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Early electrifiers: individual profile (and impact of the energy crisis)

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Introduction

- The electrification of final energy consumption is key for a successful energy transition
- The devices allowing households to produce their own clean electricity and replace fossil fuels are increasingly popular: PVs, batteries, heat pumps, EVs…
- Several analyses have been exploring what drives individual preferences or purchase decisions for each individual device
- But purchase decisions for the various devices are often connected:
  - ✓ PVs and then heatpumps / batteries / EVs
  - ✓ Good or bad experience with one device makes the following purchase decision easier
  - ✓ Financial or technical constraints may arise…
- Can we draw a profile of the early or late electrifier? Can we detect the connections across individual purchase decisions?

Data collection: the Barometer of Renewable Energies 2022

- On-going project of the Institute for the Management of Renewable Energies of the University of St Gallen (Switzerland), focussing on the German- and French-speaking regions of Switzerland
- Since 2020: cooperation with USI's Institute for Economic Research to distribute the survey in Canton Ticino (Italian-speaking region of Switzerland)
- Most questions are the same, but not all

Content of our survey

Questions on the purchase behaviour of households with respect to 4 electrification technologies:

- Photovoltaic panels
- Heat pumps
- Batteries
- Electric vehicles

Possible answers:

- I already own it since year…
- I don’t have it, but I plan to buy it in year…
- I didn’t think about it yet
- I decided not to buy it

NB: Questions asked only to homeowners, except for EVs

Content of our survey

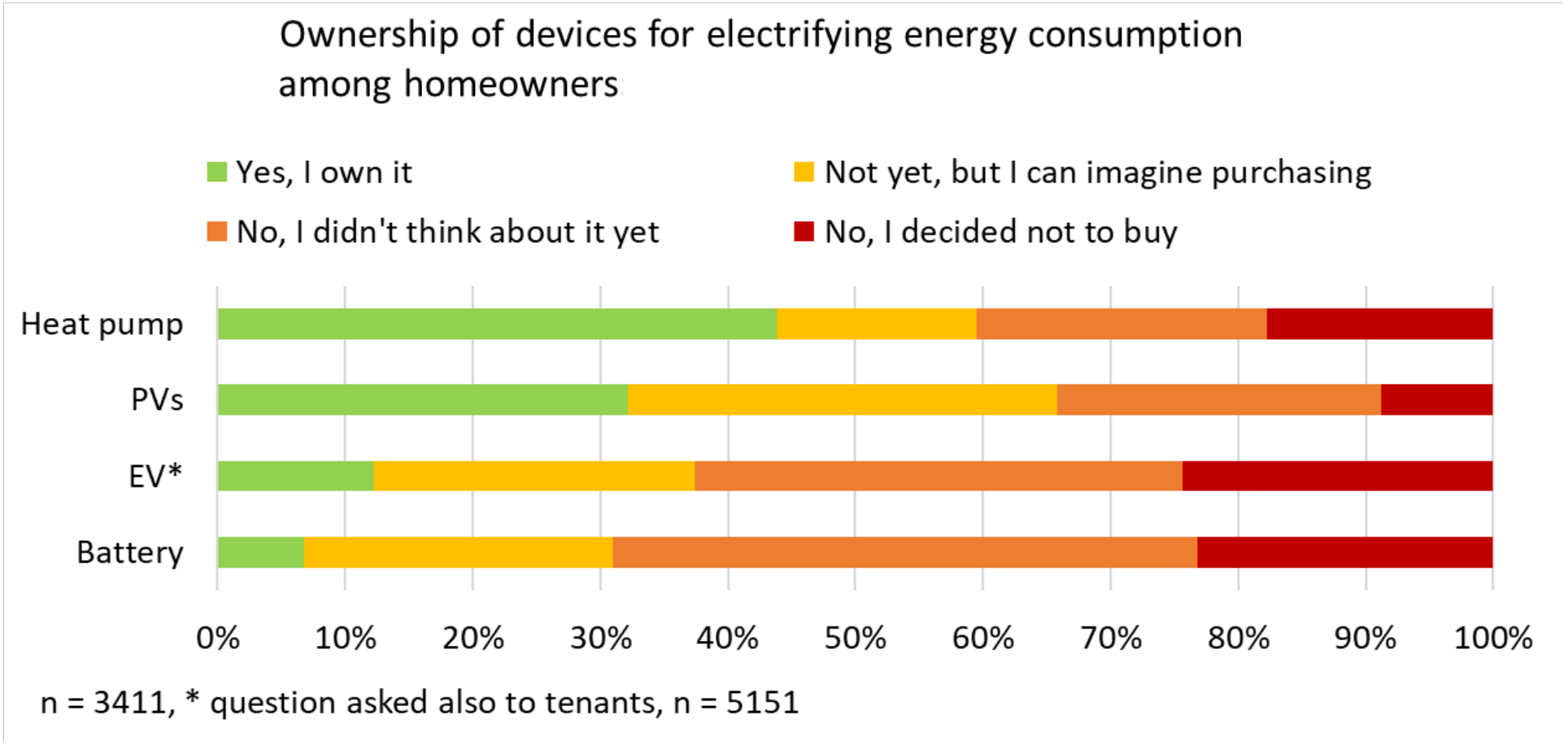
Additional questions concerning:

- Typical demographic variables
- Daily habits
- Influence of peers on purchase decisions
- Influence of past purchase decisions on current purchase decisions
- Technological affinity
- Opinions on and concern for the energy crisis, climate change, use of nuclear energy, use of private cars
- Perceived effectiveness of individual / collective energy saving effort

Survey distribution and sample

- The data collection for Canton Ticino took place between November 2022 and February 2023
- The invitation to complete the on-line survey was distributed by 7 electricity suppliers active in Ticino to their customers via:
  - ✓ E-newsletters and websites
  - ✓ Electricity bills via paper mail (with QR code and/or link)
- We offered a 500 CHF (~500 EUR) prize to one randomly selected respondent
- 5’151 respondents validly completed the whole survey
- The sample is reasonably representative of the residents of Canton Ticino in terms of place of residence, age, and demographic conditions. However, it suffers from a slight over-representation of men and environmentally concerned respondents

Ownership of the 4 devices



Purchase decisions are not independent from each other

The correlations of the ownership statuses for the 4 devices reveal that the purchase decisions are not independent

It is thus interesting to consider all the four devices together, and draw a profile of the early or late electrifier

Pairwise correlations of the probability of owning selected devices				
	PV	EV	Battery	Heatpump
PV	1			
EV	0.31*	1		
Battery	0.42*	0.22*	1	
Heatpump	0.34*	0.23*	0.15*	1

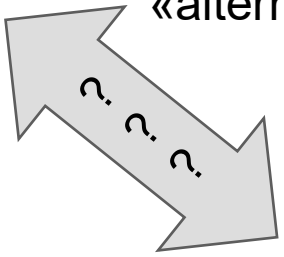
** = p-value < 0.05*

Modelling strategy: a discrete choice model for «yes» vs three shades of «no»

- Let's consider the decision of purchasing one of the devices (EV, PVs, heatpump, batteries)
- The survey does not include a «proper» discrete choice experiment

Discrete choice modellling: what product or service do consumers choose?

Each product or service is called «alternative»



The observed or stated choice is connected to explanatory variables:

- Attributes of the alternatives
- Characteristics of the consumers

Modelling strategy: outline

What if we consider the ownership status as the alternative?

- ✓ Yes, I have already purchased the device
- ✓ No, but I consider buying it soon
- ✓ No, I didn't think about this yet
- ✓ No, I decided not to buy it

→ We can link the purchase decision to the characteristics of the respondents

Can we include all the 4 devices within the same model?

- ✓ Yes: same strategy as when we combine stated preference data and revealed preference data

Econometric background: basic multinomial logit

Random Utility Theory - We model the decision of individual *k* choosing alternative *i* among all alternatives *j* in choice set *Cn* as*:*

$$U_{ik} = V_i(X_i; Z_k) + \varepsilon_{ik}$$

$$P(i) = P\left(U_i > U_j, \forall\, j \in C_n\right)$$

$$\text{If} \quad \varepsilon_{ik}\ i.i.d. \sim EV\ (\eta, \mu)$$

$$then\ \ P_k(i) = \frac{e^{V_{ik}}}{\sum_{j \in C_n} e^{V_{jk}}}$$

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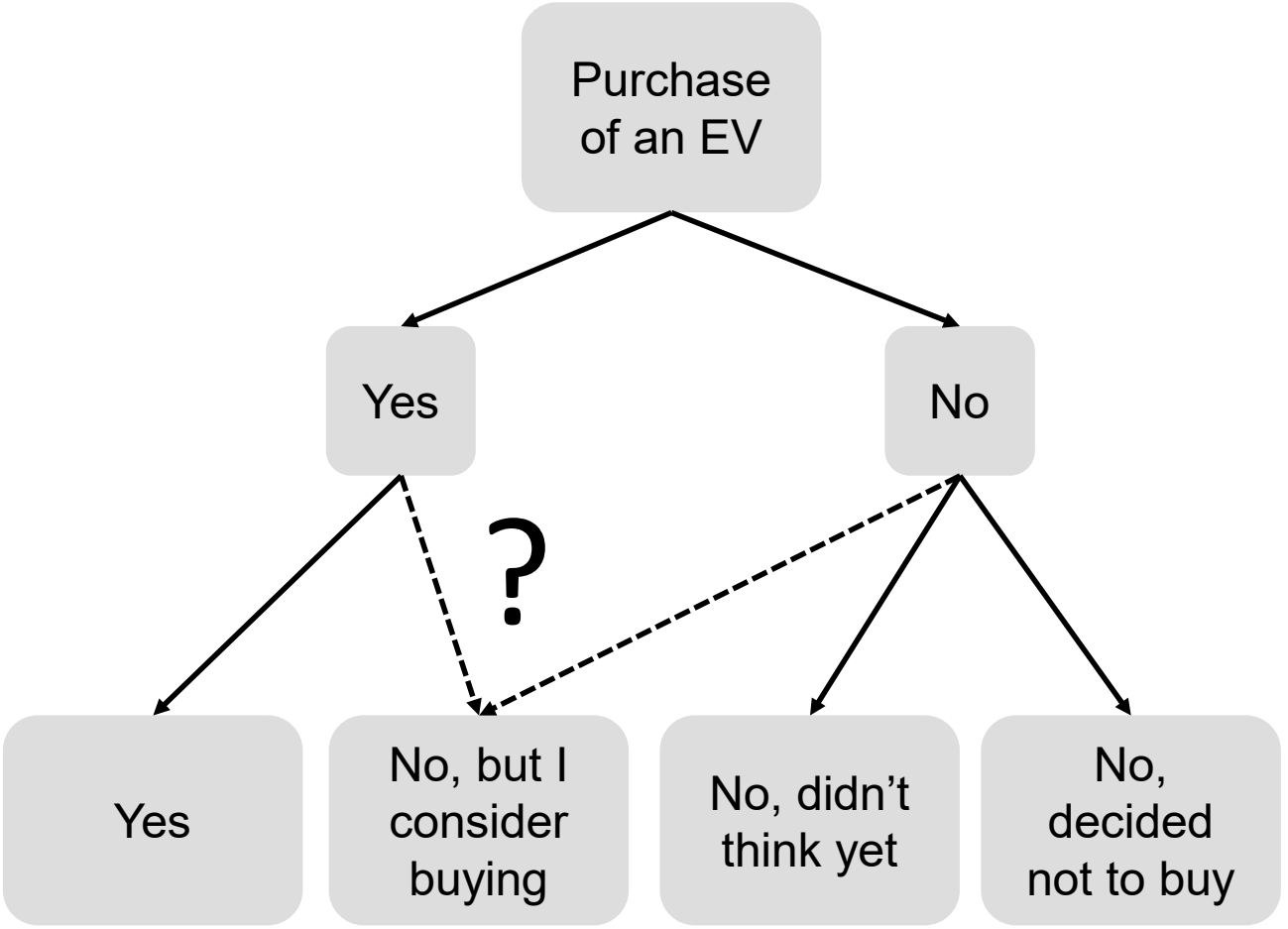
Does this hold in our case?

$$then \ \ P_k(i) = \frac{e^{V_{ik}}}{\sum_{j \in C_n} e^{V_{jk}}}$$

«Yes» versus three shades of «no»

Is «No, but I consider buying» similar to «Yes» or to «No, I decided not to buy»?

- We can test if there is a nestig structure across the alternatives
- The alternatives belonging to the same nest are more similar to each other as compared to the others
- Each alternative can belong to more than one nest

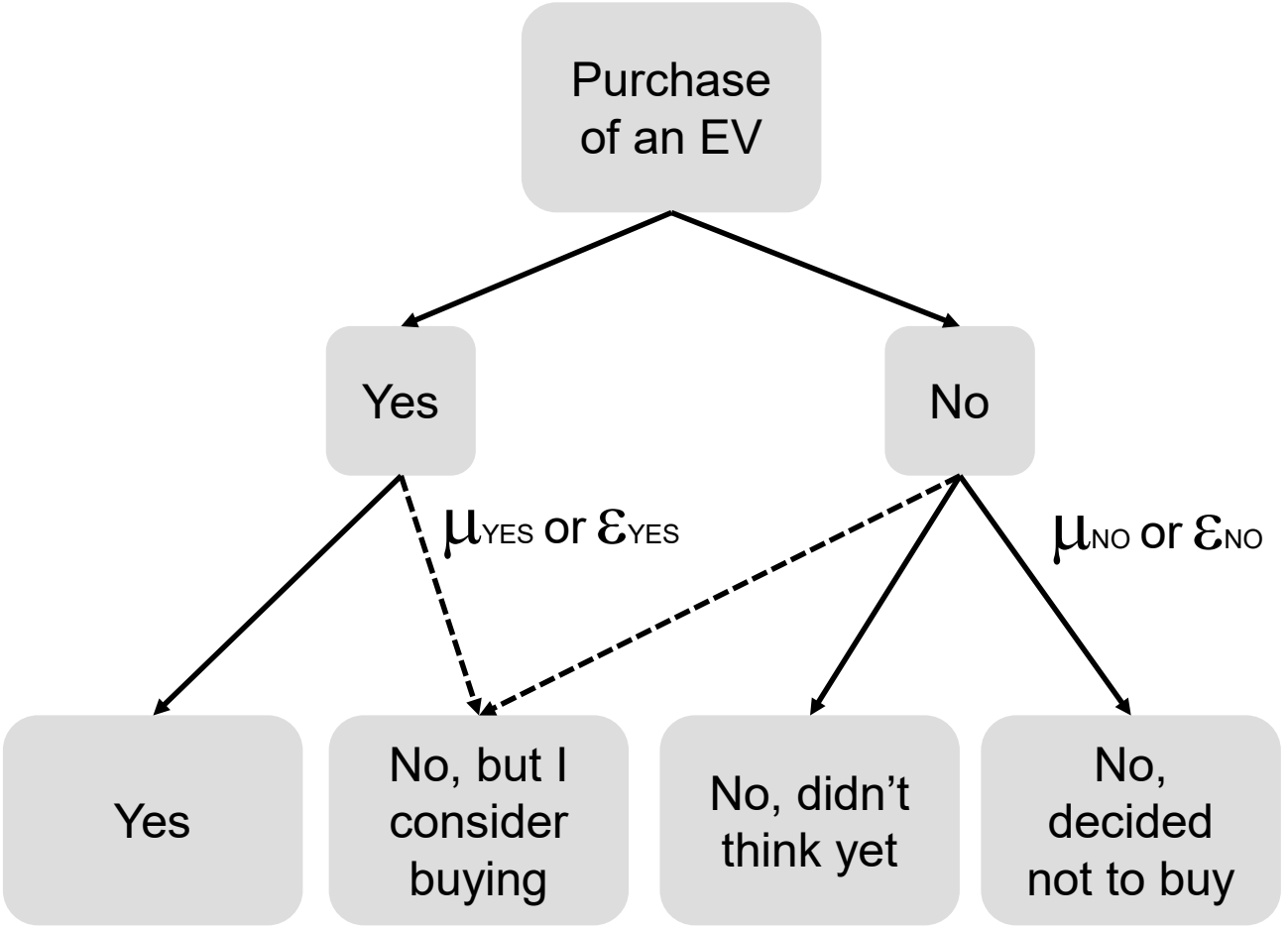


«Yes» versus three shades of «no»

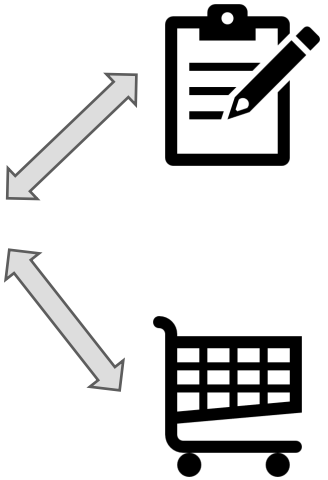
In practice, we release the assumption that all alternatives have i.i.d. errors.

We can:

- Allow the errors within a nest have a different scale, e.g. for nest «No» $\mu_{NO} > 1$
- Or add a common error term $\varepsilon_{NO} \sim N(0, \sigma_{NO})$ to the alternatives belonging to the same nest



Can we include all the devices within the same model?



With appropriate modelling techniques, we can include:

- Stated preferences (e.g. survey data)
- Revealed preferences (e.g. observed purchase behaviour)

In the same model

BUT the error terms in the stated and revealed preferences may be different – e.g. larger or smaller unexplained variance of revealed choices as compared to stated choices.

This is reflected in the scale parameter: $\varepsilon_{ik}\ i.i.d. \sim EV\ (\eta, \mu)$

Drawing from the strategies to combine stated and revealed preferences

The way out: we assume, for example:

$$Var(\varepsilon_{PV}) = Var(\theta\varepsilon_{battery}) = \theta^2 Var(\varepsilon_{battery})$$

So we rewrite the utility functions as:

$$U_{PV} = V_{PV} + \varepsilon_{PV}$$

$$\theta U_{battery} = \theta V_{battery} + \theta\varepsilon_{battery}$$

And we estimate jointly both the two models (now with i.i.d. errors), and the scale parameter θ

We can gradually expand this framework to include all the four devices: we estimate 3 scale parameters, as one is normalized

Results (1)

Model	MNL 1	MNL 2	EC 1	EC 2	EC 3	EC 4
Nr. parameters	72	84	74	74	78	90
Sample size	3411	2866	3411	3411	3411	3411
Mc Fadden adj. R2	0.115	0.12	0.14	0.153	0.148	0.149
Nr. draws				100	100	100
Error components (EC)						
EC YES, NO1			5.07***	5.06***	6.14***	5.9***
EC NO1, NO2, NO3			0			
EC NO1, NO2				0	4.28***	4.12***
EC NO3					6.89***	6.64***
Scale parameter						
Scale battery	0.986***	1.05***	0.514***	0.514***	0.437***	0.452***
Scale electric vehicle	0.867***	0.915***	0.203***	0.203***	0.161***	0.17***
Scale heat pump	0.726***	0.751***	0.205***	0.205***	0.271***	0.285***

** = p-value < 0.05, ** = p-value <0.01, *** = p-value < 0.001*

- EC4, our preferred specification, suggests that «No, but I could buy the device soon [NO1]» belongs to 2 nests: one with «Yes, I have it already» and one with «No, I didn't think about it yet [NO2]»
- «No, I decided not to buy it [NO3]» also shows a sizeable unexplained heterogeneity that is measured in its own error term
- Larger scale means larger variance of individual behaviour with respect to the decision of purchasing each specific device

Results (2)

More likely to say no:

- Singles (vs couples and bigger families)
- People living in a flat (vs detatched house)
- People without university degree (the effect is smaller if income is considered)
- No effect of urban vs rural

Model	MNL 1	MNL 2	EC 1	EC 2	EC 3	EC 4
All technologies: role of demographic variables						
NO1 constant	0.209	0.598	0.542	0.542	-1.82*	-2.32***
NO2 constant	1.21***	2.2***	5.91***	5.89***	1.84*	2.21***
NO3 constant	2.01***	3.3***	6.46***	6.44***	4.21***	4.62***
Single NO1	0.202	0.174	0.293*	0.293	0.411	0.435
Single NO2	0.48***	0.312*	1.3***	1.29***	1.25***	1.2***
Single NO3	0.455***	0.268	1.29***	1.28***	1.08*	1.03*
Couple NO1	0.11	0.097	0.168	0.168	0.464	0.445
Couple NO2	0.135	0.095	0.372	0.362	0.66*	0.629*
Couple NO3	0.103	0.091	0.327	0.318	0.558	0.521
Lives in a flat NO1	0.233*	0.168	0.467***	0.467***	0.1	0.095
Lives in a flat NO2	1.05***	0.987***	3.59***	3.58***	3.09***	3.01***
Lives in a flat NO3	0.569***	0.529***	2.74***	2.74***	1.62***	1.57***
University graduate NO1	0.157*	0.157	0.186*	0.186	0.794***	0.794***
University graduate NO2	-0.532***	-0.431***	-1.97***	-1.97***	-1.48***	-1.47***
University graduate NO3	-0.378***	-0.259*	-1.64***	-1.65***	-1.06***	-1.06***
Urban resident NO1	0.147	0.149	0.186	0.186	0.468	0.463
Urban resident NO2	0.129	0.228*	0.284	0.285	0.362	0.359
Urban resident NO3	0.241*	0.26*	0.446	0.447	0.584	0.584

** = p-value < 0.05, ** = p-value <0.01, *** = p-value < 0.001*

Results (3)

Age decreases purchase probability for EVs, batteries, and to a lesser extent heat pumps

Men are more likely to buy EVs, heat pumps, PVs

Model	MNL 1	MNL 2	EC 1	EC 2	EC 3	EC 4
Individual technologies: role of demographic variables						
Age						
Age battery NO1	0.004	-0.004	0.006	0.006	0.027	0.025
Age battery NO2	0.012*	0.001	0.035*	0.035*	0.074***	0.075***
Age battery NO3	0.009	-0.005	0.039*	0.039*	0.061***	0.061***
Age EV NO1	0.009	0.005	0.048*	0.048*	0.073*	0.071*
Age EV NO2	0.033***	0.027***	0.169***	0.169***	0.238***	0.223***
Age EV NO3	0.044***	0.035***	0.244***	0.244***	0.317***	0.295***
Age heat pump NO1	-0.006	-0.003	-0.015	-0.015	-0.008	-0.005
Age heat pump NO2	0.019***	0.018***	0.09***	0.09***	0.08***	0.077***
Age heat pump NO3	0.025***	0.025***	0.136***	0.135***	0.099***	0.096***
Age PV NO1	-0.005	-0.007	-0.009*	-0.009*	-0.016	-0.017
Age PV NO2	0.001	-0.001	0.008	0.008	0.009	0.008
Age PV NO3	0.004	0.001	0.014	0.014	0.005	0.004
Male gender						
Man battery NO1	-0.111	-0.272	-0.197	-0.197	-0.239	-0.241
Man battery NO2	-0.436*	-0.629***	-1.4***	-1.39***	-1.65***	-1.46*
Man battery NO3	-0.271	-0.456*	-0.977*	-0.975*	-1.03	-0.826
Man EV NO1	-0.241	0.009	-0.949	-0.953	-1.15	-1.02
Man EV NO2	-0.765***	-0.459*	-3.97***	-3.97***	-4.73***	-4.52***
Man EV NO3	-0.945***	-0.764***	-4.47***	-4.47***	-5.64***	-5.38***
Man PV NO1	-0.414***	-0.568***	-0.418***	-0.418***	-0.769*	-0.704*
Man PV NO2	-0.724***	-0.789***	-2.01***	-2***	-1.62***	-1.61***
Man PV NO3	-0.93***	-0.879***	-2.2***	-2.19***	-2***	-1.98***
Man heat pump NO1	-0.253	-0.314	-0.819	-0.816	-0.66	-0.569
Man heat pump NO2	-0.637***	-0.596***	-2.68***	-2.67***	-1.95***	-1.95***
Man heat pump NO3	-0.646***	-0.636***	-2.41***	-2.4***	-1.84***	-1.91***

** = p-value < 0.05, ** = p-value <0.01, *** = p-value < 0.001*

Results (4)

Income increases purchase probability for heat pumps, PVs, EVs; no effect for batteries

A subscription to public transport decreases purchase probability for EVs

No effect of availability of a private parking

Model	MNL 1	MNL 2	EC 1	EC 2	EC 3	EC 4
Income						
Income battery NO1		0.054				
Income battery NO2		-0.01				
Income battery NO3		-0.057				
Income EV NO1		-0.084				
Income EV NO2		-0.295***				
Income EV NO3		-0.275***				
Income PV NO1		-0.001				
Income PV NO2		-0.2***				
Income PV NO3		-0.292***				
Income heat pump NO1		-0.19***				
Income heat pump NO2		-0.344***				
Income heat pump NO3		-0.388***				
Use of public transport (for EVs)						
Public tr. abo EV NO1					-0.172	-0.184
Public tr. abo EV NO2					1.95*	1.86*
Public tr. abo EV NO3					1.97*	1.85*
Availability of a parking space at home (for EVs)						
Parking available EV NO1	0.005	-0.01	0.188	0.18	0.895	0.927
Parking available EV NO2	-0.367	-0.253	-0.552	-0.557	-0.829	-0.851
Parking available EV NO3	-0.625***	-0.553*	-1.16	-1.17	-0.932	-0.998

** = p-value < 0.05, ** = p-value <0.01, *** = p-value < 0.001*

Results (4)

Stated importance of specific purchase drivers in determining the purchase decisions:

- Climate protection strongest for EVs, then heat pumps, PVs, and to a lesser extent for batteries
- Cost reduction important for heatpumps and, to some extent, EVs, PVs
- Self-sufficiency important for heat pumps and batteries

Model	MNL 1	MNL 2	EC 1	EC 2	EC 3	EC 4
Individual technologies: drivers of purchase decision						
Climate						
Climate battery NO1	0.121	0.117	0.231	0.231	0.429	0.335
Climate battery NO2	-0.127	-0.196	-0.88***	-0.877***	-0.551	-0.331
Climate battery NO3	-0.445***	-0.498***	-1.46***	-1.46***	-1.39***	-1.1***
Climate EV NO1	-0.185	-0.186	-0.724	-0.721	-0.797	-0.918
Climate EV NO2	-0.621***	-0.573***	-3.1***	-3.09***	-3.27***	-3.05***
Climate EV NO3	-1.13***	-1.05***	-5.22***	-5.21***	-6.17***	-5.9***
Climate heatpump NO1	-0.044	0.021	-0.133	-0.132	0.003	-0.07
Climate heatpump NO2	-0.692***	-0.61***	-2.88***	-2.87***	-2.1***	-1.81***
Climate heatpump NO3	-1.1***	-1***	-4.26***	-4.25***	-3.12***	-2.63***
Climate PV NO1	-0.112	-0.136	-0.141*	-0.141*	-0.006	-0.109
Climate PV NO2	-0.488***	-0.476***	-1.92***	-1.91***	-1.25***	-1.16***
Climate PV NO3	-1***	-0.935***	-2.43***	-2.43***	-2.03***	-1.93***
Savings						
Savings battery NO1	0.186	0.13	0.356	0.355*	0.736***	0.632*
Savings battery NO2	0.227*	0.156	0.055	0.055	0.565*	0.868*
Savings battery NO3	-0.085	-0.158	-0.448*	-0.448*	-0.273	0.098
Savings EV NO1	0.166*	0.164*	0.711*	0.711*	1.17*	0.778
Savings EV NO2	0.064	0.069	-0.319	-0.318	0.049	0.176
Savings EV NO3	-0.162	-0.204*	-1.16***	-1.15***	-1.33*	-1.32*
Savings heatpump NO1	-0.468***	-0.385***	-1.6***	-1.6***	-1.13***	-1.15***
Savings heatpump NO2	-0.457***	-0.371***	-2.4***	-2.39***	-1.61***	-1.25***
Savings heatpump NO3	-0.723***	-0.677***	-3.16***	-3.16***	-2.54***	-1.9***
Savings PV NO1	0.202***	0.175*	0.162*	0.162*	0.779***	0.625***
Savings PV NO2	0.042	0.021	-0.901***	-0.898***	-0.272	-0.204
Savings PV NO3	-0.234***	-0.288***	-1.13***	-1.12***	-0.833***	-0.732***
Self-sufficiency						
Self-suff. battery NO1						0.383
Self-suff. battery NO2						-0.766*
Self-suff. battery NO3						-0.876*
Self-suff. EV NO1						0.715
Self-suff. EV NO2						-0.3
Self-suff. EV NO3						0.026
Self-suff. heatpump NO1						0.315
Self-suff. heatpump NO2						-0.696*
Self-suff. heatpump NO3						-1.22***
Self-suff. PV NO1						0.478***
Self-suff. PV NO2						-0.243
Self-suff. PV NO3						-0.311

** = p-value < 0.05, ** = p-value <0.01, *** = p-value < 0.001*

Conclusions

- We propose a strategy to model the probability of being an early or late electrifier, considering 4 devices at the same time
- «No, but I consider purchase» is less similar to «I have it already» than to «No, I didn't think about it yet». Still, the milder shades of «No» have nothing in common with «No, I decided not to buy it»
- We try to detect the variables that lay behind various shades of «No»
  - We find a significant role of age, gender, education, size of the household, income, and availability of a public transport subscription
  - No rural/urban divide, no impact of the availability of a private parking for EVs among households

What to do next?

- Exploring the role of additional purchase drivers or characteristics of the respondents, mainly in the field of «technological affinity»
- Exploring the magnitude of the correlation across individual purchase decisions:
  - Including the other devices in the utility functions of one specific device
  - Including specific constraints for the respondents who have more than one device: financial constraints, technical constraints, negative experience
- Possibly exploring the role of latent attitudinal drivers (latent classes? Latent variables?)

Thank you!

Comments and suggestions welcome at:

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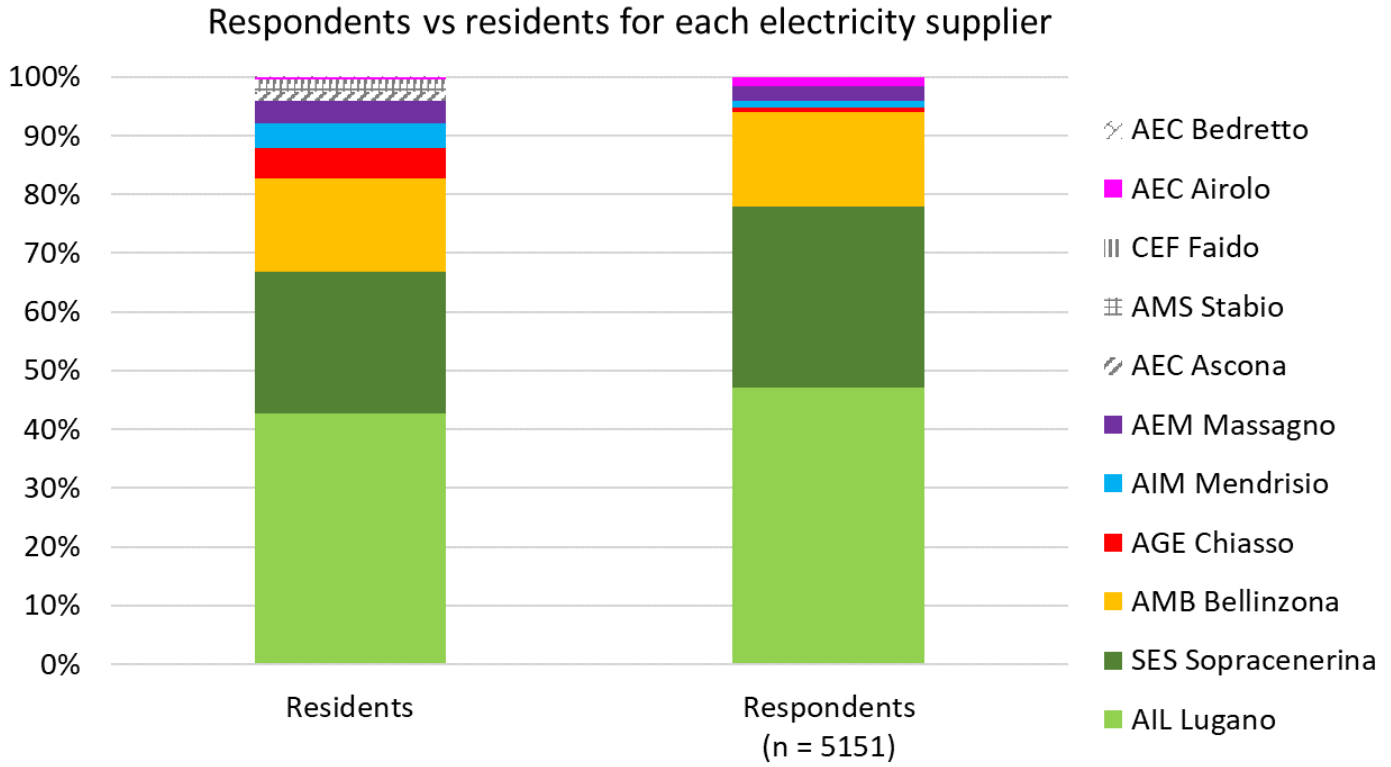
Sample description

Geographical coverage: population versus sample

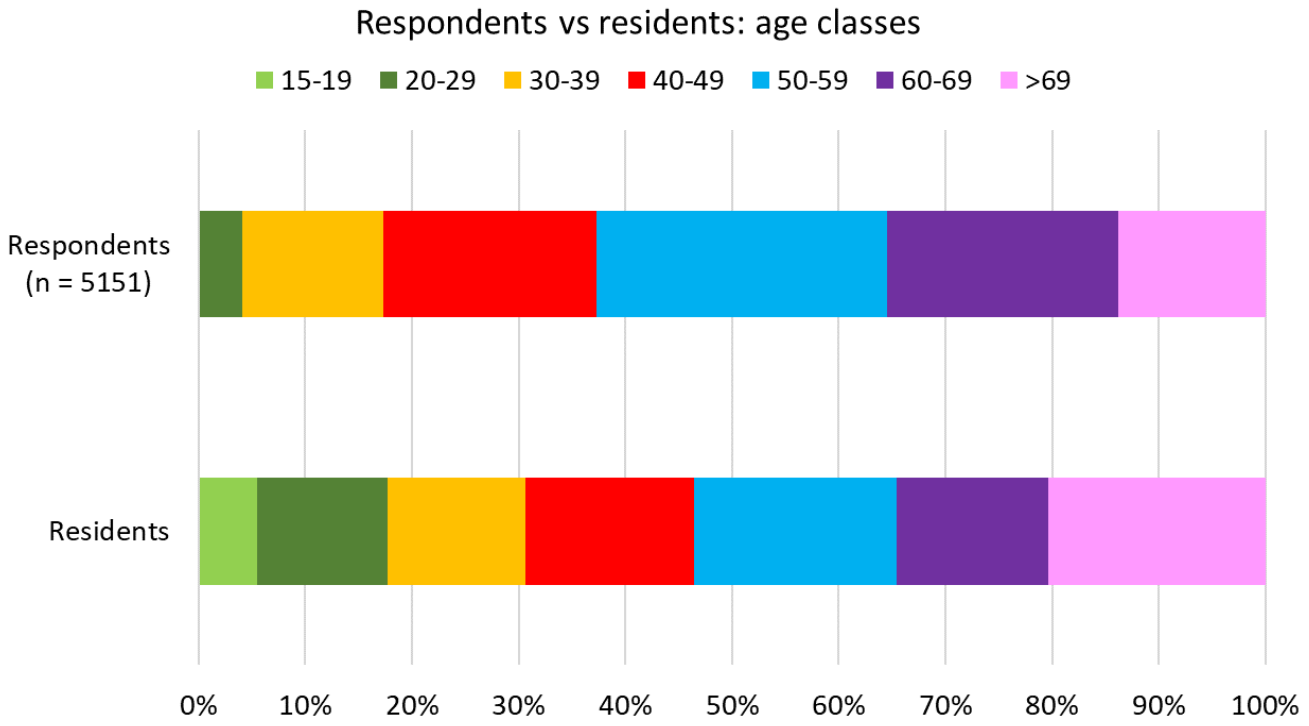


The municipalities served by the electricity retailers depicted with grey and white patterns were not included in the sample.

Respondents vs residents

The sample is reasonably representative of the population in terms of age classes.

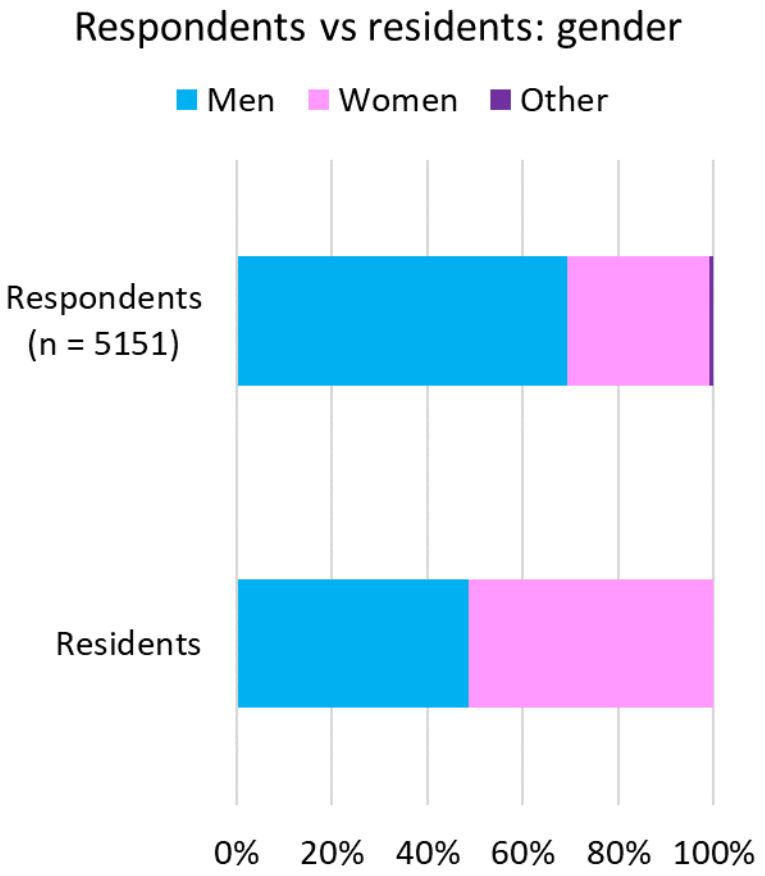
Please remind that the invitation to fill in the survey was sent to the person in charge of the household electricity contract, so people younger than 18 were mostly excluded.



Men are over-represented

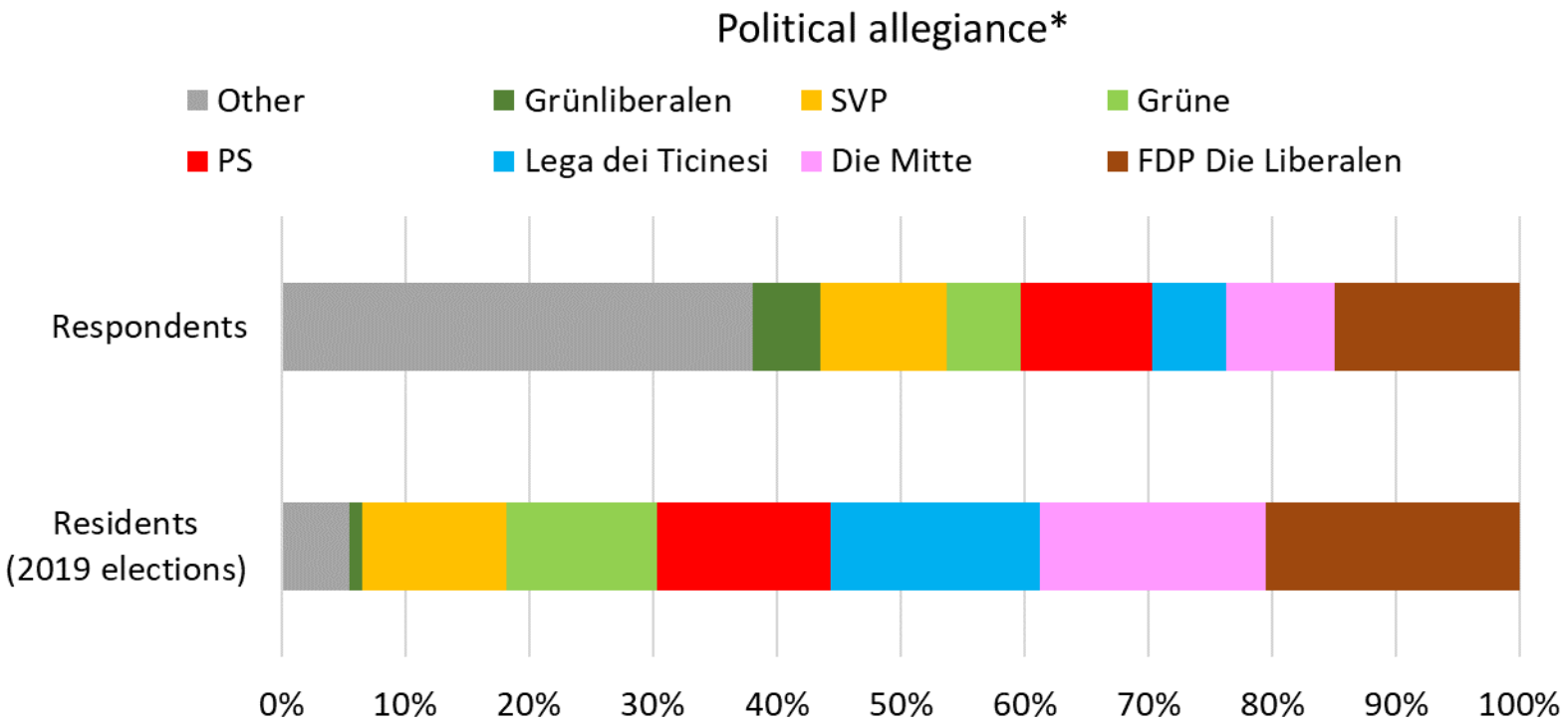
Men are often the family members in charge of signing the household's electricity contract.

As a consequence, our sample shows an over-representation of men as compared to women and people with non-binary or non-specified gender.



A fair coverage of the political spectrum

We asked more than half of the respondents to state their political allegiance, and included an option «Other» for those who didn't find their choice in our list. Our sample shows a reasonably good coverage of the political spectrum.

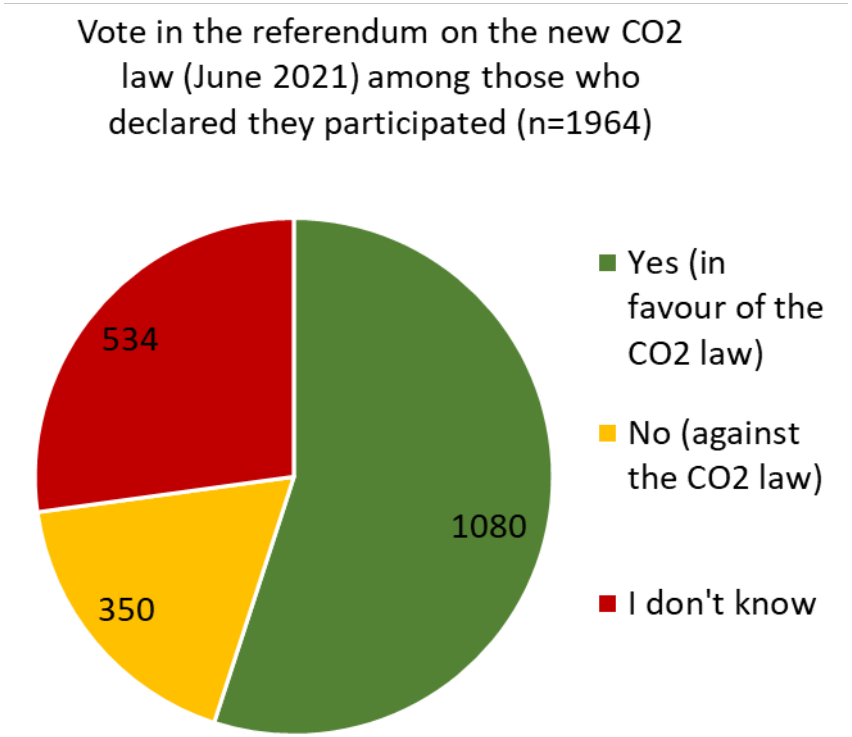


* n = 2723. Some respondents did not receive this question

Environmental concern is over-represented

We asked slightly more than half of the respondents whether they participated in the 2021 referendum on the CO2 Law.

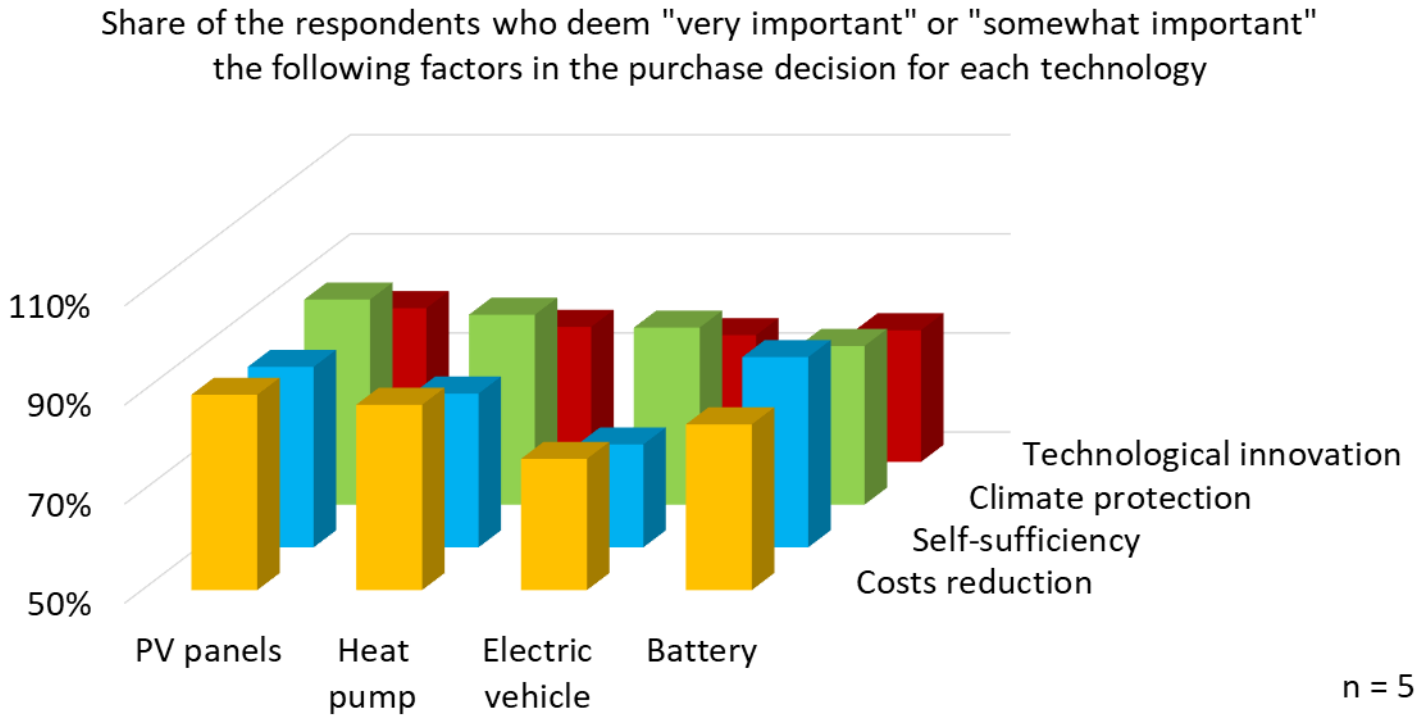
Among those who did, the supporters of the «yes» option are over-represented, with 55% against the 45% recorded in the results of the referendum for Canton Ticino.



Ownership of specific technologies

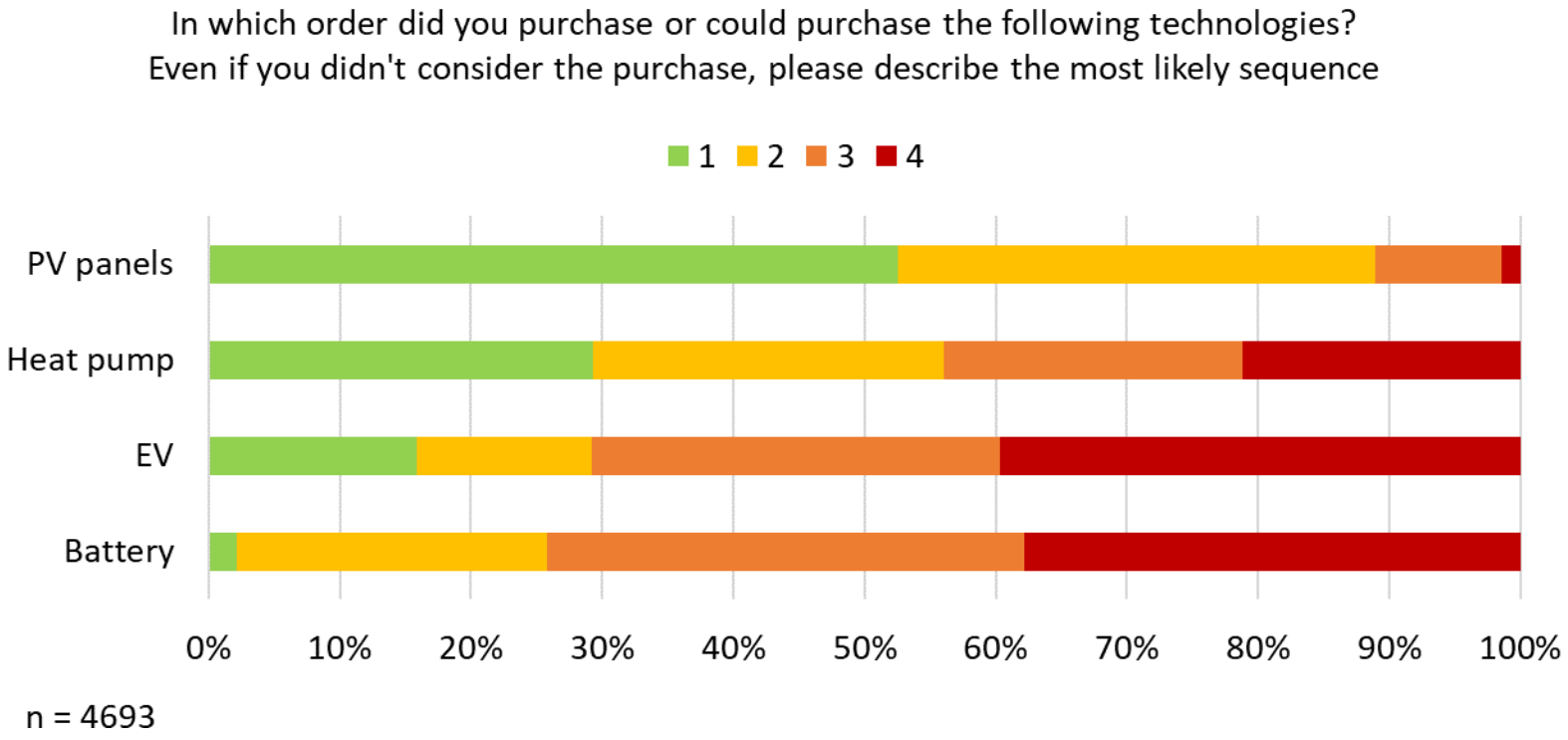
Why do respondents buy these devices?

Reducing greenhouse gas emissions is the main driver for purchasing PV panels, heat pumps and EVs. Batteries are instead mainly purchased to increase self-sufficiency in the own energy consumption. PV panels and heat pumps are also often purchased to reduce energy bills.



Which devices are purchased first?

When asked about the order in which they purchased or would purchase the four devices, homeowners state PV panels come first, followed by heat pumps, EVs, and batteries.

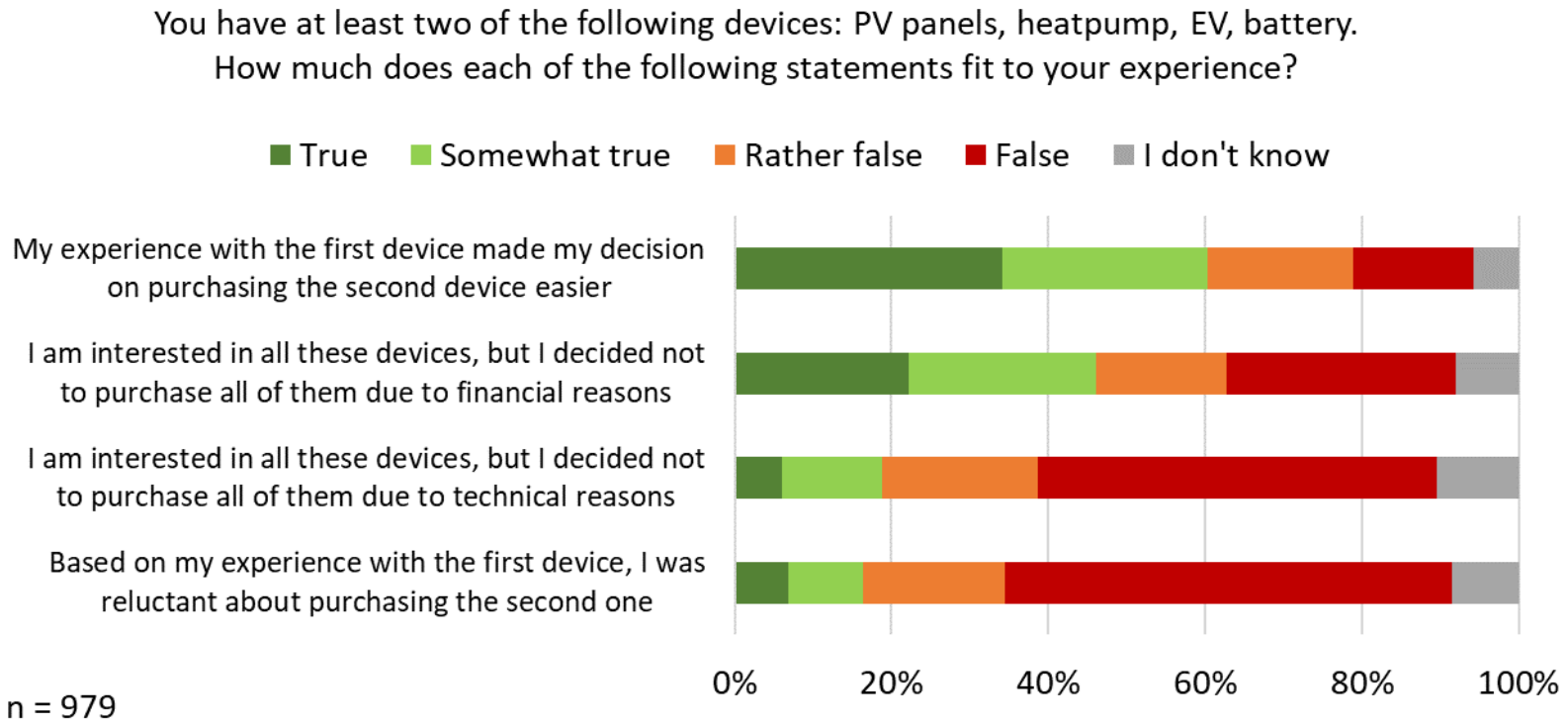


n = 4693

If you have one device, is purchasing the second one easier?

The respondents who own at least one of the four devices can decide more easily on the purchase of another device.

Budget constraints and, to a lesser extent, technical reasons may however limit purchase plans.

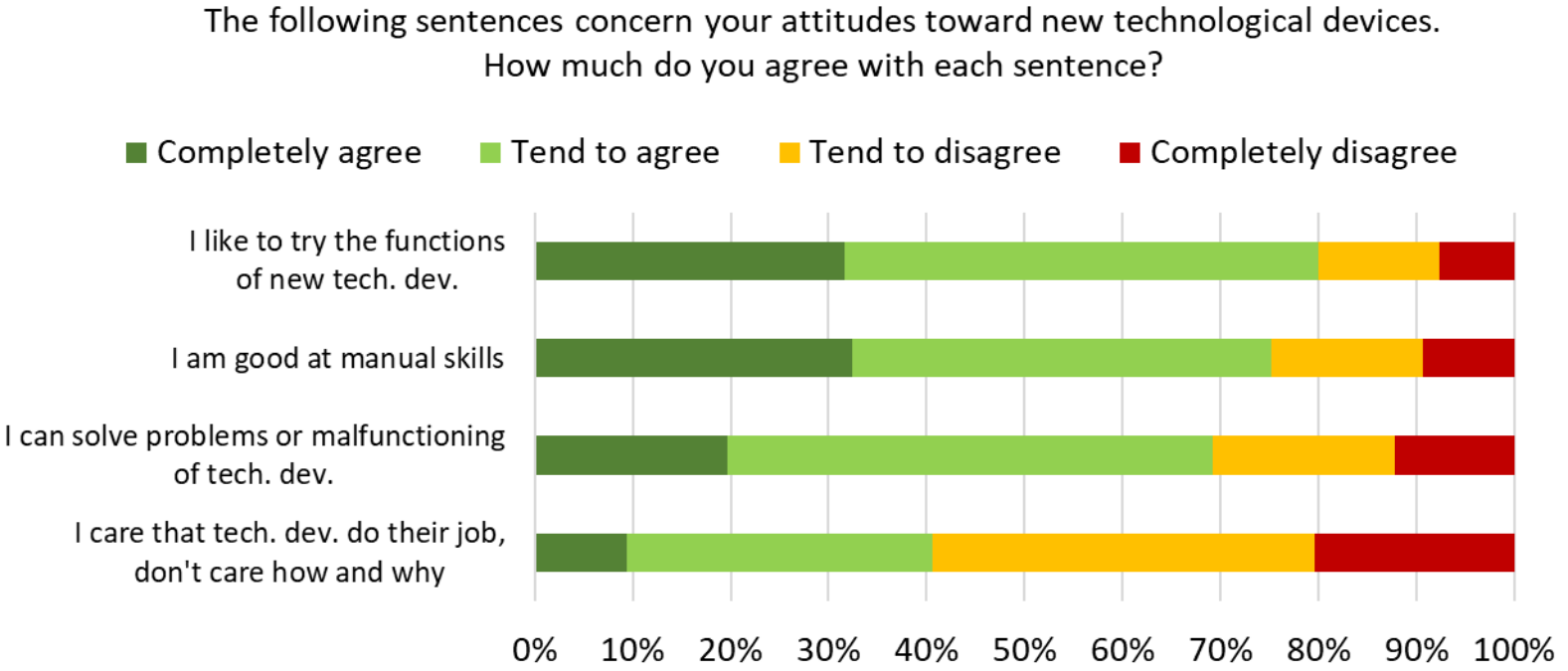


n = 979

How do responents feel about new technologies?

At least 70% of the respondents state they like to try new technologies and trust their own manual skills, and almost 70% state they can solve small problems or malfunctioning of the new devices.

Only 40% state they don't care about the technical details of the new devices, and are only concerned that the devices do their job.

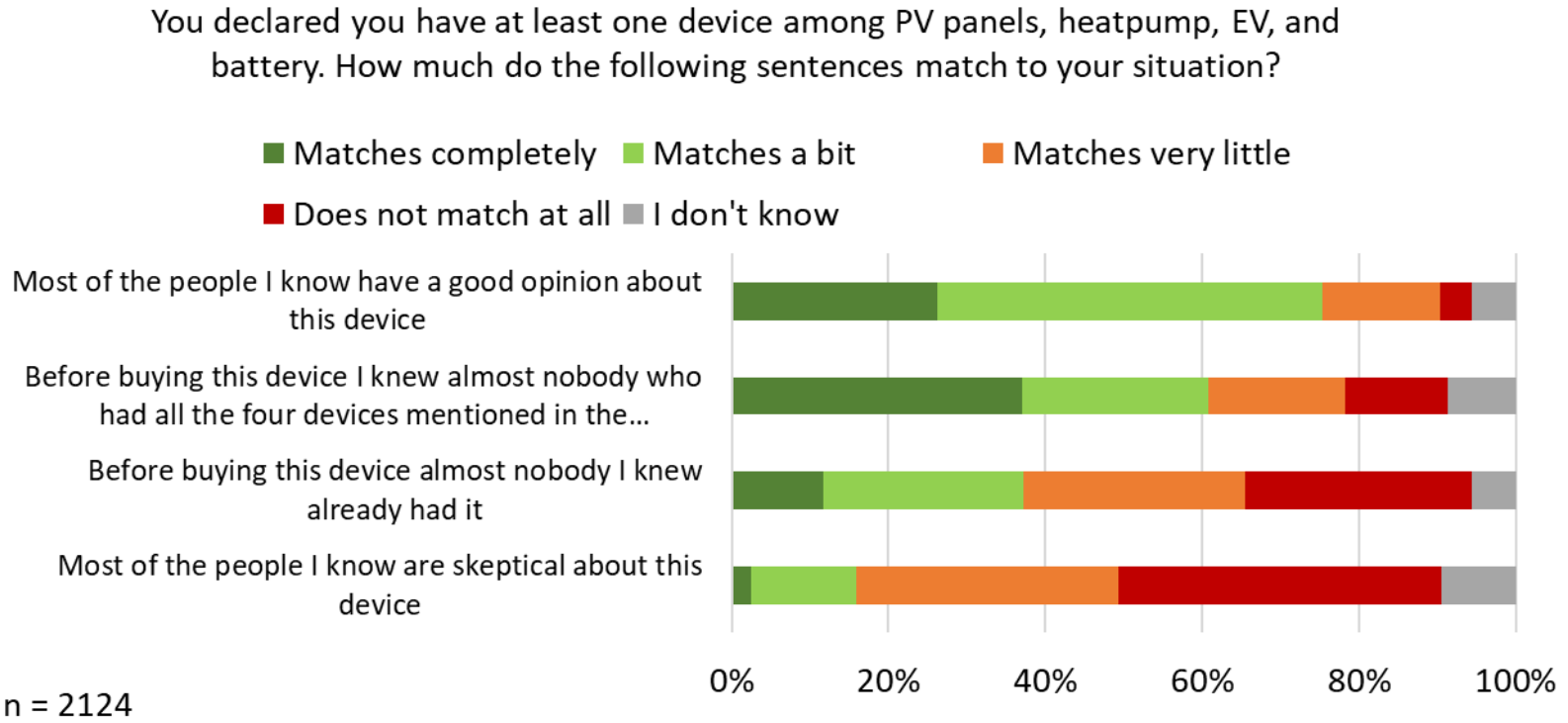


n = 5151

What is the influence of the peers?

People with whom the respondents are in touch on a regular basis have a strong impact on purchase decisions:

- More than 70% of the respondents who have at least one device state that their peers have a good opinion about it,
- Less than 40% state that they knew nobody or very few people owning a given device before they decided to purchase it.



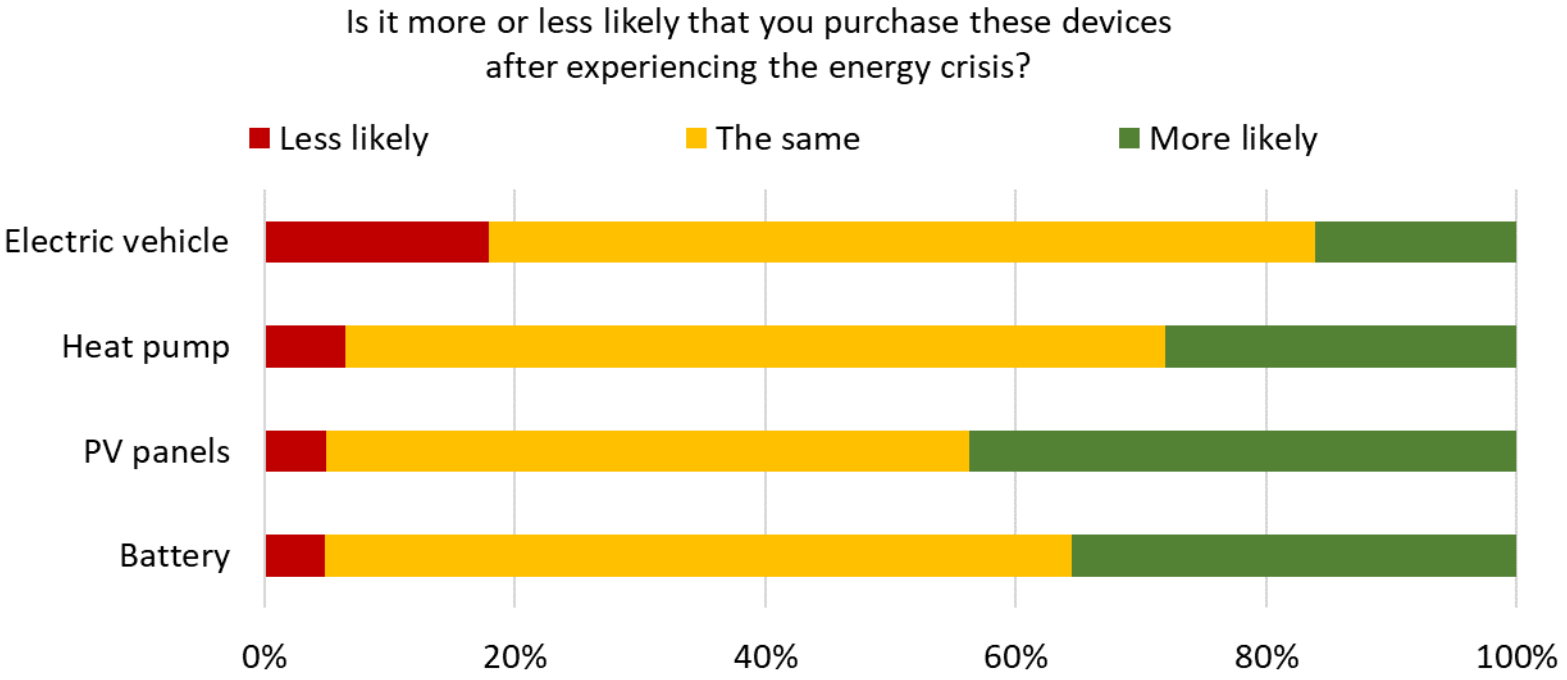
n = 2124

Energy crisis

New technologies and the energy crisis

The energy crisis has increased the likelihood of purchasing some of the devices for the electrification of households' consumptions: this is the case for PV panels, batteries, and heat pumps.

This trend does not hold for EVs. Indeed, only 17% of the respondents state that the probability of purchasing this vehicle has increased with the energy crisis, and 18% state it has decreased.

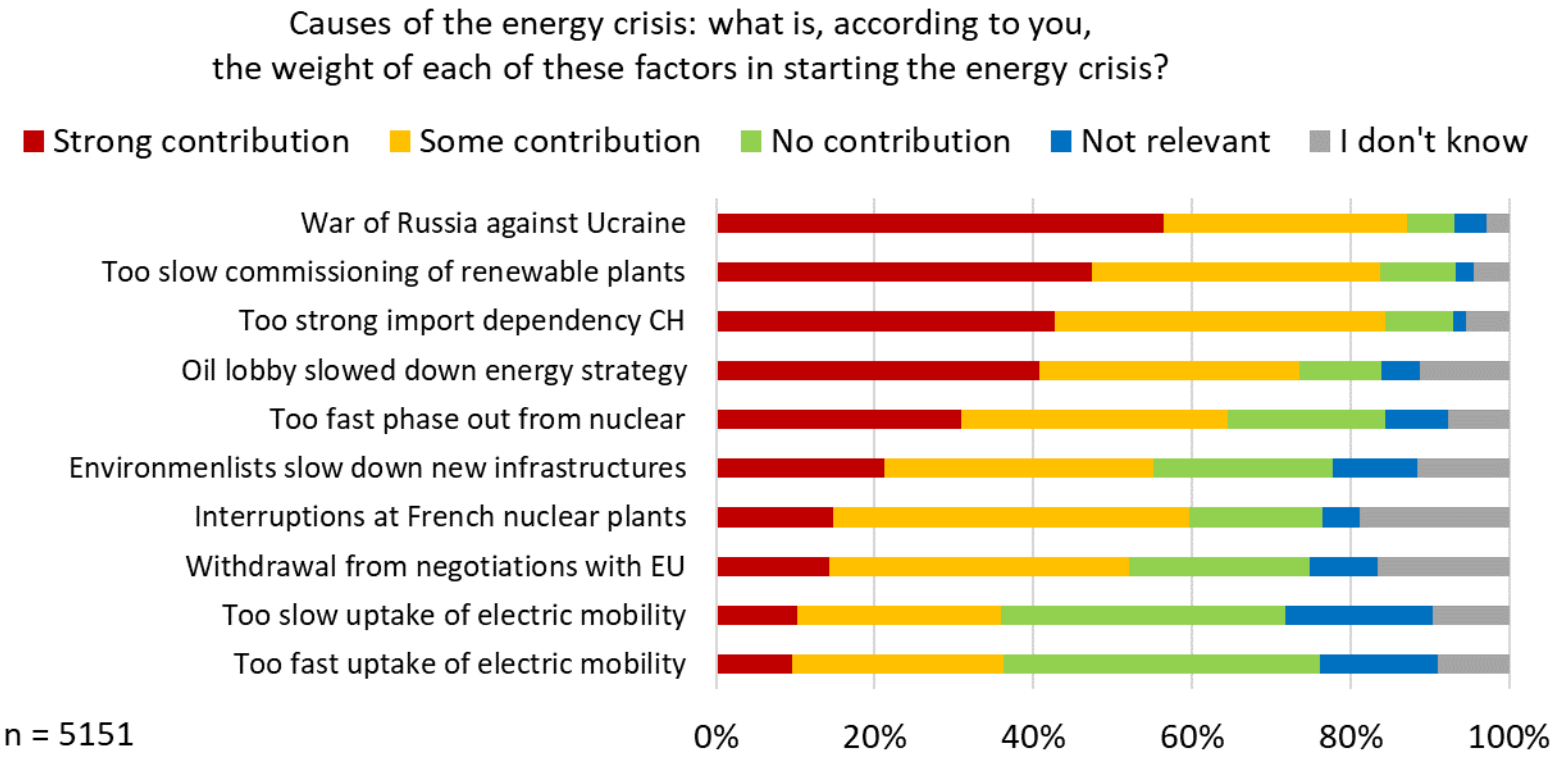


Homeowners who do not have each device yet; for EVs also tenants without EV

What are the causes of the energy crisis?

According to the respondents, the factors that contributed most to the energy crisis are the war between Russia and Ukraine, the slow commissioning of new renewable plants, the strong reliance on energy imports, the effectiveness of oil lobbies in delaying the energy transition, and finally the premature phase out of nuclear plants.

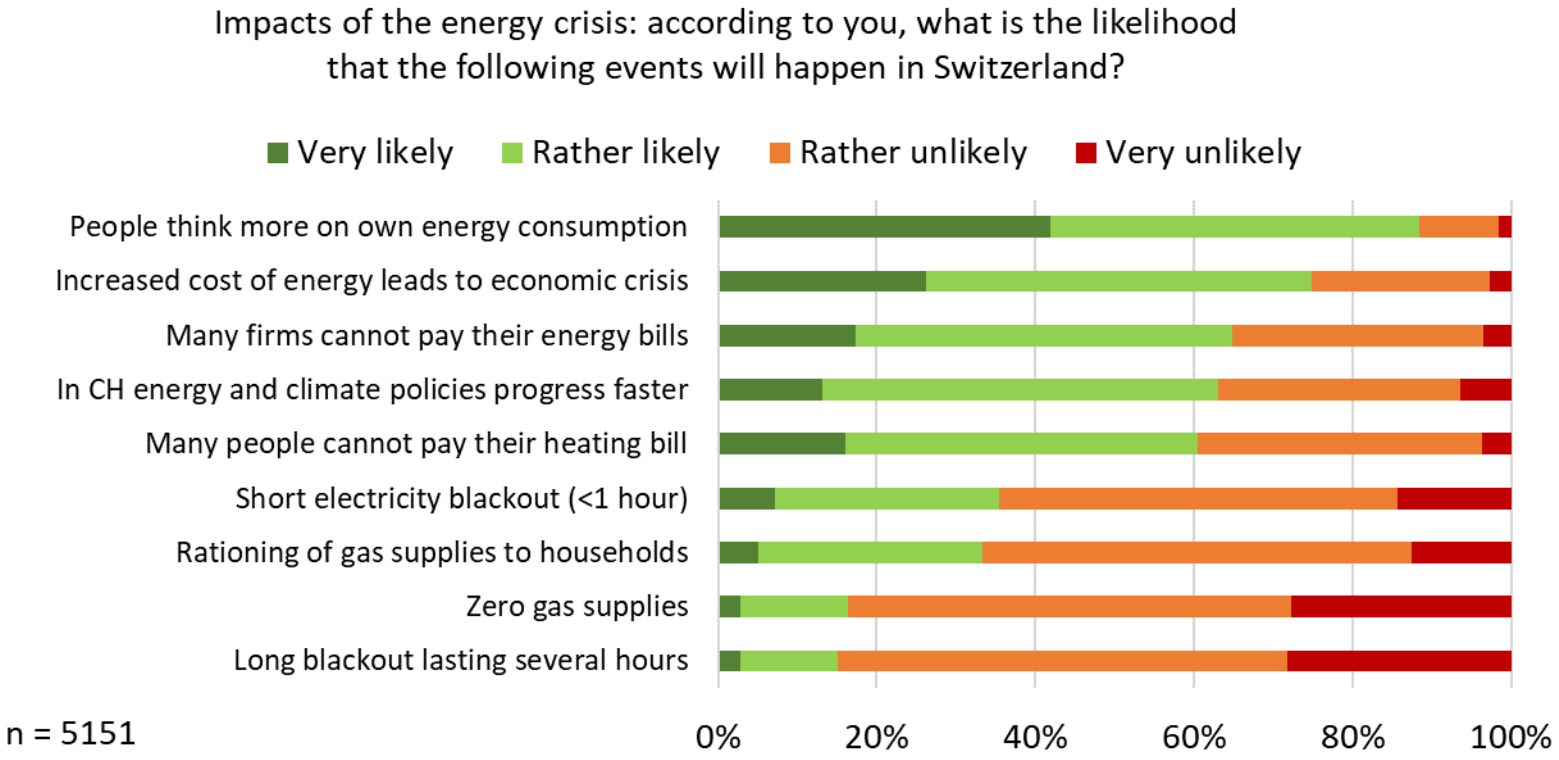
The uptake of electric mobility has instead a lesser role.



And its impacts?

Almost 90% of the respondents think that due to the energy crisis most people will think more about their energy consumption. Other likely consequences are an economic downturn, increased problems in paying the energy bills for families and businesses, and finally a push toward a faster energy transition.

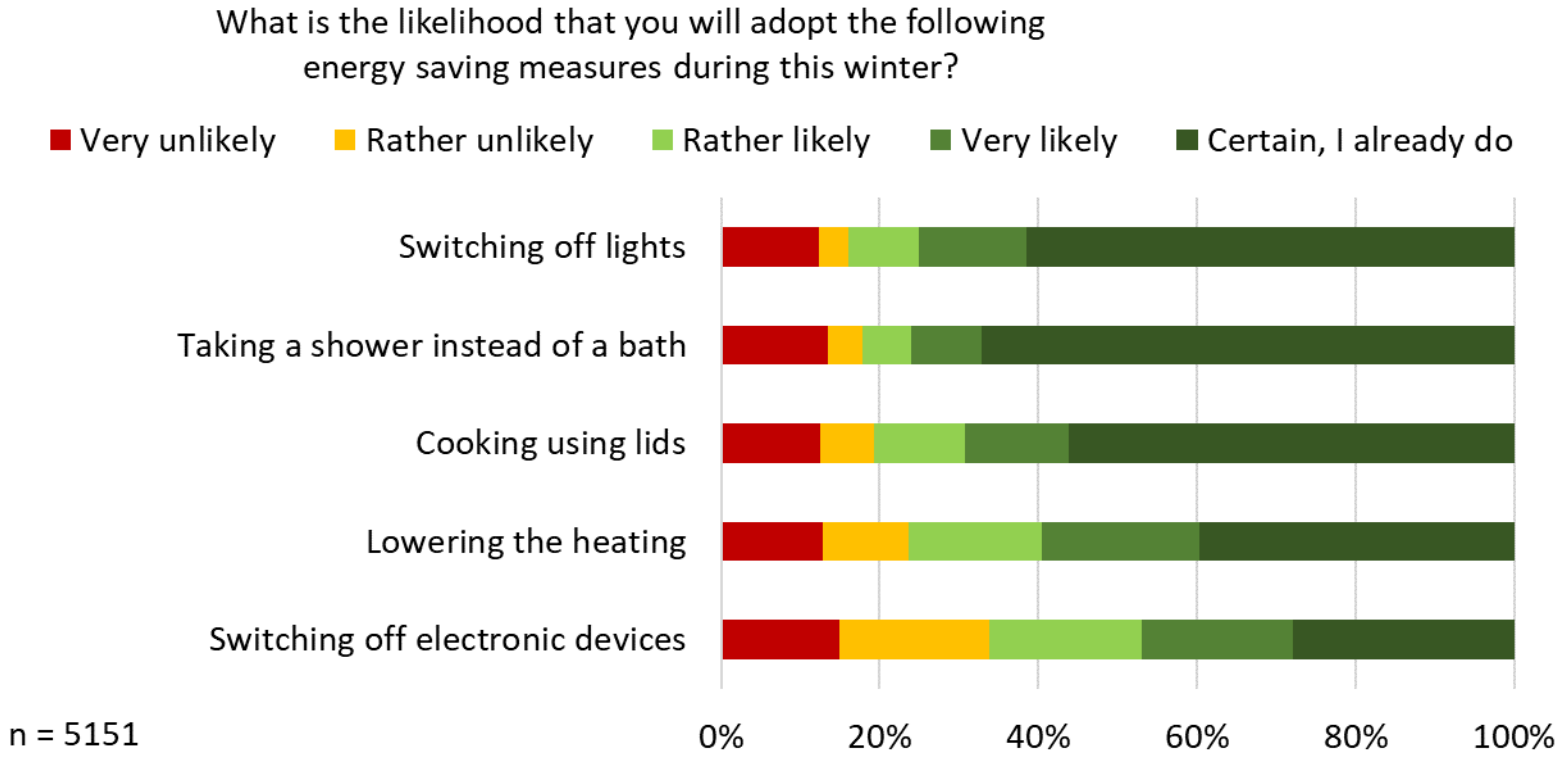
Electricity and gas blackouts, as well as rationing in energy supply, are deemed less likely.



Are respondents ready to save energy?

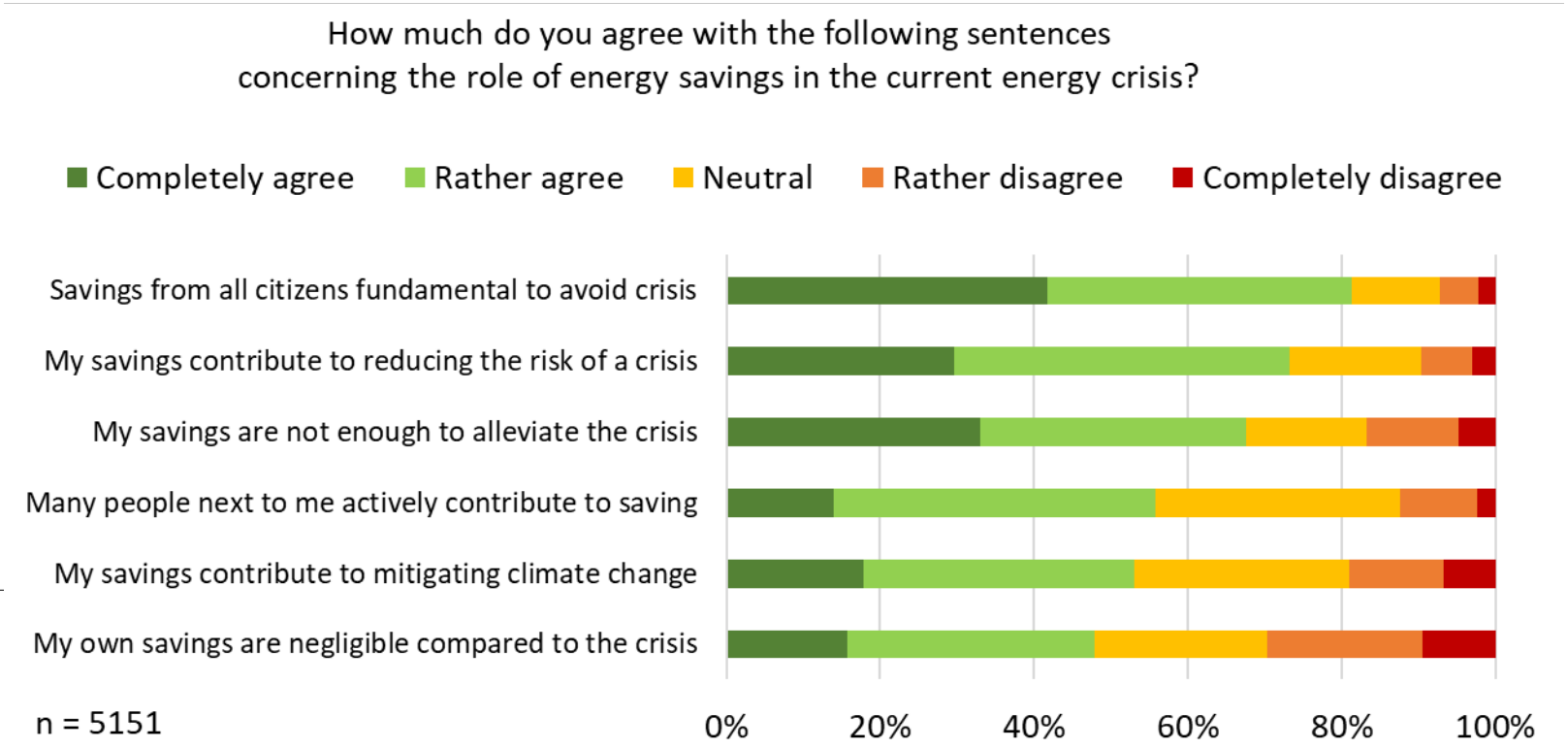
More than 80% of the respondents state they already adopt or would be ready to adopt energy saving measures such as switching off lights, taking a shower instead of a bath, and cooking using lids.

The propensity to lower the heating and switching off completely the unused electronic devices is instead a bit lower, albeit still well above 60%.



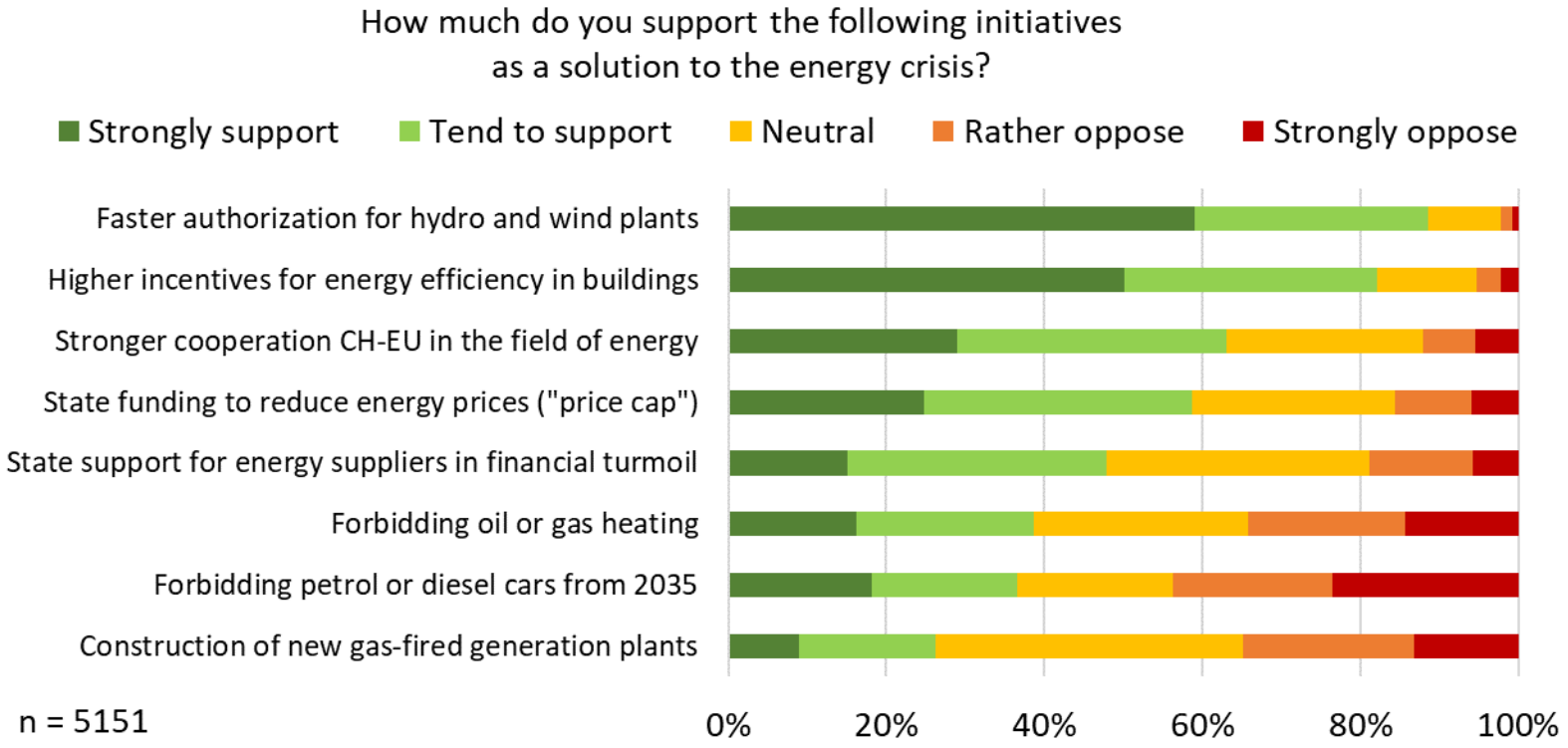
Individual effort is essential, but may not be enough

While slighly more than half of the sample think that the own savings contribute to mitigate the crisis, almost 70% believe that individual savings are not enough to solve it. When it comes to climate change, 53% of the respondents think that individual energy savings contribute to mitigation.



What is the way out of the energy crisis?

The respondents prioritize a faster authorization of hydroelectric and wind plants, higher incentives for energy efficiency in buildings, a stronger cooperation with the European Union, and some state funding to reduce energy prices.



Do blackouts, imports, and nuclear accidents cause concern?

More than 80% of the respondents consider blackouts as very costly for businesses and annoying for families. Around 80% are concerned about depending on energy imports. Only 30% think it is a good idea to phase out nuclear generation in Switzerland. The risk of a nuclear accident in the country is very low for more than 70% of the sample.