Customer Comfort When Delivering Flexibility to Aggregators (Comfort)

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EcoGrid 2.0 is a research and demonstration project funded by EUDP (Energiteknologisk Udviklings- og Demonstrationsprogram). The 9 partners in the project are:

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Summary

In the first two heating seasons, nearly no participants in the EcoGrid 2.0 demonstration experienced that their comfort had been compromised while delivering flexibility to aggregators. In the third heating season, however, several consumers reported that their comfort had been compromised. The main objective of this report is to describe these, relatively few, participants' experiences. In the report, we combine data on temperature drops during activations in heating season 3 (aggregator perspective) and data from qualitative interviews with consumers experiencing discomfort. It is found that the affected participants experience a larger temperature drop than the aggregator data show. We conclude by pointing to some implications related to the aggregators handling of consumers.

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1. Introduction

Offering flexibility to the market without compromising the comfort of customers is a key condition for the EcoGrid 2.0 project. During the first two heating seasons this was achieved, but running a rather limited amount of activations. During the third and final heating season, there has been a considerable increase in the frequency and duration of activations. The increase in activity has lead to some customers starting to feel the effects of the activations. The present report is narrowly focused on these experiences of compromised comfort during the third heating season. These experiences should be seen in the light of the two preceding heating seasons with no reports on compromised comfort.

During January 2019, the projects partners started to run several daily activations based on market demand, customers' products and various manual activations. This meant that some customers started to feel cold or to wonder why the heating was turned off. Some customers called BEOF to complain or to ask questions regarding their heating. We have interviewed four of the houses that signalled discomfort. Based on the feedback from these customers and the temperature data available from the demonstrations, the project partners have tried to identify what led to the situations in which the customers felt discomfort.

2. Methods and data

2.1 Qualitative interviews

In this section, we provide a brief overview of how the qualitative data presented were collected and what methods were used to collect them (see appendix 1 for an overview). Semi-structured interviews, observations and focus groups were used to gain insight into how the consumers perceive comfort during their participation in EcoGrid 2.0.

Qualitative methods are suitable for studying how everyday practices are related to the use of electricity and heat consumption (Gram-Hanssen, 2010; Shove and Walker, 2014). It may, however, be meaningful to combine qualitative and quantitative methods to study comfort: e.g. studies of energy- and electricity consumption in Albertslund, a suburb to Copenhagen, combined measurements of consumption and qualitative interviews, and found that different behaviours in identical houses may result in three times as much energy consumption for heating in some households (Gram-Hanssen, 2010).

In EcoGrid 2.0, very few houses are identical. We would therefore expect activations to have different impacts on participants' comfort across households. Also, the participating households' energy sources vary a lot. Therefore, unlike the study from Albertslund (Gram-Hanssen, 2010), comparing energy consumption across households in EcoGrid 2.0 is difficult. Our informants do not live in similar houses, they have very different energy sources installed in their houses, and wind and solar affects their houses very differently (Jacobsen and Pallesen, 2017).

Household visits

We conducted interviews during home visits, where we followed technicians working at BEOF. During the visits we observed interactions between technicians and consumers. The visits lasted between 20 minutes and 6 hours, depending on the technician's task (For expansion of methods used see Pallesen and Jacobsen 2018).

Interviews

In total close to 100 EcoGrid participants have been interviewed in their homes. During these interviews, we asked participants if they had experienced any discomfort during tests. As already mentioned, almost no consumers had experienced discomfort during the first two heating seasons. One exception is a participant interviewed in heating season 2. She knows the comfort limits inside her house very well, and she describes how the family is affected by weather conditions and the EcoGrid test:

"But we do feel when they are testing in the evening. We feel that the pipes go cold, and with the wind, the house quickly becomes cold. We can also see it on the heat pump when they are testing."

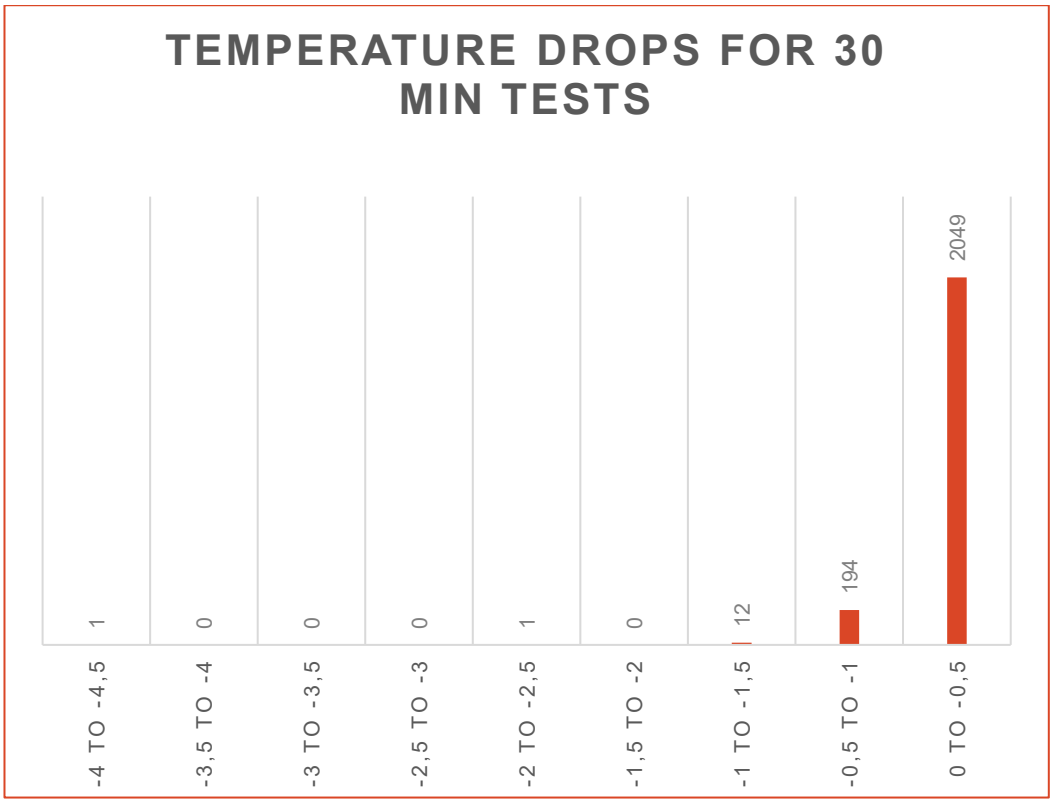
The consumers that were interviewed about discomfort in heating season 3 were interviewed during household visits in which technicians were dismantling the EcoGrid equipment.

Temperature data

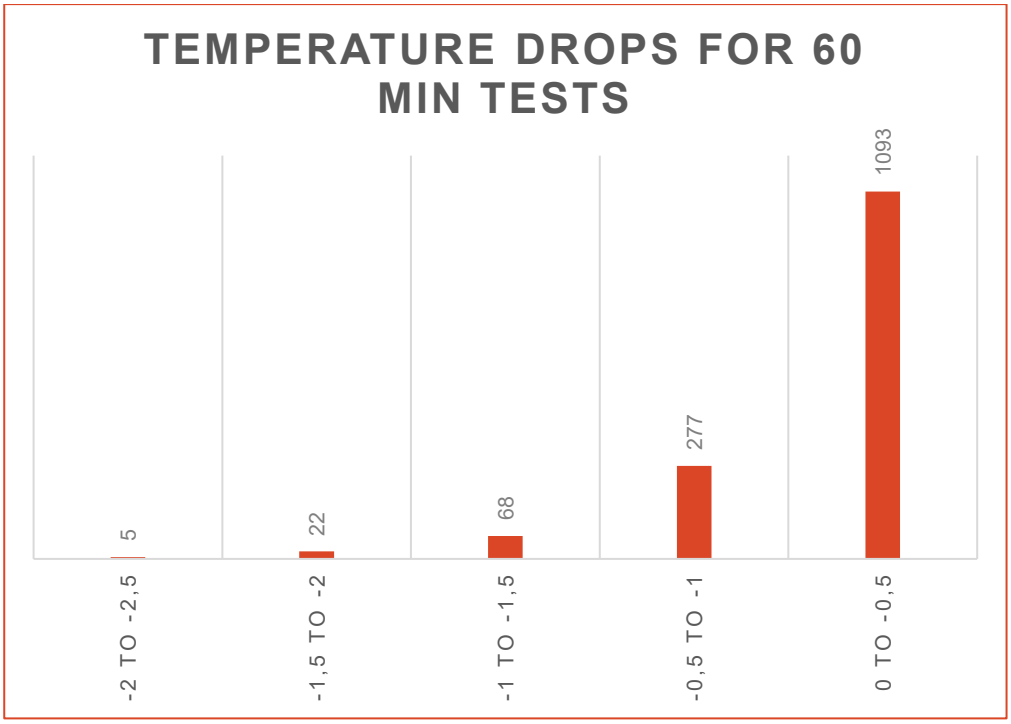
Some of the houses in EcoGrid have been fitted with temperature sensors. Unfortunately, this does not apply to all houses. This has led to the actual activations being largely executed without considering the indoor temperature. For those houses that are fitted with temperature sensors, it is usually 3 sensors placed in different rooms in the house. In the evaluations of indoor temperature fluctuations, only the average temperature from all available sensors for each house is used. This is done to counter the effect from an open window or similar effects. The downside to only use average values is that some parts of a house may be considerably hotter or colder than others, due to e.g. wind or sunlight.

3. Aggregator temperature data during activations

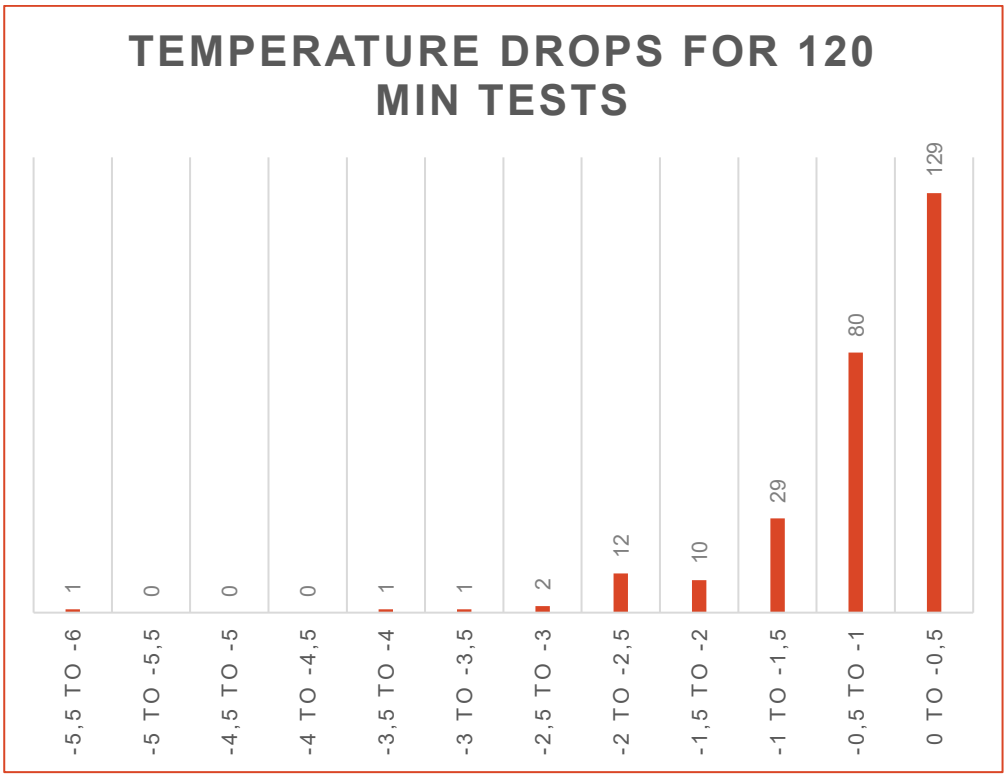
The goal for analysing the data presented above is to determine what scenarios caused situations where the households might feel discomfort. This starts with defining the parameters to look for. In this part of the analysis we focus on scenarios where houses had a starting temperature of above 20°C and where the temperature dropped during an activation. There are also cases where the starting temperature is below 20°C, but these cases are not caused by EcoGrid activations and are therefore disregarded. During the third heating season there have been activations with a duration of 30, 60 and 120 minutes. For each of these activations the average temperature drop has been calculated and the values are presented in the histograms below.



Figur 1: Temperature drop for 30 min activations for 63 Siemens houses

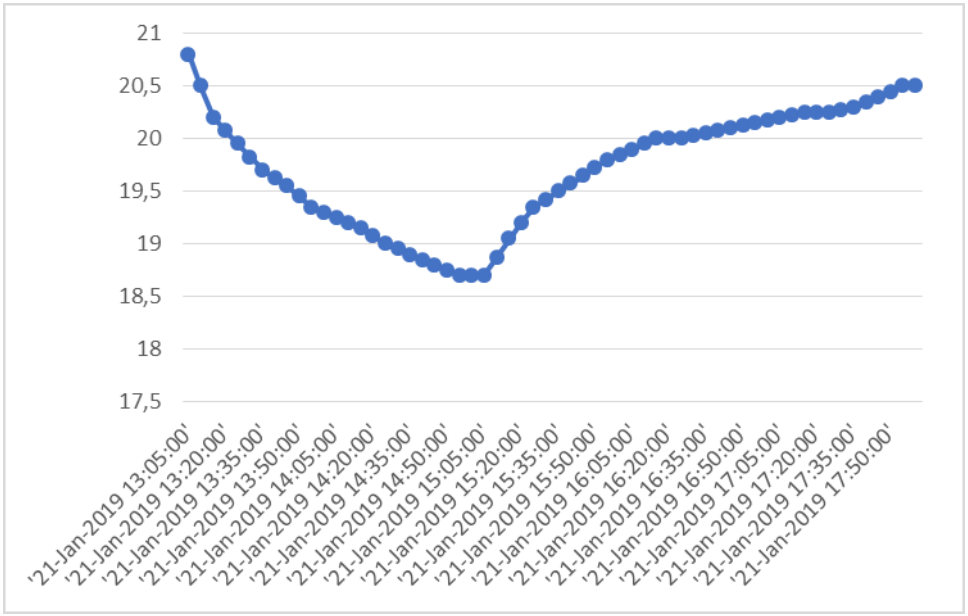


Figur 2: Temperature drop for 60 min activations for 63 Siemens houses



Figur 3: Temperature drop for 120 min activations for 63 Siemens houses

Looking at the histograms for 30 min activations, the vast majority of activations leave the temperature drop below 1°C. One activation gives a drop of more than 4°C, but this is very likely due to other factors, such as open windows. One activation leads to a drop of more than 2oC, which is a potential problem. 60 min duration activations are the worst-case scenario for market driven activations. Here we start to see several drops of more than 1°C at which point comfort could be compromised, but still the majority of activations are "safe". For the 120 min activations we see that a significant amount of activations has led to temperature drop of more than 1,5°C, and so these longer duration tests should be limited to a minimum. The conclusion based on this data is, that activations of no more than 60 minutes should be acceptable for most of the houses represented in this data. A few of these houses should be monitored for comfort issues as these may have poor insulation or other properties that make them less suitable for providing flexibility. One such house is represented in the graph below, where we see a very rapid temperature drop after the heat is turned off.



Figur 4 Temperature trace for poorly insulated house

The house in the graph above would be almost certain to have discomfort issues during activations. On the other hand, a house like this is always likely to have the heat pump or panels running to keep the indoor temperature up. This makes this house a good source of flexibility. So, in that respect these are good customers.

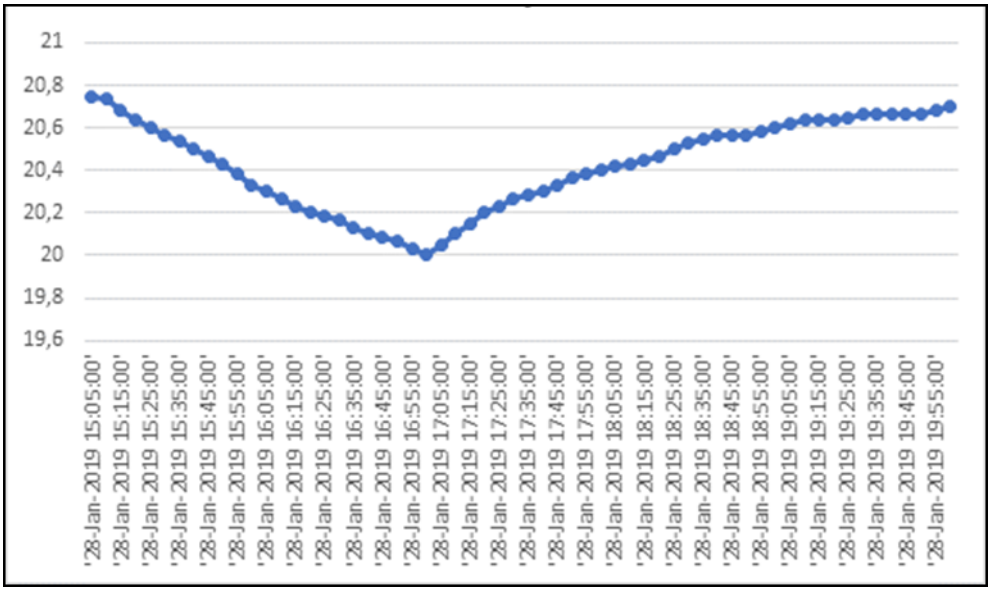
4. Consumers experiences of discomfort combined with aggregator temperature data

The temperature data does not tell the whole truth. Besides looking into the data alone, we have correlated the output from the interviews with the actual temperature data. Unfortunately, not all houses are fitted with indoor temperature meters and out of the four interviewed households on Bornholm, the aggregators only had reliable data available from two of these houses. Below we combine consumers' accounts of temperature with aggregator data about temperature drops during activations.

4.1 Illustration from Insero house

- Siemens equipment
- Older town house, Rønne.
- 100 square metre, two floors.
- Three zones: Living room, 1st floor and bathroom
- One elderly person lives in the house.
- Daily routines: She is in the house during the day except when she visits her mother.
- Heating panels and floor heating in bathroom.
- Product: Did not choose a product/Basis

The graph below shows the average indoor temperature during a two-hour long duration test in this particular house.



Figur 5 Temperature data from long duration test

The graph shows the average indoor temperature drops from close to 21°C to 20°C, which is not considered a significant drop. These temperature data could suggest a subjective experience of comfort. However, as we can see from the interview with the participant, other explanations can be found, as the relationship between temperature and daily living is complex. We are in the house to conduct the interview with a technician to take down the equipment because the consumer experienced discomfort several times in the last part of HS3.

In the interview, the consumer explained that she experienced temperature drops when she was in her living room situated at the ground floor. When asked what she did in situations when she experienced a lower temperature, she described how she took a look at the Siemens temperature meter placed in her bookshelves and saw that the temperature was 19 degrees. Normally, the temperature in her living room is 21½ degree. When asked what she did in these situations, she explained that she called 'down there' (BEOF office) or directly to the technician that took care of it. The technician explained how he has accessed the system from his car several times, and put the temperature back on 21 degrees. The participant also explained that it is only when she feels discomfort that she looks at the temperature meter. She also has a temperature meter upstairs and in the bathroom.

Further details about the discomfort situation: The technician explained that one of the three electric heating panels in the living room is controlled by the temperature on the first floor where the temperature is lowering ('natsænkning') to 18 degrees when the consumer is not there. When it is really cold, the two panels that are controlled by the temperature in the living room cannot reach the area in the other side of the living room, where the participant would usually sit in her chair. The technicians have tried hard to change the installations in the house, but it has not been possible to reconnect the panel that is linked to the first floor. The consumer explains that the wind has impact on the temperature in the house even though it is a town house.

Sum up:

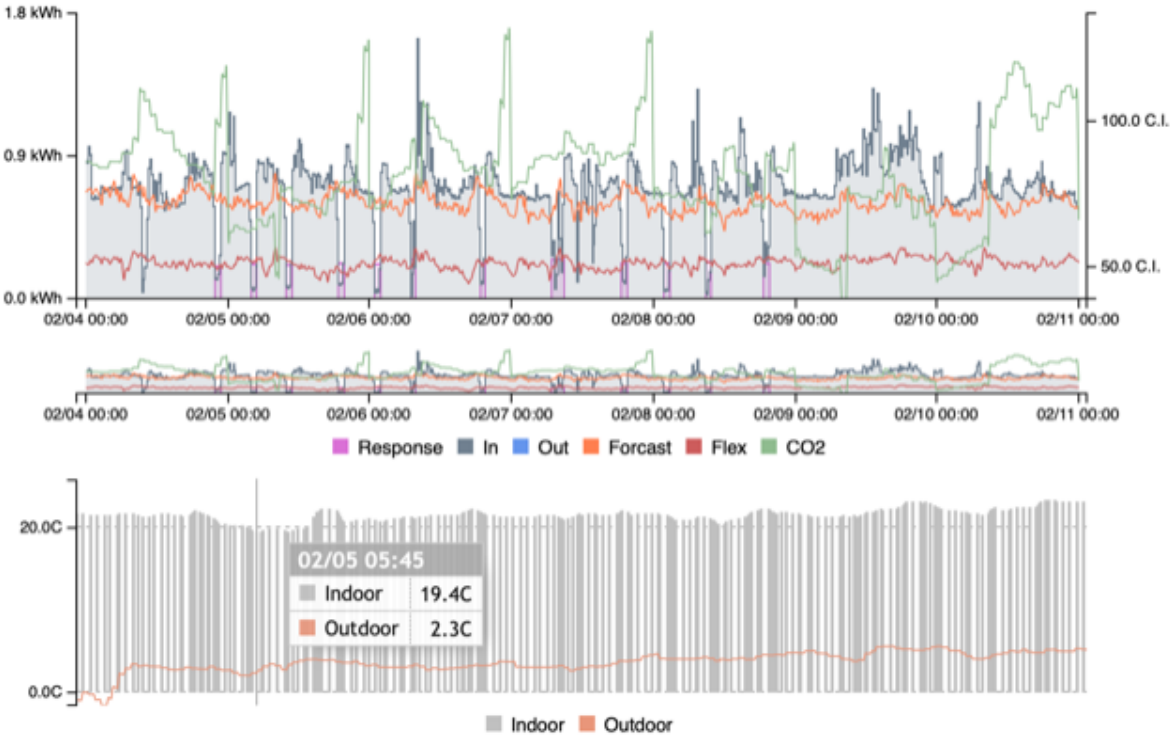
The interplay between temperature, comfort and technology is complex. From the interview with the participant (and the technician) we get some details about why the aggregator temperature

data is different from the participant's experience. First, one of the heating panels in the living room is not ideally installed in relation to control it. Second, this particular panel is placed close to where the participant usually sits in the living room. In situations where the wind cools down the house, the customer comfort is affected. Another important (and problematic) aspect illustrated by the example is that the consumer interacts with the technician to change the temperature in the house. The consumer bypasses the web page. The consumer never entered the EcoGrid web page. She is not interested in spending time on that. If the consumer had the possibility to interact better with the system, e.g. by communicating directly with the aggregator via the temperature meter in the living room some of the services calls to the technicians might be redundant.

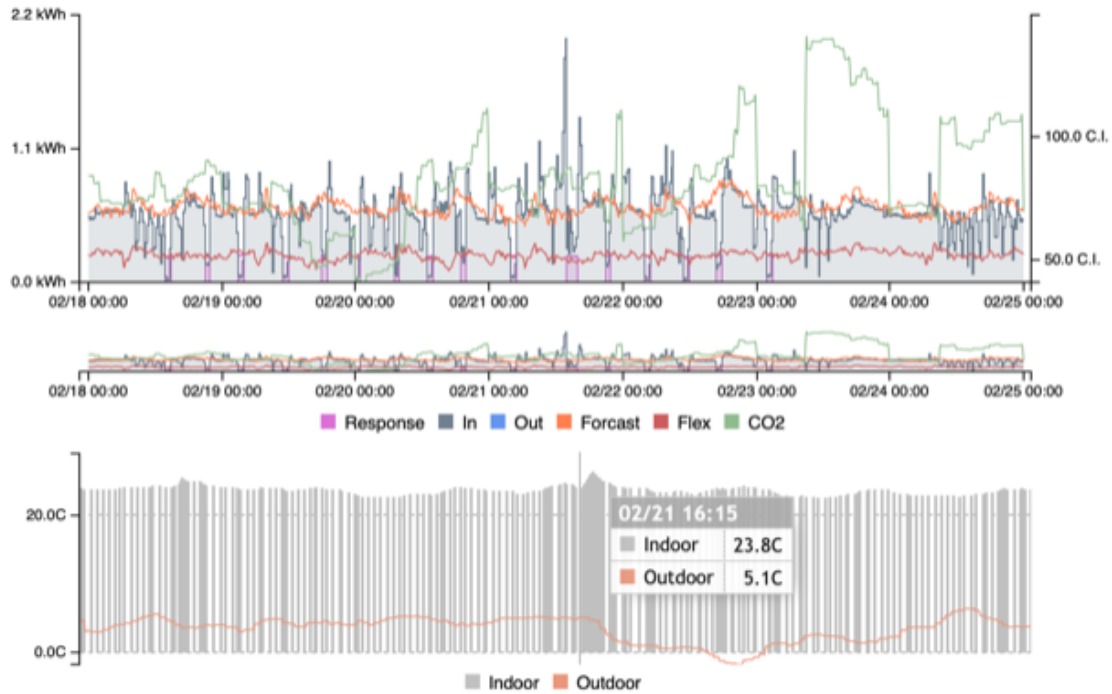
4.2. Illustration from IBM house

- GreenWave equipment
- House, close to Nexø
- 260 square metre, two floors. Parts of the house are not used in the winter.
- Two older people live in the house. Age 76 and 75.
- Daily routines: They are in the house during the day.
- Heat pump (ground heat) and heating panels at the bathroom upstairs

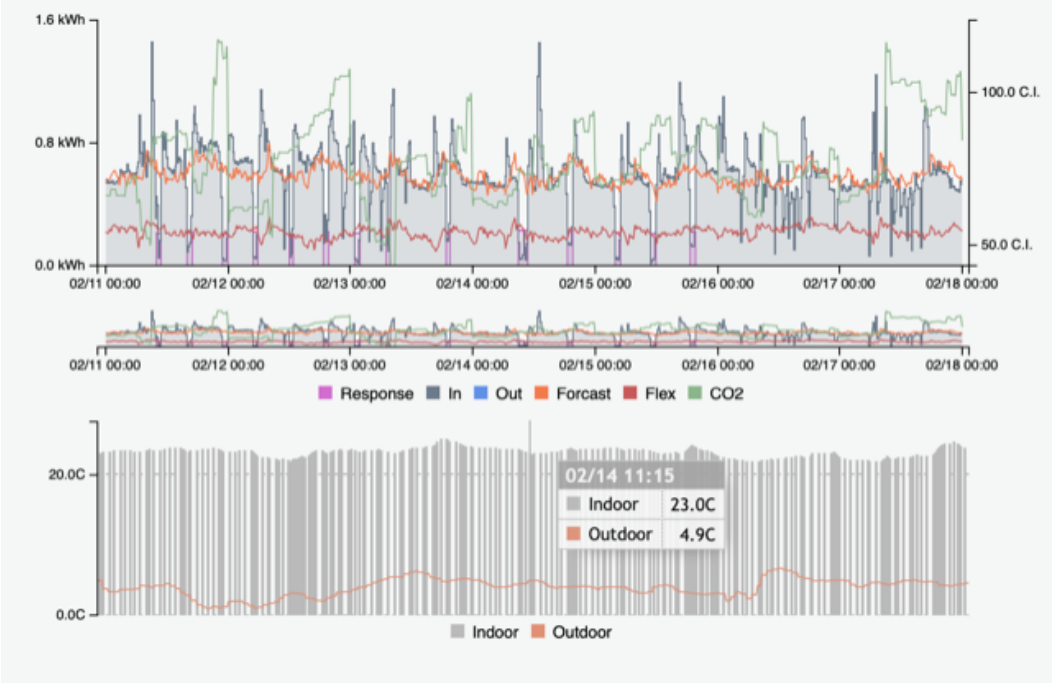
The following data show activations and temperature data from a household in IBMs portfolio. The lowest temperature during a one week period was on February 5th around 6 in the morning, where the temperature was 19.4 degrees. The temperature during this week was generally lower than the following weeks.



Figur 5: Feb. 5. temperature drops to 19.4C



Figur 6. Feb. 21 between 14-16, the temperature went from 24.4 to 23.8C



Figur 7: Feb. 14 between 9-11, the temperature went from 23.6 to 23C.

In this case too, we have combined quantitative and qualitative data. We follow the technician to the house, where he is to take down the EcoGrid equipment because the consumer experienced discomfort.

The participants have chosen ‘Basis’, because they are in the house all the time. One of them had read that if they were at work, their heat would be turned off. Because they are at home during the day, they do not want the heat to be turned off. They do not use the webpage, because they lost the code.

Some parts of the house are not used during the winter. They started to experience discomfort in January. The husband explained that his wife experienced that is was cold before him. It was cold in the morning and then: “One puts on an extra sweater”. Then it was every day, and also in the afternoon. They described the temperature as 18 degrees. The panels were ‘ice cold’: “Then we had to call them [BEOF] and say that this is too cold”. They think that BEOF does the tests.

The woman explains and shows how she has moved the GreenWave temperature meter, because she knows the system controls via temperature: “It used to be placed up there, and then I moved it down here, because it is warmer up there. And then it turns off before. Therefore I put it down here”. They also experience an issue with the heat pump: The heat pump heats the water to 54 degrees and then it takes some time to get back to 22 degrees after a test. The man explains: “When it was cold we went and touched the radiator, and it was ice cold. They have closed it down now! And then after a while the heat came back in the radiator, but as I explained to you it took a while to get the temperature back (to 22)”. The husband suspects that the heat pump uses more power when it has been turned off during a test, because it then runs at 100 % to get the temperature back to 22 degrees. “It ran on 100 % every time they had turned it off. And then I ask: “Doesn’t it use more (electricity) when it runs at 100 %?”

The husband describes that if the wind hits the house from northwest it gets cold in the house. The woman stated that this is also the case if the wind comes from northeast. In these situations the man goes down to the heat pump in the scullery and raises the temperature a few degrees. When the wind turns again he goes down and lowers the temperature manually again.

Sum up:

The aggregator data about temperature and insights from the interview with the consumer suggests that the feeling of being cold can be highly subjective and that it is difficult from the available temperature data alone to identify situations where customers may feel discomfort. Factors such as sunlight, wind and draft from old windows may also play a big role in the overall feeling of comfort (see also Jacobsen and Pallesen, 2017).

5. Consumers experiences of discomfort

5.1. Illustration from Insero house

- Siemens equipment
- Apartment (rental), Svaneke.
- 60 square metre, one floor.
- Three zones.
- One older person lives in the house.
- Daily routines: She is in the house during the day.
- Heating panels
- Product: Did not choose a product/Basis

We visit the house with a technician who takes down the EcoGrid equipment, because the consumer has experienced discomfort.

The consumer explains that she thinks that it is exciting to be in the project, but: “I don’t want to freeze. And it has become worse and worse”. The consumer explains that she has noticed when they are testing, because she had been sitting here (in her chair) freezing, and that it had been worse this winter. She has been freezing while watching TV. She has experienced discomfort several times in the afternoon and the evening. She does not, however, feel uncomfortable before the evening comes. She describes that it has happened many times now, and she has called BEOF to complain.

The consumer states that it cannot be right that tests are performed in a way that she and others are getting cold. She describes that they have raised the temperature from the BEOF office, but also that technicians have been in the house several times to fix the temperature. She has become annoyed that she keeps freezing during the tests. She doesn’t know exactly how long time a test last. Sometimes she takes on a sweater, because it “is what one does when it is cold”. Once she called the office and the women she talked to could see that she did not have much heat in the bathroom.

5.2. Illustration from IBM house

- GreenWave equipment
- House, Sorthat Muleby, 50 years old build by themselves.
- 130 square metre, one floor.
- Two older people live in the house.
- Daily routines: They are in the house during the day.
- Heating panels, fireplace in living room, wood burner in scullery.
- Product: Did not choose a product/Basis

Again, we are in the house with a technician to take down the EcoGrid equipment, because the consumers have experienced discomfort.

Two months ago, the couple explains, they started to experience discomfort during breakfast and tea in the kitchen. It began about 7.30 or 8 in the morning. Sometimes they turned on the heating panels, but then “they were turned off again”. They also experienced situations when the panels were cold and “Sometimes we could not even turn them back on”. They use the heating panels to heat the house, when they get up before the fireplace is lit up (in the living room) and the wood burner (in the scullery) took over the heating. It takes one hour before the house is heated by the fireplace and the wood burner. When the house is heated they don’t use the ‘small’ panels any more.

The first time they experienced the discomfort they called the office. After this, they learned that the discomfort was caused by tests. After this situation they were able to associate the cold panels to tests. They called BEOF several times to get heat back in the panels. In most situations, they just called the technician Lars, when they experienced discomfort, and he would attend to the problem right away. The woman estimates that they have called for help 6-8 times, but it may just be 4 times, says her husband. One time they called, the technician said that they could just go out to the installation and ‘restart it’. Then the husband said: ”I’m not touching anything”. The last time they called BEOF to report discomfort, they were informed that they were no longer part of the demonstration.

6. Findings summary

EcoGrid 2.0 has successfully achieved demand response from private households in the course of three heating seasons. The first two, no customers reported compromised comfort. The current report has described the relatively few instances of discomfort signalled by customers in the third and final heating season.

As the project is coming to an end, the conclusion from this analysis is focused on what to consider when taking the next logical step and applying the principles of providing flexibility from households on a commercial level.

- Screen the houses early in the process, e.g. by doing longer duration tests and evaluate the temperature drops. Decide how to proceed with the houses that show larger temperature drops.
- Some consumers experienced lower temperature than the aggregator meter data show. Reliable indoor temperature data is required, preferably from several rooms in all houses.
- Allow for individual comfort settings and adjust by using too hot/too cold interactions. However, the problem was that the consumers did not enter the web page to give the aggregator feedback on comfort settings. Simplicity in setting the comfort might activate more consumers, e.g. by placing devices (screens) that allows consumers to communicate with aggregators in the rooms.
- Be transparent on when activations are performed by presenting this on on-premise equipment, not just a web-page.
- If possible, control each house intelligently based on user behavior e.g. if people are home during the day. Machine learning algorithms might be applied.

7. References

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8. Appendices

Appendix 1

First round at Bornholm, EcoGrid EU (2014) • 13 semi-structured interviews with project managers, electricians and consumers • Observations of training sessions in homes of consumers • An introduction for 7 new consumers in Villa Smart Methods: Semi-structured interviews, in-situ interviews, and observations Documentation: Transcribed interviews, field notes
Second round at Bornholm, EcoGrid 2.0 (August 18, 2016) • 2 expert interviews in Villa Smart Methods: Focus group Documentation: Transcribed interviews
Third round at Bornholm (August 24-25, 2016) • 1 expert interview in Villa Smart • 1 expert interview in the home of the consumer • 2 semi-structured interviews with 3 consumers • 1 observation of training session Methods: Semi-structured interviews, in situ interviews, and observations Documentation: Transcribed interviews, field notes, digital photos, consumer's own documentation of consumption
Fourth round, Bornholm (September 20-23, 2016) • 8 semi structured interviews with 10 consumers • 12 home visits with electricians (two without consumers) • 5 observations of training sessions

• Interviews with electrician during service Methods: Semi-structured interviews, in situ interviews, and observations Documentation: Transcribed interviews, field notes, digital photos
Fifth round, Bornholm (October 25-28, 2016) • 6 semi-structured interviews with 7 consumers • 8 home visits with electricians (two without consumers) • 5 observations of training sessions • Observation of a weekly meeting with electricians, support staff and project managers Methods: Semi-structured interviews, in situ interviews, and observations Documentation: Transcribed interviews, field notes, digital photos, consumer's documentation of consumption
Sixth round, Bornholm (January/February, 2018) •Observations of two user-panels organized by BEOF •Three semi-structured interviews with BEOF project manager Methods: Semi-structured interviews, observations.
Seventh round, Bornholm (January 15-18, 2018) • 16 semi-structured interviews with 22 consumers
Eighth round (February 25th – March 2th, 2019) •8 semi-structured interviews with 11 consumers. •3 interviews with consumers and electricians •9 home visits with electricians (one without consumers) •1 interview with project manager and support staff in their office. •3 In situ interviews with technicians during lunch and in their office Methods: Semi-structured interviews, in situ interviews, and observations

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