIDENTIAL SECTOR

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 891943

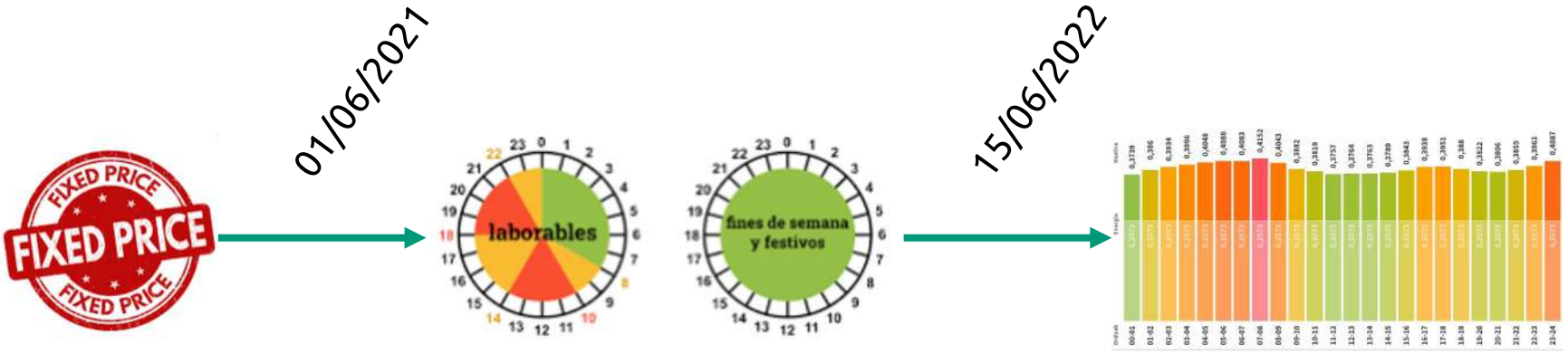
Objective

- Study if a change in the tariff can:
  - reduce energy consumption and
  - change peak demand

- Assess which groups have more difficulties to change their behaviours



The change of tariffs



Fixed Rate

Time of Use
(ToU)

Price Signal
(PS)

Contextualization

Key objective of WHY

Improve the assessment of electrical energy consumption trends on households by including **causal models** in leading Energy System Models (ESM) focusing on:

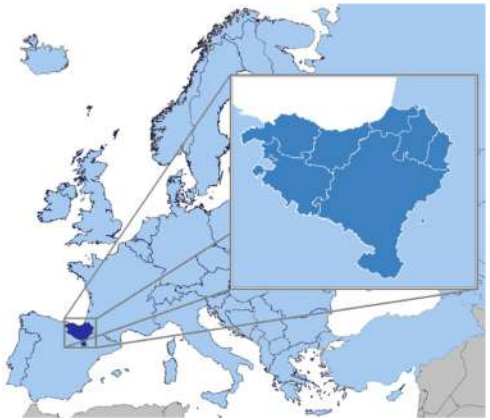
energy efficiency (EE)
distributed generation (DG)
demand response (DR)
electrification of services (ES)

Use Cases

Scenarios	Geo.	Temp.	ESM	Objective
Gniebing Microgrid Operation	City	Hourly / Yearly	HiSim	• Improve load forecasting under normal operation • Create load profiles under black-out operation
Energy Cooperative O&P	Regional	Hourly / Yearly	Own Model	• Improve load forecasting under normal operation • Test the impact of new policies / tariff have on the utility
Energy Community	City	Hourly / Yearly	HiSim	• Create tool to size the different components and to define the business and governance models • Help designing interventions that increase the participation on the energy community
2030 & 2050 European energy strategy	European	2030 / 2050	PRIMES	• Create different load profile under different interventions to foster EE, DG, DR and ES • Assess the impact of different EE campaigns
Global energy scenario	Worldwide	2100	TIAM-ECN	• Create different load profile under different interventions to foster EE, DG, DR and ES • Project business as usual energy consumption

GoiEner today

- GoiEner is a citizen energy cooperative created in 2012 that operates mainly in Euskadi and Navarra
- Its main activity is the commercialization of electricity of 100% renewable origin
- Goiener currently have:
  - 60 workers
  - 17 000 cooperativist
  - 22 000 contracts and
  - 200 volunteers



The intervention

	2021				2022				2023			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Tariff	Fixed Rate		**Time of Use**				**Price Signal**					
Interventions			**E-mails**				**App**					
Measurement			1st period				2nd period					

Objective of the different tariff

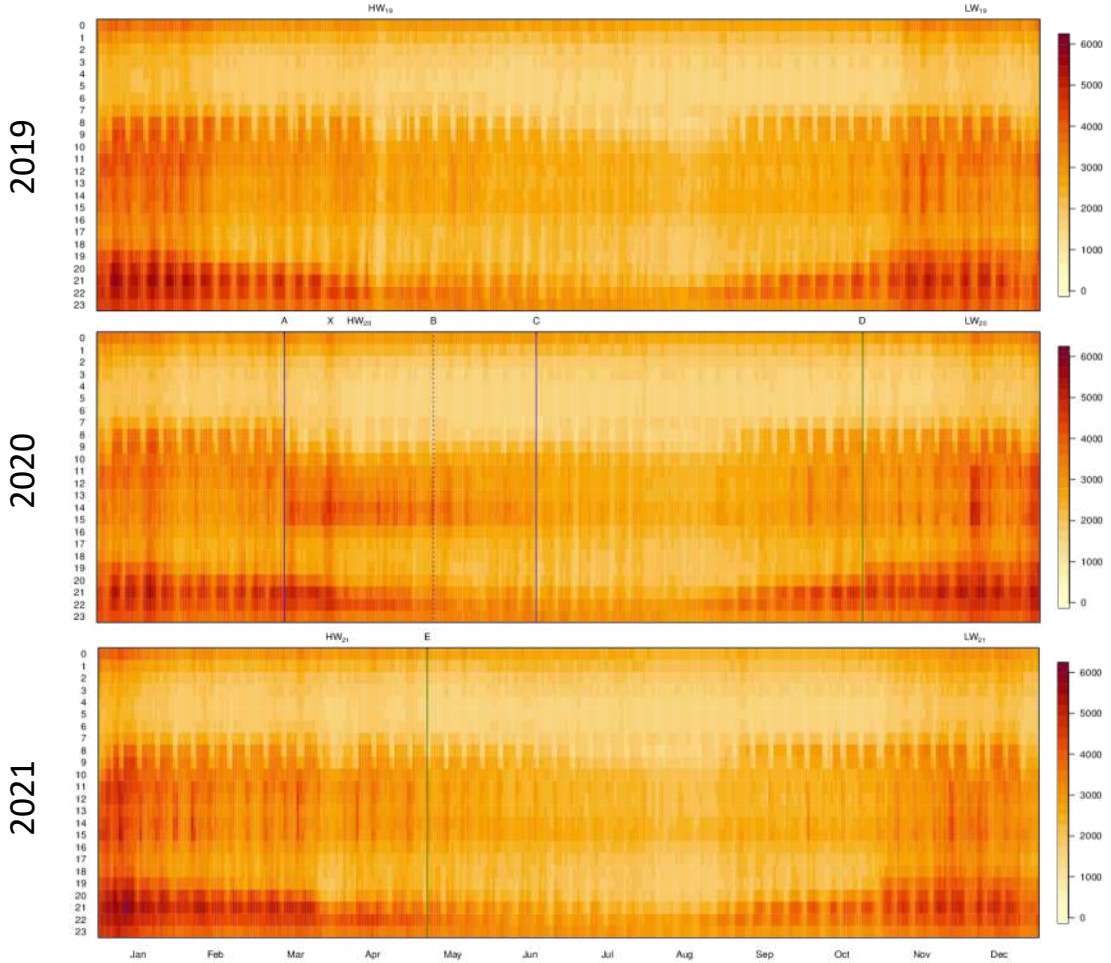
Time of Use

- Provide a better price signal to the consumers to foster energy efficiency.
- Reduce the network congestion by fostering load shifting.
- Foster the penetration of distributed generation and the electrification of services.
- Simplify the tariff structure.

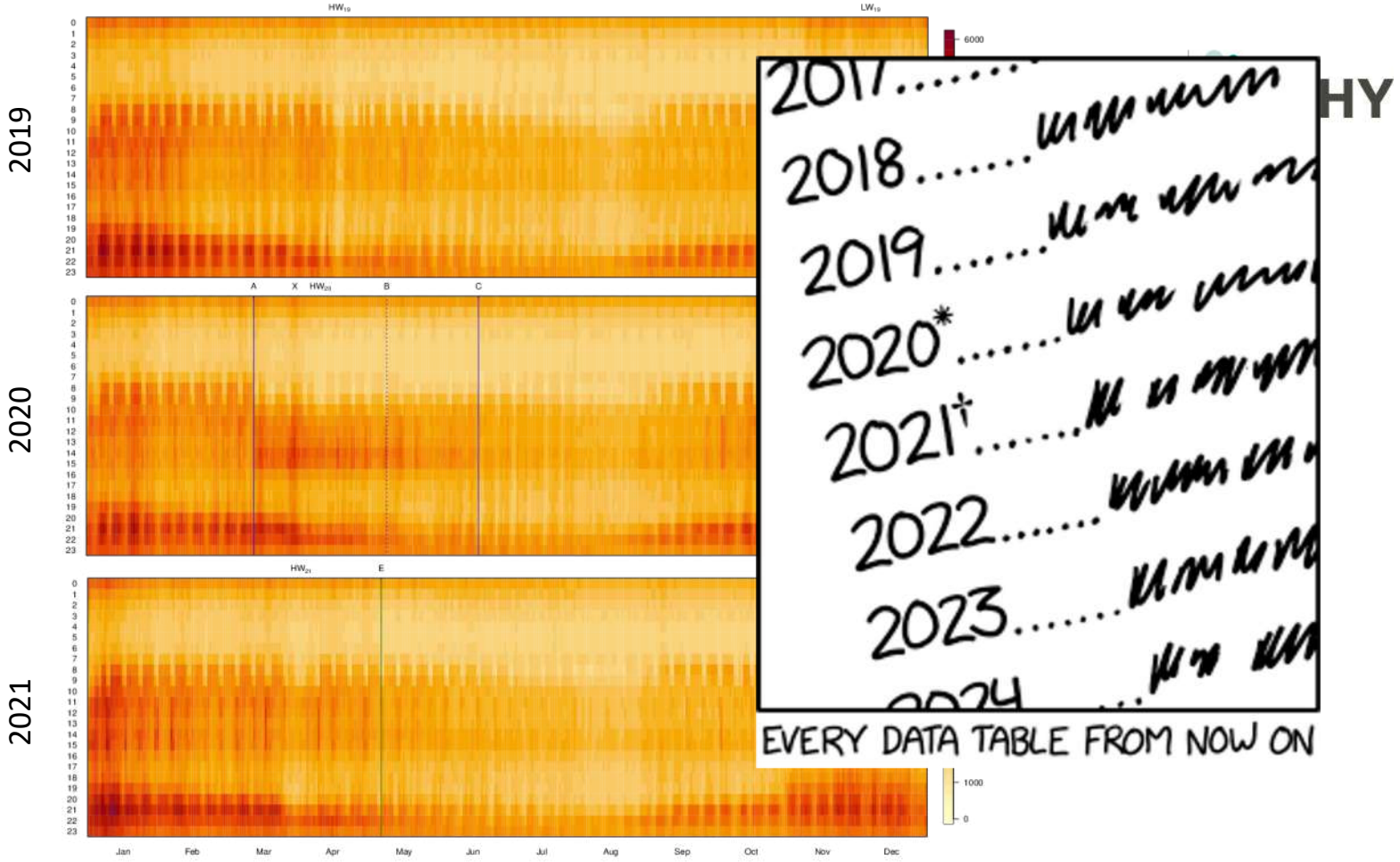
Price signal

- Limit the price of natural gas in order to reduce the offer price of fossil technologies.
- Separate the price of gas from the final price of electricity.
- Contain the price of electricity.

Periods to compare



Periods to compare

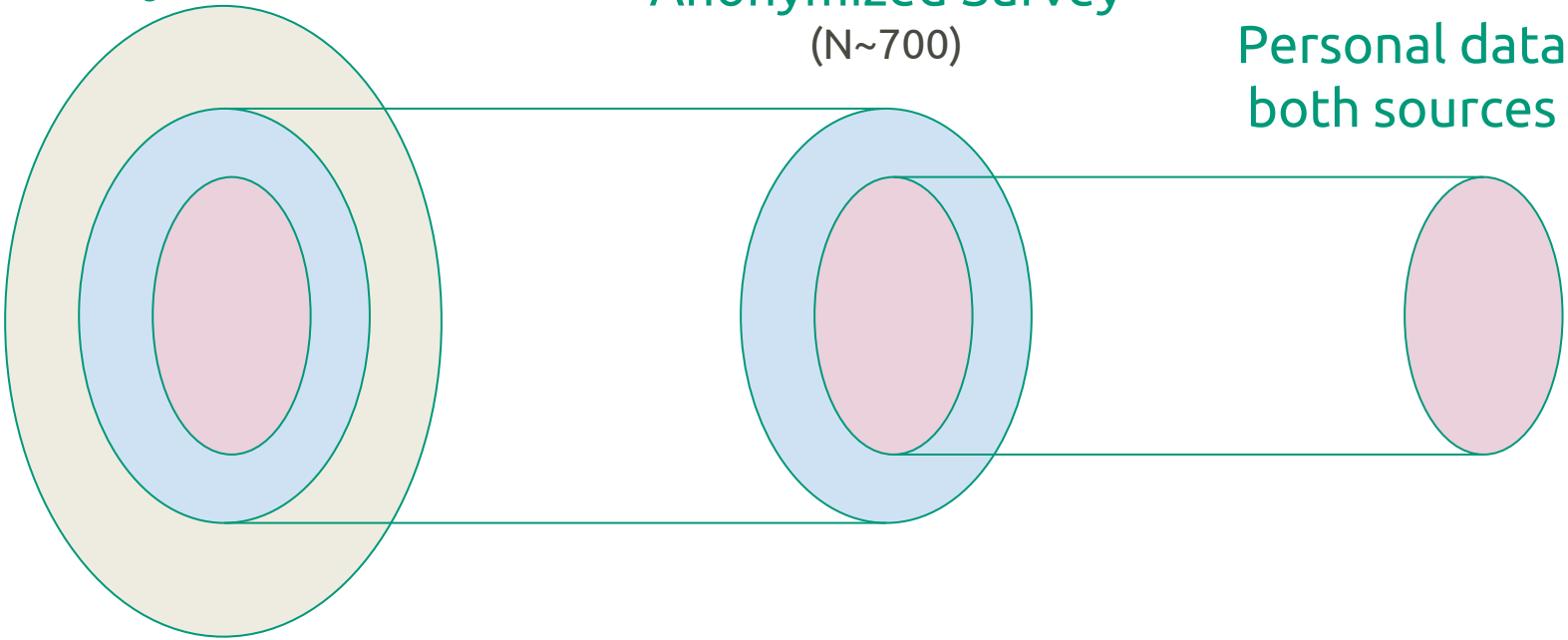


Sources of information

Smart meter census fully anonymized (N~25 000)

Anonymized Survey (N~700)

Personal data to link both sources (N~500)



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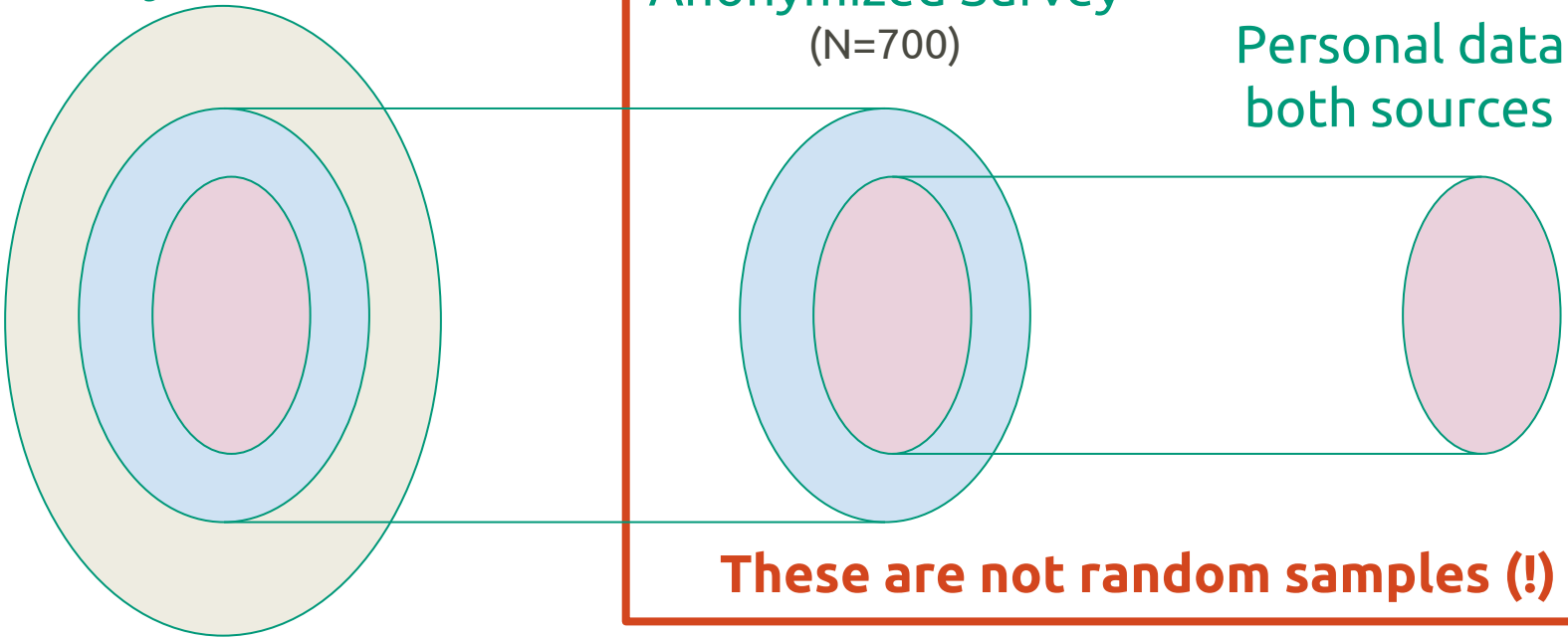
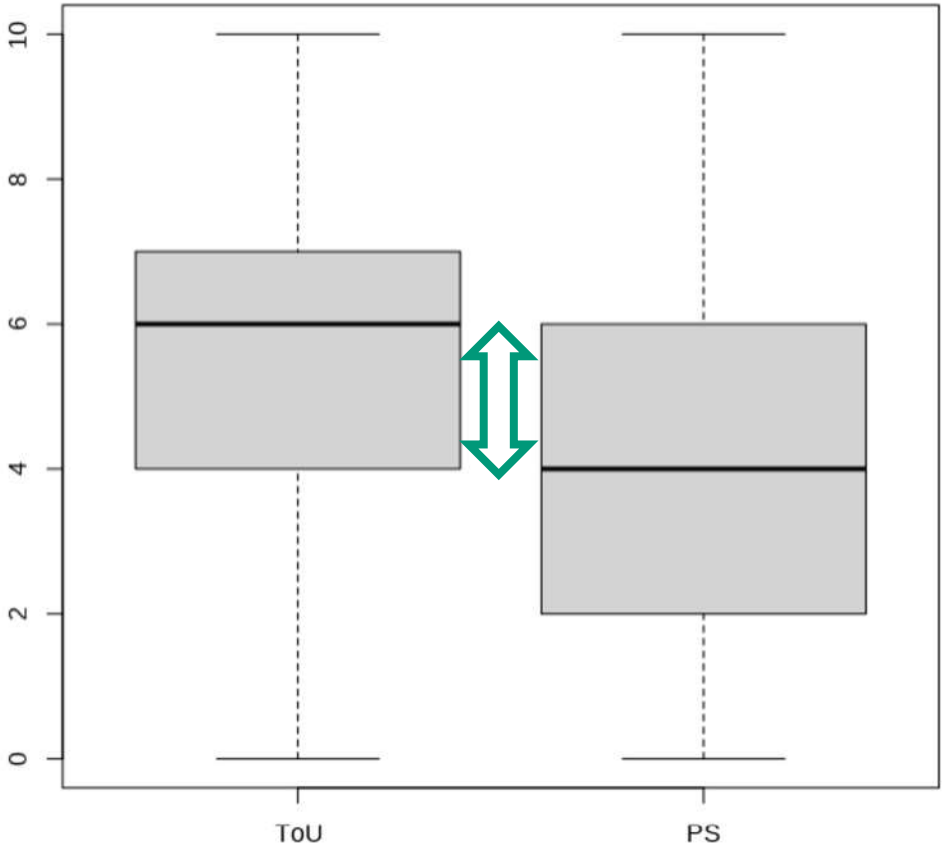


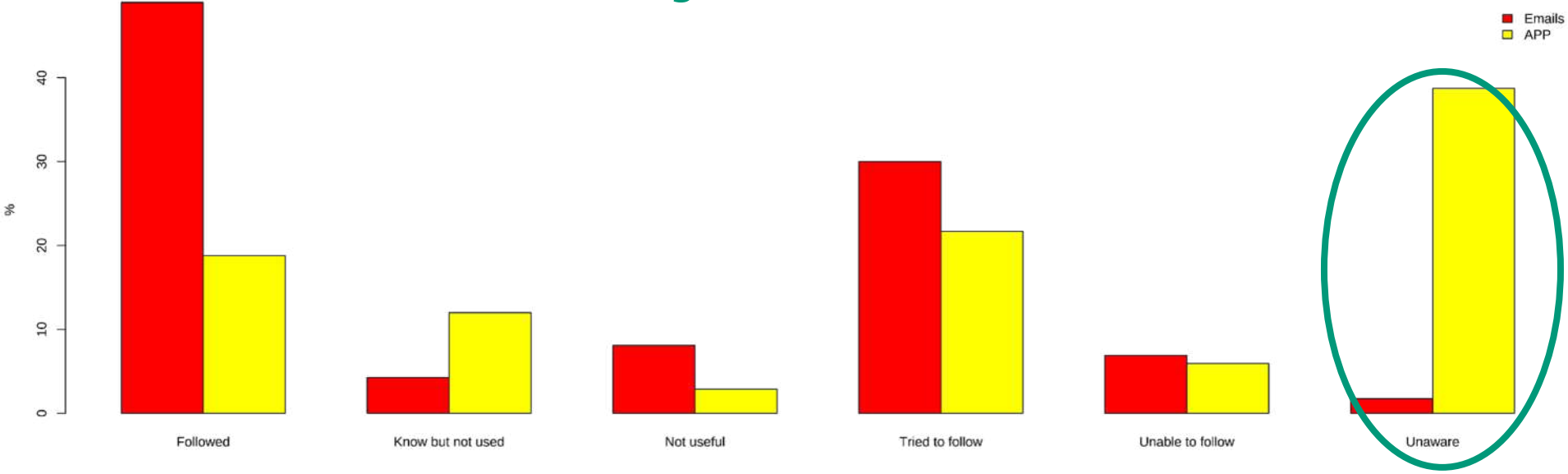
These are not random samples (!)

Results

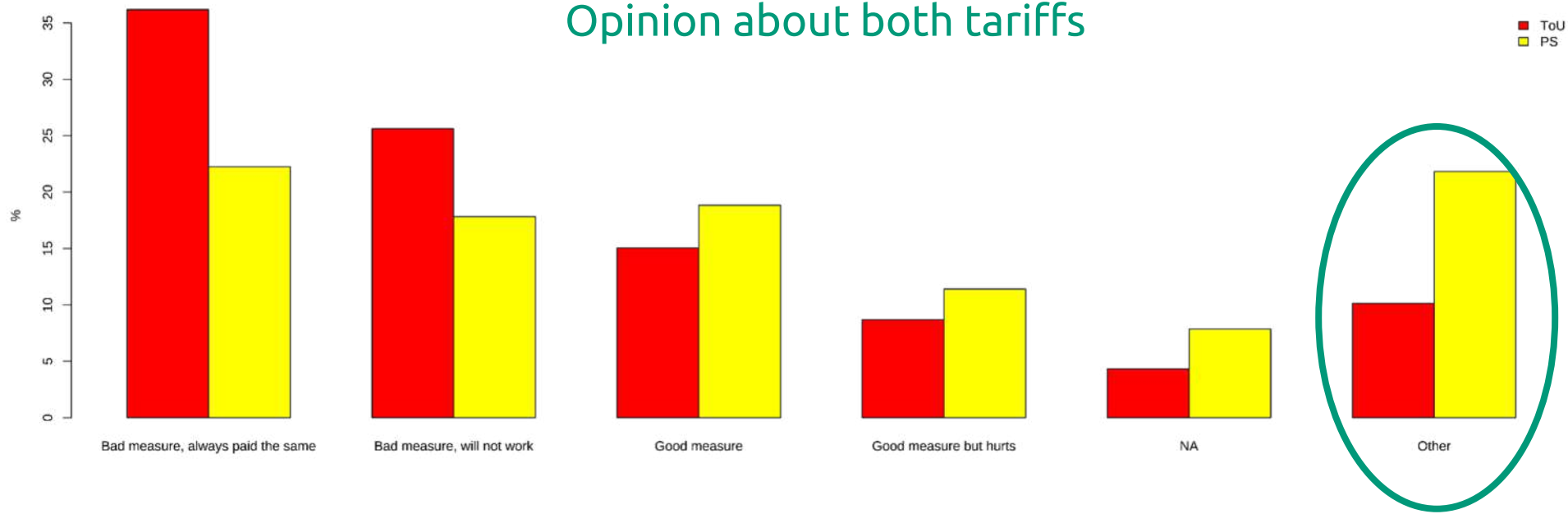


Knowledge about the tariffs

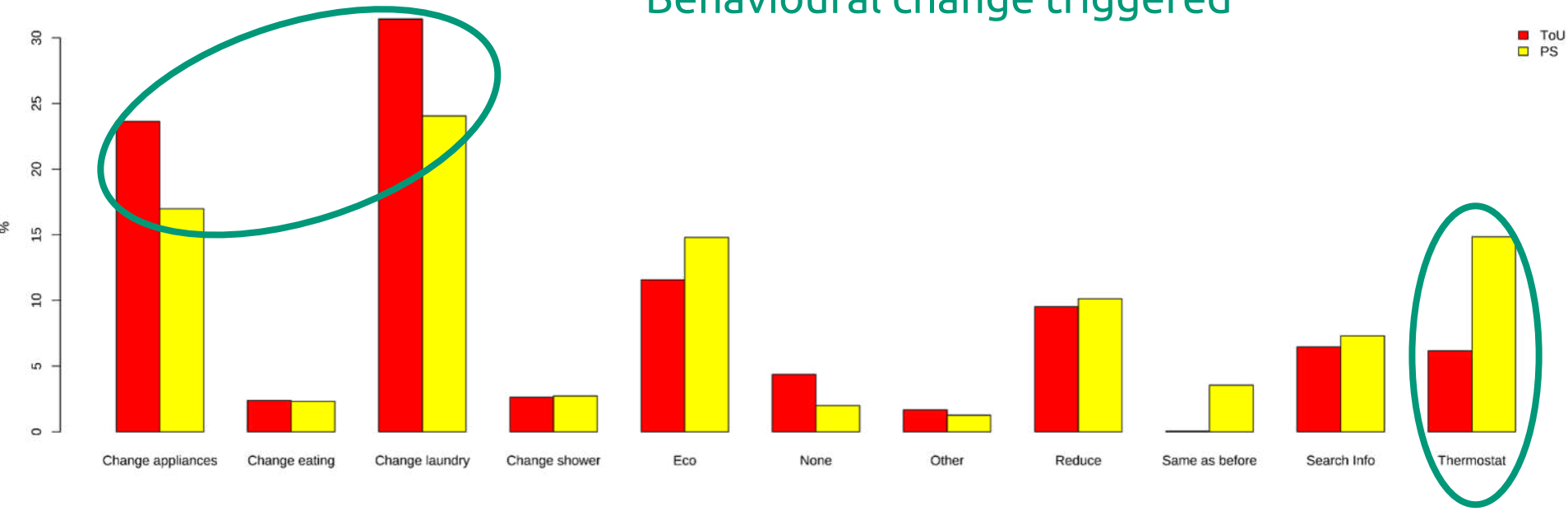
Knowledge about the interventions



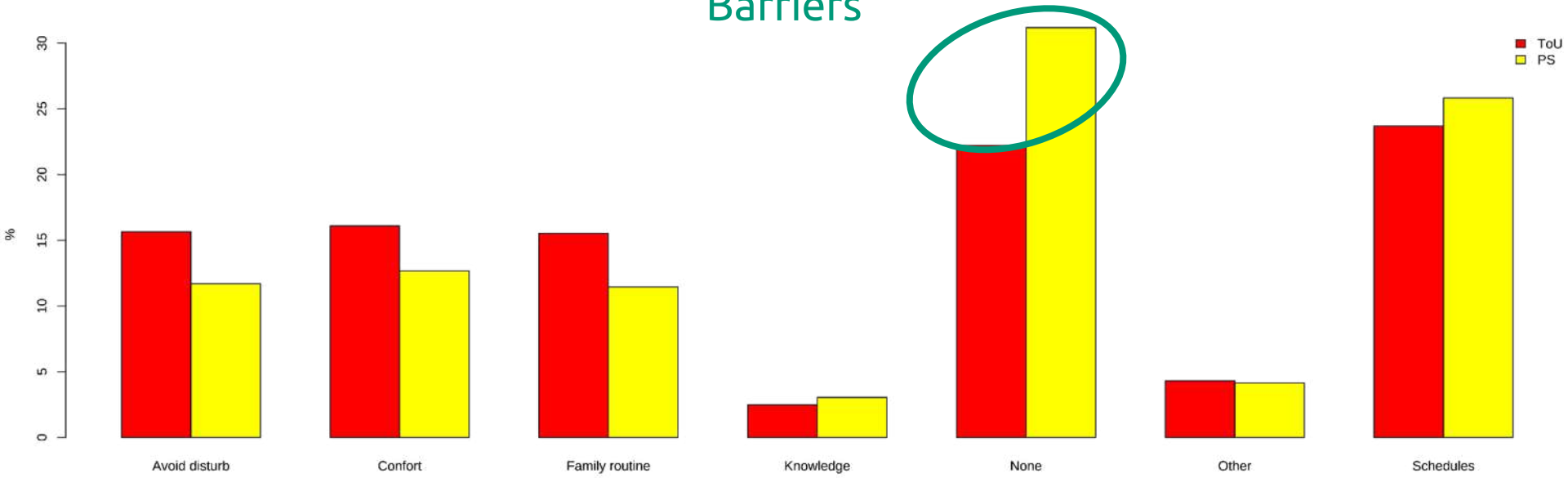
Opinion about both tariffs



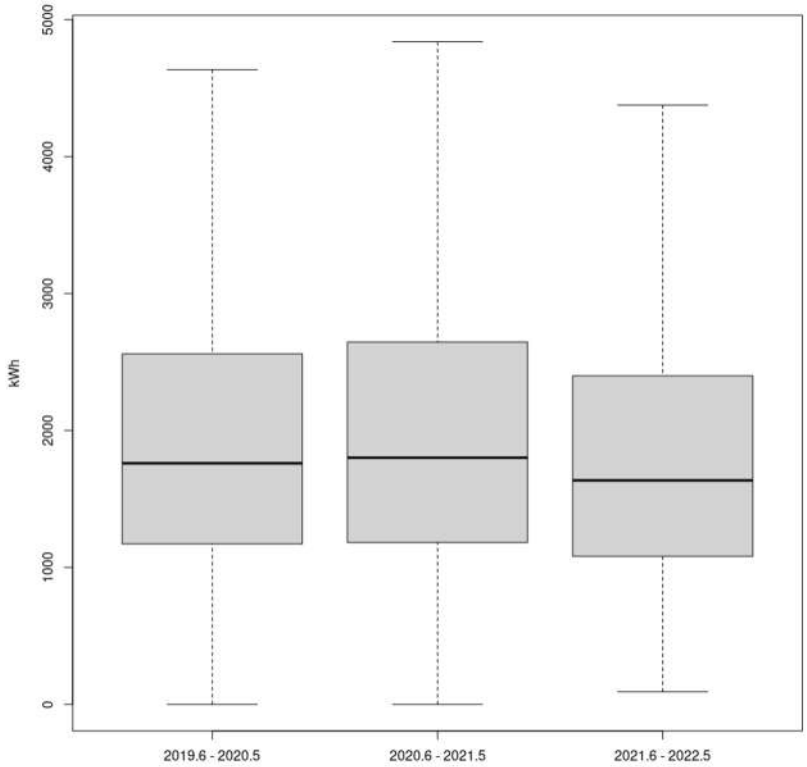
Behavioural change triggered



Barriers


ToU
PS
%
0
5
10
15
20
25
30
Avoid disturb
Confort
Family routine
Knowledge
None
Other
Schedules

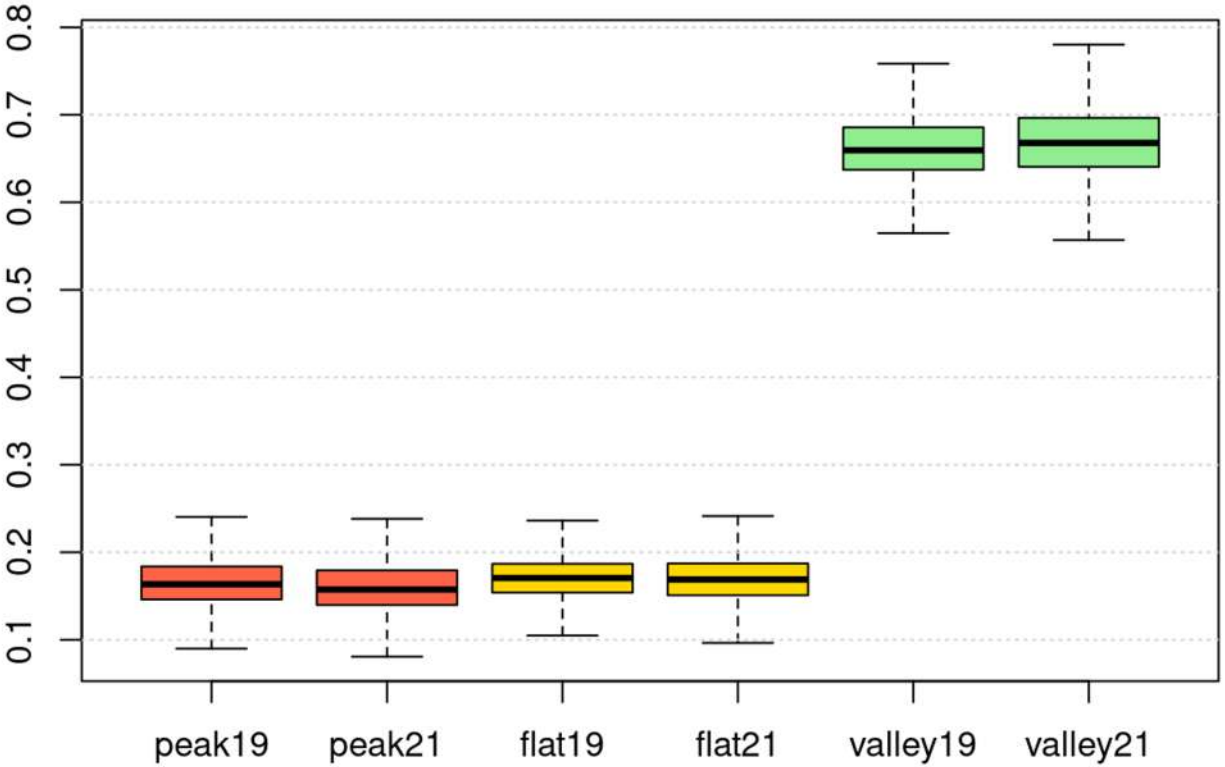
Overall energy consumption



🚧 Results only to ToU

Relative MAD(19,21) = 4.99%
Relative MAD(20,21) = 7.98%

Load shifting

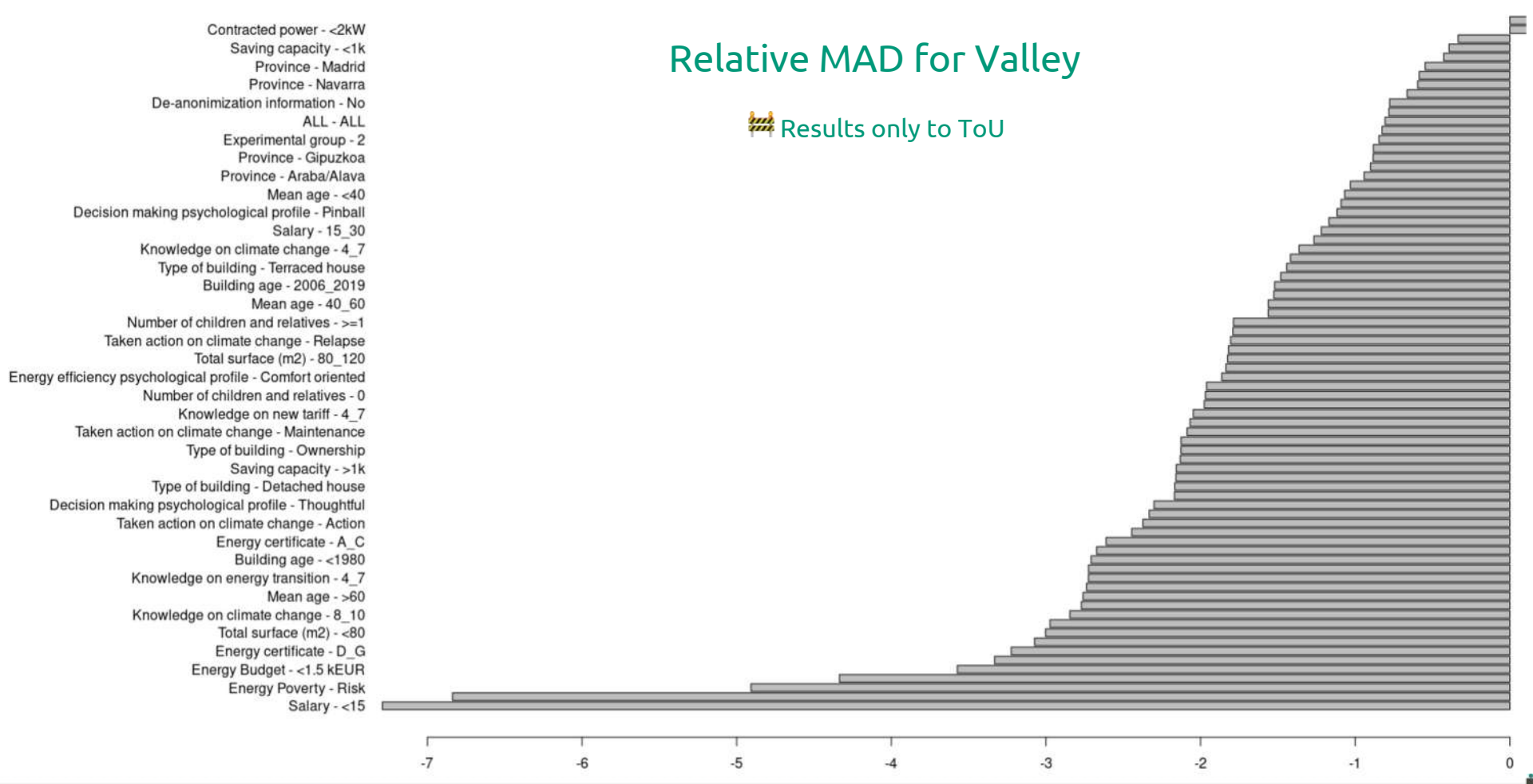


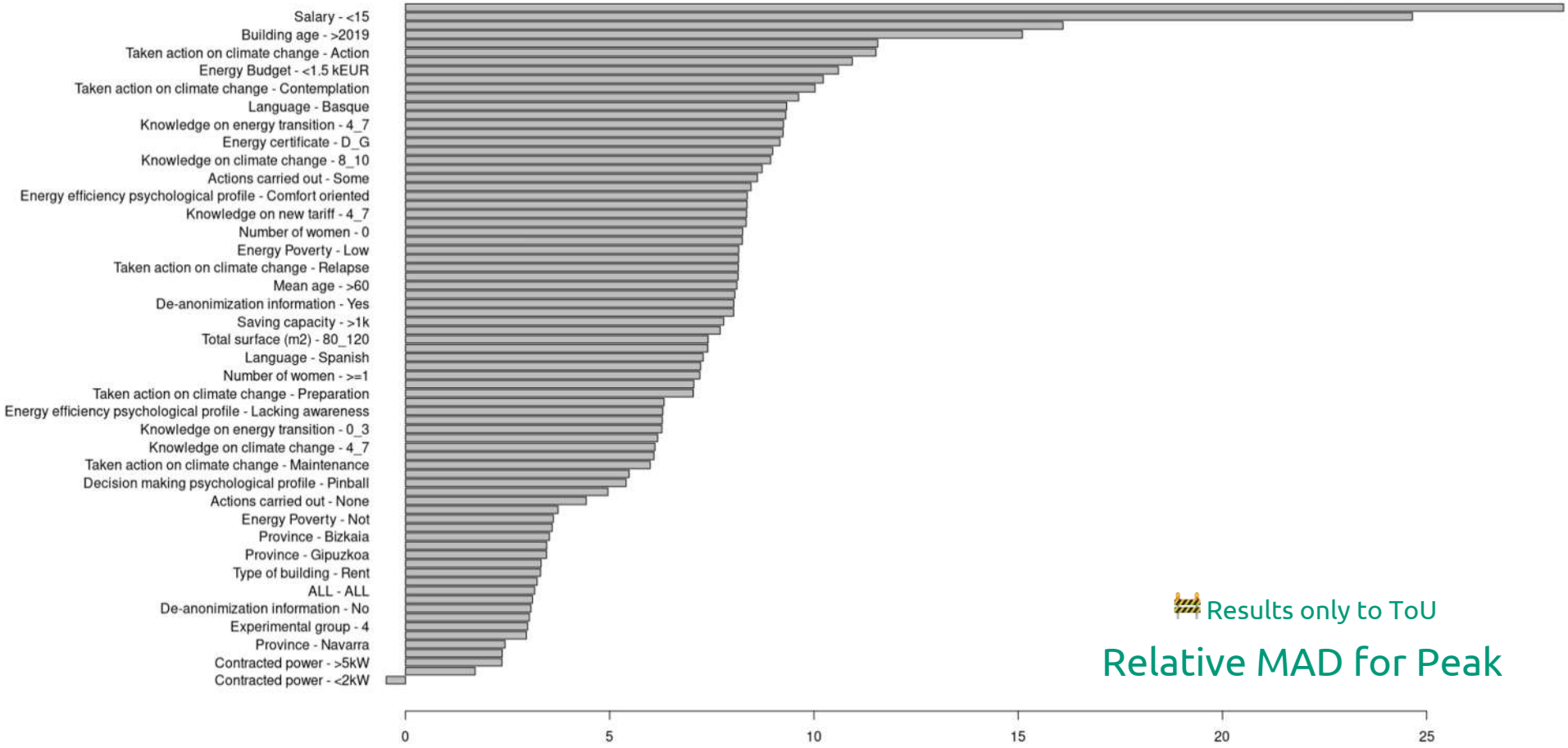
🚧 Results only to ToU

Relative MAD(p19,p21) = 3.25%
Relative MAD(f19,f21) = 0.42%
Relative MAD(v19,v21) = -0.8%

Relative MAD for Valley

🚧 Results only to ToU



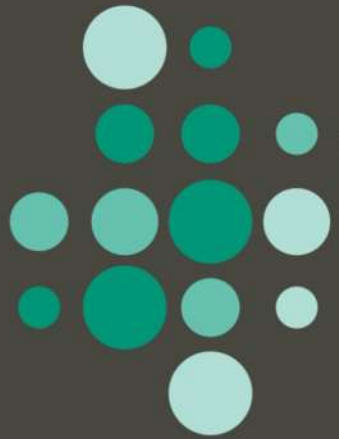


🚧 Results only to ToU

Relative MAD for Peak

Main takeaways

- General lack of knowledge about PS
- Similar opinion about both tariff
- Good knowledge and acceptance of the interventions taken to foster the adoption of the tariffs
- Both tariff trigger the same type of behavioral change and are affected by the same barriers
- People adapt easily to ToU tariff but not to PS (even with helping tools)
- Both trigger energy reduction and flexibility
- The amount of flexibility triggered by ToU small (not assessed PS yet)
- ToU tariff has large differences on the impact at different social group (not assessed PS yet)



WHY

CLIMBING THE CAUSALITY LADDER TO UNDERSTAND THE ENERGY DEMAND ON THE RESIDENTIAL SECTOR

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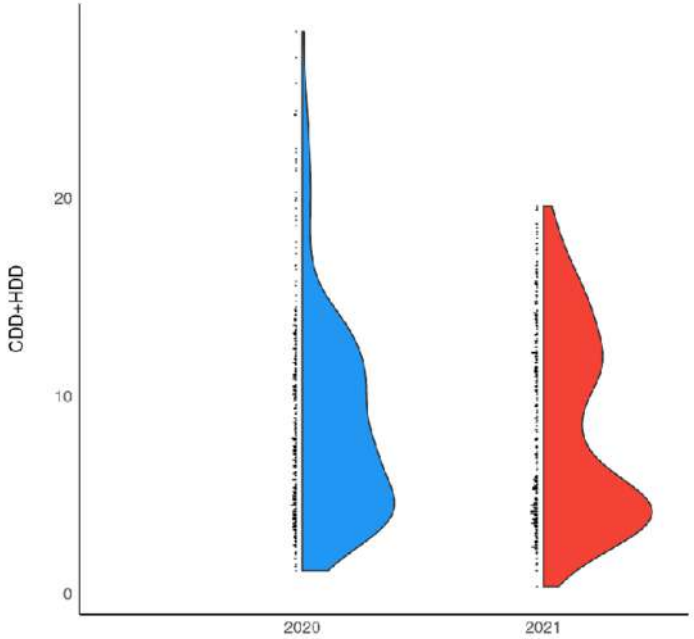
Potential confounders

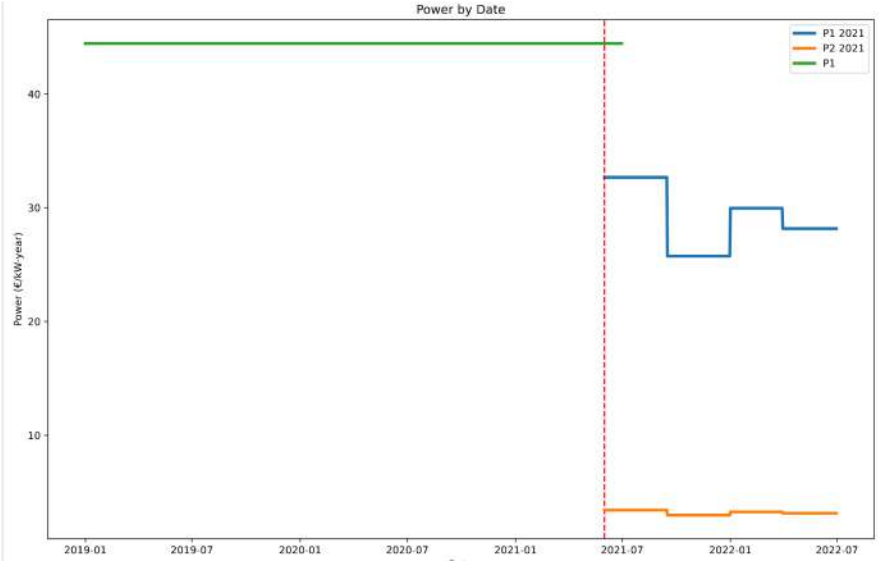
No significant differences related to the weather these years

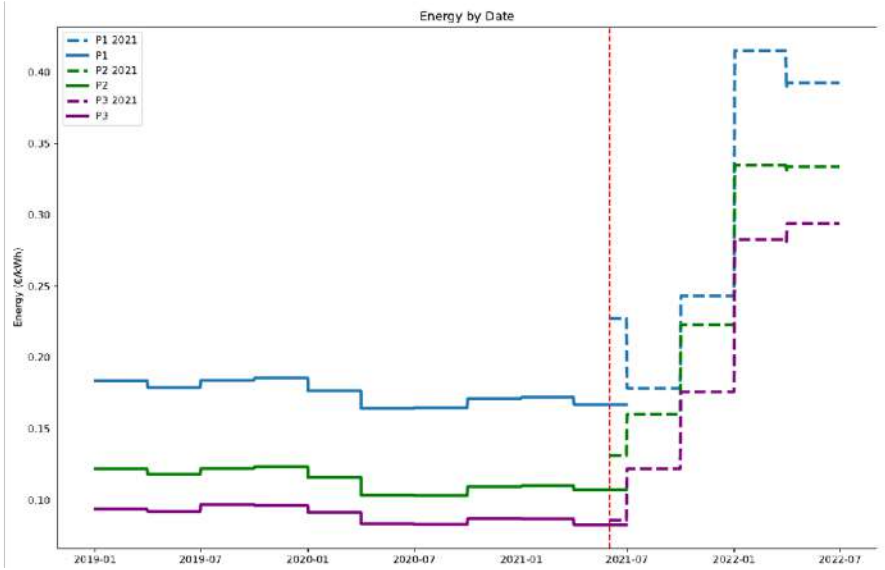


Province	Correlation coefficient	Wilcox test p-value
Bizkaia	0.63	0.147
Gipuzkoa	0.59	0.091
Alaba	0.73	0.334
Navarra	0.78	0.412
Madrid	0.81	0.524

Potential confounders

Significant increase of energy prices



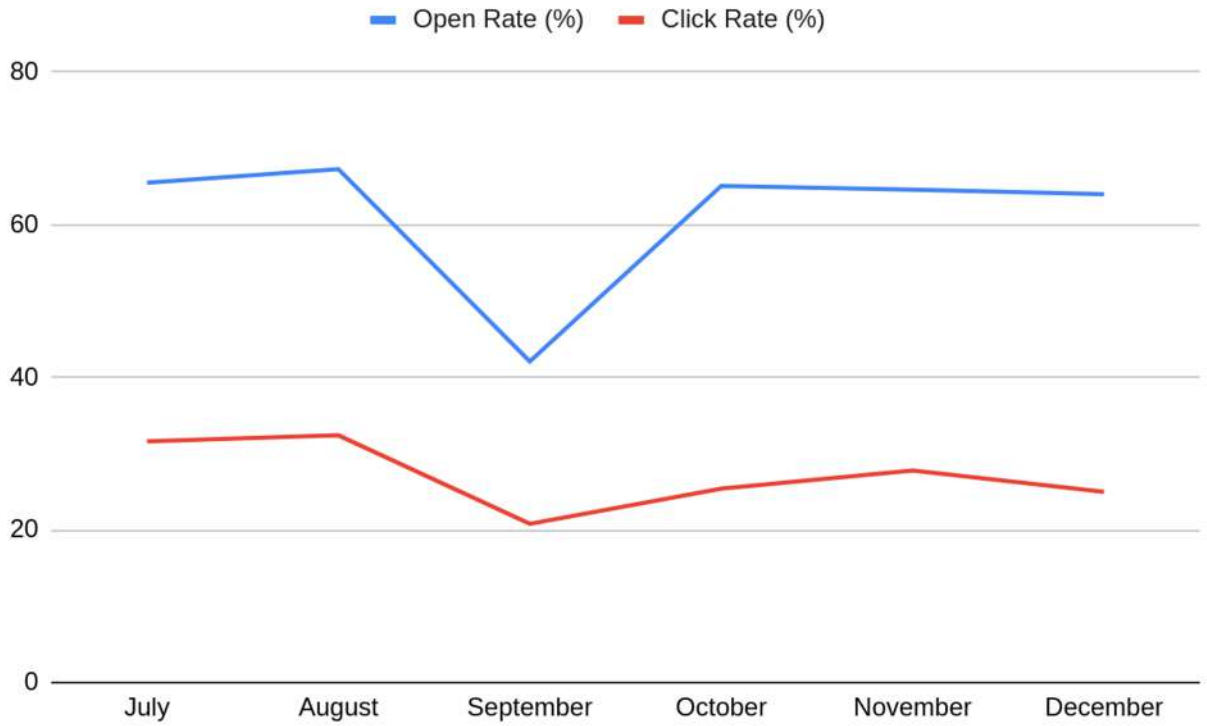


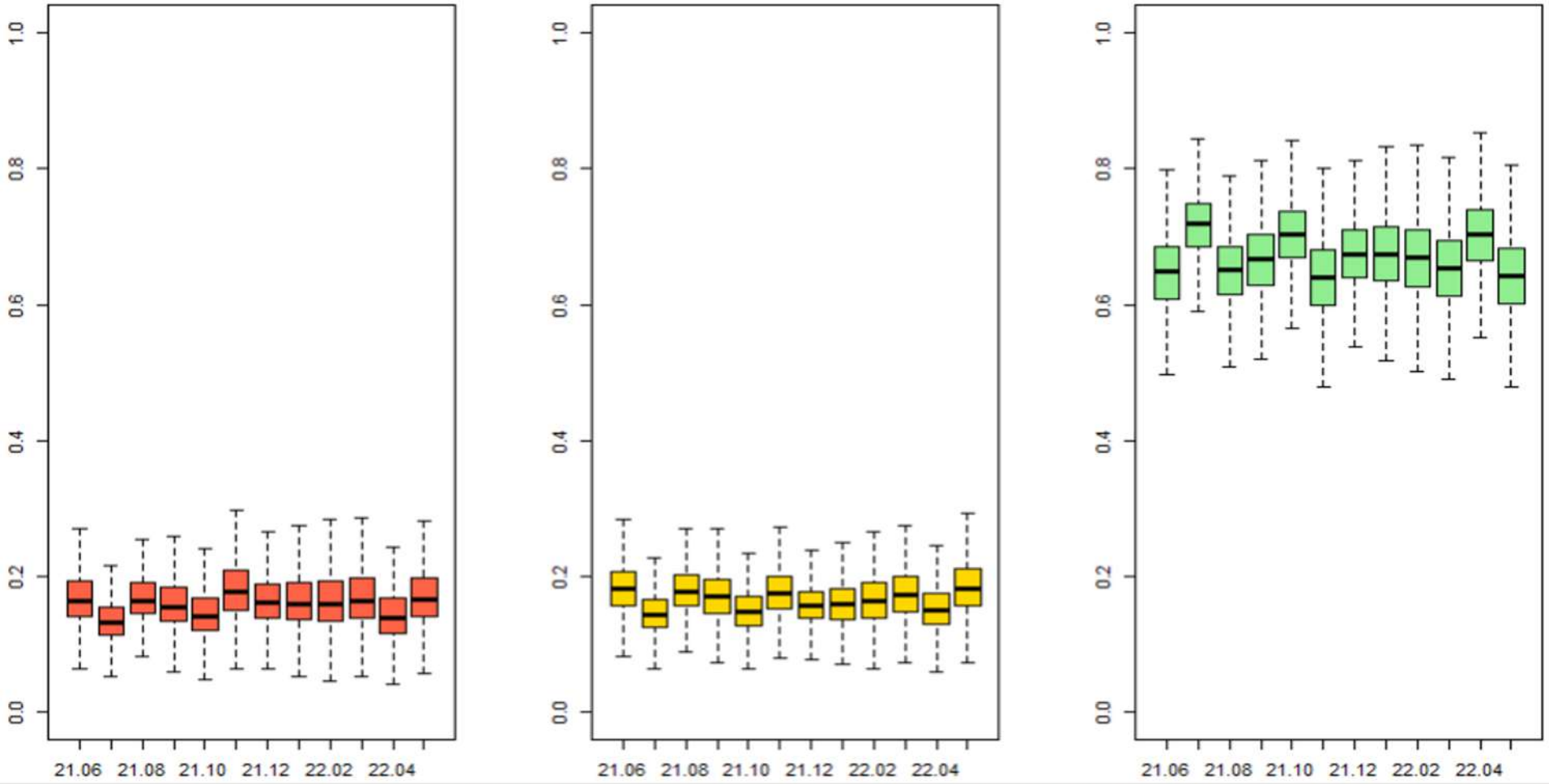
Potential confounders

Amount of work days

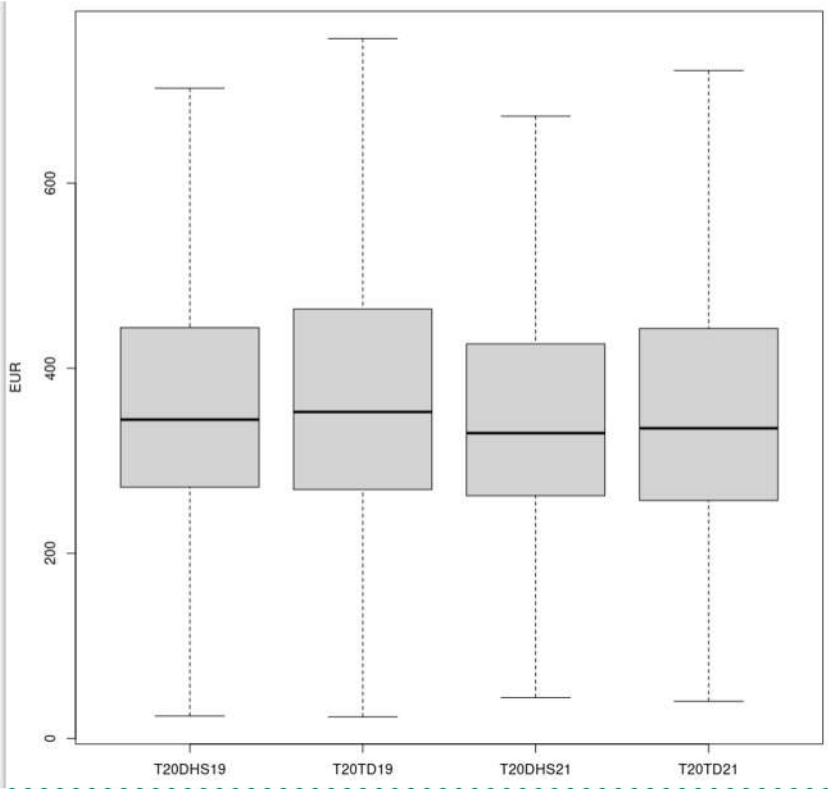
	2019	2020	2021
Work days	107	108	109
Saturdays	21	20	22
Sundays	22	21	21
Bank holidays	3	3	1

KPI: Consumer engagement



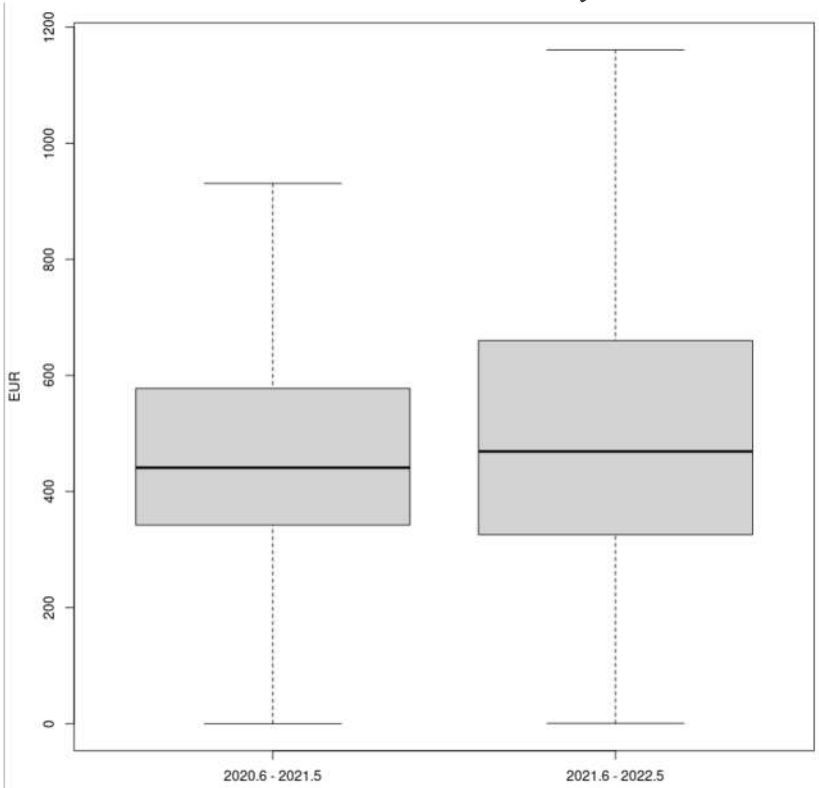

0.0
0.2
0.4
0.6
0.8
1.0
21.06
21.08
21.10
21.12
22.02
22.04

KPIs: cost for consumers (fixed price)



Relative MAD(19,21) = 1.96%
Relative MAD(20,21) = 3.48%

KPIs: cost for consumers (real tariff)



Relative MAD(20,21) = -7.36%

KPIs: socio-economic profile

	Sample	Groups
Experimental Group	Census	Control, Economic, Environmental, EE
Contracted Power	Census	**<2 kW**, 2-5 kW, > 5kW
Total salary	Survey	**<15 k€, 15-30 k€**, **30-50 k€**, >50 k€
Total saving capacity	Survey	**<1 k€**, 1-10 k€, **>10 k€**
Energy budget	Survey	**<1.5 k€, 1.5-3 k€, >3 k€**

Red means not significant with significance level α<0.05 applying Bonferroni correction

KPIs: socio-economic profile

	Sample	Groups
Region	Survey	**Madrid**, Bizkaia, Gipuzkoa, Araba/Álaba, Navarra
Type of municipality	Survey	City, Rural town, **Isolated area**
Lenguaje	Survey	EUS, ES
Gender distribution	Survey	**All men**, Other
Children and other relatives	Survey	No children or relatives, **Other**
Mean age	Survey	**<40**, 40-60, **>60**
Maximum education level	Survey	Tertiary, **Other**
Has provided de-anonymization?	Survey	Yes, No

Red means not significant with significance level $\alpha<0.05$ applying Bonferroni correction

KPIs: socio-economic profile

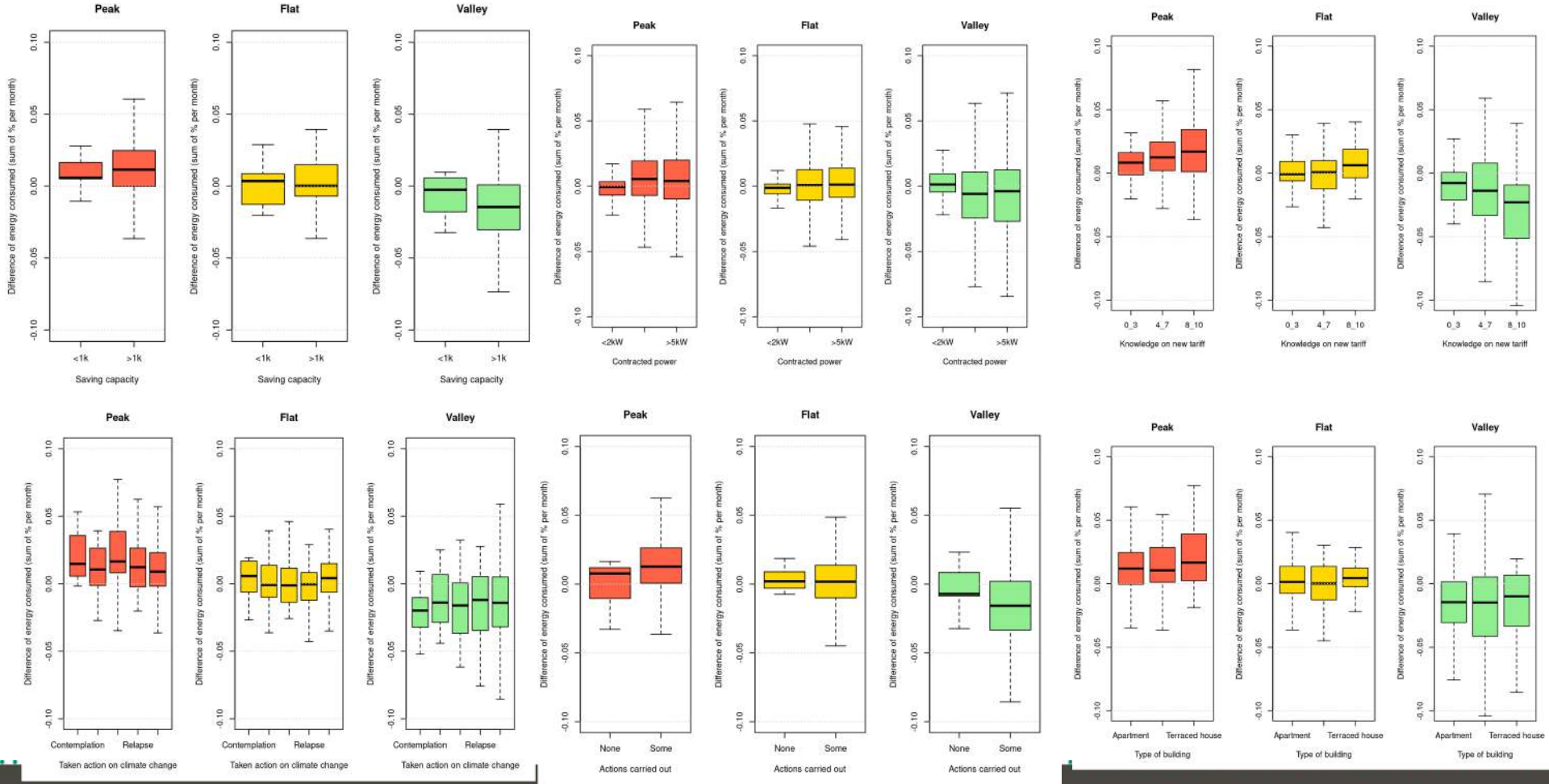
	Sample	Groups
Knowledge about the new tariff	Survey	**<4**,4-8,>=8
Knowledge about the energy transition	Survey	**<4**,4-8,>=8
Knowledge about the climate change	Survey	**<4**,4-8,>=8
State of change towards climate action	Survey	**Contemplation, Preparation**, Action, **Relapse**, Maintenance
Decision making psychological profile	Survey	**Pinball, Shortcut**, Thoughtful
Energy efficiency psychological profile	Survey	Conscious, **Comfort oriented, Lacking awareness, Materialistic**
Self perception of actions carried out	Survey	**None**, Some

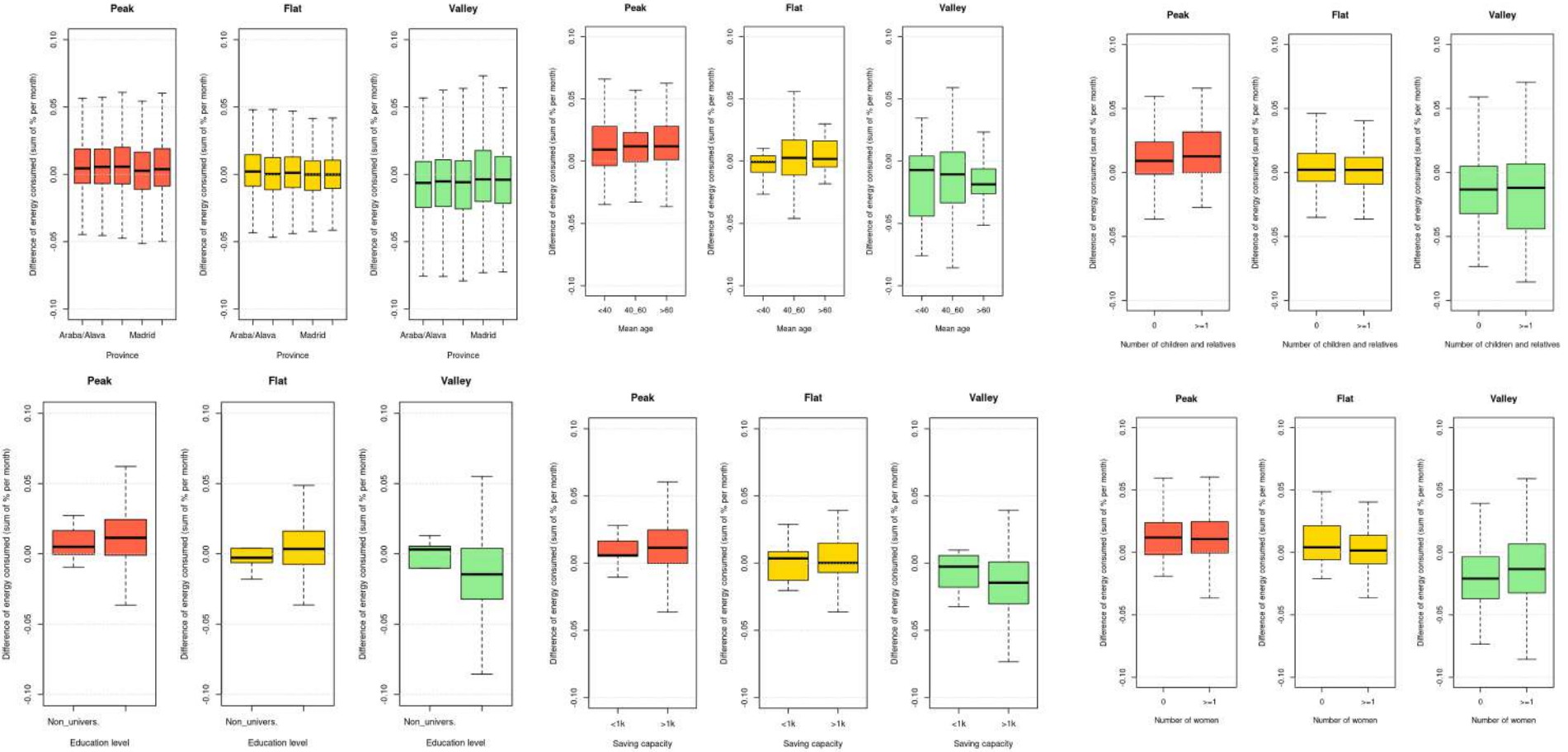
Red means not significant with significance level α<0.05 applying Bonferroni correction

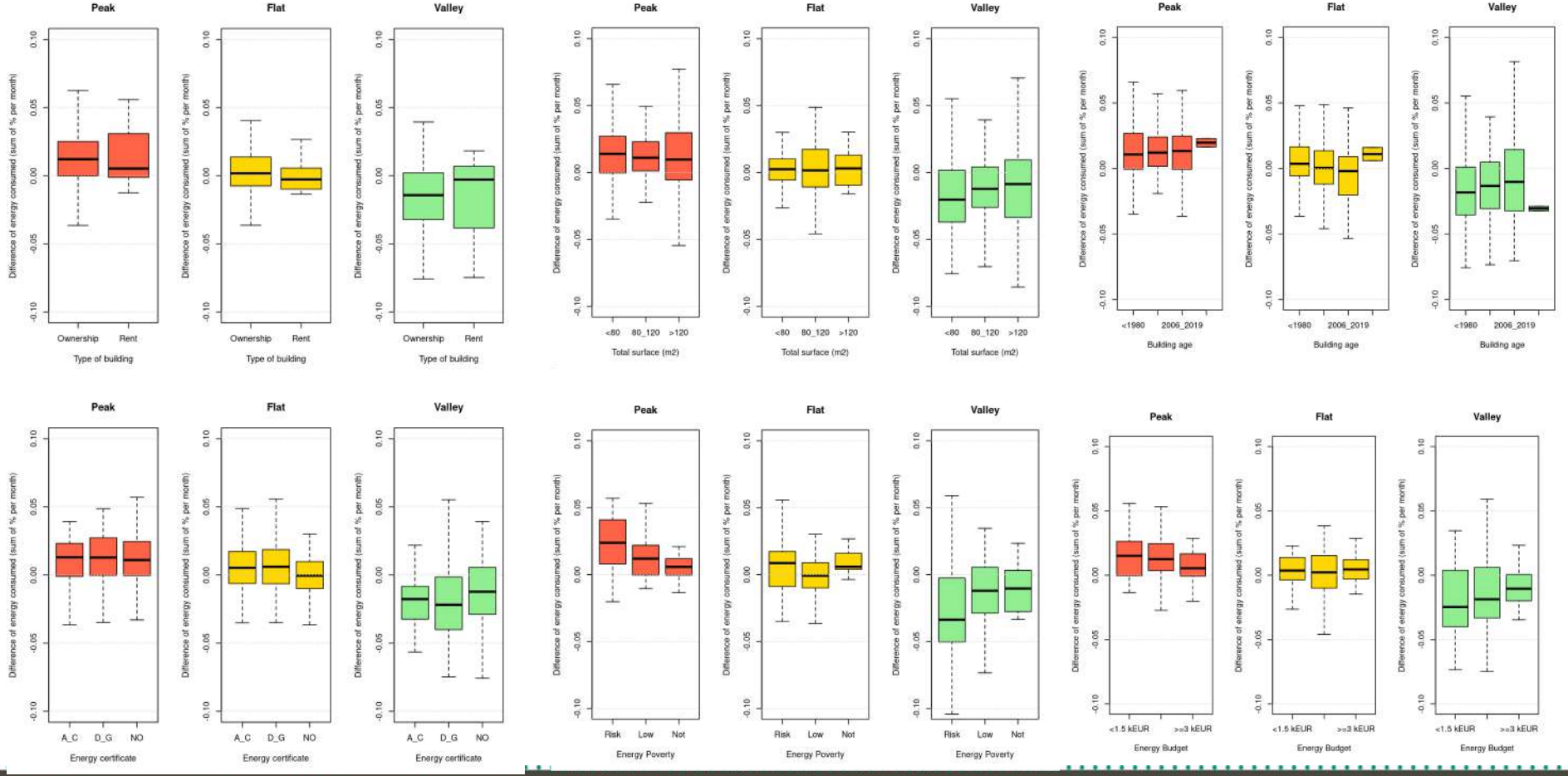
KPIs: socio-economic profile

	Sample	Groups
Type of building	Survey	**Terraced, Detached**, Apartment
Ownership	Survey	**Rent,** Owned
Total surface	Survey	< 80 m², 80-120 m², **> 120 m²**
Building age	Survey	<1980, 1980-2006, **2006-2019, >2019**
Energy certificate	Survey	**Insulated (A-C)**, Not insulated (D-G), No
Energy Poverty Risk	Survey	Risk, Low Risk, No Risk

Red means not significant with significance level α<0.05 applying Bonferroni correction


Peak
Flat
Valley
Difference of energy consumed (sum of % per month)
<1k
>1k
Saving capacity
<2kW
>5kW
Contracted power
0_3
4_7
8_10
Knowledge on new tariff
Contemplation
Relapse
Taken action on climate change
None
Some
Actions carried out
Apartment
Terraced house
Type of building


Peak
Flat
Valley
Difference of energy consumed (sum of % per month)
Araba/Alava
Madrid
Province
<40
40_60
>60
Mean age
0
>=1
Number of children and relatives
Non_univers.
Education level
<1k
>1k
Saving capacity
Number of women


Peak
Flat
Valley
Difference of energy consumed (sum of % per month)
Ownership
Rent
Type of building
<80
80_120
>120
Total surface (m2)
<1980
2006_2019
Building age
A_C
D_G
NO
Energy certificate
Risk
Low
Not
Energy Poverty
<1.5 kEUR
>=3 kEUR
Energy Budget