Overcoming Salience Bias: How Real-Time Feedback Fosters Resource Conservation
Supplementary Information

August 18, 2016

Abstract

This Supplementary Information provides the statistical background and the full set of empirical results referred to in the companion paper.

Contents

1. Materials and Methods

1.1 Smart shower meter amphiro a1

The feedback device used in this study and shown in Figure 1 of the main article is the smart shower meter *amphiro a1*. Users install the device without any tools between the shower hose and the hand-held showerhead (which more than 95% of showers in Europe have). The device was developed by Amphiro AG, a spinoff company from ETH Zurich, Switzerland. The smart shower meter is energy-autarkic, which eliminates the need for batteries and allows tracking behavior over extended periods of time (standard device: up to 507 showers): a built-in micro-generator harvests energy from the water flow, supplying the device with the power required for its processing unit and display.

During each shower, the device continuously measures the generator speed and water temperature. Based on these variables, water and energy consumption of the current shower are calculated. The energy consumption in Wh (resp. kWh) displayed on the treatment devices is based on the standard engineering formula for heat energy, without generation and storage losses ($Q = m * c_p * \Delta T$, with heat energy Q, mass of water m, heat capacity c_p, and ΔT the difference between the measured water temperature and cold water temperature). Thus the approach does not make any assumptions about the setup of the individual heating system in a specific household (e.g., fuel type, vintage) and represents the lower bound of the actual energy use. However, these losses are taken into account in the overall data analysis where we use a detailed breakdown of residential water heating systems in Switzerland (please refer to SI Section 1.5 for details). Showers can be interrupted up to three minutes (e.g., for lathering up) to be stored as one coherent shower (after three minutes the device restarts counting from zero). Water extractions below five liters are not considered as showers and are not stored: the underlying assumption is that most of these occurrences serve other purposes (e.g., flower watering or bathtub cleaning). For the purpose of this study, memory allocation and display content of the device were modified. As for the memory, study devices also recorded the duration (in seconds) and interruptions (both their number and duration) of each shower. As a result, study devices could only record up to 205 showers, which was the main reason why the duration of the study had to be limited to two months and the household size to one- and two-person households.

Energy consumption was displayed in several ways: a) in Wh (resp. kWh for values $>$ 999 Wh, both at the end of the shower), b) with an energy efficiency class (ranging from A to G), and c) with a polar bear animation (i.e., an ice floe that progressively shrinks as the amount of energy used increases). Water use was displayed more prominently than energy use, as liters are commonly used in many aspects in everyday life in Europe (e.g., when purchasing beverages, car fuel, drinks), whereas most people are unable to relate to kWh. The energy efficiency classes were defined based on the distribution of energy consumed per shower in a pilot study. Every shower starts in class 'A' (0-700 Wh); the subsequent classes B to F each cover a 525 kWh interval. The energy efficiency class is accompanied by a polar bear animation: at the transition from energy efficiency class B to C (and again at the transition from D to E), the ice floe shrinks. At the transition from energy efficiency class E to F (2.975 kWh), the animation disappears.

The amphiro a1 stores the shower data (up to 205 showers in the modified study version), but the data are not being transmitted. To retrieve the data stored on the study devices, participants were asked to temporarily ship their device back to the research lab in postpaid envelopes. The data readout was carried out using a dedicated optical readout terminal with a webcam and a self-written readout application. A detailed description of the technical aspects and the data readout procedure is available in (*1*).

1.2 Recruitment of participants

The utility company ewz contacted 5,919 households by mail; all of them had previously participated in an electricity smart metering study. The size of the study had been limited upfront to 700 households for cost and implementation reasons; among those registered who fulfilled the qualification criteria (the number of household members in particular), participants were chosen on a first-come-first-served basis. All others were invited to participate in a one-year (long-term) study instead.

A total of 1348 households filled out the online survey to register for the study (23%). Participants who did not have a hand-held shower at home, who planned to relocate to a new home during the study or who planned to travel for more than three weeks during the study were discarded. Moreover, survey respondents were asked to agree with the data privacy statements, with installing the device within a few days upon reception and to ship back the device at the end of the study for the data readout. Furthermore - and this was by far the most limiting constraint - participation had to be restricted to one- and two-person households for technical reasons: due to a limited data storage capacity of the devices (205 showers), not all shower data might be recorded over the two-month duration of the study in larger households (assuming that the shower frequency is roughly one shower per day and person). An equal number of one- and two-person households was pursued to compare the effect on individuals in isolation with the effect on individuals sharing one roof (and shower). However, due to an under-representation of one-person households compared to the number of two-person households in the pool of households contacted, the number of participating one-person households ended up being slightly smaller (324 single- vs. 373 two-person households). Of the 697 households, 102 showed a changing household structure. This includes different cases: non-cohabiting couples (where one partner sometimes, but not always sleeps over), inconsistent answers between the initial and the final survey, households where one of the cohabitants moved out or a new cohabitant moved in, or households in which one of the cohabitants was absent for a long time.

Out of the initial 697 households, shower data are available from 636 devices and a complete set of all surveys from 620 households. Among the 61 households whose shower data are not available, 37 did not send back their shower meter or had dropped out of the study for various reasons (including unrelated events like hospitalization or breakup of partnerships), and 24 datasets from devices that were defective or had the wrong software installed could not be used.

Table S1 compares the demographics of our study participants with all 3,989 one- and two-person households who had participated in the electricity smart metering study. As the restriction of our study to one- and two-person households was for technical reasons, it is important to apply the same restriction on household size to the sample of the electricity smart metering sample to avoid a bias arising from differences in household size and composition. As the table shows, we cannot reject the null hypothesis of no difference in means of the two samples for any of the socio-demographic variables.

Table S1: Comparison of our sample with the ewz electricity smart metering (SM) sample

	Our sample			Electricity SM sample			Test statistics
Variable	Mean	SD	N	Mean	SD	N	t-value (p-value)
Household size (persons)	1.56	0.56	583	1.56	0.51	4,006	0.14 (0.89)
Age (years)	46.3	14.4	607	45.1	14.6	4,024	1.76 (0.08)
Monthly income (CHF)	8,160	3,962	567	8,215	3,979	3,612	0.30 (0.76)
Housing sit. (rent=1/own=0)	0.91	0.29	601	0.90	0.30	3,981	-0.55 (0.58)
Living space (m^2)	79.21	27.5	605	79.8	28.6	4,017	0.52 (0.60)

1.3 Questionnaire items to assess household characteristics, personality factors, and attitudes

Age
Age of the study participants was collected in six age brackets (0-19 years, 20-29 years, 30-39 years, 40-49 years, 50-64 years, 65 and older).

Income
The participants were asked to indicate their monthly net income in 11 brackets ranging from “Up to 3,000 CHF” to “More than 15,000 CHF”.

Education
The participants were asked to indicate their highest degree or level of school they had completed:
- No schooling completed
- Compulsory school completed
- 2-3 years of specialized middle school (“Diplommittelschule oder Fachmittelschule”)
- Trade/technical/vocational training
- A higher vocational school leaving certificate (“Berufsmaturität”)
- Grammar school
- Specialized college of higher education, university of applied sciences, college (“Höhere Fachschule”)
- University or university of applied sciences
- Other

Housing situation The participants were asked whether they rent or own the space they live in.

Personality factors
Personality factors were measured by administering the 60 item version of the HEXACO-PI-R scale (*2*). The HEXACO inventory measures 24 facet-level personality traits that define six personality factors: agreeableness, conscientiousness, emotionality, extraversion, honesty-humility and openness to experience.

Quantifying progress towards goals
An individual’s tendency to monitor progress towards goals was measured with two survey items prior to the intervention. Both items were measured on a 5-point Likert scale (1 = Never, 5 = Often). The trait was calculated based on the mean of these two items:
“Do you often measure your performance against self-set goals?”
“Do you often evaluate your performance against the performance of your peers?”

Environmental attitude
An individual’s environmental attitude was measured by an item originally formulated by (*3*)

on a 5-point Likert scale (1 = “Strongly disagree”, 5 “Strongly agree”). The participants were asked to rate their agreement with the following statement: “I act environmentally responsible, even if this is associated with higher costs and efforts”.

Extended periods of absence
The post-study survey asked participants whether they had been absent for longer trips of several consecutive days during the study, for instance on Christmas vacation or on an extended business trip. In case of several trips, they were asked to sum up the periods of absence (1= “Less than a week”, 2= “1-2 weeks”, 3= “2-3 weeks”, 4= “3-4 weeks”, 5= “More than 4 weeks”, = “Generally away more than 50% of the time (e.g. secondary residence)”,)

1.4 Calculation of energy consumption

Energy consumption is primarily calculated based on the amount of water used and water temperature: $Q = m * c_p * \Delta T$, where Q represents the thermal energy, m the mass of water consumed, c_p the heat capacity of water (4.184 kJ/(kg*K)), and ΔT the difference between the measured temperature and the typical cold water temperature in Switzerland (12 °C (*4*)). The result, however, is only the lower bound of the actual energy use, as this formula assumes 100% boiler efficiency and does not consider any generation and storage losses. The actual energy use depends on the fuel type, boiler size and age, and distribution infrastructure. The average boiler efficiency for water heating in Swiss households is 65% (*5*) and distribution losses range between 24 and 36% (*6*). We use a more conservative estimate of 24% in all calculations. The average shower in the baseline period (44.8 liters, 36.1 °C) thus requires 2.6 kWh of energy.

1.5 Baseline phase

The first shower was excluded in all datasets, as it was detected as an outlier in the distributions of both, temperature and water volume. The mean volume extracted in the first shower was 34.8 liters at a mean water temperature of 33.8°C. This is far below the means of the remaining 9 showers of the baseline dataset: the mean water volume of shower #2-#10 was 44.8 liters (with a standard deviation of 2.0 liters) and a mean temperature of 36.1°C (with a standard deviation of 0.1°C). The low volume mean of the first shower is mainly driven by an unusually high occurrence of ”very short” showers below 10 liters. Our conjecture is that in many cases, the first water extraction was not an actual shower; instead, participants who had just completed the installation turned on the water for several seconds to see if the device worked and what information it displays.

2. Estimation of the treatment effects

This section provides details on the statistical methodology and the detailed results, referred to in the main text of the paper. It details the unit of observations, the equations estimated and the corrections applied to the standard errors in the estimations.

2.1 The impact of real-time information on resource use

In Figure 2 and Figure 3 of the main text, we display treatment effects of the experimental intervention on resource use. This subsection details their estimation and reports the full results.

2.1.1 The statistical model

The baseline model for our estimation is

$$y_{it} = \alpha_i + \beta_1 T_{1it} + \beta_2 T_{2it} + d_t + \epsilon_{it} \tag{1}$$

where y_{it} is our dependent variable, either energy consumption (in kWh) or water use (in liters) in shower t. We include an individual fixed effect α_i for each household in order to eliminate all variance stemming from fixed differences in shower outcomes between households. The indicators T_{1it} and T_{2it} are all zero for the first 10 showers and then take on the value of 1 if household i is assigned to the *real-time information* and *real-time plus past information* treatment, respectively. We also include a shower fixed effect d_t to capture time trends in the best possible way. The error term ϵ captures any unmodeled effects.

We estimate Equation 1 by ordinary least squares (OLS) and allow the residuals to be correlated within a household in arbitrary ways. We correct for this by reporting standard errors clustered at the household level.

We also estimate Equation (1) separately for one-person and two-person households. These specifications also form the basis for the formal tests of equality of treatment effects, i.e. whether we can reject the hypothesis that $\beta_1 = \beta_2$ within each type of household. We then also test whether, across one-person and two-person households, the treatment effects are the same, i.e. whether we can reject the joint hypothesis that $\beta_1^1 = \beta_1^2$ $\beta_2^1 = \beta_2^2$, where the superscripts indicate the household size (one-person or two-person households).

2.1.2 The empirical results

Table S2 shows the results. The first two columns show the results on which the significance statements accompanying Figure 2 were based, exhibiting the main treatment effects on all of the households. As can be seen, both treatments have a statistically highly significant effect on energy use per shower and on the amount of water used per shower.

In the remaining four columns, we display the main treatment effects estimated separately for one-person and two-person households. In these specifications, we also conduct the tests of equality of treatment effects. As can be seen in the table, the treatment effects are estimated to be very similar in both of the specifications. For each of the four specifications, we never reject the hypothesis that adding the past information has no effect on the outcome variable (all $p > 0.63$, see Table S2), as cited in the discussion of Figure 3 in the main text. Similarly, we do not reject the hypothesis that each of the treatments had the same effect on one-person and two-person households ($p = 0.92$ for kWh and $p = 0.91$ for liters).

Table S2: The main experimental outcomes

Dependent variable	All households kWh	All households liters	One-person households kWh	One-person households liters	Two-person households kWh	Two-person households liters
Real-time information (=1)	-0.586***	-9.281***	-0.597***	-8.996***	-0.577***	-9.519***
	(0.073)	(1.134)	(0.104)	(1.602)	(0.103)	(1.604)
Real-time and past information (=1)	-0.599***	-9.663***	-0.639***	-10.040***	-0.565***	-9.341***
	(0.080)	(1.251)	(0.141)	(2.196)	(0.090)	(1.424)
Constant	2.625***	44.110***	2.649***	43.865***	2.617***	44.411***
	(0.067)	(1.051)	(0.101)	(1.545)	(0.090)	(1.441)
t-test: both treatments have the same effect on the dependent variable	$p = 0.88$	$p = 0.77$	$p = 0.77$	$p = 0.64$	$p = 0.92$	$p = 0.91$
F-test: equality of treatment effects across household types			$p = 0.91$	$p = 0.91$		
R^2	0.441	0.430	0.530	0.527	0.381	0.367
Obs	45,036	45,036	16,068	16,068	28,968	28,968

Notes: The table displays the main treatment effects on energy and water use, controlling for household and time fixed effects. Standard errors are in parentheses, adjusted for clustering at the household level. See Equation 1 for a complete description of the statistical model. *,**,*** indicate significance at the 10, 5 and 1 percent level, respectively.

2.2 Interaction effects of the treatment with household characteristics

In this subsection, we detail the specifications and estimation results that underlie Tables 4 and 5 in the main text.

2.2.1 The statistical model

We estimate the following model

$$y_{it} = \alpha_i + \beta_1 T_{it} + \gamma_1' \mathbf{z}_i \cdot T_{it} + \gamma_2 \bar{y}_{i0} \cdot T_{it} + \delta_1' \mathbf{z}_i \cdot t + d_t + \epsilon_{it} \quad (2)$$

where T_{it} is an indicator equal to 1 after shower 10 if household i is in either the real-time or real-time and past information condition. As the previous section shows that the two treatments had the same effects on behavior, we collapse both treatments into one. For the same reason, we also do not distinguish between different households. We interact the treatment effect with a vector of personality factors $\mathbf{z}_i$ in order to test the different hypotheses formulated in the paper. Variable $\bar{y}_{i0}$ is the mean per-shower energy consumption of household i during the baseline period (where none of the devices displayed any information about resource use). We also include interactions between the personality factors $\mathbf{z}_i$ and a time (shower) trend. We include these interaction terms in order to account for possible differences in Hawthorne effects that may be related to personality differences, and create characteristic-specific trends. As before, we include household fixed effects α_i and shower fixed effects d_t. We adjust the standard errors for clustering at the household level. In the estimation, we had to drop all the observations from households with missing survey responses in the personality factors. In addition, we dropped the observations with an unstable household status mentioned in Section 1.2 of the *SI*.

Equation (2) is the equation that allows us to calculate the predicted treatment effects for the top and bottom quintiles of household characteristics by inserting the mean of the personality factor z_k in the top or bottom quintile of z_k into the equation, respectively.

2.2.2 The empirical results

Table S3 presents the estimation results of equation (2).

Table S3: Interaction effects of the treatment with household characteristics

	(1)
Treatment Effect (T_{it})	-0.625***
	(0.062)
$T_{it} \times \bar{y}_0$	-0.308***
	(0.071)
$T_{it} \times$ environmental attitude	-0.160**
	(0.081)
$T_{it} \times$ quantifying goal progress	-0.119**
	(0.060)
$T_{it} \times$ fraction of women in household	0.148
	(0.134)
$T_{it} \times$ age	0.030
	(0.052)
$T_{it} \times$ household income	0.011
	(0.014)
$T_{it} \times$ conscientiousness	0.207*
	(0.107)
$T_{it} \times$ emotionality	0.025
	(0.089)
$T_{it} \times$ honesty	-0.031
	(0.074)
$T_{it} \times$ extroversion	0.057
	(0.079)
$T_{it} \times$ agreeableness	-0.034
	(0.073)
$T_{it} \times$ openness	-0.003
	(0.078)
Constant	2.497***
	(0.078)
F-test: significance of interactions with environmental attitude and tendency to quantify.	$p = 0.02$
R^2	0.445
Obs	29718

Notes: Treatment effects on energy use (kWh) depending on a range of household characteristics. The regressions control for household and time fixed effects, as well as time (shower) trends interacted with characteristics, as specified in equation (2). Standard errors are in parentheses, adjusted for clustering at the household level. *,**,*** indicate significance at the 10, 5 and 1 percent level, respectively.

3. Carbon abatement

Carbon intensity of showering largely depends on the type of fuels used for water heating and varies from country to country. We calculate the impact of the shower feedback intervention on carbon emissions based on the fuel mix of Switzerland (where the intervention took place). Given the large variance between countries in the carbon intensity of water heating, we also calculate the figures for the U.S. for comparison (assuming the same baseline water use, water temperature, and treatment effect).

The majority of Swiss households rely on fossil fuels for water heating: 40% use fuel oil, 25% electricity, and 21% natural gas; renewable energy sources such as wood, solar thermal or ambient air only account for a relatively small fraction (*7*). In the U.S., water heating mainly relies on natural gas (51%) and electricity (42%); 3% use fuel oil (*8*).

In the case of electric water heaters, one must further take into account country-specific differences in the electricity generation. In Switzerland, electricity is mainly generated from fossil-free resources - hydro power (56%) (*9*) and nuclear power (39%) (*10*) - resulting in a carbon intensity of 102 g/kWh at the plug level (*11*). In the U.S., electricity production is primarily based on coal (39%), natural gas (27%), nuclear power (19%) and hydropower (6%), amounting to a carbon intensity of 559 g/kWh (*12*).

Table S4 shows the carbon intensity of water heating for Switzerland and the U.S.. Water heating in Switzerland results in a carbon intensity of 216 g of CO2/kWh, nearly twice as much as per kWh of electricity generated. Due to a higher share of fossil fuels, both electricity generation (559 g of CO2/kWh of electricity) and water heating (382 g of CO2/kWh of thermal energy) are substantially more carbon-intense in the U.S. Consequently, a 215 kWh reduction per person and year in water heating results in reduced carbon emissions of 47 kg and 82 kg in Switzerland and the U.S., respectively.

Table S4: Carbon intensity of water heating in Switzerland and in the U.S.

Fuel type	Swiss share of fuel for res. water heating	Swiss carbon intensity of fuel [kg/kWh]	U.S. share of fuel for res. water heating	U.S. carbon intensity of fuel [kg/kWh]
Oil	40%[1]	0.299[2]	3%[4]	0.299[2]
Natural gas & LPG	21%[1]	0.252[2]	55%[4]	0.252[2]
Electric	25%[1]	0.102[3]	42%[4]	0.559[5]
Other (wood, district heating...)	14%[1]	0.125[2]	0%	-
Weighted average		0.216		0.382

References: [1] (*7*), [2] (*13*), [3] (*11*), [4] (*8*), [5] (*12*)

4. Cost effectiveness

Aside from the average treatment effect, the scalability of feedback interventions largely depends on the cost-effectiveness of the intervention. Household cost savings take into account both fuel and water cost savings. We conduct a cost-benefit analysis for the average Swiss household (2.1 persons) using the average Swiss fuel mix for water heating (see SI section 3.) and average fuel and water prices. Panel A of table S5 contains the relative share of the different fuel types along with their associated cost per kWh, resulting in a weighted average fuel cost for Switzerland of 0.128 CHF/kWh. Panel B displays the cost of water: Swiss households pay both for their consumption of drinking water and a fee for the resulting quantity of waste water. Panel C contains the yearly fuel and water savings for the average household projected to one year (assuming stability of the effects).

Table S5: Cost calculation: Cost of water heating in Switzerland

Panel A: fuel cost	Swiss share of fuel for res. water heating[1]	Cost (CHF/kWh)
Oil	40%	0.105[2]
Natural gas & LPG	21%	0.100[3]
Electricity	25%	0.197[4]
Wood, pellets	4%	0.070[5]
District heating	3%	0.087[6]
Other (solar thermal etc.)	8%	0.120[7]
Weighted average fuel cost		0.128
Panel B: water cost		Cost (CHF/m^3)[8]
Drinking water		1.45
Waste water fee		2.35
Total water cost		3.80
Panel C: yearly household savings	Quantity	Cost savings
Energy savings	452 kWh	57.9 CHF
Water savings	7300 l	27.7 CHF
Total cost savings		85.6 CHF

References: [1] (*7*), [2] (*14*), [3] (*15, 16*), [4] (*17*),[5] (*18*), [6] (*19*),[7] (*20*), [8] (*21, 22*)

The average household thus saves CHF 85.6 on fuel and water cost, resulting in a payback period of 9.3 months.

5. Comparison of the present study with a prior electricity smart metering study

When comparing the impact of the present study with other smart metering studies - mainly in the electricity sector - one must carefully consider the focus of each study (household electricity consumption vs. energy and water consumption in the shower) as well as the sample of participants / recruitment strategy.

Our setting allows for a relatively straightforward comparison with conservation effects of existing feedback interventions, since all the participants had previously completed an electricity smart metering study (*23*). In order to opt into the present study, households had to fill out an online survey, which yielded a 23% response rate. A total of 697 households were finally selected for this study based on their shower type and household size. Participants of the current study are thus a subset of the households who had previously completed an electricity smart metering study (opt-in design in both cases). As Table S1 shows, there is not significant difference between the two samples on any of the socio-demographic variables analyzed.

While the prior study investigated the impact of an in-home display on *aggregated household electricity use*, the study described in this article focuses on the *energy consumption in the shower*. We therefore distinguish between *electric energy* and *thermal energy* and take into account the different fuel mixes for the generation of one kWh in each domain.

From an energy conservation perspective, the average treatment effect amounts to *thermal* energy savings of 452 kWh per household (2.1 persons) and year in the present study. By contrast, (*23*) report a reduction of 86 kWh of *electric* energy per household (*23*). As SI Section 4 shows, fuel mixes used for electricity and hot water generation are highly country-specific. Table S4 presents the figures both for Switzerland (where the interventions took place) and for the U.S. (assuming the same treatment effects).

Table S6 compares the resulting reductions in carbon emissions per household and year based on the fuel mix used for electricity generation and water heating in Switzerland. The table further gives the corresponding carbon abatement figures based on the U.S. fuel mix presented in table S4:

Table S6: Comparison of carbon reduction per household and year in the electricity smart metering study (*23*) vs. by the shower feedback intervention

Behavioral intervention	Energy savings per household and year	Carbon abatement in Switzerland per household (kg of CO2/yr)	Carbon abatement in the U.S. per household (kg of CO2/yr)
Electricity smart metering trial	86 kWh (electric energy)	8.8	48.1
Present study (shower feedback)	452 kWh (thermal energy)	97.6	172.9

As table S6 shows, the impact on carbon abatement of the present study exceeds the impact of the prior electricity smart metering study in Switzerland by a factor of 11. In the U.S., both studies would yield a higher absolute impact on carbon abatement (assuming the same absolute numbers for energy conservation as in Switzerland), with the present study outperforming the electricity smart metering study by a factor of 3.6. Figures for energy savings of the two studies can only be directly compared to the 25% (resp. 42%) of Swiss (resp. U.S.) households that use electricity for water heating. In that case, the present study exceeds the energy conservation impact of the electricity smart metering study by a factor of 5.2. For all households that use a different fuel for water heating, the comparison would require more complex calculations on energy conversion, which is beyond the scope of this article.

References

1. V. Tiefenbeck, V. Tasic, S. Schoeb, T. Staake, *Proceedings of the IEEE IECON 2013, special section on energy informatics*, Energy Informatics 2013 (IEEE, 2013).
2. K. Lee, M. C. Ashton, *Multivariate Behavioral Research* **39**, 329 (2004).
3. A. Diekmann, R. Meyer, C. Mühlemann, A. Diem, Schweizer Umweltsurvey 2007: Analysen und Ergebnisse, *Report to the Swiss Federal Statistical Office and the Swiss Federal Office for the Environment* (2008).
4. Geberit, Planungshandbuch Sanitär - Trinkwasserhygiene, *Tech. rep.* (2011).
5. Prognos AG, Ex-Post-Analyse des Energieverbrauchs der Schweizerischen Haushalte 2000 bis 2012 nach Bestimmungsfaktoren und Verwendungszwecken, *Tech. rep.*, Basel (2013). <http://www.bfe.admin.ch/themen/00526/00541/00542/02721/ index.html?lang=de&dossier_id=02722>.
6. A. Tschui, B. Stadelmann, Studie Warmwasserverteilung - Kurzstudie über die Energieverluste der verschiedenen Verteilsituationen von Warmwasser im Mehrfamilienhaus, *Tech. Rep. 1100280* (2006).

7. Prognos AG, Der Energieverbrauch der Privaten Haushalte 2000 - 2012. Ex-Post-Analyse nach Verwendungszwecken und Ursachen der Veränderungen, *Tech. rep.* (2013). <http://www.bfe.admin.ch/themen/00526/00541/00542/02721/ index.html?lang=de&dossier_id=02722>.

8. eia, 2009 RECS survey data - water heating (2013).

9. SFOE, *Wasserkraft* (2013). Swiss Federal Office of Energy (BFE). <http://www.bfe.admin.ch/themen/00490/00491/index.html?lang=de>.

10. SFOE, *Kernenergie* (2013). Swiss Federal Office of Energy (BFE). <http://www.bfe.admin.ch/themen/00511/index.html?lang=de>.

11. P. Stolz, R. Frischknecht, Umweltbilanz Strommix Schweiz 2011 (2015).

12. US Environmental Protection Agency, eGRID 9th edition Version 1.0 Year 2010 GHG Annual Output Emission Rates (2010).

13. European Environment Agency, Achieving energy efficiency through behaviour change: what does it take?, *EEA technical report no 5/2013* (2013).

14. Hauseigentuemerverband Schweiz, HEV Schweiz Heizölpreise 2013 (2013). <http://www.hev-schweiz.ch/ vermieten-verwalten/heizoelpreise/heizoelpreise-2013/>.

15. M. Fischer, *K-Tipp* **2013** (2013). K-Tipp 2013(08). <www.ktipp.ch/artikel/d/privatkunden-werden-benachteiligt/>.

16. Stadtwerk Winterthur, Preise Erdgas für Haushalt (2014). 2014-01-01. http://stadtwerk.winterthur.ch/angebot/erdgas/preise/erdgas-fuer-haushalt/.

17. Bundesverwaltung admin.ch, Strompreise 2014: Im Durchschnitt leicht steigende Tarife fuer Haushalte, keine Veraenderung für mittlere Betriebe (2013). <http://www.news.admin.ch/message/index.html?lang=de&msg-id=50162>.

18. Holzenergie Emmental, Energieholzpreise 2013/2014 (2014). <http://www.holzenergie-emmental.ch/pdf/energieholzpreise.pdf>.

19. iwb, Energie- und Wassertarife: Erdgastarife (2012). <http://www.iwb.ch/de/privatkunden/ kundenservice/tarife_preise/>.

20. R. Gloor, *Heizungsvergleich: Leistungs- und Kostenvergleich verschiedener Heizungen* (2013).

21. Statistisches Amt des Kantons Basel Landschaft, Wasser- und Abwassergebühren der Gemeinden 2013 - Kanton Basel-Landschaft (2013).

22. A. Zanzi, Vergleich der Wasser-, Abwasser- und Abfallgebühren in den 50 grössten Städten der Schweiz, *Tech. rep.*, Eidgenössisches Volkswirtschaftsdepartement EVD, Bern (2011).

23. K. Degen, C. Efferson, F. Frei, L. Goette, R. Lalive, Smart Metering, Beratung oder Sozialer Vergleich: Was beeinflusst den Elektrizitätsverbrauch?, *Final report to the Swiss Federal Office of Energy* (2013).