



Quantifying the Social Potential of Community-Based Energy Cooperatives to Contribute to EU-28 Climate and Renewable Energy Targets

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Why do we care about energy cooperatives?

- ▶ Ability to bring under-privileged groups into the **energy transition**
 - ▶ Allows participation for those low on capital or with improper infrastructure
 - ▶ Can be used to bridge the **investment gap** by collecting extra funding
- ▶ Can be used to motivate consumers through **group-efficacy**
- ▶ Possibility to improve grid efficiency through local balancing / consumption
- ▶ Possibilities to pay dividends into community development (improved grid resilience, public works, etc.)

Ongoing research into energy communities

- ▶ How should they be set up (functionally, socially, financially)
- ▶ Technologies to improve / implement them
- ▶ Possibility explorations – using energy communities in the grid-context
- ▶ Social acceptance, inclusion and equity issues

Among others...

Despite all this research we have no benchmark estimates for the impacts of energy communities in the short – medium term!

The investment gap

- **To reach 2030 Energy targets:**
- 380 billion EUR per year needed as investment^{1,2}
- Last year only 201 billion EUR was invested
- **Investment GAP = 179 billion EUR per year**
- 34 billion² per year needed in new **renewable energy capacity**

Research Question:

To what extent can renewable energy cooperatives help to fill in the investment gap?

¹ European Commission. (2018a). *Commission staff working document impact assessment*. (SWD(2018) 264 final).

² Williams, R., Eichler, L., Gottmann, N., Förster, H., & Siemprns, A. (2018). *Energy and the MFF*.

How to address this research question?



Enter:

Survey Based Social Simulation (SBSS)

Basic Idea:

1. Use stated choices from surveys to impute choice probabilities
2. Given the estimated choice probabilities optimize some objective function

Quantity of interest



SOCIAL POTENTIAL:

The maximum amount of funds able to be collected for RE cooperatives from citizen participation in country N

Mathematically:

$$\tilde{\pi}_N = (P_n b_n) pop_N$$

- π_N is the social potential
- P_N is the probability that a representative individual in country N chooses to invest in an energy cooperative
- b_N is the capital requirement for an investment
- pop_N is the number of investment aged individuals (25- 65)

How to calculate the social potential? echoes

First step:

Need an estimate of P_N , the probability of investing in a cooperative under given conditions

Enter:

**The Investment Choice Experiment
Survey**

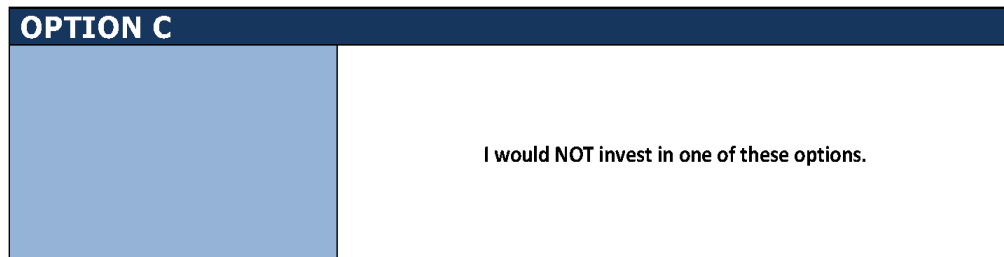
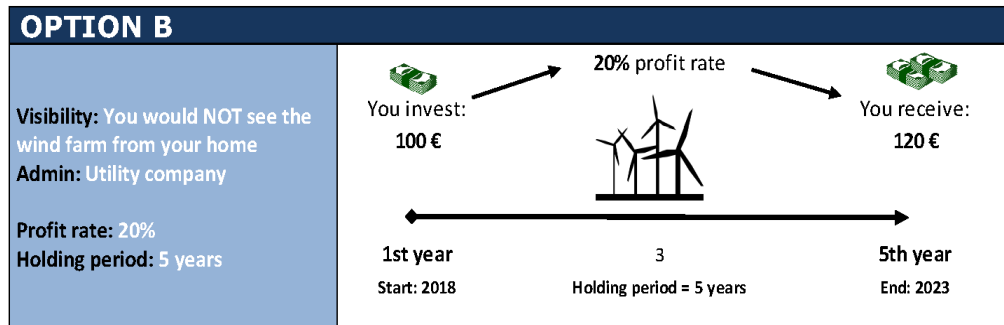
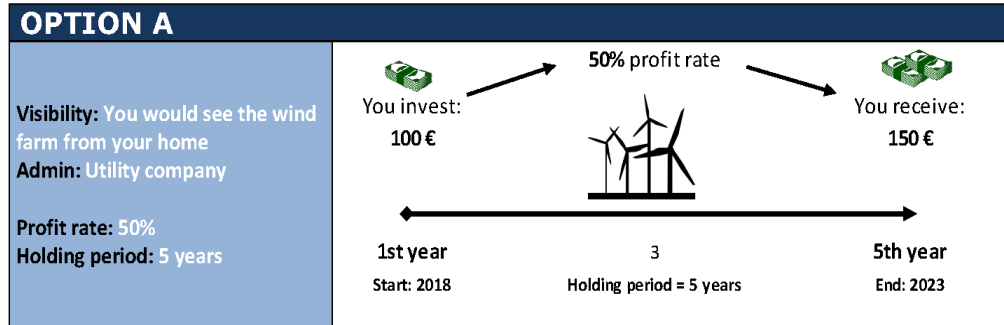
Energy choice experiment

Example scenario

► Imagine a scenario where you are being offered the opportunity to buy a share of a community renewable electricity project that will cost you b_N EUR. $b_N \in [100, 5000]$

► Community renewable projects are solar or wind power plants that are made possible by financing from groups of private citizens who each put some money towards the project.

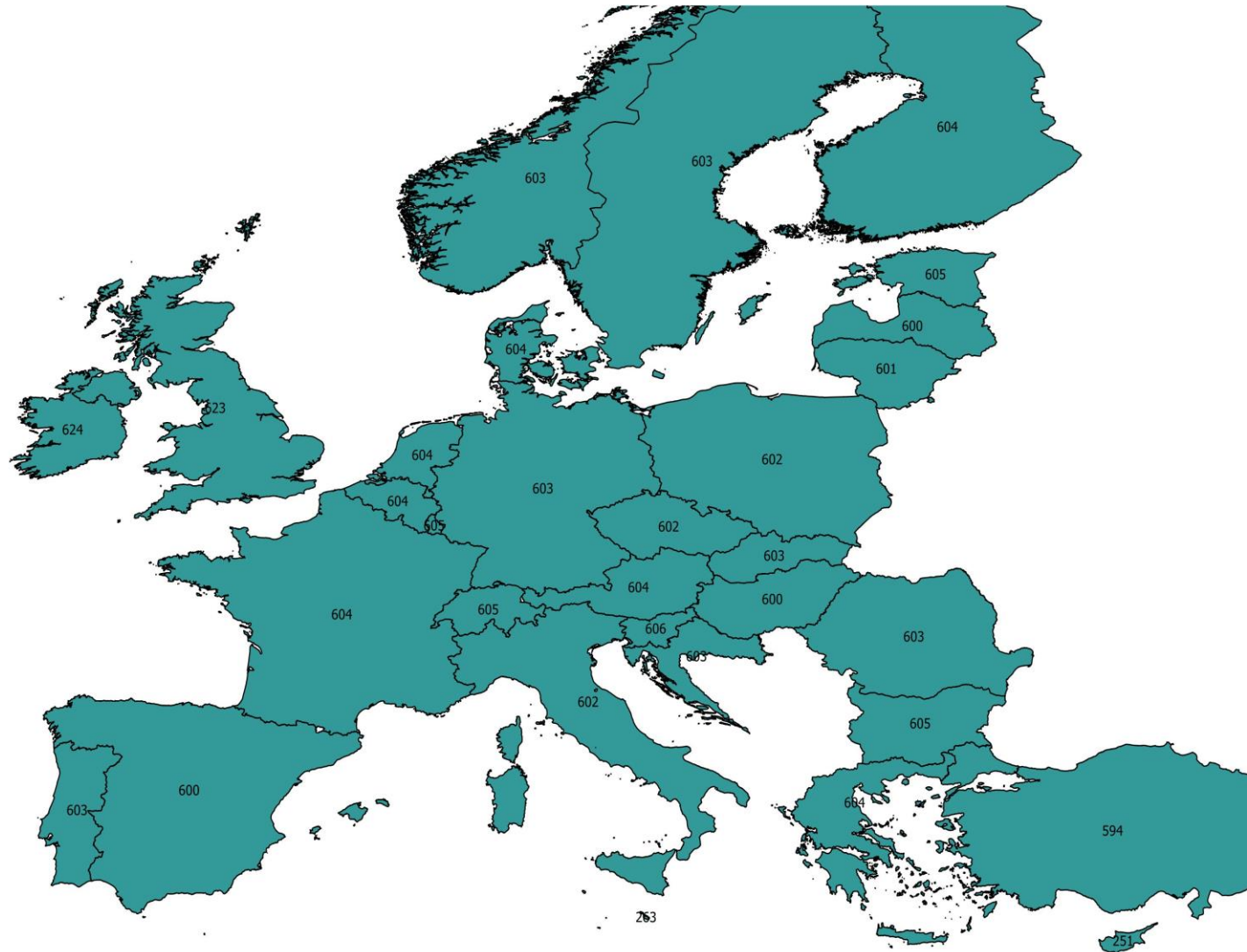
► Which option would you choose?



The International Survey



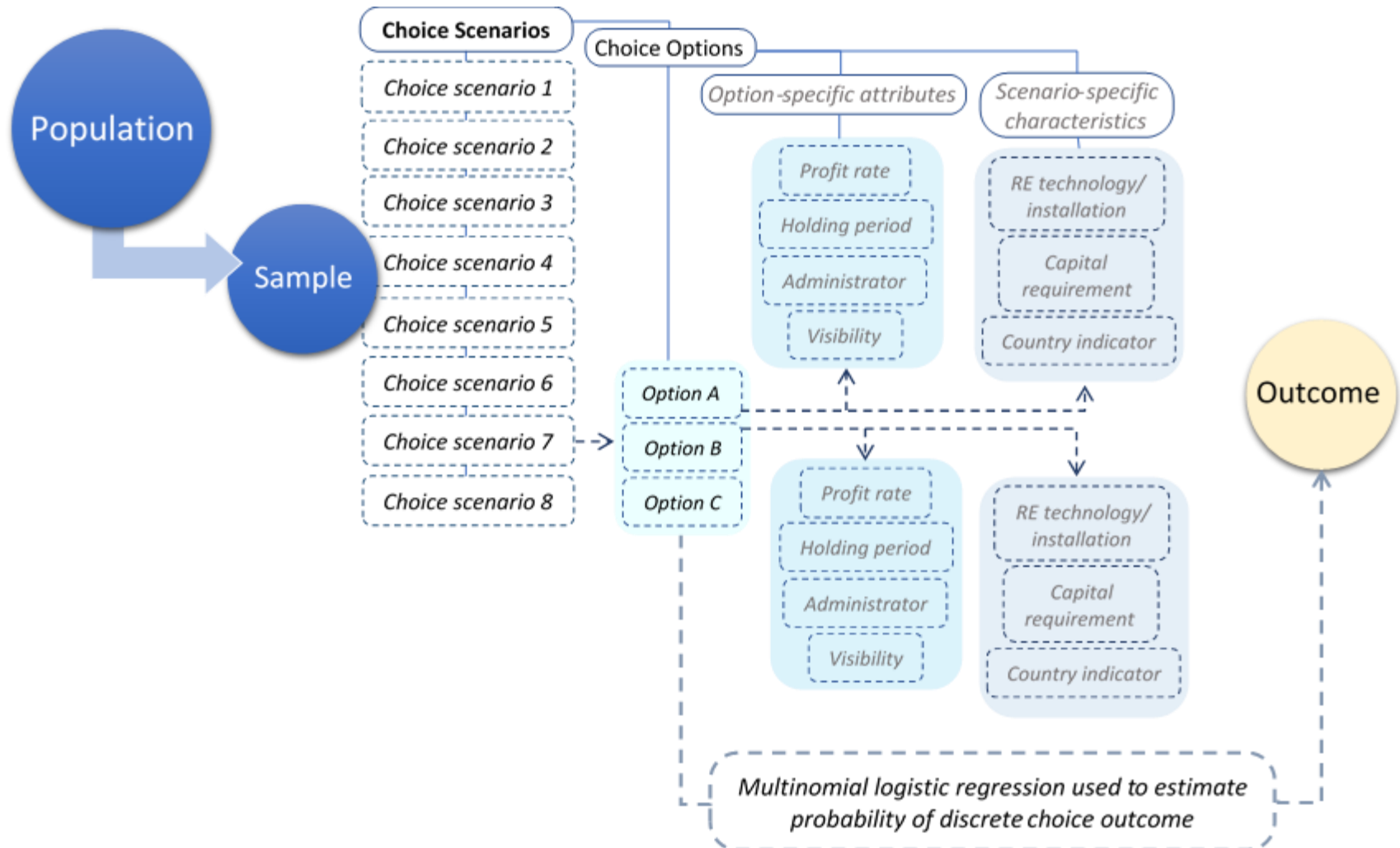
- ▶ 31 Nations
- ▶ 28 Languages
- ▶ ~600 respondents per nation
- ▶ ~20 minutes per response
- ▶ Web-based interface



Survey Sampling

- ▶ EU-28 + Norway, Switzerland and Turkey
- ▶ Representative sampling quotas in age, gender, income dimensions
- ▶ Online panel companies provide email contacts in each nation
- ▶ Respondents earn credits with the contractor for completing the survey
 - ▶ Not only people interested in the topic take the survey!
- ▶ Respondents were randomly assigned to a survey version
 - ▶ Different versions test various treatment effects
 - ▶ They can also control for biases that come from the survey structure (question order, etc.)

Multinomial choice model - Overview



Multinomial choice model – Random Utility echoes

Indirect utility for choice option i for person n

$$U_{in} = Z_{in}\boldsymbol{\beta} + S_n\boldsymbol{\alpha}_i + \epsilon_{in}$$

Social potential target quantity:

$$\tilde{\pi}_N = (P_n b_n) \text{pop}_N$$

Thus, for an investment choice with 3 options A, B and C:

$$P_n = \text{Prob}(U_{An} > U_{Cn} | U_{Bn} > U_{Cn})$$

Multinomial choice model – Choice Probabilities

P_n is a CONDITIONAL probability, conditioned on the estimated coefficients and observed variables that define the indirect utility:

$$U_{in} = Z_{in}\beta + S_n\alpha_i + \epsilon_{in}$$

Since this is a social potential (maximum) we use the observed preferred settings in the overall sample to calculate P_N

Variable/trait	β & α_i effects	Std. Err.	P-value
Community admin.	0,031473	0,002579	0
Holding period	-0,021723	0,00032	0
Solar farm	-0,01774	0,001945	0
Visibility	0,005923	0,001938	0,002
Profit	0,000267	3,70E-06	0
Level of investment	-0,000059	2,10E-06	0
Government admin.	-0,002493	0,002626	0,342

Multinomial choice model – Choice imputation

Avg. **Preferred investment** over all EU-28 respondents:

- **Wind park**
- Visible from home
- Community administered
- 20 year holding period – set based on turbine life span
- Profit rate – calculated based on market data

F_N – the imputed choice probability of an avg. respondent of country N investing in a cooperative with the above characteristics, with 0 capital

$$P_n = \hat{F}_n + \hat{\gamma}_{1N} b_n + \hat{\gamma}_{2N} (b_n r_n)$$

Calculating social potential

Maximize invested funds from representative individual:

$$\pi_n = P_n b_n$$

Subject to:

$$P_n = \hat{F}_n + \hat{\gamma}_{1N} b_n + \hat{\gamma}_{2N} (b_n r_n)$$

Gives the optimal investment ask per person:

$$b_n^* = \frac{-\hat{F}_n}{2(\hat{\gamma}_{1n} + \hat{\gamma}_{2n} r_n)}$$

<i>Estimated social potential for a sample of EU-28 nations</i>						
Sample Countries	Respondents saying “yes” to at least 1 investment	Optimal scenario bN	Probability of accepting investment PN	Expected collection per adult citizen	Pop. expected to invest	Social potential: expected EUR collected per country Mil. EUR
Austria	82%	€ 3,560.18	21.20%	€ 754.73	4,877,713	€ 3,681.35
Belgium	71%	€ 3,087.35	12.01%	€ 370.94	6,016,415	€ 2,231.73
Cyprus	82%	€ 2,797.81	28.93%	€ 809.47	465,867	€ 377.11
Czech Rep.	80%	€ 2,747.61	16.70%	€ 458.86	5,934,718	€ 2,723.21
Denmark	64%	€ 6,383.83	13.53%	€ 863.51	2,949,119	€ 2,546.58
Estonia	91%	€ 5,955.53	34.68%	€ 2 065.57	718,337	€ 1,483.78
Finland	74%	€ 2,466.23	14.28%	€ 352.22	2,828,695	€ 996.32
France	71%	€ 2,774.88	13.47%	€ 373.90	33,896,476	€ 12,674.02
Germany	74%	€ 3,488.24	12.99%	€ 453.20	45,221,866	€ 20,494.59
Greece	88%	€ 3,127.40	27.02%	€ 845.09	5,804,056	€ 4,904.92
Hungary	84%	€ 2,908.52	20.93%	€ 608.66	5,457,241	€ 3,321.61
Slovenia	82%	€ 4,517.52	26.6%	€ 1,205	1,171,362	€ 1,411.77
EU28	79%	€ 3,847.19	20.12%	€ 638.02	276,273,139	€ 176,267.55

Summarized Results



Descriptive

- 79% of respondents chose at least one investment option.
- Respondents chose to invest in 57% of the choice scenarios presented to them.
- On average across the EU28:
 - Strongly prefer a community-owned legal entity (i.e. energy cooperative) as admin.
 - Prefer wind parks above solar farms.
 - 0.6% more likely to invest if RE installation visible from household.
 - Every additional €100 profit → 2.7% increase in willingness to invest.
 - 2.2% decrease in willingness to invest for every extra year waiting



Social potential

- €176 billion to wind cooperatives = 91GW of new wind power (an 8% increase in EU RES)
- Introducing RE support mechanisms increases social potential to €224 billion (1.5% of the EU's GDP in 2017) = 27% increase



Bridging the investment gap with wind cooperatives

- **Investment GAP** to 2030 targets = 179 billion EUR per year
- 34 billion per year needed in new **renewable energy capacity**
- **Social potential** for wind cooperatives = 176 billion EUR

Research Question:

To what extent can renewable energy cooperatives help to fill in the investment gap?

Answer:

One year of the next decade's investment gap, and 5 years (half) of the necessary investment in renewables could be provided by wind farm cooperatives across the EU – 28, based on the social potential for participation

Policy Implications

- Investments in energy cooperatives can be a significant aid to energy transition but by no means are fix for investment fund issues.
- Taking advantage of the social potential requires that the conditions of the choice experiment exist in more nations
 - Cooperatives have only taken off in Denmark and Germany so far
- Low-risk, **trustworthy** community investment options are needed in the other EU nations
- These options should be **visible** and offered actively to the citizenry
- **Insured investment** and **community organization development** initiatives are promising policy steps

Robustness Check for hypothetical bias



- The experiment included a built-in control for hypothetical bias, by asking respondents to give their email for follow-up investments
- Responses to the choice experiment that were inconsistent with responses to the email question were discarded due to potential hypothetical bias / lack of attention
- Re-running the analysis with the sub-sample of 'un-biased' responses results in similar coefficient estimates and an estimated social potential of **150 billion EUR** (a 14% decrease)

Final thoughts on the SBSS (Survey Based Social Simulation) method



SBSS compared to Agent Based Models (ABM)

SBSS	ABM
Based in an accepted theoretical framework (random utility theory)	Ad hoc or no theory, depending on the implementation
Standardized data collection (via choice experiments)	Ad hoc data collection and adaptation of data to models
Limited in scope and research questions	Completely flexible and adaptable to any research question
Possibility to add error quantification (via bootstrapping)	Unclear, error bounds not usually estimated
Subject to hypothetical / sampling biases	Subject to strong assumptions about agent actions / utilities
Focuses on representative individual(s) – hides heterogeneity	Can embrace heterogeneity in simulated populations



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