ENERGISE

EUROPEAN NETWORK FOR RESEARCH, GOOD PRACTICE AND INNOVATION FOR SUSTAINABLE ENERGY

LIVING LAB COUNTRY REPORT – GERMANY

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Alpine Landscape near ELL2 site of Murnau am Staffelsee

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

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SUMMARY PAGE

The German ENERGISE living labs were rolled out by the LMU ENERGISE team to 40 participant households over the course of eight months from August 2018 to April 2019 in the Oberland region of Bavaria. During that time, over the course of a number of interviews and surveys households in and around the towns of Weilheim (ELL1) and Murnau (ELL2) were asked to do a thorough examination of their practices in the areas of heating and laundry with a specific focus on trying to encourage households to reduce the energy use associated with those practices by means of finding sufficiency focused strategies to enable them to heat less and launder less.

Households were challenged to try to minimise indoor temperatures to 18 degrees Celsius and to halve their regular number of laundry cycles over four weeks in a 7 week overlapping challenge period. In order to assist the households in attempting these challenges the ENERGISE team provided each participant with a challenge box which contained a combination of practical materials as well as tips and tricks style energy saving information. The essence of the two challenges was to try to focus on heating people rather than heating space and to figure out ways of how to wear clothes for longer.

While the vast majority of households did not achieve the ENERGISE pre-defined challenge, households did report substantial gains in both domains. Households reported a mean indoor temperature reduction in the order of 1.14 degrees while in the domain of laundry, households reported an average laundry cycle reduction of 19%. In the follow-up survey 3 months after the end of the study it was found that these gains had been substantially retained since the end of the active phase of the project.

A diverse recruitment strategy was a significant factor in gaining access to a wide diversity of participants with different motivations. While certainly some highly sustainability conscious participants got involved, very few of the participants had previous experience with such a project before. The vagaries of participant approaches to the challenges were also revealed as while some households were enthused by the thought of trying to meet a difficult challenge, others approached the situation with significant apprehension. Some participants were very open and enthusiastic about testing themselves while others were worried about “failing”.

No significant difference was discernible in the performance of the individual based lab (ELL1) and the community of place based lab (ELL2) however, ELL1 furnished the LMU ENERGISE team with the primary source of qualitative information with more detailed qualitative descriptions about the reasons behind the choices people made and the reasons why people did/n’t engage in practice change. While the roll out and scaling up of ELL1 would be impractical in terms of resources, it does provide a useful structure for the piloting of such schemes which could then be rolled out at a community level.

SECTION 1. ELL DESCRIPTION

The German ELLs were carried out in the towns and surrounding hinterlands of Weilheim and Murnau in the Oberland region of Southern Bavaria. Lead by the ENERGISE team from LMU Munich (Ludwig-Maximilians-Universität München), a diverse set of urban, semi-urban and rural households were recruited with assistance from local partners Energiewende – Oberland (EWO). This region was primarily chosen on the grounds that in addition to providing a potential for a mix of urban, semi-urban and rural households, Oberland provided an interesting test site as the regional municipalities have set themselves a number of sustainability goals including being entirely supplied by renewable energy by 2035. In addition, practical considerations such as accessibility, proximity and logistical efficacy were also taken into consideration as well as established outreach networks.

Given that the ultimate goal was to recruit a diverse set of households including hard to reach groups it was decided that the recruitment strategy should be similarly diverse so as to decrease the likelihood of missing particular demographic or and/or socio-economic groups. Carried out over the course of 8-10 weeks during the summer months of June, July and August, the recruitment strategy consisted of a combination of local news articles, on street local recruitment drives, promotional media and word of mouth snowball campaigns. This resulted in a diverse set of participant households in terms of tenure, household size, building type and stage of life. Participant households were first recruited initially and then divided into ELL1 and ELL2, with ELL2 acting as a community of place. Since the 20 participant households from the town and surrounding hinterlands of Weilheim in Oberbayern were significantly dispersed it was decided that this would be the site for the individual labs (ELL1) while the 20 participants for the community of place labs (ELL2) were significantly more clustered as a result of snowball effects and drawn from two neighbourhoods clustered in Murnau and the nearby village of Iffledorf.

The German approach focused on making a determined effort to develop good relations with the participant households. A significant amount of time was spent getting to know the participants during each contact session with a special emphasis on the first meeting which was typically scheduled 4-6 weeks in advance. A minimum of two ENERGISE team members were present at each contact meeting with both a male and female member present in almost all cases. The lengthier surveys were filled out with the participants in person and this had the effect of stimulating a natural conversational exchange. It was felt that this was an important part of the engagement process and that it aided future contact sessions and response rates for survey completion. Despite positive feedback on structure and workload of the study, over the course of the ELL active phase two households from ELL2 dropped out leaving a final sample of 38 households.

This section first presents the socioeconomic and demographic characteristics of the initial 40 participants that took part in the German ELLs. A summary of dwelling characteristics and living environments are then presented, and finally, evidence of any prior engagement with energy initiatives. The data presented are based on both a recruitment and baseline practice survey completed at the first face-to-face meeting with the participants and is self-reported. This is complemented with observations made when visiting the households for the first time. It should also be noted that since the German approach involved face-to-face interactions, participants had, at all times, the option of choosing not to answer any particular question. Additionally, some participants were simply not able to give answers to certain questions e.g. on estimated energy use. This is the reason for the display of “n=40-x” responses in various tables.

It is important to note that apart from the measured temperature data, all tables and summary descriptive information presented are based on self-reported figures and descriptions by the participants. Information was gathered firstly through the recruitment and baseline surveys (which were substantially conducted in person), and then through a series of online surveys that participants filled out themselves; as well as descriptions given during the exit interview. Additionally, where

comparative aggregate statistics from before, during and directly after the challenges show a movement in activity (positive or negative), these should be interpreted as indicative of a *potential* move in a general direction by the collective rather than a statement of fact; since in a small sample particularly (in)active outliers can result in perverse aggregate descriptives. Additionally, given the topic strongly relates to environmental issues there is likely to be some element of social desirability bias in what households report (Grimm 2010). More in depth analysis, beyond the scope of this country report would be required to deliver indicative statements with a higher degree of certainty.

1.1 SOCIODEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS OF THE ELL PARTICIPANTS

A stated aim in terms of the profile and characteristics of participants was to recruit a cohort of households that would reflect insofar as possible the general sociodemographic and socioeconomic composition of the population and include hard to reach groups. However, there was a clear acknowledgement that ultimately achieving accurate representativeness in even 2-3 variable factors (e.g. age sex and education) would be virtually impossible given the small target sample size. Additionally, even if agreement could be reached on a selected number of factors it would require either a significant oversubscription of willing participants from which to choose from (a challenging task) or appropriate statistical weighting (a task far beyond the core objectives of the project i.e. the study of practice change). Consequently, it was felt that the requirements for participation should initially be limited to availability, willingness to participate and the few basic elements required to try the proposed challenges i.e. ownership of a washing machine and the ability to adjust indoor heating temperature. The decision was taken to employ a diverse recruitment strategy to mimic random sampling and then perform an ex-post evaluation in advance of the commencement of the ELLs to ensure a reasonably heterogeneous sample.

Table 1 displays the basic sociodemographic and socioeconomic characteristics of participating households in terms of household size, age, education and employment. With regard to household size single households are notably under-represented (Table 1) at 8%[1] of the sample. This is in significant contrast with the population household size representation with single households representing approximately 40% of total households at both the national and state level (Statistisches Bundesamt 2019a). The consequence of this is that all other household sizes are "over-represented" when assessed against the national and state level particularly in the four or more persons category. Two person households made up 35% of participants, 20% of households consisted of three person households with 38% of households consisting of four or more household members, typically consisting of two parents and two children. Two, three and four or more person households make up 32%, 12% and 10% of households at the state level respectively

Table 1. Sociodemographic and socioeconomic characteristics of participating households Source: recruitment survey.

Household size (n= 40)	**1 member**	**2 members**	**3 members**	**4 members or more**
No.	3	14	8	15
%	8%	35%	20%	38%
Age of contact person (n=40)	**29 or younger**	**30-49**	**50-69**	**70 or older**
No.	2	22	12	4
%	5%	55%	30%	10%

[1] All percentages have been rounded to the nearest whole number.

Employment status of contact person (n=39)	Full-time employed or entrepreneurs	Part-time	Student/ Unemployed	Retired
No.	21	12	1	5
%	54%	31%	3%	13%
Educational level of contact person (n=39)	**Tertiary**	**Secondary 2nd Phase/Vocational**	**Secondary 1st Phase**	**Other or unknown**
No.	26	10	3	1
%	65%	25%	8%	3%

The second characteristic displayed in Table 1 is the age of the contact person, which in the case of families (the largest common household unit), was typically close to the age of the other spouse. There were two households where our primary contact was aged 29 or less representing 5% of the sample, 22 primary household contacts (55%) reported themselves as being between the ages of 30-49 (the largest cohort). Twelve primary contacts (30%) described themselves as being aged between 50-69, with just 4 households (10%) where the primary participant described themselves as aged 70 or more. While this would broadly resemble the population age profiles of reference persons reported nationally both the oldest and youngest cohorts are significantly underrepresented. It should be noted that the figures may reasonably mirror head of household statistics reported by the Federal Statistics Office albeit reported for different age group classifications (Statistisches Bundesamt 2019b).

In terms of employment status, 21 of the 40 ELLs primary participant contacts were primarily full-time employed or self-employed (54%). Twelve primary participant contacts reported working part-time (31%) in the home, nine of which had children in the household. While, only one principal contact reported themselves as being unemployed, this person was stay at home parent with two very small children. The absence of significant unemployed representation was not a surprising outcome given the region's relatively strong economic performance in recent years. The Oberland region and Weilheim-Schongau in particular has very low levels of unemployment (at less than 3% August 2018). Finally, five contact participants reported themselves as being retired.

In terms of education (Table 1), German ELL participants include a larger share of people with tertiary education (university or higher level professional training) than the population as a whole (62% vs. 32%) and fewer people with only 1st phase secondary education or lower (11% vs. 41% in the general population). However, this is not unexpected since the distribution is naturally skewed in terms of age profile i.e. a considerable proportion of those with only lower secondary education are children and thus unlikely to be a participant contact. Ten participant contacts (25%) reported having higher secondary education which closely mirrors the national rate of 23% (Statistisches Bundesamt 2019c[2]).

While comparisons with distributions at a national or federal level can provide a guideline in terms of selection, in practice, without definitive quotas or statistically representative sample size, any attempt to draw significant conclusions from such comparisons so would be unfruitful. Additionally, requiring householders to voluntary engage in energy practice changes will necessarily result in selection bias towards households who feel they can devote time and/or effort to such a project. This can result in participant households being more likely to belong to a particular socio-economic group or class, however this is always a risk in any voluntary participative research project. Overall, given that the primary goal was to achieve a level of saturation of experience rather than statistical

[2] Figures for 2017

representativeness the LMU research team was happy with the level of diversity present in the sample.

1.2 REASONS FOR PARTICIPATING AND PRIOR EXPERIENCE OF ENERGY INITIATIVES

Participants were not asked directly on their reasons for participating in the ENERGISE project however, reasons were expressed in informal conversations both in face to face meetings and after the focus groups. Many expressed that they were simply very interested in participating in a research project while others had more specific energy related goals. A few household participant contacts expressed their frustration at the level of laundry in their household and welcomed the opportunity to have a structured way to challenge current practices while other households self-identified themselves as having significant energy costs particularly in the area of heating. It should also be noted that there was a distinct difference in terms of sourcing between ELL1 and ELL2. Of the 20 ELL1 members, 17 were recruited through self-expressions of interest through the local country ENERGISE website most of which had seen the news article announcing the project in the local paper under the sub-headline, “LMU seeks participants for energy-saving study”. In contrast, a significant amount of ELL2 participants were recruited through a snowballing word of mouth campaign resulting in a significant clustering of participants. Additionally, most households that signed up had a very general overview of the project, i.e. that it was something to do with energy saving in the areas of heating and laundry and that it took place over 3 months during the Autumn/Winter period. This was partly by design as it was decided that too much information too quickly might put people off and that it would be better to ease people into the project. This was an important consideration in the first face-to-face meeting to install monitoring equipment and further explain the project as significant time was spent with participants explaining a practice approach to the issue of energy use. This was initially confusing for some participants, particularly those orientated around and/or anticipating an efficiency focused approach. The small incentives on offer (donation of monitoring equipment and closing small token of appreciation) were positively received and on recruitment did perhaps help in getting some people to confirm their participation but it is unclear as to what extent this was deciding influence while no household mentioned the incentives as determining factor in their participation.

Picture 1: ENERGISE Recruitment Stand in Murnau

With regard to prior exposure, in general, participants had very little prior experience of energy initiatives with exposure generally limited to information campaigns and efficiency focused measures (Table 2).

Table 2. Share of participants having prior experience of energy initiatives, %, n=40 Source: recruitment survey.

(n=40)	At home	%	At work	%	At school	%
Information campaign, tips for saving energy	3	8%	2	5%	0	0%
Incentive to buy efficient appliances (including light bulbs)	0	0%	1	3%	0	0%
Incentives to invest in renewable energy	6	15%	2	5%	0	0%
Incentives or support for energy efficiency	1	3%	1	3%	0	0%
Challenge/discussion to change habits and everyday routines	0	0%	2	5%	0	0%
Other (we can expand here on what is included)	0	0%	0	0%	0	0%

1.3 BUILDING CHARACTERISTICS OF ELL PARTICIPANTS

The Oberland region is one of the more prosperous regions of Germany with average household disposable incomes well above the German and Bavarian average (Landesamt für Statistik 2017, Statistisches Bundesamt, 2017). Additionally, while Weilheim (22,500 in habitants) and Murnau (12,200 inhabitants) are sizable towns they would not have the levels of dense urban development and apartment living that would typify the larger urban centres in Germany. As a consequence the size of housing in the Weilheim-Schongau administrative area would generally be higher than the national average with for example apartment sizes approximately 10m^2 larger than the national average of 91.4m^2 (Statistisches Bundesamt 2015). Again, while the sample as a whole could not be considered to be reflective of the national picture with a higher number of detached and semi-detached dwellings, a saturation of experience rather than representativeness was the sampling goal.

In terms of housing type (Table 3) most participants lived in either a detached “Einfamilienhaus”[3] (14 or 35%) or semi-detached “Zweifamilienhaus“ (19 or 48%) with just 7 remaining participants (18%) living in apartment buildings. A similar pattern is seen in terms of living area with 31 of the 40 participants living in dwelling with over 100m^2 of living area with the majority of these dwellings housing family sizes between 3 and 5. The mean dwelling size was just under 140m^2 with an average area per household member of approximately 51m^2, considerable above the national average of 92 m^2 and 46m^2 respectively (Statistisches Bundesamt, 2019). This is a more meaningful national comparison as it represents the ELL participant grouping a whole relative to the general population with direct consequences for energy use, especially in the area of heating. In terms of tenure, 10 out

[3] Literally translated meaning “one-family house” this word is commonly understood to simply mean a detatched house however the literal meaning has an interesting connection in terms of housing expection.

the 40 German ELL participants were renting their dwelling with the remaining 30 identifying themselves as home owners.

In terms of age of dwelling age, 27 (68%) of the 40 participants' dwellings were built in the last 40 years with 7 dwellings build since the turn of the century. 10 dwellings (25%) were built in the period from 1920-1970 however all. Two dwellings were built before 1920 while one participant was unable to say for certain when their dwelling was built. It should be noted that very few participants knew the energy rating/efficiency class of their building with only 8 out of 40 households able to furnish this information.

Table 3. Characteristics of the participants' dwellings
Source: recruitment survey.

Type of dwelling (n=40)	**Apartment**	**terraced/semi-detached**	**detached**	**other**
No.	7	19	14	0
%	18%	48%	35%	0%
Size of dwelling (n=39)	**<60 m2**	**60-100 m2**	**101-140 m2**	**>140 m2**
No.	1	7	16	15
%	3%	18%	41%	38%
Age of dwelling, built (n=39)	**before 1920**	**1920s-1970s**	**1980s-2000s**	**After 2000**
No.	2	10	20	7
%	5%	25%	50%	18%
Tenure	Tenant	Owner		
No.	10	30		
	25%	75%		

More generally in terms of structure, a substantial number of dwellings were oriented to the south with large windows off the main living areas. This had the effect of warming the dwelling naturally during the day when sunshine was present. Additionally, many households had access to a garden to the rear which meant that these households had the space and opportunity to air dry laundry without substantial inconvenience or a significant imposition on space inside the dwelling. Furthermore, some dwellings had the benefit of traditional architecture in the region which typically provides a substantial roof overhand providing shelter for air drying outside.

Table 4 displays the primary and secondary heating sources for all 40 participant households. Gas (23 households) and Oil (7 households) were the dominant primary heating sources for ELL participants with electricity (2) biomass (2) (supplying domestic boiler) heat pump (2) and solar collector completing the profile of independent primary heating systems. District or communal heating accounted for the primary heating source for three households.

In terms of secondary sources, 60% of participant household had access to a *Holzofen,* a solid fuel (wood) stove. This is a form of heating which has a strong historical tradition not just within the Oberland region but also within greater Bavaria. A third of the entire land area of Bavaria is covered in forestry with 57% of this privately owned (Bayerische Landesanstalt für Wald und Forstwirtschaft 2019). Thus large amounts of managed forestry dot the Bavarian landscape provide a relatively plentiful supply of locally produced biomass. Consequently, the presence of a wood stove as a secondary heating source is a common occurrence and maintains a strong cultural connection. This is also true even in suburban houses and also some modern apartment buildings with building designs often facilitating their installation. Interestingly, many of the ELL households did not necessary relate use of the wood stove as being part of their "Heizungsystem" or heating system. When asked about different alternative strategies to keep warm apart from using the heating, one participant responded "I fire the stove in the living room".

Picture 2 -Swedish Style Wood Stove from participant household

Table 4. Heating sources of ELL participants (n=40) Source: recruitment survey.

	Primary heating source	%	Secondary heating source	%
Gas	23	58%	0	0%
Oil	7	18%	0	0%
Coal	0	0%	0	0%
Electricity	2	5%	1	3%
Biomass	2	5%	24	60%
Solar collectors	1	3%	14	35%
Heat pump	2	5%	0	0%
District heat	3	8%	0	0%
Other/don't know	0	0%	2	5%

All participant households owned their own washing machine and this was a condition of participation in the project given the design of the living labs. Households were then surveyed for the presence of specific laundering elements such as the presence of a tumble dryer, an A++ rated washing machine, the presence of an eco-programme and access or use of a shared laundry space. Over half (21) of participant households possessed or had access to a tumble dryer with over a quarter (12) of participants washing machines energy rated at A++ or better. The majority of household's washing machines (66%) had an eco-program or button but it was notable that during the completion of the recruitment survey at the first household visit that most participants were unable to answer the efficiency rating question or the eco-program question without first going to their washing machine to check. Only one household used a shared laundry space which was with their relatives who lived next door.

Table 5. Laundry equipment owned or used by the households (n=39)
Source: recruitment survey and baseline survey[4].

	No. of Households which own/use or have access to:	%
Tumble dryer or drying cabinet (n=40)	21	53%
A++ rated washing machine (n=38)	12	32%
Washing machine with eco-programme(n=38)	25	66%
Regular use of laundry room (n=40)	1	3%

1.4 TOOLS AND APPROACHES USED FOR ELL1 AND ELL2 OUTREACH AND COMMUNICATION

In order to encourage households and give participants some helpful hints and materials to take part in the challenges, each participant received a challenge box which contained materials for both the laundry and heating challenges. The box was split into two sections with the top section to be opened on the 15th October (the first day of the laundry challenge) and the second section to be opened on the 5th November (the first day of the heating challenge). For the laundry challenge, the contents included wet and dry stain removers, a clothes brush and lint remover set, and over the door clothes hanger and an apron. The contents were chosen to help encourage the households to attempt some of suggested strategies to reduce the speed at which clothes ended up in the laundry basket. For the heating

Picture 3 Laundry Challenge Box Contents

[4] AA+ rated washing machine and washing machine with eco-programme are from the baseline survey

challenge, the box contained a large blanket, an eco-hot water bottle, “Energise Me” tea and an ENERGISE mug. While most household already had some of the items in the challenge box, it was explained to each participant that the challenge box was designed to provide some simple ideas and materials to aid them in their attempts to meet the ELL challenges.

Additionally, households were provided with electricity meters for their washing machine and tumble dryer (where present) and three thermometers which had large and easily visible displays. The effect of these measurement tools had the effect of giving constant feedback to the participants.

Picture 4 Heating Challenge Box Contents

PID:281: “We have become more sensitised [to the internal temperature], certainly. Especially while looking at the thermometers.”

Picture 5 Electricity Meter

Picture 6 Thermometer/Hygrometer

A closed messaging group was set up to stimulate interaction between ELL2 participants however this was not used. While the implementation team attempted to stimulate interaction, the participants choose not to use the platform to interact. This may be partly explained by the fact that those ELL2 participants who were recruited by word of mouth had a pre-existing social connection were able to easily discuss the project outside of the group on a one to one basis.


Wochenende
Kreisbote
Weilheim-Murnau
Auf dem Weg zum Titel
Fußball-mini-WM 2018 in Polling: Phantastische Fans, begeisternde Spiele
Wer macht mit?
LMU-Forscherteam sucht Haushalte für Energiespar-Studie

Picture 7 Appearance on front page of local newspaper Kreisbote

Picture 8 Online promotional recruitment video

Outreach and communication was prioritised during the recruitment phases with an online promotional recruitment video (Picture 8) recorded and embedded in the national ENERGISE website which people were guided to through local media (Picture 1: circulation 45,000) and promotion both on the University and project partner websites (Energie-Wende Oberland).

2. PRACTICES BEFORE THE CHALLENGE (FROM THE DELIBERATION PHASE)

This section examines the practices existing in the households before the challenge. It is based on a survey sent to participants and on qualitative interviews (ELL1) or focus group discussions (ELL2) conducted before the start of the challenge. These datasets are complemented, where necessary, with observations made during home visits. In the following, we first discuss practices related to thermal comfort, and then, practices surrounding laundry patterns in the participating ELL households.

2.1 PRACTICES RELATED TO THERMAL COMFORT

Among the German ELL households, it could be said that evidence of home heating as still being a gendered practice among the sampled households exists with responsibility for temperature and heating system settings resting with the male adult in 16 (48%) out of 33 households where both a female and male adult were present. 10 households (30%) reported that both adults were responsible for the heating while just 4 households (12%) reported that the female adult was responsible for managing the heat settings.

Table 6 displays the mean, max and min temperatures given by participants when asked what they would consider to be ideal temperatures in the winter during daytime for the living area (n=38), bedroom (n=38) and a child's bedroom (n=31[5]). The most striking aspect of initial thermal comfort practices reported by participant households was the wide range of temperatures preferred or desired in different settings. An 8 degree range from 25.5°C to 18°C was reported for desirable living room temperatures with ELL2 participants reported a slightly lower mean of 21.3°C compared to ELL1 households with a value of 21.9°C with an overall mean for all households of 21.6°C. When asked about desirable bedroom temperatures, a 14 degree range from 24°C to 10°C was reported with ELL2 participants again reporting a slightly lower mean of 17.1°C compared to ELL1 households with a value of 17.3°C with an overall mean for all households of 17.2°C. When asked about appropriate temperatures for a child's bedroom a 12 degree range from 25°C to 13°C was reported with ELL2 participants again reporting a slightly lower mean of 19.6°C compared to ELL1 households with a value of 21.2°C with an overall mean for all households of 20.4°C.

The extent of the range of temperature preferences expressed was a surprising initial finding and meant certain households were presented with a much greater challenge to their normal heating practices than others in terms of the uniform heating challenge outlined for the ELL active challenge phase.

[5] Where no children we present in the household, the participants were asked their ideal temperature for a third room in the house, typically an office.

Table 6. ELL participants' perceptions of desirable temperatures in the winter during daytime before taking part in the ENERGISE challenges (n=38)
Source: baseline survey

N=38	Mean ELL1	Mean ELL2	Mean	Max	Min
Living area, °C	21.9	21.3	21.6	25.5	18.0
Bedroom, °C	17.3	17.1	17.2	24.0	10.0
Child's bedroom*, °C	21.2	19.6	20.4	25.0	13.0

In the majority of cases participants were rather satisfied with their current indoor temperatures. Around 68% of respondents felt that their general indoor temperatures were "just right" with a similar figure (65%) reported for living temperatures. Almost 85% made the same assessment of their bedroom temperatures. In most cases the remaining participants reported that they felt that the temperatures were too low with a small proportion reporting that they felt the temperature too high in the house (11%), living room (3%) and bedroom (11%) respectively. Only 42% of respondents reported that the other household members had the same view on the indoor temperature as the respondent did. In the 22 cases where differences in temperature preferences were reported, an equal gender balance was found while 4 respondents reported that the children found the temperatures too cold.

In terms of heating related practices, we asked participants about whether or not they engaged in a number of actions that either reduced the total heating required or minimised heat loss. The material conditions present were key determinants on the performance of such practices. Most households (74%) could adjust the heating settings separately in each room. In contrast, 10% of households reported that the heating was centrally controlled for the entire dwelling while 16% reported that both methods of adjustment were possible. An interesting observation was that of participant households who had underfloor heating. Households reported that since the underfloor heating took so long to react to changes in adjustment that it would not make sense to turn the heating down for short or medium term periods e.g. when airing out rooms.

PID:320: "the underfloor heating makes this impractical for us".

Additionally, while some households expressed satisfaction with their underfloor heating a number of households with underfloor heating expressed frustration with its slow response time and temperature minimum.

PID:307:" Yes, this sluggishness of this floor heating bothers me…the problem are the rooms of the kids, which must be warm during the day (i.e. in the afternoon when they are home) and quickly cold in the evening. And that is not possible with floor heating".

This was a contributory factor to the figure of only 32% of households saying that they regularly turn down the heat when airing rooms. In terms of turning down the heating at various times, 37% (14 of the 38 households) reported turning down the heating manually at night, while 45% households reported turning down the heating for extended periods of absence. Many households reported having proprietary heating programs to turn down the heating at certain times with a number of households reporting the presence of a "Nachtsabsenkung" program on their heating system to reduce the temperature levels during the night.

Further with regard to airing patterns, the concept of *Stoßlütfen* is a common airing practice with a particular meaning to German households. When asked how they aired their rooms, the majority of ELL households said that they practiced *Stoßlütfen* i.e. opening all of the windows (and doors where

applicable) wide for a short period of time of about 5-10 minutes (typically morning and evening) to allow a full air exchange. This practice is in part due to high levels of importance/concern attached to ensuring that mould does not develop. This can in turn be partly explained by differences in construction with airtight rooms more common in German dwellings and ventilation ducts from individual rooms to outer walls less common.

PID:302: I'm just afraid that if you do not heat the rooms here, we would have a mould problem. That's the next issue, we have new windows, we had them done when we moved in. It is of course always a question of what is better, to have constantly cold air and have to heat again, or I have no draft and need to air and heat differently to prevent mould.

Table 7. Frequency of various heating-related practices among the ELL participants in winter-time before participating in the ENERGISE challenges (n=39)
Source: baseline survey.

	No. of Households	Share of Households **%**
Turn down heating for the night	14	37%
Turn down heating when not at home	17	45%
Turn down heating in unused rooms	25	66%
Has program to automatically turn down heating at certain times	23	61%
Air rooms for more than a few minutes per day	2	5%
Turn down heating when airing rooms	12	32%
T**otal respondents**	**38**	

When asked about changes in heating practices they had in the past, households responded with a wide variety of experiences which were determined primarily by their material conditions and historical circumstances but also by their relationships with other people in the household and the presence of power dynamics. Many respondents remember colder temperatures from their childhood, typically as a function of their circumstances while others with more comfortable beginnings appeared to have a less emotional connection to the subject.

PID:281: "Sometimes there even have been frost flowers at the windows."10m34s: "We have more comfort [now], one could say. Sometimes we heat in summer if it's very cold and we're freezing."

PID:304L: "I don't want to have it like back then…"

PID:307: "Too cold. Definitely too cold. The house is [was] ice cold"

PID:287F: "My parents who were the generation of (during/after) the war. Some of them had not been able to heat their houses at all. They were happy that they had something combustible for grandma's stove, which she had. And that was the room where the whole family was"

PID:310F: *"We had coal but we never had a heating system. So really we were freezing…we slept with a blanket under a down duvet in winter and with a hot water bottle or something. That was really…. 'och'."*

Others remembered different heating practices from when they lived alone or lived with another person with different temperature preferences/requirements.

PID:304 "Male: I personally had less temperature. But just for cost reasons. Even if I think I'd rather put on a pair of sweaters instead of turning the thermostat higher, because the sweater has no running costs and heating for me and I've just adjusted a bit to be honest. Yes, so I can live at 18 degrees. I mean I think that's nice too and that's fine"

PID:285: "Before I always turned up the heater. From off to on and from small to big." 05m30s: "This has changed, because there was no one telling me that they were too cold."

PID:308: "So in my apartment I had a heater. I turned it on when I was actually there. […] In her parent's house, yea. Well, in mother's living room there was always a good fire."

When participants were asked about their existing systems and whether or not they were satisfied, most responded in the affirmative however some households pointed to disappointment about certain technical aspects such as the responsiveness of the heating system and how the system can(not) be used to control different areas of the dwelling.

*PID:281: "You only can adjust it very roughly (*underfloor heating*), then it's too hot, then too cold again…that means, that in the evening I already have to consider how the temperature will be the next day.(regularly) it's still warm even though I don't need it warm anymore."*

PID:283: "the thermostat for the bathroom heating system is located inside the heating system cover outside the bathroom. This is not well planned".

PID:309: [male]: "I don't like that you can only control the temperature here [living room]. And all other rooms are depending on it. That is stupid."

One household voiced their frustration at being unable to install a wooden stove due to their tenure status[6].

PID:288F: "we are not able to install a stove, a wood stove…that's actually the only thing that really annoys me."

Picture 9 Photo elicitation for heating norms Picture 1

Picture 10 Photo elicitation for heating norms Picture 2

[6]Tenure status also cited by households PID:280, PID:303, PID:285, PID:308 and PID:288 as reasons given for not undertaking any energy investments in the recent past (Baseline Survey)

When discussion norms and expectations around heating, the participants where shown two images (Picture 9 and Picture 10) illustrate two contrasting approaches to keeping warm. The first picture portrays heating space with a mother and daughter in light summer clothing in the living room beside a *Weihnachtsbaum* (Christmas Tree). The second shows an example of heating bodies instead of space with a man wearing a "snuggy" (a blanket with holes for the arms) on a sofa. Participants where asked on their thoughts without prompts on the two images.

In relation to the first picture (Picture 9), depicting heating space sufficiently to enable the wearing of light clothes in winter, the majority of participants identified heating to such a level as unnecessary, with some participants identifying it as wasteful. However, only a small number of participants made a direct link with heating "excessively" and environmental cost rather than personal cost.

PID:281: "It is definitely too hot…..If this (the Christmas tree in the visual) symbolises the season, then it's too hot, too much heating, yeah"

PID:302: "I think it's a pity because so much energy is used that does not make our footprint any better. Everyone has a sweater and can put on clothes and that does not hurt anyone. Yes, it's basically that, just take a blanket and think about the environment"

PID:283: "for me, this would be too warm. I am irritated that they are wearing short clothes and then the Christmas tree … floor hearing is somehow comfy, but this Christmas tree bothers me".

PID:304: [Male] "at a minimum long trousers and long sleeved tops should be worn. Everything above 23 or 24 degrees is luxury.

PID:285: "It is probably too warm if they run around in short pants on Christmas…if I am too cold, I put myself in bed or wear a pullover. I don't turn on the heater just because my body thinks it's cold."

PID:308 [female]: "So, I find it needless. Definitely. You already took out your long things for winter. And then you heat THAT high, if you open the door, the warmth goes out quickly. I find this excessive."

PID:283: [Male] "No that is sheer waste".

However other households felt that it was a personal choice and noted the different temperatures at which others feel comfortable at. The notion of limits in terms of energy saving versus personal preferences were highlighted and issues relating to the ability to afford such "luxury" were discussed. In particular, one participant stated that they [couple] felt that they had worked hard during their life and felt that they had earned the right to have higher temperatures indoors. The female participant had grown up in the East of Germany and had experienced very cold temperatures as a child and could be said to be unapologetic about being really happy that they [the whole family] could walk barefoot at home.

PID:301: "I'd like it like that. […] That's cosiness. It's nice when I don't have to wear a fleece pullover in my house".

PID:284 "Turn the heating down, but I don't know if they feel comfortable? There is also the question of how expensive is it for them? How much money do they have? What area do they heat? On the other hand, it's environmentally friendly to turn down, isn't it? To drop 2 degrees, you can do something for the environment."

PID:307: "After all, everyone has to decide for themselves. There are also "hot" people who are wearing a T-shirt, shorts and walk barefoot all year. We have such a neighbour who does not heat much but who is wearing a T-shirt and runs around barefoot in winter."

PID:310 [female]: "That's definitely me."

When asked to reflect on the second picture (Picture 10), a number of participants identified with the person portrayed, remarking how they often require a blanket or extra clothing in comparison to the other adult in the household (PID:307, PID:308, PID:288). One household agreed with the principle portrayed but raised concern that not heating to a minimum level could result in mould development (PID:302) while others worried that it would not be comfortable when moving through the house (PID:309, FG). One participant remarked that such action could be regarded as extreme and though about how one may not be favourably perceived.

FG[7] [female]: "Well I would like this blanket. With the sleeves for the hands. It could be me, theoretically."

PID:283: "It is a little bit stingy. Of course that is also possible and I know as well such families, where it must not be warmer than 18 degrees in the house and (...) then (...) So for me it is not necessary. I enjoy that I can also move freely that I do not always have to wear a thick jacket or need to take a blanket and scarf."

PID:309: "For the energy efficiency it would probably not be bad. But I want to come home and have it warm."

FG [female]: "I would feel cramped in this thing."

Overall the breadth of responses mirrored the wide range of desirable temperatures reported in Table 6. Additionally, it should be noted that a number of households had very favourable material conditions with very efficient heating systems and insulation. Given that these households were very aware of these circumstances it was understandably difficult to compare qualitative assessments of what was perceived as unnecessary or luxurious with each household perhaps perceiving the different scenarios within the context of their own material conditions. Additionally, given the design of the ELLs and the emphasis on sufficiency vs efficiency actions, challenging very energy efficiency households to lower temperatures to levels below which they had built or designed the house to maintain was understandably a difficult topic. It required a sensitive approach as such actions could be interpreted as challenging life decisions and choices which the households would heretofore be quite proud of, i.e. investing in a highly energy efficiency house so as to enjoy pleasant indoor temperatures at low energy cost.

2.2 PRACTICES RELATED TO LAUNDRY

While the figures related to heating practices indicated that there were significantly male dominated, the gender division of labour in relation to laundry practices in the German ELL households was heavily female dominated. Out of 33 households with both a male and female adult present, no male adult was responsible for the laundry. 28 households reported that the female adult was responsible for the laundry with the remaining households reporting that both the female and male adult shared the responsibility 50/50. Consequently, where both adults were present for interview, the female typically dominated the exchanges. This did mean however that in a small number of cases, the male was the principle participant contact and the female adult was not available for interview, i.e. the person describing the laundry routine and standards was not the person primarily responsible for it.

[7] FG= Focus Group where household could not be identified from recording.

German ELL participants mostly identified length of wear (45%) as the primary reason why a piece of clothing ends up in the wash with (39%) identifying stains as the primary cause. A minority (16%) identified smell as the primary reason. The number of weekly laundry cycles washed by households varied widely with an average of 3.8 cycles per week with one household reporting that they could wash 8-9 loads per week. The weekly frequency of cycles depended largely on the number of household members, however there is evidence to suggest that there are marginal efficiencies with the number of cycles per week per person with cycles per week per person decreasing from 1.4, to 1 when moving from a two person household to a three person household. The four person households had an average of 1.4 cycles per person per week, however many of these households had young children whom were cited by participants as being significant laundry generators. The other household sizes were too small to provide a meaningful point of reference.

Table 8. Laundry practices in different types of households before participating in the ENERGISE challenges (n=38)[8]

Source: baseline survey.

	Number of household members				
	1[9] (n=1)	2 (n=14)	3 (n=8)	4 (n=14)	5 (n=1)
number of laundry cycles	2.5	2.8	3.0	5.5	5.0
share using dryer regularly	33%	21%	63%	7%	0%
share ironing regularly	0%	36%	50%	43%	0%
Mean of laundry cycles pp. per week	2.5	1.375	1.0	1.375	1

Households most commonly washed their clothing at 40°C and bedlinen at 60°C. However, there was a relatively large variation between temperatures deemed as necessary, particularly with bed linen (Table 9).

[9] While 3 one-person households were in the sample, two could not give a weekly cycle estimate for the baseline survey.

Table 9 Washing temperatures among the ELL participants before participating in the ENERGISE challenges (n=39)
Source: baseline survey

	Mode	Mean	Lowest	Highest
Dark clothing, °C	40	41	30	60
White clothing, °C	40	37	30	50
Bedlinen, °C	60	57	30	75

Before the start of the laundry challenge, household were asked about the frequency of their performance of certain practices designed to reduce the amount of laundry required to be done. The common strategies were airing out clothes (61% of respondents did this), stain prevention e.g. taking care when eating (39%), brushing out stains, (32%) and washing out stains, (29%). Additionally, some households described their own strategies which largely involved changing into particular sets of clothes for particular activities (housework, cooking, gardening, playing and changing out of work clothes immediately when arriving home (PID:292, PID:316, PID:299, PID:320). Interestingly, 7 of 38 households (18%) reported that they did not employ any of the listed practices to reduce the level of laundry.

In terms of the primary material condition for laundry (i.e. the washing machine), many households mainly used only one or a few of the existing programs in their washing machine and some households were not sure if their washing machine had an Eco-button/programme option. Half of the 38 participants did not know the energy classification of their washing machine when asked while many households who gave an answer were unsure and wanted to check to confirm during the course of the baseline survey which was conducted face-to-face. This is an interesting result given that 34 out of 38 participants (80%) answered in the affirmative when asked whether they consider energy efficiency when buying electrical appliances/devices. It may be that once a purchasing decision is made, that people simply consider the purchase as a sunk cost and do not reassess the purchase until the appliance/device needs to be replaced. Regarding energy use, none of the German ELL participants were served by companies providing different day/night tariffs (not a common occurrence) thus the decision making process in terms of timing of laundry was not openly influenced or effected by any cost considerations while any altruistic environmental considerations in terms of timing of laundry were not mentioned other than noise pollution.

PID:304: "In the old days it was only because of the neighbours. We did not want to shake them out of bed in the morning because our washing machine was very vibratory."

When asked to describe their typical laundry routine, households described a wide variety of approaches with some households describing the laundry as more or less a regular or planned activity while other described it as a task that is performed when it needs to be done, either because the washing basket is full or they need more clothes. Those that described it as a more planned activity were typically larger sized households with young children/children still living at home indicating the influence of life stage factors. The description of special occasion laundry is also mentioned with the changing of the seasons, holidays, and the presence of overnight guests/visitors bringing about more washing than normal.

PID:302: "Normally I try to wash at weekends and not during the week, because that just suits me better in terms of time."

PID:283: "If the laundry basket is full the process starts. Sometimes the basket is overloaded so then there are more laundry loads. So let's say I'll do five washes per week on average. The washing is not done on a specific date. It is possible that I don't wash for four days but then I'll have to wash

three washes that day. So on average there are five washes. But if we return from holiday or I'll do linen or something bigger it's more."

PID:304: "Just wash twice a week because we have work clothes yes. But I have overlooked that Autumn has just started. That means, I then washed the sheets again, as I took other bed linen. Plus we have all the summer towels, which one has taken for bathing."

PID:285: "[I wash] if I have time and if there is a fair amount of clothes."

PID:310: "We don't have a fixed washing day. If the box is full, I wash it. Then I sort it. It is possible that we have three machines on that day."

The nature of one's occupation was also described as an influencing factor One respondent who works in sales admitted that they had a habit of occasional "emergency" washing of shirts if he needs them for work the next day which results in a non-full load but described how his wife *PID:282: "pays attention to this, that she really washes a full machine"*

During the group discussions (both focus group and where both male and female adults were present for interview), the gendered division of labour was very present with the female participants dominating the conversation. When asked to discuss changes from the past participants noted marked differences in terms of what was deemed necessary previously and what is deemed necessary today. Some mentioned negative memories of doing laundry in childhood describing how their parents (typically their mother) regularly washed at very high temperatures at 95 degrees in wash boilers and how they used to iron much more in the past.

FG: "My Mum would have told me [how to do the laundry]. But I found a more suitable way for me. For example, all this separating and stuff... I recognised that one could do it, but I don't practice it. My Mum, she washed with ninety-five degrees. […] I never did that.

PID:313: "My mother did a lot more of hot-water laundry. But I mean, back than you had much more white things. Bed sheets were white; underwear was white."

With regard to dryer use, time was identified as highly influential factor, as the use of a dryer avoided a significant time cost in terms of hanging up the laundry particularly with children typically having many small items.

Regarding appropriate temperatures, there was a wide variance/difference of opinion on what was necessary for certain categories of laundry.

PID:302: "Most of the time I run everything at 40 degrees (cotton cycle). This is my standard program"

PID:283: "Mostly 30, except for linen and towels. They are washed at 60 degrees Celsius."

PID:286: "Basically, I wash only at 30 degrees. I do not fear from bacteria and other stuff. So we do not need higher temperatures and then everything runs fine on a low program."

Some reported being prevented by washing at lower temperatures by the material condition of their washing machine

PID:295: "Mix is for cotton and synthetic fabrics and things like that. It's a program for mixed laundry. And it's a relatively fast program, well, it does take an hour or so. But it's not available below forty degrees. So the temperature options start at forty degrees and you also can wash with sixty in that mix-program".

Picture 11 Photo elicitation for laundry norms Picture 1

Picture 12 Photo elicitation for laundry norms Picture 2 "no laundry pile is too high"

Picture 13 Photo elicitation for laundry norms No. 3 "An up to date laundry detergent for the woman from today"

In an attempt to gather perceptions and impression around social norms related to laundry, participants were asked to reflect on Pictures 11, 12 and 13 and give their thoughts. In each case the participants were asked for their initial thoughts with follow up questions and prompts asked where necessary.

With regard to Picture 11, participants were asked about their perceptions of cleanliness and whether things had to be "strahlend weiß" or bright to be clean and if washing routines were linked to health, i.e. does cleanliness translate to healthiness? Many participants expressed the view that the cleaner we become the less resistance we have to infection and it is not necessary for clothes to be completely germ free.

PID:280: "For sure, clean clothes. But not as extreme as that. All this disinfection-stuff and what else is there. I don't believe this is necessary"

PID:281: "We are too clean now…were are in a "Teufelkreis" [devil's circle] where children are not getting enough germs!"

PID:302: "Nah,…I believe that this is counterproductive and that we breed more allergies, the cleaner we become".

PID:285: ""I don't know. If we had more dirty clothes maybe we would be less sick."

FG: [female] "Well but we actually know that the opposite is true. Kids which have been raised on a farm, in the so-called dirt. They have less autoimmune illnesses, than clinical clean kids which are disinfected at all times."

PID:310: "No. This has just something to do with comfort, not with being healthy."

Other participants did however attach meaning to whites staying white and the importance of appearance particularly in certain situations.

PID:301: "No, but for the look. When I wear something white, it is because I bought it specifically for that purpose. I bought it because it is white and not grey. Otherwise I could have bought something black or grey from the beginning".

PID:303: "Yes, of course. I mean, if you are sweating a lot, then you'll get yellow stains under the arms. But, I mean, you can't avoid it, but in case of doubt just buy a new shirt [laughs]".

PID:283: So that is way too strong for me. It is okay, it is beautiful. I like it as well if it is nicely bright and white. I find it impressive if others have it (this white), but I know that this is not comfortable wearing the chemical stuff on the skin. Or if you take it out of the wardrobe and you smell a cloud of perfume. I don't like that…So in everyday life I think it should be clean and hygienic. (…) As well if the kids go to school it (they) should be proper.

PID:304: [male] "Me, I do not know how I feel because I have the opinion that white does give a clean impression. A white shirt always has something clean about it"

PID:284: [male] "just right, clean, pure, mindful. Well, one who has a white shirt, and there's a stain on it, that's not good"

PID:289: [male] "I think that it does not have to be sparkling white to be clean." female]: "Well it depends what it is. Because I think a shirt has to be white."

With regard to Picture 12, participants were asked if they identified with the mountain of laundry/ironing presented. Most associated the picture with the amount of time devoted to the consequent practices associated with laundry cycles rather than the washing of the clothes themselves, discussing the time spent sorting, folding, (in fewer cases ironing) and putting away the laundry. Some participants again referred to the topic of special occasion laundry. Understandably, participants from smaller households generally did not typically identify with the problem as they wash less frequently and are "responsible" for less laundry than other larger households.

PID:301: "I reduced as much [ironing] as I could. Like I said before, we are all working, and it must go fast. We don't have the time."

PID:307: "Yes, but rarely. It's really rarely that bad. It's usually only when so many appointments come together, a lot of work plus many visits. Or maybe after holidays, but not really."

PID:288: [female] "So just now I've folded the laundry. That took half an hour. Yes, if you do that three times a week, yes, it takes a lot of time."

FG: [female] "while the washing itself is not [time consuming]. I mean you don't stand there and do the wash, but the machine does it for you. But everything after, when you put the things into the basket and then don't find the time to put it into the drawer. That is very time-consuming."

Participants were asked to consider a third picture, (Picture 13-*"An up to date laundry detergent for the woman from today"*) and give their response. The picture was hoped to elicit a conversation around gender norms related to laundry however in almost all cases, the participants did not make this association and enter into a discussion about the topic without prompting. It is unclear why this was the case given the heavily gendered division of labour in participant households. One possible explanation is that over half of the female adult participants worked part-time[10] meaning that the gendered nature of laundry in the sample could be seen to be more reflective of family circumstances rather than laundry being seen primarily as women's work.

[10] While only one male adult worked part-time

PID:307: "That's because I'm working part time now. Conscious of the children, of the family, and um, yes, and then I just have the "wind" (time/energy) for it. "Ich habe da einfach ehr die Luft dafür"…Additionally the technical operation of a washing machine is so complicated that some men don't want to go through it (laughs ironically)"

When the topic was eventually discussed, a generational element was heavily present with the younger males more likely to assist or share the laundry workload with older males much less likely to be involved. There was also evidence of the indirect acknowledgement of this gender imbalance in the laundry workload from the older male participants, typically delivered through humour rather than direct admission.

PID:319 [Male]: "The one who does it better, has to do it." [female] "It's amazing, how much we (women) can do it better! [laughter]"

However, participants generally agreed that laundry was no longer seen as women's work. One could conclude that the gendered division of laundry work in the sample may be due to more complex gender issues not explored in this study such as part-time involvement in market and the traditional division of labour and gender roles (Stier and Lewin-Epstein 2000)

3. PRACTICES DURING AND DIRECTLY AFTER THE CHALLENGES (FROM WEEKLY AND EXIT PHASE)

This section describes the changes reported by households participating in the ELLs during and directly after the laundry and heating Energise challenges.

All households were challenged and agreed to "*versuchen"* (try/attempt) the general energise challenge i.e. to reduce indoor temperatures to 18°C and to cut the number of laundry cycles by half. However it was discovered that during the course of the closing survey that a number of households had written in their own challenges when ask whether they had attempted the general ENERGISE challenge or their own personal challenge. Since the closing survey was completed by most households during the scheduled exit interview period there was no opportunity to review analyse and discuss this challenges with the household, thus it is unclear whether or not the households viewed these as additional personal challenges or simply revised their challenge based on how they were coping with the general challenge. Table 10 shows the share of households signing up to the common challenge, and provides examples of individual challenges.

Table 10. Share of households signing up for common or/and individual challenges Source: interviews and closing survey

	Common challenge	Individual challenges (described ex-post)	Examples of individual challenges
Laundry challenge	All Households	8	*PID:301: "washing only full loads of laundry"* *PID:305: "thinking more about whether it is necessary to wash or not"* *PID:286: "airing out and removing stains"* *PID:311: "won't buy a new dryer - the old one had broken down briefly before the challenge"* *PID:292: "washing three instead of four laundry cycles per week"* *PID:297: "trying to optimize the wearing period of clothing"* *PID:298: "reducing the overall amount of laundry and washing constantly at 30 degrees"* *PID:318: "quit using the dryer"*
Heating challenge	All Households	5	*PID:305: "set the temperature to 19 degrees* *PID:290: "set the temperature to 19.5 degrees* *PID:312: "heat the children's rooms not at all and heat the living room with wood* *PID:313: "set the temperature to 19-20 degrees in the living room* *PID:298: "set the temperature a little lower than the usual sense of comfort"*

The following sections reflect on changes in practices reported by households in the areas of laundry and heating. The data for this section is derived from the baseline survey, the weekly survey sent to households, a closing survey directly sent after the end of the challenges, as well as a closing interview (ELL1) and focus group discussion (ELL2). Additionally, indoor temperatures were monitored in the main living area in each household with a temperature logger while electricity use for laundry machines i.e. washing machine (and dryer if used) was monitored with a power meter and recorded by the household in their laundry diary which helped the households keep track and report their laundering activity for the weekly surveys.

3.1 CHANGES IN REPORTED HEATING PRACTICES

The heating challenge started on November 5th in the German ELL households. Households were asked to try to reduce their indoor temperatures to 18 degrees. In order to help with the challenge, participants were supplied with three thermometers/hygrometers (Picture 6) which were placed in their main living area, bedroom and a third room of their choosing based on where they felt the spent the most about of time. Additionally, temperature loggers were installed. The temperature loggers were installed as a "black box" independent monitoring station which households were encouraged to forget about. While the temperature loggers were calibrated (Picture 14) the thermometers/hygrometers were not. This was partly due to practical cost considerations but also due to the desire to simulate a real world setting i.e. with households using and interacting with non-specialised equipment. In a period of ad hoc testing before the commencement of the lab it was found that while the thermometers had a stated measurement range of +/- 2 degrees, on average the thermometers underestimated the calibrated temperature measurements taken by the temperature loggers by approximately 0.5 of a degree. While this was not a statistically controlled calibration experiment, self-reported values taken from the placed thermometers should be viewed with this difference in mind. Additionally, it should be noted that in post processing, temperature limits were imposed to avoid outliers perverting the sample, such as in the case of the temperature logger being temporarily moved to a location of intense heat or cold during cleaning or by being interfered with by children. Temperatures we bounded to a low of 14 degree and a high of 30 degrees. This range was only broken in two cases and for a short amount of time (less than a day).

Figure 14 Omega OM-92 Temperature/Humidity Logger

Figure 14 presents the measured mean differences in indoor temperatures for both ELL1 and ELL2, based on temperature logger data from the participants main living area, during the four week baseline period[11] (8th of October to the 4th of November) and during the four week challenge period (November 5th to December 2nd).

On average, the temperature in the main living area of ELL1 participants decreased from 21.36 during the baseline period to 20.3 degrees during the challenge period, a reduction of 1.06 degrees. The temperature in the main living area of ELL2 participants decreased from 21.52 during the baseline period to 20.29 degrees during the challenge period, a reduction of 1.23 degrees with an overall reduction for the sample as a whole of 1.14 degrees.

This would indicate similar challenge outcomes for the two groups with temperatures for ELL2 participants coming from a slightly higher baseline average. It should be remembered however that between the baseline and challenge period, external mean temperatures fell approximately 6 degrees from 11.5 to 5.5 degrees[12]. While we assume that households are both in control of their

[11] Given that the Bavarian summer typically maintains average daily highs of 19 degrees during the month of September, most households had not yet turned on their heating systems until early/mid-october. Thus is was felt that the inclusion of ELL monitoring weeks 1-3 in the baseline period would not provide a reasonable basis of comparison for before, during and after the heating challenge.

[12] Averaged figures from two external temperature loggers placed in Iffledorf and Murnau. An additional third external temperature logger was placed in the center of the town of Weilheim but appeared to suffer from a significant heat island effect in the order of +2 degrees which would not have been availed of by the majority of ELL1 participants in the surrounding suburbs and villages. Therefore the average figures from the Murnau and Iffledorf loggers which recorded very similar profiles have be used to create a common external temperature for the purposed of comparison.

heating system and control the desired temperature in the main living areas, it is clear that some of the reductions reported in Figure 1 could be simply attributable to the changes in the external temperature rather than changes in the practices of households. However, given that households during the baseline and challenge periods are on average maintaining temperatures 10 and 15 degrees higher than the external temperature this would seem to be a reasonable assumption. More in depth targeted individual analysis into the temperature profiles from the heat required hours where the householder is more likely to be home would be required in order to give more definitive statements on temperature changes for both groups.

Additionally, it should be noted that two ELL2 households reported in the closing survey that they were unable to realistically attempt the heating challenge because of repeated illness in the household and because of pre-existing material conditions.

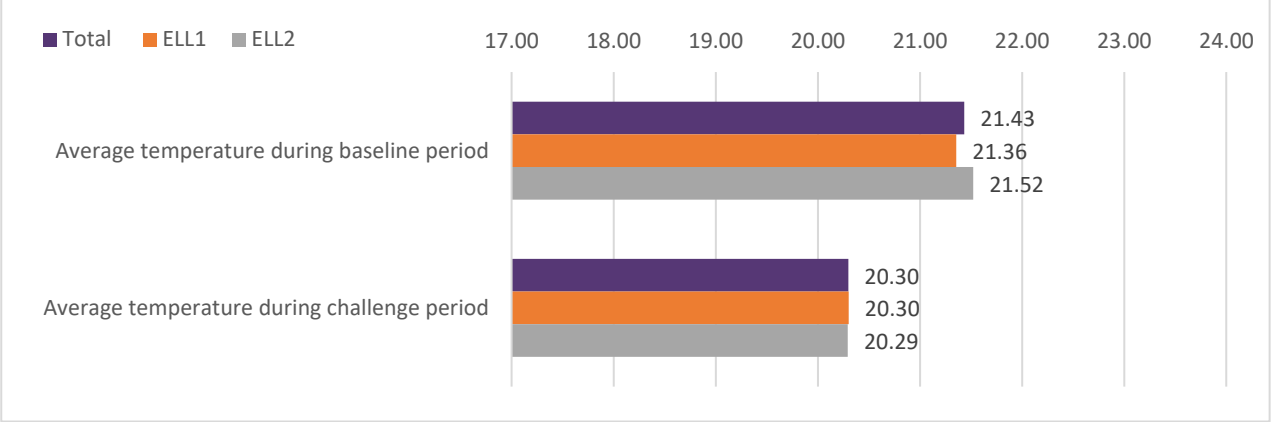

Figure 1. Changes in indoor temperatures before and after the heating challenge. Source: Temperature loggers

In the exit interview, households were asked how they got on during the challenge generally and more specifically, what changes they made and how routines were altered. Most households found reducing the indoor temperature to 18 degrees to be very difficult with some household expressing that they simply couldn't meet the challenge. Some households reported that their material conditions made it difficult to achieve such a low temperature during the day, particularly the more modern dwelling with large windows oriented to the south.

PID:304: [female] "We wanted to participate but it was not possible, because it was not cold." [male] "It was a minimum of 19.5 degrees during the first two weeks. During the day the sun heated up the rooms."

PID:297: "due to the automatically set temperature regulation in the living rooms little influence on temperature regulation [was] possible".

However, many of the reasons given were subjective assessments of what was acceptable to the household. These ranged from concerns about illness/health to statements of personal preference and expressions of limits in what participants would accept/be prepared to do with some households simply stating that they simply set the temperature at their desired minimum.

PID:292: "as almost constantly one of the household members was ill, [it was] hardly possible to reduce temperature.

PID:280: "We waited with turning on the heat until it got really uncomfortable. We discovered that during cooking in the kitchen 19 degrees or so are fine. But because we both work at home in front of the PC, 18 degrees is definitively too cold".

In that respect, it could be said that the range of commitment devoted to the heating challenge and the ease at which people accepted it varied considerably between households with some commitment to fully achieve the 18 degree challenge more than others. Predictably, those who expressed that they had lower personal temperature preferences before the start of the challenge did not find the challenge overly difficult.

PID:285: [things] did not change much. The heater was running on two everywhere. If it was really cold or I had visitors, I turned on the bio-ethanol oven."

PID:307: Yes, eighteen degrees is feasible during the daytime until, until midday, until the afternoon. And then, so in the evening it is / WE found, it's sporty [quite brisk]. So since then, I have been drinking tea again, which I did not do before, I drink tea and hot water. My children too [laughs], my husband does not drink tea, but coffee instead, but that's OK too [laughs].

In fact, a couple of households got very close to maintaining 18 degree temperatures throughout the challenge period despite one household (PID:310) stating preferences for much higher temperatures.

PID:310: "Fortunately, it wasn´t that cold outside… The plants survived it. And we as well. It was difficult to get the temperature down. But then we didn´t have more than 19.8°degrees. You get used to it. And we did not spend so much time at home. I think the cat was freezing the most (laughs), it needed more food".

Other households sought to lower temperatures to find out their comfort limit or what they felt they could live with, while one household simply stating that if they set the thermostat lower than what it was programmed to that they would feel uncomfortable.

PID:280: "In the bedroom 16° is fine and I´m cozy with a thick blanket, but in the living area 18 degrees is too cold, uncomfortable. But I´m sure before the heating challenge it was 2 or 3 degrees warmer, we reduced the temperature certainly."

PID:303: "We paid attention not to heat the rooms up to 24, 25 degrees but rather to 22 degrees in the living room, or in the office 21, 22."

PID:282: "Well, I have to admit this was really a challenge for us. Because 18 degrees…. I felt cold very easily. We did not have 18 degrees in any room, that didn´t work, rooms that we live in – living room, bed room. The temperature was never below 19°degrees. 18°degrees is really impossible. I sit there wearing my bath robe or covered in a blanket, but when I get up and I´m freezing, I´m having enough right away. When you gave us the challenge we said immediately 'we´ll try it, but we'll certainly will not stick to it, because it won´t work for us. 20°degrees or more are fine, but not below that".

PID:306: "Then most of the time we heated up to 20 degrees so that it is not overly warm, but that the temperature is raised a little bit so that you feel a bit more comfortable again. So that was really difficult."

PID:286 "I put 23 degrees [on the thermostat], so it always has this temperature. I know, if I would turn it down, I would feel uncomfortable."

As described previously in section 1.3, another common observation was that some households used the wood stoves to provide additional heat and did not necessarily see them as an equal part of the heating system as such and seem to interpret the challenge more in terms of their use of the primary (fossil fuel) heating system rather than the secondary wood based system.

PID:301: "We programmed the app for the heating system to 18 degrees. But in the evenings it was quite cold so we used the wood fired oven additionally. During day time, when the sun was shining…

we have windows to the south side, the sun heated the living room. During day time we had 20 or 22 degrees."

PID:281: "The temperatures were not really that high before the challenge. 21, 22 degrees. When it got too cold, we lit up [einschüren] the tiled stove. Then it got warm and cosy and we could set the [floor] heating to a lower level….We did not change any particular routine significantly. Everything remained quite as it was before… We drank more tea. But apart from that…nothing. We heated additionally with the wood fired oven. Sometimes a little bit earlier – doing this the room is and dos not get too cold. It is important that you do not let it cool down too much"

PID:283: "The heating system in the living room is still turned off, we just heat with the wood fired oven. And that works for us. Last year we would have combined the heating already"

PID:299: "18 degrees was quite a challenge…[but] the kids weren't that bothered by the heating challenge and it wasn't a big deal for them (the kids)… we used blankets and used the wood stove on occasion.

Others described their use of the wood stove when they needed quick heat.

PID:301: "One or two days it was very cold and wet outside, but then we lit the oven. I didn´t re-program the whole thing [the heating system]… the oven gets warm very fast."

PID:310: "Sometimes, when we came home from outside we felt the need to light the wood fired oven"

Some households remarked on how it's a lot more difficult to regulate and control the temperature when using the wood stove.

PID:307: "And then every three or four days we simply heated up the stove in order to reach the basic temperature again. But that was usually not eighteen degrees, because that is not so easy to control then, because when it's running, it just runs. What I mean is, often it simply rose to nineteen degrees, or nineteen point five, even."

When asked during the exit interview about changes in actions to heat bodies rather than space, households typically reported[13] performing more of the suggested tips discussed during the deliberation process such as warm socks (PID:306, PID:309, PID:310), extra blankets (PID:301, PID:282, PID:303, PID:283, PID:284, PID:306, PID:306, PID:308, PID:288), more hot drinks or food (PID:280, PID:283) and hot water bottle (PID:288, PID:309).

Additionally, one households reported a change in their heating habits for the room that they exercise in as well as offering a tip for hot water bottle use.

PID:302: "Usually I like doing my workout in a warm room. The first two times it took me some effort doing my workout in the cold room. But then I realised that it gets warm anyway… hot water bottle and blanket that´s the main thing… with a bit of salt [in the bottle] because it lasts longer."

However, one household described certain limits to the strategy of heating bodies rather than space in a work environment.

PID:280: "We´ve tried to eat hot meals, teas or wear more layers. But wearing more clothes is limited – I can´t walk around the house or office like a bear, sometimes customers are coming. As an estate agent I have to look decent… [also] the feeling of comfort is missing when you´re wrapped in too many layers"

[13] Households also reported other activities in the online surveys which are reported in section 3.3

Households did not report any substantial changes to the way they oriented their furniture or how they aired rooms generally, rather some households reported simply turning off or down the heating in rooms which are used less often or spending less time in colder rooms.

PID:282: "Yes, usually I get dressed in the bedroom, but I moved to the bathroom in the morning. There is floor heating and it had 22, 23 degrees. In the morning the 19degrees was too cold for me. Usually the heating is only turned on in the living room, bed room and bath room. We have more rooms, but the heating is completely off….We didn´t use the windows differently. I do [Stoßlüften], so the windows are completely open for five or ten minutes. But otherwise, I don´t think you can use the windows differently".

PID:283: "yes, the boys spend more time in the living room to do their homework, because it was warmer. But apart from that nothing really changed in the everyday life."

In terms of required activity or time, the households did not find the heating challenge onerous. The primary challenge for household could be better described in terms of a challenge to individual's perceptions/assessment of where the true minimum of their temperature comfort limit was and how far they were willing to go in terms of alternative body heating strategies, to counteract feelings of discomfort.

PID:301: "My wife and son were quite happy that the heating challenge was over. I think it is better to adjust the heating all the time. Yes, of course we can adjust the system manually but the temperatures that we had set before the challenge worked perfect for us. During day time, when all are back home at 13:00 pm the heating goes up to 22/23 degrees. In the living room. It is more comfortable to turn up the heating than to wear more clothes".

PID:281: "When it got chilly, we put on something [more clothes] or lit up the oven. Apart from that we did not do anything special. While watching TV or when you´re not actively moving it got chilly. Then we cuddled up in a blanket, uses the woollen blanket more often"

3.2 CHANGES IN LAUNDRY PRACTICES

The laundry challenge started on the 15th October (Week 5) after 4 weeks of baseline measurements. At the initial deliberation meeting all participants agreed to the general ENERGISE challenge of attempted to halve the amount of laundry cycles. Participants in the ELLs did not manage to reduce their number of laundry cycles by half during the challenge period. However, participants did reduce their number of laundry cycles by approximately 19% on average during the challenge period with ELL1 participants (22% reduction) fairing slightly better than ELL2 participants (17% reduction). This may be due to the differing composition of household numbers between the two groups with ELL1 households having a slightly higher proportion of adult household members (45 from 57 or 79% for ELL1 vs 36 from 54 or 66% for ELL2) meaning ELL2 households having a higher proportion of child members (18 from 54 or 33% for ELL2 vs. 12 from 57 or 21% for ELL1)

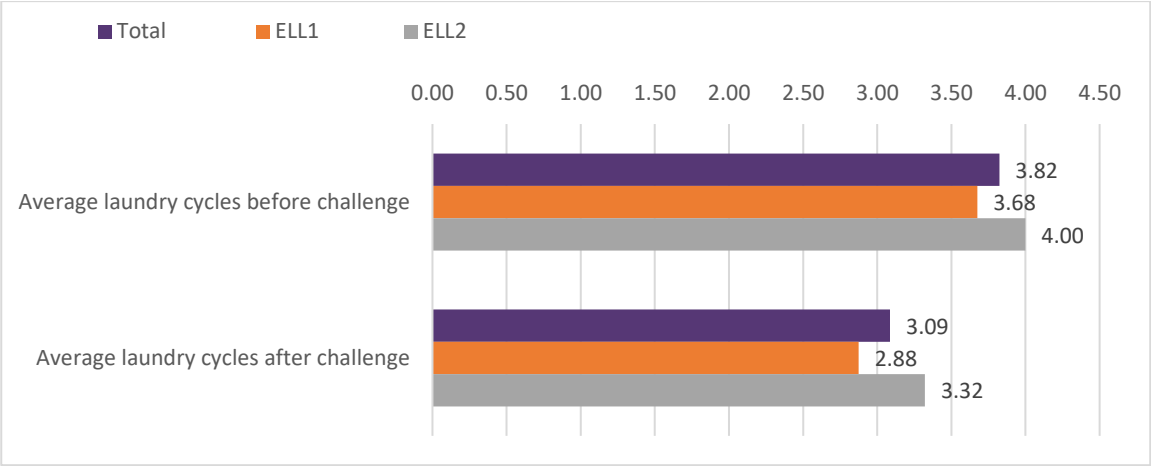

Figure 2: Number of laundry cycles washed during baseline and challenge periods. Source: baseline and closing surveys.

Table 11 shows how the changes in laundry practices are reflected in changes in electricity consumption for the washing machine. Mean weekly energy consumption dropped 28% from 2.26 kWh/week to 1.62 kWh/week for all households. While ELL2 households as a group started from a higher baseline, both ELL1 and ELL2 achieved the same 28% reduction in energy required for laundry. While the number of cycles (Figure 1) only reduced on average by 19%. The selection of lower temperature programs is likely to have contributed to this additional energy saving. After the laundry challenge period was over, 29 of the 38 households continued to use the laundry diaries over the remaining 3 week period. Changes from the baseline for this subset of participants are include in parentheses in the first row and final row of Table 11. These figures suggest that there is some evidence that households rebounded somewhat in their initial efforts after the end of the laundry challenge phase with an initial 27% reduction during the challenge phase falling back to a 15% reduction on the baseline period for the subset of participants who continued their laundry monitoring.

Table 11: Weekly electricity consumption for washing machines during baseline and challenge period Source: Laundry diaries.

Power consumption for laundry appliances, kWh/week	Mean	ELL1	ELL2	Lowest	Highest
Baseline (4 weeks) n=38	2.26 (2.29)	2.02	2.52	0.22	7.83
Challenge (4 weeks) n=38	1.62 (1.67)	1.45	1.81	0.23	4.05
After challenge (during heating challenge 3 weeks) n=30	(1.94)	(2.35)	(1.32)	(0.18)	(4.52)

During the exit interview, the response from households was that the laundry challenge was generally very accessible.

PID:280: "It was relatively easy, we had only 1 or 2 laundry cycles per week".

PID:284: "It think the challenge was really great, especially with the meter. "It was not difficult and was really fun."

PID:285: "It was very instructive and highly interesting. […] to pay attention to air out things and that you can wear clothes longer."

PID:286: "Yes, if you only have one or two washing cycles per week, you cannot really reduce that "I had 6kw during the challenge for washing. I think that is a little less than before."

The issue of household dynamics was heavily present with some participants describing how the new regime was either adopted or rejected by the other members of the household.

PID:281: "We tried to produce less laundry. It was easy for us but hard for my son. He did not produce less laundry than before. He is quite happy having all the clothes available, just wearing one piece and then… we could not convince him. We aired out clothes and wore clothes twice. We did this before as well, more sporadically, but had not been really aware".

PID:302: "I did not tell them that the challenge stopped (laughs). It just continues and goes on. This is absolutely great. Saves a lot of time.

PID:283: "It was ok. What I really liked was that since the beginning, it emerged as a topic in our family 'what can we do to reduce the amount of laundry'. We also had had spill-over effects to topics such as heating, environment, plastic – I think it was exciting that the challenge started this. Regarding the implementation, there was a 'click' present in the mind [to stop and think]. Do I really have to wash this or can I wear it for longer, or air them out? The kids are now moving slowly to the other extreme: I´m the one, who says 'no, that is really filthy, we have to wash it'. We try to find the middle ground. And I think we managed – for everyday life – to reduce the amount of wash cycles. Not to the half but almost. That´s not easy for five persons. The problem starts as soon as we have bedsheets or towels, these fill automatically two loads. Fortunately, that´s not weekly, but… I would like to separate the 'everyday laundry' and the 'special laundry'. We reduced it to 4 or 5 cycles per week, something else is not realistic for us, because of the 'special laundry'."

Households generally found the laundry challenge adaptable to their own needs with each household developing their own set of strategies based on their own particular circumstances

PID:282: "It was relatively easy. Well, I used the ECO-program anyway, but I`ve tried to use it more often. The aim of the challenge was to cut the amount of laundry in half. That worked at the beginning, because I was not at home. I was away while my husband was at home. During that time it worked quite well. When I came back home, ironically it didn´t work. Although I´m not the one with the huge amount of laundry. That´s my husband. He is a bit more challenging. We tried to keep the temperature low for washing. Usually, we wash towels or so with 60°degrees, I washed them with 40°degrees…"

PID:304: [female] "So, the laundry challenge was quite easy. We get working clothes from our employer. So, the amount is in general not that much compared to other households… I had the feeling that it is possible to have less laundry... [male]…You get more conscious. It wasn't hard. You were thinking twice about wearing clothes…[female]…Maybe I have changed clothes for different occasions more often".

PID:306: "It [the laundry challenge] was, honestly, relatively okay. "What I did, was to put more into the washing drum. So, I did not wash the linen after every guest for example but collected until I had two sets of linen and then washed it together."

PID:309: "[male]…I only saved on pullovers. During the challenge I hung them up or folded them. They were all right. All other things went directly into the washing basket….[female]….He always used the apron. He was happy about it."

PID:307: "Well, I was most scared of the laundry challenge, because I did do a relatively large amount of washing, and that was a large part of the housework [laughs]. And, right, through the

challenge I noticed that it's not worth it. And, like, and this laundry became less important, and it came to matter SO LITTLE to me that it's quite pleasant [laughs]."

3.3. POTENTIAL RUPTURES AND SUFFICIENCY POTENTIAL

Participants were monitored on a weekly basis about how they felt during the challenges. The vast majority of participants in both ELL1 and ELL2 reported feeling "relaxed" or "more or less fine" about the challenges throughout the challenge period (Figure 3). Comparing ELL 1 and ELL2, ELL2 participants generally reported that they were worried or annoyed more than ELL1 participants, perhaps due in part to the higher presence of young children in the ELL2 group but also perhaps due to less one-to-one contact hours between implementation team and ELL2 which could have made participants more comfortable in communicating dissatisfaction. In terms of comparing the laundry and heating challenges, it is clear that the heating challenge caused household more problems with a significant number of households expressing annoyance with the heating challenge in both groups and substantially lower expressions of feeling relaxed when compared with the laundry challenge.

Figure 3. How participants felt during the laundry (a) and heating (b) challenge, % of participants with different feelings during weeks 1-4 of the challenge Source: weekly surveys.

In assessing whether sufficiency measures and/or potential rupture effects have been caused by the ELLs a comparison of reported adaptive practices of thermal comfort and keeping clean before and after the challenge periods was undertaken.

Figure 4 shows changes in the number of adaptive practices of thermal comfort used by participants before and after the heating challenge. The vertical axis shows the type of adaptive practice, while

the horizontal axis shows the percentage of participants engaging in these practices. The most common adaptive practices reported before the challenge were to use warm socks or slippers (74%) to use an extra blanket (74%) and to use extra clothing (71%). At the end of the challenge period, the reported use of these three adaptive practices increased to 89%, 82% and 87% respectively. The increase in reported use of these body warming strategies is in contrast with the decreases in reported use of space heating strategies such as the use of blinds/curtains (down 5%), draught excluders (down 8%). The percentage of households reporting taking a hot bath or shower (not perceived as a positive measure from a sustainability viewpoint) decreased 26% meaning 10 of the 38 households in the sample reported abandoning this strategy. In contrast to the baseline survey, no household reported doing nothing (down 5%).

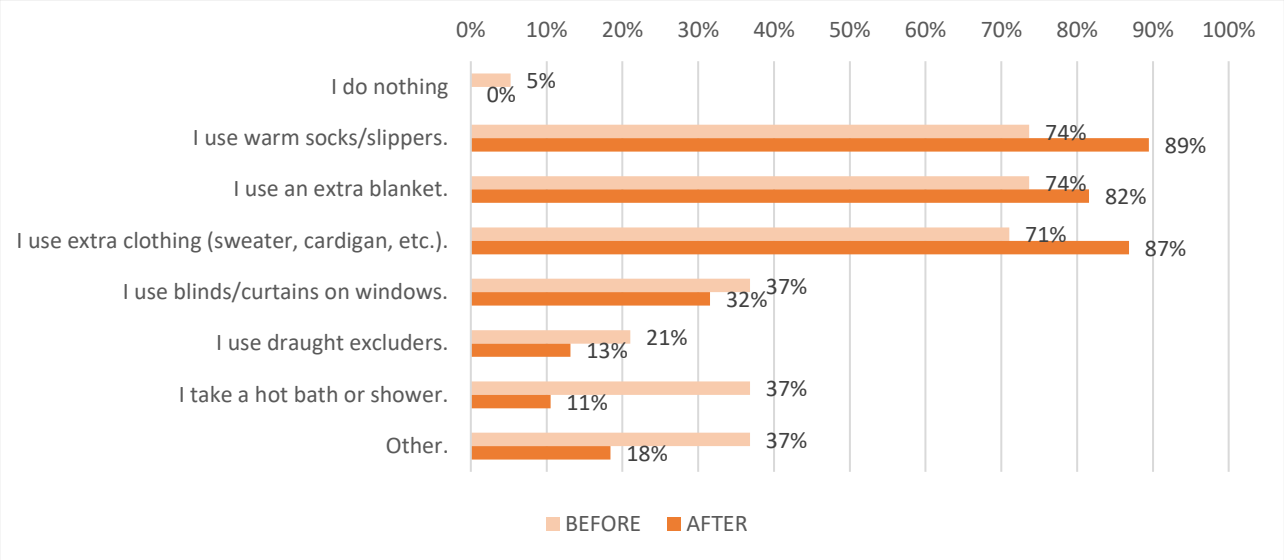

Figure 4. Changes in the performance of different types of adaptive practices of thermal comfort Source: baseline and closing surveys

Other strategies reported during the baseline and closing surveys included the use of hot water bottles, drinking hot drinks/food, exercising, cooking and cuddling.

It should be noted that the baseline survey was conducted at the start of the living lab process, i.e. 8 weeks before the start of the heating challenge while the weather was still warm. Thus households reporting of alternative heating strategies would not have been performed from recent memory and would have included any strategies they would have engaged in previously over a longer period than the closing survey which focused on strategies practiced over the four week challenge period. This would perhaps explain the reasons for the drop in self-reported use of the space heat saving strategies of draught excluders and windows/curtains/blinds.

When asked in the exit interview if the household thought that they would continue to engage in practices to stay warm at lower temperatures some households responded positively and said that they had reappraised what they considered necessary/sufficient. They also indicated changes or ruptures in the way they performed certain practices e.g. how they assessed whether they needed to turn up the heating, relying on the visual aid of the thermometer rather than simply by feeling.

PID:280: "Yes, we definitively try to keep the temperature 2 or 3 degrees lower than before".

PID:281: "I think we will continue to do some things. Maybe to lower the temperature by one degree. This has an impact".

PID:303 reported that they will continue to find ways to stay warm at lower temperatures and that they found their comfort temperature. *"Yes, that´s the plan, we have that in mind"*

PID:284: "Before the challenge I adjusted the radiator by feeling – now I´m controlling the temperature in the room".

PID:287: "We will close the doors more consistently".

PID:288: "We have the thermometers and look at them in the evening. For example, when the temperature increased over 21 degrees, we turned off the heating. I think we will keep to that. That is easier to control than keeping the new laundry practices."

One household (PID:319) reported that they are now using 40% to 60% of the heating fuel they had used before.

However, while many households reported ruptures in lowering temperatures, many reported that 18 degrees was simply too low and/or that a slightly higher temperature was more feasible.

PID:304: "I have recognised that my comfort temperature does not need to be at 23 degrees. 21 is totally fine."

PID:284: ""I will pay attention not to heat with the highest program. Too cold is not good for the walls. But I´ll pay attention not to heat up to 22, 23 degrees, I try to keep the level at 19, 19.5 degrees."

PID:308: "18 degrees is in the long-term view too cold. [male] I did not have a big problem with it, for you it was the other way around. You really froze. We have to find a compromise. [female] The rooms where you are staying for example the living room and so on should be warm, that you feel comfortable and do not get sick immediately"

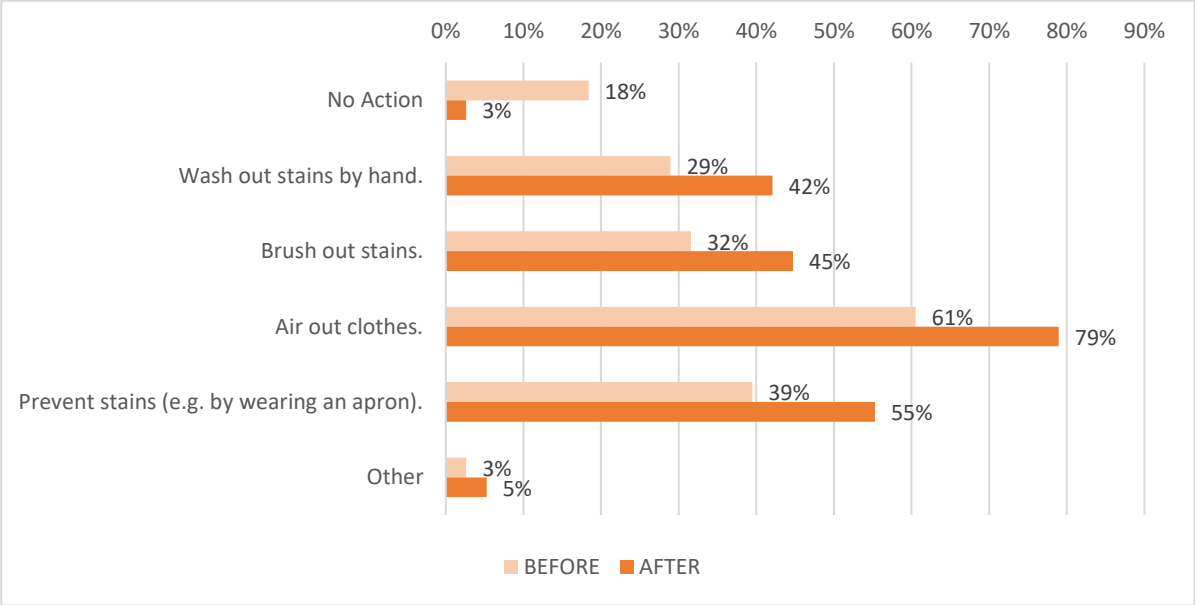

Figure 6. Changes in the performance of different types of adaptive laundry practices
Source: baseline and closing surveys

Figure 6 displays the changes in the performance of different types of adaptive laundry practices from the baseline survey to the closing survey. Here we see a substantial increase in self-reported use across all adaptive laundry practices with the largest increase seen in the airing out clothes category with the percentage of participants engaging in this practice increasing from 61% to 79% (up 18%). The percentage of households engaging in stain prevention rose from 39% to 55%

(up16%) while similar increases were reported for washing out stains by hand (up 13%) and brushing out stains (up 13%). Significantly, the number of households reporting no use of adaptive laundry practices fell by 15%.

Other strategies reported predominantly focused on having special clothes for different activities which can be used a number of times without having to be washed such as clothes for outdoor work/gardening/playing. The idea of changing once one comes home in the afternoon/evening into comfortable house wear which can be repeatedly worn without washing was also discussed.

When asked in the exit interview if the households thought that they would continue to engage in practices to reduce the amount of laundry responses were mostly positive especially with continuing preventative measures.

PID:281: "We will certainly continue to do some things, yes yes. For example, soaking the clothes. Then we can wash with lower temperatures, this is very good. And hanging the clothes outside, depending on the weather and the sun, to dry outside. We´ll do this more often. We discovered that the dryer uses an incredible amount of electricity and power".

PID:282: "We try to keep the temperature low and air out clothes. And we wear the clothes longer, I don´t change my outfits everyday".

PID:310: "Yes, we decided to keep the new practices and maintain the higher awareness".

Some respondents admitted that they will return to using the dryer as it is a significant time saver for them while others committed to using the dryer less due to its high consumption level.

PID:306: "We after all only use it [the dryer] for towels and underwear. And, speaking honestly, I would keep using it for these things. Because for me, the fluffiness and softness of the towels is something that I personally would not like to give up and for the underwear it is simply the time effort, I find."

PID:310: "We found out that our dryer is a real energy guzzler. Also it was not part of the laundry challenge [it was, but they forgot] and we took initiative and stopped using it. We used it before for the towels, now we have the harder version (laughs). And we could reduce more than half of the laundry than before. The awareness increased thanks to the meters."

One participant described in detail the significant impact the change in laundry practices has had on their daily routine.

PID:307: "I will keep up the washing technique. I only wash when it's really necessary, one or at most two wash days…. the laundry became / less important, and as the main woman in the house I find that very pleasant. And just the fact that it is no longer really the central focus of housework. And meanwhile sometimes I bake cookies or do some handicrafts with the children, instead of doing ironing or something like that… And that was / of course I can't admit that too openly, but my husband was right in some respects after all, when he said, you do too much washing…."

In the focus group exit discussion, one participant (PID:299) described that they will keep the strategies to keep clothes clean for a longer time, such as airing out the clothes. They also said that they will also continue to ensure that the load is full but will not continue washing at 30 degrees, since they perceived that their laundry as being not clean enough. Participant PID:312 remarked that in general the challenge made them think more about what they really need to wash, i.e. if it's really necessary. She also remarked on the effect of the speed of the spin cycle on the washing machine and its consequences for the time required in the dryer with higher spin speeds meaning less dryer time required. PID:319 and PID:290 both agreed that they will continue to prewash items and to really think if something really needs to go in the machine.

4. PRACTICES A FEW MONTHS AFTER THE CHALLENGE

This section explores the extent to which changes in practices arising as a result of the laundry and heating challenges were perceived as having persisted. These observations are based on a comparison between the baseline and closing surveys as well as a follow-up survey administered approximately three months after the end of the challenges. In the follow-up survey, households were asked which practices the felt they had retained, and explored potential rebound effects. It should be noted that for the follow up survey the households did not have the aid of diaries to refer to when describing frequencies and quantities of certain practices so results should be treated with caution. Additionally, the number of respondents to the final follow-up survey was less than the closing survey with only 32 of the remaining initial 40 households completing the baseline, closing and follow-up surveys. For an accurate comparison, an examination of the baseline, closing and follow-up surveys from this subset of respondents is provided for Tables 13 through 18.

4.1 PERSISTENCE OF CHANGES IN HEATING PRACTICES

Table 12 explores the persistence of indoor temperatures and indicates that for the most part the gains made during the ELLs have been maintained. Average reported living room temperatures were reported to have reduced initially by 1.3 degrees directly after the end of the active phases with a reduction of 1.2 degrees maintained over 3 months later. Similarly, average reported bedroom temperatures were reported to have reduced initially by 2.4 degrees directly after the end of the active phase with a reduction of 2.4 degrees reported over 3 months later. Average reported temperatures for a third room were reported to have reduced initially by 2.0 degrees directly after the end of the active phase with a reduction of 1.5 degrees reported over 3 months later indicating a half degree slippage on initial gains.

Table 12[14]. Reported Indoor temperatures before, immediately after and 3 months after the challenge period. Source: weekly, and follow-up surveys.

	Mean temperatures before and after the challenge			
	T1: Before (n=38)	T2: Directly after (n=38)	T3: Three months after (n=33)	Difference T3-T1*
Living area, °C	21.4	20.1	20.2	1.2
Bedroom 1 °C	19.7	17.3	17.2	2.5
Third Room °C	20.6	18.6	19.1	1.5

Table 13 presents information on the persistence of alternative practices of keeping warm which does show some evidence of slippage with gains eroded in the reported use of slippers/thick socks, using an extra blanket and extra clothing. There is also evidence of significant slippage at the extremes with an increase of households reported that they do nothing in terms of alternative practices and an increase in those reporting taking a hot bath or shower.

Table 13. Persistence of alternative practices of keeping warm. Source: Baseline, closing and follow-up surveys. n=32

[14] A direct comparison subset for the follow up survey was not available for Table 12 as this contained weekly survey data which while well responded to, was not completed by all participants every week leaving a subset too low for meaningful comparison

n=32	% of participants taking these measures, before taking part in the challenge	% of participants taking these measures immediately after	% of participants taking these measures, three months after
I do nothing	6%	0%	13%
I use warm socks/slippers.	75%	97%	72%
I use an extra blanket.	72%	81%	72%
I use extra clothing (sweater, cardigan, etc.).	69%	84%	81%
I use blinds/curtains on windows.	38%	38%	41%
I use draught excluders.	22%	13%	13%
I take a hot bath or shower.	38%	9%	16%

Table 14 examines the persistence of potential changes in expectations toward indoor comfort which shows that while some participants may have slipped back and returned to previous practice patterns the shift in their perception of desirable temperatures for the living room and bedroom have been maintained indicating a consistent awareness and evaluation of desirable temperatures after the end of the ELLs and in the months that followed.

Table 14. ELL participants' perceptions of desirable temperatures in the winter during daytime before and after the challenge. Source: baseline, closing and follow-up surveys.

n=32	Mean before	Mean directly	Mean 3 months
Living area, °C	21.8	20.5	20.5
Bedroom, °C	17.5	17.2	17.2
Child's bedroom*, °C	20.6	19.9	n/a

4.2 PERSISTANCE OF CHANGES IN PRACTICES OF CLEANLINESS

Table 15 shows the self-reported mean laundry cycles per week for all ELL participants before, directly after and 3 months following the living lab active phase. On average households reported that they were washing 2.8 cycles per week, a long term reduction of 1.3 cycles per week from the mean of 4.1 cycles per week measured for the subset during the baseline period. This represents a signification long term reduction of 32%.

Table 15. Average number of laundry cycles before and after the challenge. Source: baseline, closing and follow-up surveys.

n=32	Mean before	Mean directly after	Mean 3 months after
Number of laundry cycles	4.1	3.1	2.8

Table 16 examines the persistence of alternative practices of keeping clean. While there is some evidence to suggest that some household have returned to normal routines (9% of participants report doing nothing additional as opposed to 3% directly after the end of the ELL challenge period) the increases in alternative practices seen immediately after the end of the ELL challenge period such as washing out stains by hand, airing out clothes and preventing stains have largely been maintained and have in fact increased with only the practice of brushing out stains seeing a slight reduction in the follow-up survey compared to the closing survey.

Table 16. Persistence of alternative practices of keeping clean. Source: baseline, closing and follow-up surveys.

n=32	% of participants taking these measures, before	% of participants taking these measures immediately after	% of participants taking these measures, three months after
No other ways	22%	3%	9%
Wash out stains by hand.	31%	47%	56%
Brush out stains.	34%	47%	44%
Air out clothes.	53%	75%	84%
Prevent stains (e.g. apron)	38%	47%	56%

Table 17 examines potential changes in norms related to laundering by exploring changes in how households decide when an item requires washing. Substantial reductions in the share of those washing clothes primarily due to the presence of stains and length of wear have been maintained with smell now the dominant reason for washing a piece of clothing moving from the least cited reason to the most cited one.

Table 17. Persistence of changes in criteria for deciding when items require washing Source: baseline, closing and follow-up surveys.

	Share of households using this criterion, %		
n=32	**Before**	**Directly after**	**3 months after**
I don't know	0%	0%	0%
Stains	41%	22%	21%
Smell	16%	50%	48%
Length of wear	44%	25%	24%
Don't know or other	0%	3%	3%

4.3 POTENTIAL EFFECTS: SAVINGS, SPILLOVER EFFECTS, REBOUND EFFECTS AND POTENTIAL FOR SCALING UP

The level of information to determine specific energy and related CO_2 savings was not available for the German ELLs. This is largely due to institutional norms with annual billing cycles where changes in required energy cannot be immediately perceived and are typically realised at the end of an annual billing period. Additionally, access to meters was not readily available for participant households with rental tenure status and many households had only partial information e.g. (previous year's electricity bill but not the Gas/Oil bill). Also, given the high level of wood stove oven use it was felt that there

was simply not enough information to make a reasonably accurate estimation of energy savings particularly in the domain of space heating. However, in the course of the follow-up survey, when asked if participants thought their household had saved money over the past six months as a result of participating in the ENERGISE project the vast majority of participants reported that they had felt they had saved at least some money with only 15% feeling that no money was saved. Notwithstanding this lack of information, one household was able to give a significant verifiable cost indication as to the effect participation in the ENERGISE project had on their gas and electricity bills.

PID:316: "..I was very happy that we got back more than 100 euros for both the electricity and the gas bill [account settled after estimate compared to actual use].

In addition to savings achieved in laundry and heating, it was expected that experimentation with new practices in the ELLs might also encourage households to experiment with new energy saving practices in other areas. Table 18 explores spillover effects from the ELLs into broader engagement with energy, as well as the persistence of these changes three months after the end of the challenge.

Table 18. Spillover effects from the ELLs: changes in general engagement with energy and climate issues. Source: baseline, closing and follow-up surveys.

n=32	T1 : Before challenge, %	T2 : Directly after challenge, %	T/3, three months after challenge, %	Change, %, T3/T1
Not Specifically	6%	19%	13%	6%
Raise energy and climate issues at home or with friends	66%	69%	75%	9%
Raise energy and climate issues at work	34%	28%	41%	6%
Raise energy and climate issues in NGOs or other groups of which I am a member	19%	9%	19%	0%
Actively search for news or information on energy and climate issues	41%	22%	44%	3%
Consider energy and climate issues when voting	59%	41%	66%	6%
Consider energy efficiency when buying electrical appliances/devices	88%	31%	94%	6%

While positive increases are seen across most categories the inconsistency of responses from T1 to T2 to T3 may be indicative of survey fatigue. The results from this table should be treated with caution.

Table 19 summarises the results when households were asked about the likely destination of rebound effects for both time and money saved. Interestingly, the majority of households did not perceive a time saving. However, of those households that did report a perceived saving the majority identified Holiday/travel as the area where they would spend this saved time. When asked to considering monetary savings, participants were more confident that savings had been made

however a significant proportion were unable to give a monetary estimate for such savings and couldn't say what they might spend such savings on. However, 39% of participants did indicate that any savings that would be made would be spent on every day running costs.

Table 19 What would savings be used for: most common responses (n=33) Source: follow-up survey.

Time Saved would be used for (n=33)	%	Money Saved would be used for (n=33)	
Not Applicable-Didn't save time	61%	**Not Applicable-Didn't save Money**	15%
Sleeping	0%	**Everyday running costs**	39%
Reading	9%	**Savings**	6%
T.V/Computer	0%	**Eating out**	9%
Cooking	3%	**Buy new items**	0%
Other Housework	3%	**Entertainment**	0%
Maintenance	6%	**Holidays/Travel**	0%
Sport or Outdoor Activity	9%	**I don't know**	39%
Cultural Activities	6%	**Other**	0%
Social Activities	6%	**Specific Plans**	0%
Work	0%		
Holidays/Travel	21%		
I don't know	0%		
Other	6%		

The broader impacts of the ELLs on everyday practices depend on the dissemination of the new norms beyond the participating households. Table 20 presents the extent to which participants have shared or would consider sharing their experiences from the challenge.

Table 20. Share of households having shared or willing to share experiences (n= 33). Source: follow-up survey.

Not Especially	**4**	**12%**
Other members of the household	**7**	**21%**
Relatives	**20**	**61%**
Friends	**24**	**73%**
Neighbours	**16**	**48%**
Co-workers	**11**	**33%**
Groups/associations	**6**	**18%**
Children's school or e.g. sports club	**6**	**18%**
Other face-to-face	**0**	**0%**
Facebook, Twitter or Instagram	**32**	**97%**
Blog post	**2**	**6%**
Newspaper article	**0**	**0%**

Other	**0**	**0%**

Household were asked in the follow-up survey if any spin-off effects occurred in terms of everyday life as a result of participating in the project. A small number of households reported sustainability conscious efforts in other areas such as lighting, mobility, water conservation, cooking/heating, airing and energy consumption generally.

PID:281: "[we] make better use of the hotplates or use after-heat, better plan for further cooking and baking."

PID:302: "We're also trying to save water."

PID:283: "we ask ourselves if the light off when we leave the room."

PID:306: "sort laundry and collect longer until the drum is full."

PID:307: "I air the house even more controlled now and control several times daily the temperature and humidity."

PID:288: "[more] conscious use of resources."

PID:318: "More cycling, always turn off lights."

Also in the follow-up survey, households were asked what would increase their engagement and motivation to reduce laundry and/or heating, or change their level of consumption in other areas. Some households identified visible and/or tangible cost savings as a significant factor in increasing their engagement while others cited environmental concerns

PID:281: "saving money"

PID:299: "clearly seeing positive effects (e.g. saving etc.)"

PID:319: "significant cost savings"

PID:309: "cheap electricity prices, [monitoring] equipment"

PID:302: "for environmental reasons"

PID:283: "being less exposed to climate catastrophes ..."

Some households pointed to the role of the state/regulatory authorities in helping reduce personal consumption through involuntary measures or hurdles and discussed that perhaps negative or prohibitive measures might be more effective while one household stated that financial incentives would have no effect.

PID:280: "I believe that on the one hand it simply needs comprehensive information for people and then also the experience (exchange in groups, workshops) as such that it does not have to mean a

loss of comfort, to restrict oneself or to establish new behaviours (e.g. We also try to share our experiences with friends, be it through exchanges or invitations, if there is something vegetarian or vegan to eat, without emphasizing this (just wait and see the reactions - so far, everyone has tasted it.) For us, the topic of housing (land use) would still be a big task. With the current market, it is hardly possible to downsize and if so, then often at almost the same cost as before to know that we have made good progress and are also sufficiently motivated, so incentives would not really be enough, at least for us. But we certainly are not representative. "

PID:303: "Consumption could be further limited by more durable products."

PID:307: "Not an incentive, but a hurdle: if electricity, water and heat are not always so easy available (a locking lever on the faucet, which must first be removed to get to water)? A reward system? who consumes less than in the previous year (electricity, water, heating) in addition to the repayment [for usage under the estimated amount]."

PID:288: "Consistent education work for children from elementary school – political rethinking and / or even legislative changes."

PID:310: "Government support and promotion of programs that are truly sustainable and are turning things around."

PID:312 "In our family, everything is very timed, organized, so in terms of behavioural change, this requires a lot of time and effort. Financial incentives would have no effect on me, but governmental regulation would require everyone to rethink, so I would see this as an (involuntary, but meaningful) incentive."

PID:292: "Loose grocery stores [no packaging]. Better public transport in the area."

PID:318: "Incentives do not come to mind, maybe prohibitions ..."

Other households concentrated on technical aspect and potential efficiencies while one household expressed the frustration of performing sustainable practices while having to bear witness to others acting in unsustainable ways leading to a demotivating feeling.

PID:312 "When building a new house, I would install a floor heating system, so you can still achieve a comfortable living climate and warm feet at lower room and heating temperatures."

PID:295: "External wall insulation Hydraulic adjustment of the heating system to allow re-heating in a reasonable time."

PID:316: "It would motivate me even more if all people would pay more attention to the environment in Germany and in other countries Sometimes it's frustrating when I hang my laundry [to air dry] while elsewhere people drive large SUV's or missiles and/or aircraft take off, where people don't care."

Additionally, it should be noted that some households reported that they had reached their limit of what they could be expected to do

PID:301: "We already have the optimal solution"

PID:286: "No further incentives needed"

PID:287: "No more"

PID:306: "I do not want to heat less, because the feel-good factor is lost."

PID:293: "I see no way to save more laundry or heat for children that like to be outside and get dirty."

These comments highlight the complex set of personal motivations that exist for participants and illustrate that uniform approaches which cannot account for the unique and diverse nature of household characteristics are unlikely to be successful.

5. FEEDBACK FROM PARTICIPANTS AND IMPLEMENTATION TEAM ON ELL IMPLEMENTATION

Overall impressions from ELL participants in terms of the delivery, outlay and format of the study were very positive. When asked to elaborate on the changes households made in monitoring energy use, many households pointed to the fact that the ELLs heightened their awareness of the issue and the monitoring devices/tools keep it more present in their minds

PID:280: "The project has made us even more aware, even though the issue of energy saving has been taken into account so far [by us previously]."

PID:301: "Pay more attention to energy consumption"

PID:302: "We are all more attentive to the temperature in the rooms, the heating is much rarer and at much lower temperatures, and we also make sure to wash everything out and only wash it when it's really necessary."

PID:303: "Temperature of the rooms monitored by the thermometer and then controlled."

PID:287: "[we] look at the included meters"

PID:310: "We pay more attention to when and how we consume the energy as we also produce ourselves, and the instruments we provide are a very good support."

PID:311: "More temperature control. Attention to the laundry inspection"

PID:312: "In the family, the awareness of electricity (lamps off!) And heat consumption (door closed!) Has changed." Energy "has been around for months and has been raised again and again (education for the youngest) children are not allowed to remove new clothes all the time, but choose "sandbox clothing" and "indoor play clothes"

PID:295: "Temperature control via thermometer"

PID:319: "There has always been energy saving, but more attention to the subject altogether

PID:320: "Overall, the topic is more present in everyday life, which often changes smaller processes or at least questions whether there might be another, better solution."

Some households described how they more diligently strategize around heating and laundry and other related energy practices to reduce the energy required.

PID:281: "I am now thinking more carefully about whether the drum is full, whether the laundry can be hung without a dryer, if you could maybe take a blanket for an hour in the evening, ventilate better and not so long when it's cold outside…[we will] continue [using] the electricity meter while washing"

PID:309: "Watch the weather [in terms of drying laundry]"

PID:288: "Water and washing powder consumption reduced

PID:289: "When monitoring the room temperature, we pay more attention to the temperature and not to the well-being, for example, if you feel cold at 20 degrees, you put on something instead of heating more."

PID:313: "Lowering the temperature of the heating, monitoring the light sources and possibly switching them off"

PID:299: "Change slightly: I have already taken good care of it (e.g. only full washing machines, showers take me a maximum of 2 minutes, lights off when nobody in the room, heating in unused rooms, etc.)

Other households were confident in their pre-existing energy awareness and in their daily actions without the need to monitor consumption while some households admitted that some aspects of their practices had return to pre-ELL levels.

PID:283: "Heating / laundry as described above - we take care, but do not monitor consumption"

PID:316: I'm not consciously reading the meter readings, but I'm constantly trying to save energy, eg. Turn off the light. And we also try to teach the children.

PID:292: "We were already energy-conscious before the study"

PID:315: "I have been questioning my energy consumption for a long time and will keep doing it"

PID:318: "Changes in heating: stayed at 18-19 degrees, washing and dryer use more like previous pattern."

PID:316: "…and I was very happy that we received more than 100 euros for both the electricity and the gas bill."

PID:306: "How much gas is saved when the living room temperature is lowered"

Specifically on the delivery of the project itself households were again, generally very positive with households citing that the project was informative and helpful in terms of energy awareness with the inclusion of monitoring equipment highlighted as a very positive element.

PID:280: "It was interesting and rewarding for us…Thanks to Energise, but also to the events of the Volksbegehren Artenvielfalt[15] [and] our work in a transition group "Fridays for Future", our commitment to environmental issues has increased again."

PID:281: "The most important thing was that you think about it better, and make yourself aware of whether you save this or that or make it more targeted."

[15]Successful petition for a state referendum in Bavarian on increased environmental protections with an emphasis on increasing bio-diversity protection measures

PID:302: "Many thanks to all of you, we really enjoyed joining in. We came through the winter healthy, even though we froze from time to time, all in all, everything was very well done for us, I hope there is still much left motivating more people to save and the environment will be grateful."

PID:303: "Thank you very much for your participation. :-)"

PID:307: "Very interesting and I am looking forward to the evaluation Thank you for the electricity meters - have already changed the place! I use the Thermometer several times a day! Thanks! My more relaxed approach to what washing needs to be done does us all good! "

PID:309: "We had fun and a more conscious use of energy"

PID:310: "Great project, thanks for the experience"

PID:312: "Thank you for the support! Can we see / get the evaluations of our household? Are there any comparative numbers of households that are visible?"

PID:292: "Save the Planet !!"

PID:293: "Thank you very much for the study"

PID:315: "The average temperature was very variable in the bedroom, for example, since I do not heat it depends on the outside temperature"

PID:295: "It was fun, thanks for the good idea !!!"

PID:316: "Thank you so much for the great ideas, the nice conversations and the nice Christmas party, we took a lot of this time with us, heating was difficult, but it was still very interesting where the comfort zone is."

PID:318: "The whole climate debate has made us more thoughtful about our meat consumption and we have reduced that"

The heating challenge was criticised however by one household who felt that a uniform target temperature was very difficult to maintain. This point was also reflected by another household who said that they felt it would be better to reduce the existing relative daily temperature profile rather than set a uniform target temperature for the entire day.

PID:306: "The generalization that the room temperature was not allowed to be over 18 degrees was a little difficult for us because we have a stove and would therefore not waste energy to heat our rooms. So it would have been nice if the heating of the stove had been allowed. Otherwise, a great project that was accompanied by your team very well. "

PID:301: "I think it is better to adjust the heating all the time. Yes, of course we can adjust the system manually but the temperatures that we had set before the challenge worked perfect for us. During day time, when all are back home at 13:00 pm the heating goes up to 22/23 degrees. In the living room. It is more comfortable to turn up the heating than to wear more clothes."

6. CONCLUSIONS/REFLECTION

The primary effect of the ELLs would appear to have been that households are left more acutely aware of their energy use in the performance of their laundry and heating practices. The impact of having a large visual display of the current temperature (heating) and the practice of noting the

energy requirement of every wash cycle was described as keeping energy considerations more present in everyday life and thus more likely to be maintained over time.

What the study showed is that there are substantial voluntary gains to be made when the issue of energy consumption is more present in daily life. However it also showed that there are limits to gains without tangible consequence and illustrated the difficulty of relying on personal motivations to achieve a challenge. The non-engagement of some households with certain aspects of the challenges is an important result as the presence of such households must be recognised if progress is to be made. Those who feel that they "do enough" are unapologetic about wanting to enjoy the benefits of their investments and despite an extended period of deliberation and interaction with such households they could not be engaged to lower temperatures.

A lack of independent advice on standards and what is actually required in the areas of heating and laundry was noticeable with a wide diversion between participant's perceptions on what is necessary, sufficient or "required" particularly in relation to laundry standards. Manufacturer's instructions with respect to care labels are an insufficient source of information and are not necessarily viewed as an independent arbiter of what is necessary or sufficient particularly in relation to items which traditionally been washed at higher temperatures while in terms of heating standards, there is no clear direction towards what is sufficient due perhaps to the very subjective nature of what temperature is perceived as being warm enough.

Considering practical matters, there was no discernible difference between the two ELL groups with ELL2 performing more or less the same as ELL1 in terms of the primary challenges. Therefore it could be said that in terms of upscaling, ELL2 has more practical applicability as it is much less labour intensive in terms of contact hours and the resources required for delivery and information gathering. However from a research perspective, ELL1 was the primary source of qualitative information with detailed qualitative descriptions about the reasons behind the choices people made and the reasons why people did/n't engage in practice change. Therefore it could be argued that ELLs are conducive to a two stage process where it is first piloted at an individual level and then rolled out on a community basis.

While results should be treated with caution, the overall impression is of the German ELLs having a very positive and persistent effect on the participating households, not just in terms of their laundry and heating practices but from a wider sufficiency perspective with real reductions in use/demand reported. Further analysis is required from those individual households that lie at the extremes, i.e. those that made very good progress with the challenges and those who made very little progress.

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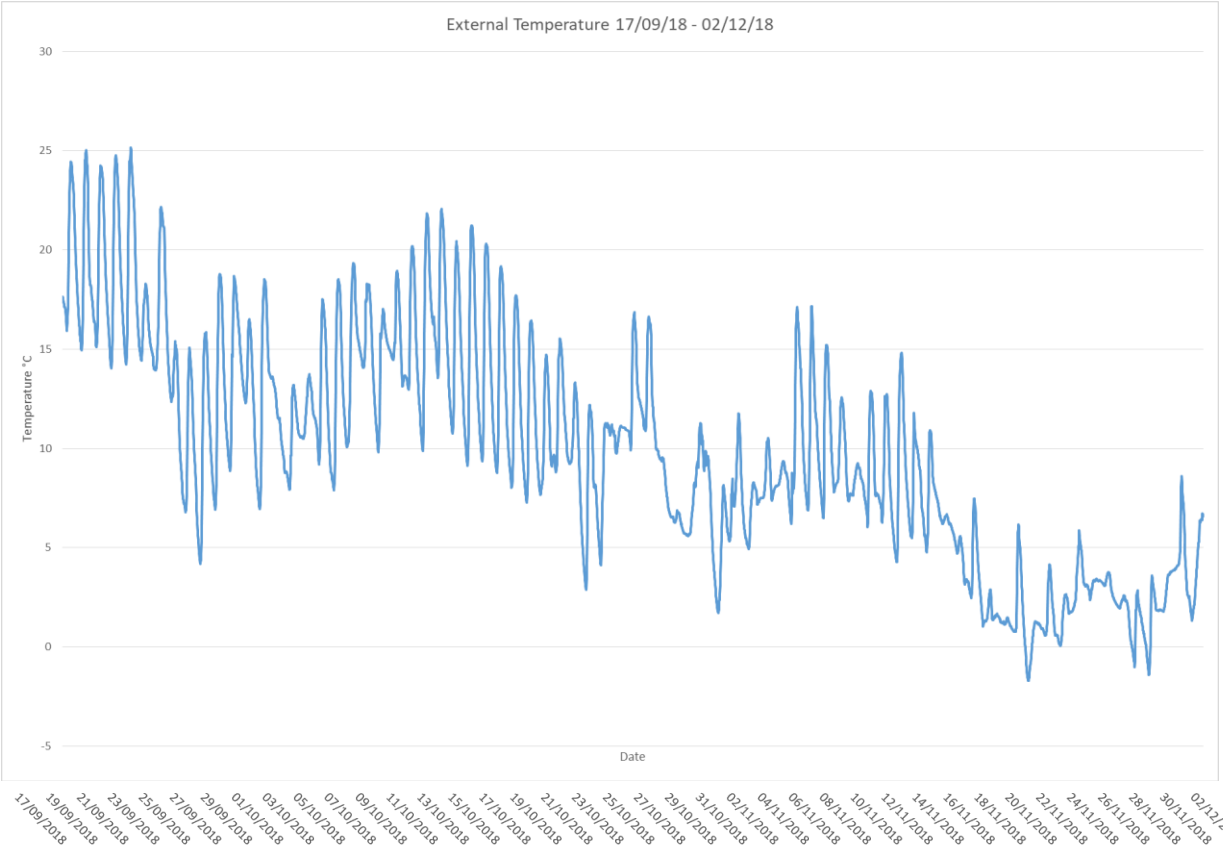
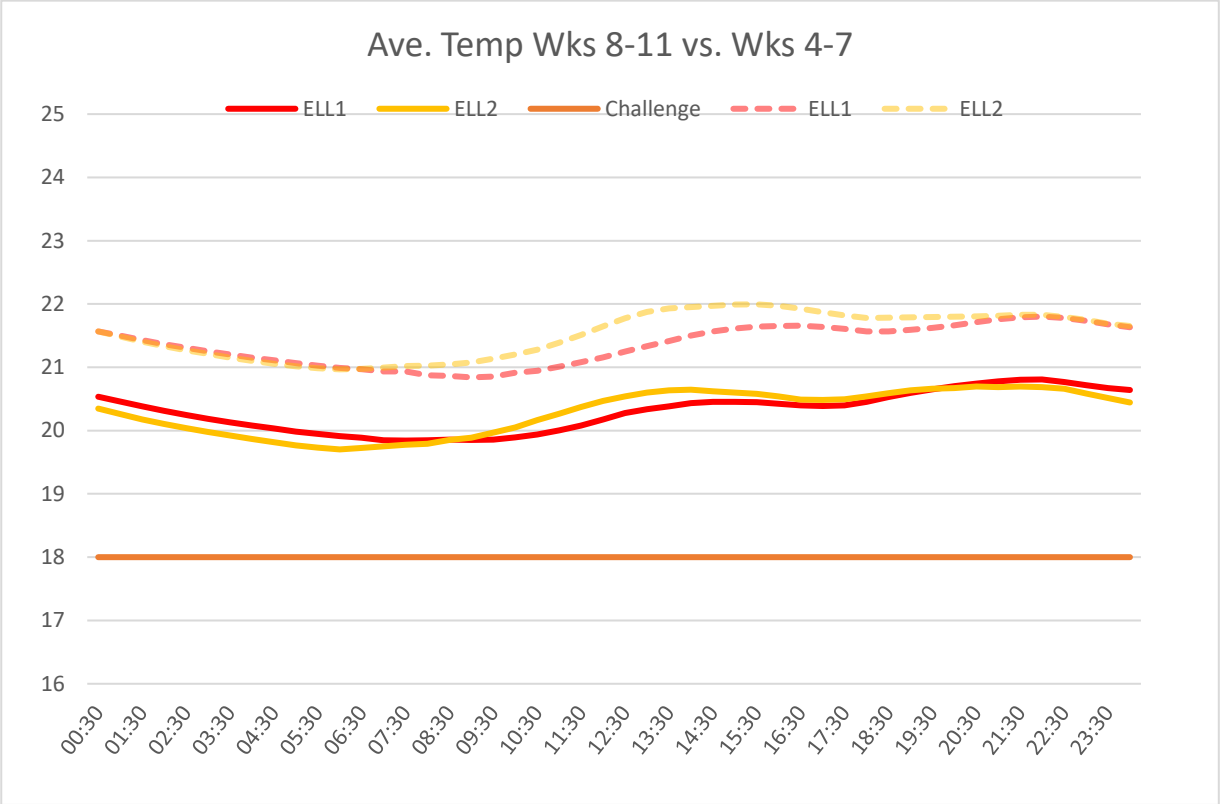
Annex 1. Changes in indoor and outdoor temperatures before and after the heating challenge
Averaged externally measured site temperature profile over the 11-week active phase period of the German ELLs



Annex 2. Mean half hourly temperatures for ELL1 and ELL2 households for the Baseline Weeks 4-7 (dotted lines) and challenge weeks 8-11 (solid lines).



Annex C Selected key data related to energy use and life style from the Oberland region

District	Weilheim-Schongau	Germany
Average electricity consumption per capita (kWhel/P) [16]	1500	1800
Electricity: share of renewable energy production (%)[4]	47.4	36.2
Average heat consumption per household (kWh/m^{2}a)[4]	169	168
Heating: Share of renewable energy production (%) [4]	13.9	12.9
Average living space per apartment (m^2)[17]	103.9	91.4[18]
Regional purchase power per capita (€)[19]	23,757	22,992[20]
Disposable household income per capita, per month (€) [3]	1,973	1,755
Motorised population (cars/1000 inhabitants)[5(own calculation)]	603	548[21]

[16] Data is based on the current calculations of the INOLA project partners Kempten University of Applied Sciences and the Department of Geography and Remote Sensing at LMU Munich (Hofer et al. (2017); Reinhardt et al. (2017))
[17] LfStat (2017a, 2017b, 2017c)
[18] Statistisches Bundesamt (2015)
[19] LfStat (2016)
[20] GfK (2017)
[21] Radke (2017)