# Electronic Home Energy Reports: A Bust for Energy Conservation?

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# Energy Conservation in the EU

- Target of a 55% reduction in economy-wide greenhouse gas emissions by 2030 compared to 1990 for EU member states (EU 2018)
- Energy sector: Clean generation and energy efficiency/savings as two strands to reduce carbon emissions
- Increased electrification of heating and transport sector will challenge electricity supply → Induce electricity savings where possible, e.g. for private households
    - Economic incentives
    - Non-price-based instruments, e.g. improved information and social comparisons → Home Energy Reports (HER)

# Energy Conservation and HERs

- Considerable electricity savings from HERs found in the U.S. (Allcott 2011; Allcott and Rogers 2014):
    - Reductions in electricity consumption of 1.4-3.3%
- Smaller effect sizes in Europe reduce cost-effectiveness:
    - Average energy consumption reduction by 0.7% found in RCT for Germany (Andor et al. 2020) $\rightarrow$ Electronic HERs

# Energy Conservation and HERs

- Considerable electricity savings from HERs found in the U.S. (Allcott 2011; Allcott and Rogers 2014):
  - Reductions in electricity consumption of 1.4-3.3%
- Smaller effect sizes in Europe reduce cost-effectiveness:
  - Average energy consumption reduction by 0.7% found in RCT for Germany (Andor et al. 2020) $\rightarrow$ Electronic HERs
- Heterogeneity: Mixed evidence
  - Stronger effects for high-consumers (Allcott 2011; Ferraro and Price 2013; Andor et al. 2020) vs. boomerang effects (Ayres et al. 2013; Byrne et al. 2018) $\rightarrow$ Targeting
  - Electronic HERs and no heterogeneity (Henry et al. 2019)
  - Role of (political) ideology (Costa and Kahn 2013)

## Research Question

- Do electronic home energy reports in Austria lead to energy savings for eco-electricity customers?

## Our Contribution

- Evaluation of the effect of electronic HERs on electricity consumption in an European country
- Analysis of the effectiveness of electronic HERs for customers of eco-electricity provider
- Novel heterogeneity analysis according to deviation between household's pre-treatment electricity consumption and average zip code consumption

# Data

- Consumer data from RCT with eco-electricity customers in Austria 2013-2016:
    - 9,039 households
    - Four e-mails with social comparisons and energy saving tips HER
    - Mails sent on (roughly) quarterly basis between 2015 and 2016
    - 2 periods of interest: Baseline and treatment period
    - Annual consumption converted to daily levels due to different lengths of billing periods

# Balancing

| | All | Control | Treatment | t-Statistic |
|---|---|---|---|---|
| Daily baseline consumption, in kWh | 7.70 | 7.72 | 7.68 | -0.41 |
| Length of baseline period, in days | 309.72 | 309.98 | 309.46 | -0.24 |
| Number of households | 9,039 | 4,533 | 4,506 | |

Population

# Difference-in-differences (DiD) Estimation

$$\Delta Y_i = \alpha + \beta * T_i + \tau_w + \epsilon_i \tag{1}$$

- $\Delta Y_i = (Y_i^T - Y_i^B)/Y_{i,c}^T$ corresponds to the change in daily electricity consumption of household $i$ before ($Y_i^B$) and after the HER treatment ($Y_i^T$), normalized by the average post-period control group consumption ($Y_{i,c}^T$) (see Allcott 2011)
- $T_i$ is the treatment variable
- $\beta$ is the coefficient that captures the average treatment effect (ATE), expressed as average electricity savings as percentage of the average consumption level
- $\tau_w$ includes weekly dummies for both baseline and treatment period
- $\epsilon_i$ is an idiosyncratic error term

# Heterogeneity and Treatment Intensity

1. Standard approach in literature: Differing treatment effects according to absolute level of baseline consumption, e.g. baseline consumption deciles
2. Our approach: Differing treatment effects according to treatment intensity given by social comparison in the HER
    - Intensity defined by deviation of mean baseline consumption within a household's zip code from household baseline consumption ($Y_i^B - \bar{Y}^B$) HER

## DiD: Social Comparison Treatment Intensity

$$\Delta Y_i = \alpha + \lambda_1 * T_i + \lambda_2 * T_i * D_{Y_i^B - \bar{Y}^B} + \tau_w + \epsilon_i. \qquad (2)$$

$$\left.\frac{\partial \Delta Y_i}{\partial T_i}\right|_{d_h} = \lambda_1 + \lambda_{2,d_h} * (Y_i^B - \bar{Y}^B) \qquad (3)$$

- $D_{Y_i^B - \bar{Y}^B}$ denotes deciles of the deviation of the mean zip code baseline consumption from household baseline consumption
- $\lambda_1 + \lambda_{2,d_h} * (Y_i^B - \bar{Y}^B)$ captures the treatment intensity depending on the deviation of the mean zip code baseline consumption from a household's baseline consumption for each decile $h$

# ATE and Heterogeneity according to Baseline Consumption

## Effect of HER on electricity consumption

| | Model 1 | |
|---|---|---|
| | Coeff. | s.e. |
| $T_{min.1}$ | 0.079 | (0.335) |
| Constant | 1.871 | (8.867) |
| Week controls | Yes | |
| $R^2$ | 0.0880 | |
| Observations | 8,994 | |

Notes: Robust standard errors are in parentheses.

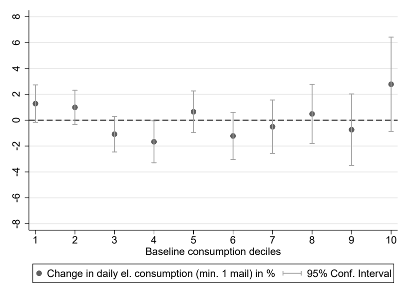


**Figure:** Model 2 - Effect of HER according to baseline consumption deciles.

Table

## Heterogeneity: Deviation of Zip Code Mean Consumption

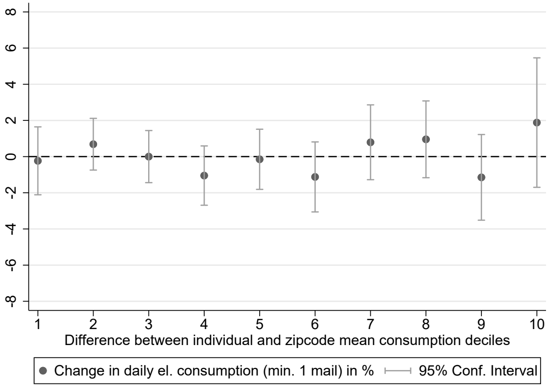


**Figure:** Model 3 - Effect of HER according to deviation deciles of mean zip code consumption from individual baseline consumption.

Table

# Discussion

- On average, no evidence for significant consumption reductions for sample households
- No evidence for significant reductions for any baseline consumption or deviation group
- Role of eco-electricity customers
  - Voluntary restraint by eco-electricity customers already before HER intervention (Kotchen and Moore 2008)?
  - Expectation of higher responsiveness of ”environmentalists” (Costa and Kahn 2013) not met
  - No response of high-consuming households: Potential moral licensing effect by purchasing green electricity (Dütschke et al. 2018)

# Conclusions

- No evidence for any significant electricity consumption reductions for our sample
- No evidence for boomerang effect
- Eco-electricity customers not responsive
- Context-dependency matters
- Limited electricity consumption reduction potential with HERs beyond eco-electricity customers

Thank you! kathrin.kaestner@rwi-essen.de

# HER Example

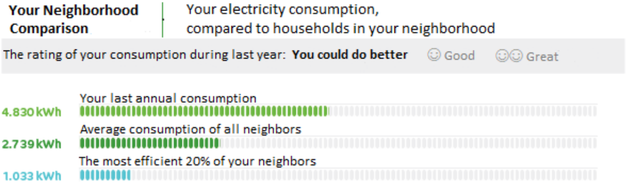


**Figure:** Social Comparison Element in HER.

Data Treatment

## Number of HER

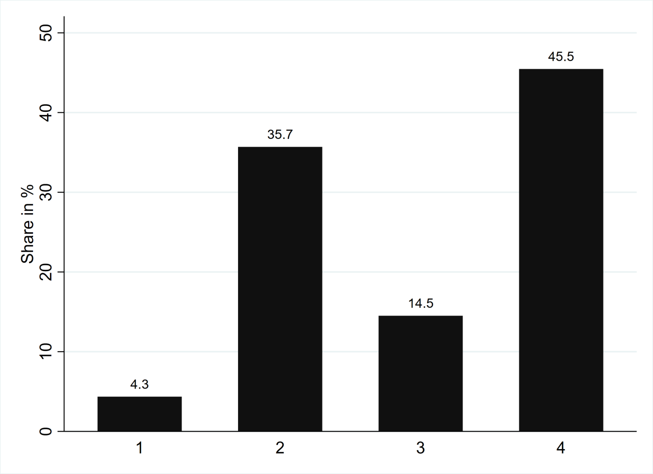


**Figure:** Number of mails received by treated households until end of study.

# Comparison with Austrian Population

**Table:** Comparison of sample with population.

| | Estimation Sample | Austria |
|---|---|---|
| Annual Consumption, in kWh | 2,811 | 4,002 |
| Share of households in Vienna, in % | 50.22 | 23.15 |

Notes: Average electricity consumption data for Austria taken from Statistik Austria 2021 for the most common treatment year of our RCT, 2015. Household data from `https://de.statista.com/statistik/daten/studie/886910/umfrage/privathaushalte-in-wien/`.

Sample

# ATE and heterogeneity according to Baseline Consumption

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | Coeff. | s.e. | Coeff. | s.e. |
| $T_{min.1}$ | 0.079 | (0.335) | 1.281* | (0.739) |
| $T_{min.1} * Baseline_2$ | – | – | -0.290 | (0.998) |
| $T_{min.1} * Baseline_3$ | – | – | -2.363** | (1.012) |
| $T_{min.1} * Baseline_4$ | – | – | -2.949*** | (1.115) |
| $T_{min.1} * Baseline_5$ | – | – | -0.630 | (1.109) |
| $T_{min.1} * Baseline_6$ | – | – | -2.500** | (1.192) |
| $T_{min.1} * Baseline_7$ | – | – | -1.787 | (1.286) |
| $T_{min.1} * Baseline_8$ | – | – | -0.796 | (1.379) |
| $T_{min.1} * Baseline_9$ | – | – | -2.016 | (1.589) |
| $T_{min.1} * Baseline_{10}$ | – | – | 1.496 | (1.998) |
| Constant | 1.871 | (8.867) | 6.823 | (7.760) |
| Baseline dummies | No | | Yes | |
| Week controls | Yes | | Yes | |
| $R^2$ | 0.0880 | | 0.1067 | |
| Observations | 8,994 | | 8,994 | |

Notes: Robust standard errors are in parentheses. *, ** and *** denote significance at the 10, 5, and 1 % level, respectively.

Results

# Heterogeneity: Deviation of Zip Code Mean Consumption

| | Model 3 | |
|---|---|---|
| | Coeff. | s.e. |
| $T_{min.1}$ | -0.234 | (0.958) |
| $T_{min.1} * Deviation_2$ | 0.919 | (1.207) |
| $T_{min.1} * Deviation_3$ | 0.234 | (1.204) |
| $T_{min.1} * Deviation_4$ | -0.815 | (1.274) |
| $T_{min.1} * Deviation_5$ | 0.085 | (1.283) |
| $T_{min.1} * Deviation_6$ | -0.890 | (1.373) |
| $T_{min.1} * Deviation_7$ | 1.025 | (1.432) |
| $T_{min.1} * Deviation_8$ | 1.189 | (1.440) |
| $T_{min.1} * Deviation_9$ | -0.914 | (1.541) |
| $T_{min.1} * Deviation_{10}$ | 2.115 | (2.059) |
| Constant | 6.011 | (7.101) |
| Deviation dummies | Yes | |
| Week controls | Yes | |
| $R^2$ | 0.1077 | |
| Observations | 8,994 | |

Notes: Robust standard errors are in parentheses.
*** denotes significance at the 1 % level.

Results

# ATE and Heterogeneity according to Baseline Consumption for sub-sample of households that received all 4 mails

## Effect of HER on electricity consumption

| | Model 1 | |
|---|---|---|
| | Coeff. | s.e. |
| $T_{all4}$ | 0.036 | (0.528) |
| Constant | 6.305 | (7.636) |
| Week controls | Yes | |
| $R^2$ | 0.0961 | |
| Observations | 6,561 | |

Notes: Robust standard errors are in parentheses.

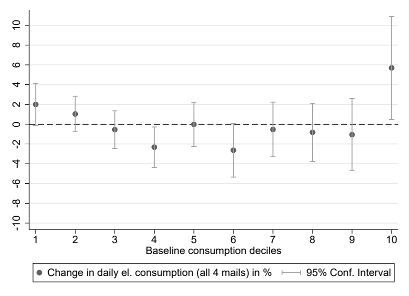


**Figure:** Model 2 - Effect of HER according to baseline consumption deciles.

## Heterogeneity: Deviation of Zip Code Mean Consumption for sub-sample of households that received all 4 mails

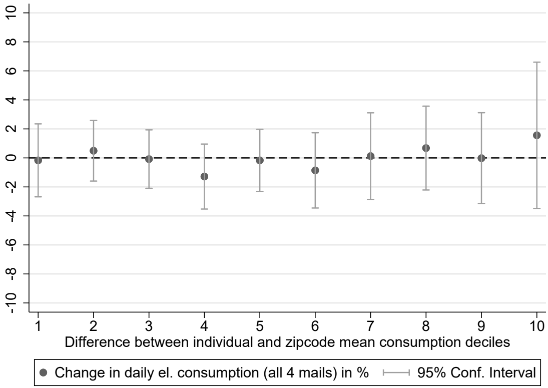


**Figure:** Model 3 - Effect of HER according to deviation deciles of mean zip code consumption from individual baseline consumption.

**Table:** Average treatment effect (ATE) on households' electricity consumption according to zip code deviation with sub-sample of households that received all 4 mails.

| | Model 3 | |
|---|---|---|
| | Coeff. | s.e. |
| $T_{all4}$ | -0.168 | (1.283) |
| $T_{all4} * Deviation_2$ | 0.662 | (1.633) |
| $T_{all4} * Deviation_3$ | 0.088 | (1.591) |
| $T_{all4} * Deviation_4$ | -1.117 | (1.678) |
| $T_{all4} * Deviation_5$ | -0.002 | (1.642) |
| $T_{all4} * Deviation_6$ | -0.692 | (1.815) |
| $T_{all4} * Deviation_7$ | 0.293 | (1.945) |
| $T_{all4} * Deviation_8$ | 0.848 | (1.907) |
| $T_{all4} * Deviation_9$ | 0.150 | (2.011) |
| $T_{all4} * Deviation_{10}$ | 1.728 | (2.819) |
| Constant | 7.509 | (6.345) |
| Deviation dummies | Yes | |
| Week controls | Yes | |
| $R^2$ | 0.1148 | |
| Observations | 6,561 | |

Notes: Robust standard errors are in parentheses.