# Unplugged: To Reduce Phantom Energy

A behavioral change intervention to reduce phantom energy by unplugging devices before leaving the room

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## 1 INTRODUCTION AND DEFINITION OF DESIGN BRIEF

Imagining a society without energy is impossible for most people. However, energy is also a topic of discussion due to its negative influence on the climate, the energy crisis, and the rising costs. Therefore, it is crucial to change the way energy is used. Already with the smallest action an impact can be made. Most people never unplug their devices when not in use resulting that they are either switched on or on stand-by. Mobile phone chargers that are not charging a device consume around 0.26 watts and laptop chargers use around 4.42 watts [J.P. Ross and A. Meier 2000]. This wasteful energy consumption of unused appliances or electronic devices that are plugged in, is called *phantom energy* [Save on Energy n.d.].

Because of the societal relevance, the relatively accessible way to make an impact, and the fact that the research group relates to this issue, a design challenge was formulated: to reduce phantom energy by making the user unplug devices before leaving their room. The target users are students aged between 18 and 28 living in student houses where they have their own room. The context for the design case consists of the room of the student within the student house. Possible involved stakeholders are the landlord and service people of the student's house.

A new habit of unplugging devices should be added to the user's current routine. The moment of intervention is when the user is leaving the room with the intention to leave the house for a longer period. The intervention aims to tackle the automatic motivation. With the right intervention, the designers hope to change the habits of the user and give them a cue that will remind users to unplug their devices before leaving the room. Possible obstacles for the behavior change are laziness, a lack of time (users are often in a rush) and forgetting. However, the location of the device in the room is chosen to tackle the obstacle of forgetting.

To accomplish this behavior change, the intervention function of environmental restructuring was chosen. For the theoretical background, the Habit Theory [S. Orbell and B. Verplanken 2020] and the Transtheoretical Model [J.O. Prochaska et al. 2008] were used. Several frameworks were used like the Behavior Change Wheel [S. Michie et al. 2011] and Design for Intent [D. Lockton et al. 2010].

## 2 DESIGN PROCESS AND CONCEPT DESCRIPTION

### 2.1 Challenge Definition and Specification

In a broad sense, the design challenge was defined as reducing the energy consumption in gregarious student rooms. To get a clear view of the situation, we specified the design brief at some points, as shown in Appendix B.

### 2.2 Selecting target behavior

Several target behaviors were generated based on the challenge defined. These behaviors included turning off the lights when leaving the room for a short time and unplugging your devices (Appendix C). An assessment of these behaviors was made in terms of Impact, Likelihood, Spillover and Measurement. Among these behaviors, unplugging the electronic devices before leaving the room was ranked as the most promising, with a promising impact.

After selecting the target behavior, the target behavior was specified even further (Appendix D). Based on such, a COM-B analysis of the behavior was made (Appendix E), concluding that reflective and automatic motivations need to be established. The determinants include the strength of habits, motivation to change habits, awareness of alternatives, and access to alternatives.

Based on the concept of creating the habit of unplugging electronic devices, it was decided to apply the Habit Theory [S. Orbell and B. Verplanken 2020]. Other theories used for designing the intervention are the Transtheoretical Model [J.O. Prochaska et al. 2008] and the Behavior Change Wheel [S. Michie et al. 2011]. In chapter 3 the application of these theories will be elaborated on in more detail.

### 2.3 Concept Ideation and Development

Aiming at designing to remind people to unplug the devices, several ideas and the corresponding categorization were made according to the different intervention functions. An overall assessment was made regarding aesthetics, interaction, and ethics. The intervention function Environmental Restructuring was selected. The initial idea was a switch asking the user if they unplugged the electronic devices when leaving the room. The reasons why it was selected were: (i) The device itself could work without power supply, which does not conflict with the end goal of energy saving; (ii) Serving as a reminder, the cue asks users to behave themselves in a mild way, which is confronting but not intrusive; (iii) The cue has a flexible portability, which means it could be applied in different places. Preferably next to the door so the cue is seen before the user leaves the room. (iv) The simple structure has a high visual affordance and makes the device easy to manipulate.

Based on these fundaments, new shapes, interaction, and aesthetics of the intervention were discussed (Appendix F). The shape of sockets and plugs was used as an argument because of their visual relation to energy.

Eventually, the interaction of a switch triggered by a cord was decided on, as shown in Figure 1. The switch looked like a socket, and the cord had the shape of a lightning symbol attached to it. The top of the cue asks “Unplugged?”, while the base of the switch indicates the status by text: the default status says, “Pull if yes”. If the user pulls the cord down because they have performed the unplugging behavior, the original text gets covered, and the new text “Well done” is revealed.

The concept was chosen for the following specific reasons: (i) The cord that is in the shape of lightning, as well as the main shape of a switch, has a clear and explicit connection with energy consumption; (ii) The cue is constructed in a whole part. Different from the plug-socket form, it does not need extra space for placing the widgets; (iii) Pulling a cord down is a very intuitive action, which carries little information and would not bother users.

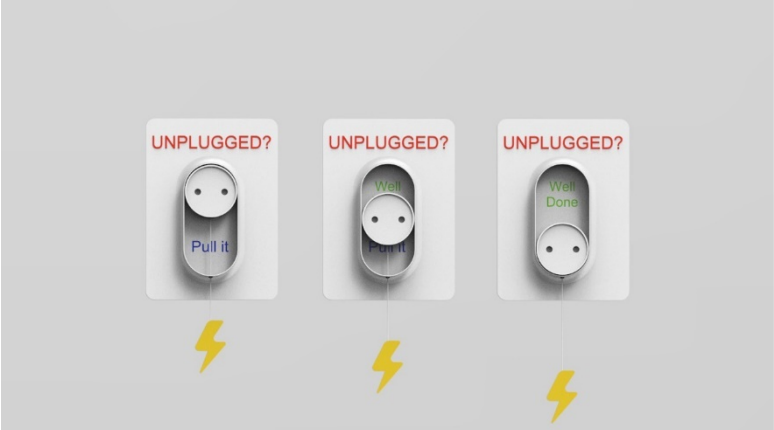


Figure 1: Final Design Concept

## 3 THEORETICAL RATIONALIZATION FOR DESIGN CONCEPT

The designed intervention is elaborated on and explained in this section using the Habit theory [S. Orbell and B. Verplanken 2020] and the Transtheoretical Model [J.O. Prochaska et al. 2008]. The habit theory was dominant in designing the intervention, and the Transtheoretical Model was used to structure where the intervention could occur.

### 3.1 Habit Theory

The intervention addresses environmental restructuring as an intervention function. In this case, a cue or prompt is added to the environment to support behavior change. The added cue is a switch, preferably next to the door inside the room. If users prefer something other than this location, they still have the autonomy to change locations. By giving the tool a distinctive look, it serves as a trigger in the environment. The tool aims to form the habit of unplugging devices once leaving the room. Habits are cue-contingent, meaning the cue is necessary to trigger the habit [S. Orbell and B. Verplanken 2020]. Habits can have the ability to change behavior. Unplugging devices before leaving the room is the specific behavior being tackled in this case. The first step in changing behavior via the habit theory is to create an environment where it is easy to perform this behavior. The behavior could be more accessible by using extension cords with an on/off button to turn off multiple devices simultaneously. Secondly, a critical cue needs to be added to the environment where the intervention design comes into place. Thirdly, a plan for performing the action when the cue is encountered must be created and consistently executed. The cue is event-based “when I leave the room, I unplug the devices” instead of time-based “in the evening”. McDaniel & Einstein [2000] argued that event-based cues are more perceivable.

### 3.2 Transtheoretical Model

The second mechanism in the intervention is from the Transtheoretical Model [J.O. Prochaska et al. 2008]. The intervention happens in three stages of change. Stage one is preparation because the intervention aims for stimulus control by addressing how people can structure their way of plugging devices. By suggesting putting it all in an extension cord, the person only needs to unplug one plug instead of seven separate plugs. By making the targeted behavior more accessible, self-efficacy will also increase because a person can start to see that it is possible to unplug devices when they leave the room. Once this is done, the person continues to the next stage, action. In this stage, the intervention functions as a cue to remind the person to unplug devices when leaving the house. The cue will play an active role as a reminder to unplug the devices before leaving the house. The intervention has the possibility to interact with, and therefore it aims for stimulus control as a process of change. When the person interacts with the intervention, the sentence ‘Well done’ becomes visible. It is essential in the action phase to encourage the person [P. Markopoulos 2021]. The ‘Well done’ congratulates success. Once unplugging devices becomes an established routine, the person will continue to the maintenance stage. In this stage, it

becomes more automated to unplug the devices before leaving the room, and the intervention will slowly become more unnecessary. Lastly, in the termination stage, the tool is no longer necessary to stimulate the person to unplug devices as it is now part of their routine. Regarding sustainability, the person can now give the tool to someone else.

## 4 IMPLEMENTATION DESIGN RATIONALE

In this chapter it will be discussed how three theoretical frameworks for behavior change are implemented and support the intervention.

### 4.1 Behavior Change Wheel

The first framework used in to design the desired behavior change intervention is the Behavior Change Wheel (BCW) [S. Michie et al. 2011]. As already mentioned in chapter 2, the design process, by using the BCW framework the COM-B model was used to analyze the target behavior and where improvement was possible. As a result, from the COM-B analysis, multiple components were possible to design an intervention for. Automatic motivation was chosen as component to focus on. One way of achieving automatic motivation is through habit formation [S. Michie et al. 2011]. In the case of unplugging your devices it is often not in the routine of a person. Creating a design intervention, therefore, would probably have the highest impact on the behavior change.

### 4.2 Functional Triad

The second framework used was the Function Triad by B.J. Fogg [2002]. With this framework an analysis of the role of the design intervention was done, allowing to improve the intervention. The design concept was evaluated first on its role as a tool to increase capability to perform the behavior. As this element was not very strong at first, the concept was improved. The target behavior was made easier to perform, by adding a suggestion to make unplugging your devices easier. Secondly, the role of the design concept as a medium was evaluated. The design concept aims to function in the context of everyday life. To strengthen the relationship between the design concept and desired behavior, two features were added. One to have the design give a similar look and feel as a regular power socket and plug and secondly, a lightning bolt was added to show that you perform the action of unplugging the plugs to save energy. The main focus of the design concept is on helping people to continuously remind them to unplug their devices and therefore stimulate rehearsing the behavior. Lastly, it was evaluated if the design concept serves as a social actor. As the design concept focusses on changing individual behavior, it does not facilitate social action. However, the design concept has a social dynamic integrated, namely giving a reward in the form of saying ‘Well done!’ when you move the plug to unplugged.

### 4.3 Design with Intent Toolkit

Simultaneous to using the Function Triad framework, the Design with Intent cards [D. Lockton et al. 2010] were used to discuss several elements of the design concept. Most lenses related to the design concept. By discussing every lens, multiple alternatives for the design concept were evaluated. For example, the interaction lens was used to discuss the level of interaction the design concept should provide whether it should be a static intervention aiming to only serve as a trigger or cue to perform the behavior or if the user should also interact with the intervention. It was decided to implement a symbolic interaction, so it does not influence anything, and is for satisfying and confirmation purposes only. Other lenses that were discussed are the perceptual lens, cognitive lens, ludic lens.

## 5 ETHICS ANALYSIS OF DESIGN CONCEPT

### 5.1 Value and stakeholder analysis

As the designed product is a product that individuals will use in their rooms, there is a limited list of stakeholders. The most important stakeholder is the user of the intervention, who is defined as our target group, a student aged 18 to 28. The product will serve as an intervention to change or maintain the user’s habit of reducing energy consumption while the user

will still have autonomy, an important value. Also, this could lead to a feeling of responsibility for energy consumption as the user bumps into the product every time he exits the room.

Other stakeholders of the design case could be (the possible) people with whom the user shares their room, apartment, or home. Even though they still experience all the freedom, they might be influenced by the user or feel compelled to collaborate. They might enter and leave the user's room regularly and see the intervention, which might spark their interest, curiosity, or their own will to change their energy consumption habits. The landlord is a minor stakeholder in this design case. Depending on the way the energy contract or bill is arranged, the reduction of energy consumption could lead to lower costs for the landlord.

Lastly, the energy company is also a minor stakeholder in this case. By correctly using the intervention and the habit of unplugging is formed and maintained, energy consumption could decrease. If the habit of unplugging is established on a large scale, the energy company will make less profit. However, looking at individual use in this design case, the result might be negligible.

### 5.2 Values

As discussed in the stakeholder analysis, there are some moral values relevant to this design case. First of all, *autonomy*. The intervention to reduce energy consumption must be a guide or help to achieve the desired goal. It must something other than an intervention that reflects authority over the user. With the designed intervention, autonomy will remain to exist for the user. The user must act and have the will to change or maintain their habit. Secondly, *responsibility*. The target user needs to feel responsible for the end goal of the intervention, which is saving energy to counteract climate change, to safe on energy costs, or to prolong the life of devices. Feeling responsible for one or several of these goals can support the user to change or adopt the intended habit. Thirdly, *curiosity.* Curiosity could be relevant to the roommates of the user. They might see the user interacting with or seeing the intervention when exiting the roommate's room. This could spark their interest or curiosity and lead to a new interest in changing their habit. Lastly, *structure*. The intervention could provide a form of structure to the life and to the particular habit of reducing user's energy consumption. Some users might need this structure in order to maintain their habits and perform it on a regular structural basis.

### 5.3 Potential value conflicts

The most relevant moral values are discussed in the previous section. However, there are also possible value conflicts for the intervention. For example, the value of autonomy might conflict with the value of authority, because some users may see the intervention as an authority as it always appears on their door when leaving their room.

Another value conflict can happen between curiosity and responsibility. The conflict can happen not for the user but for their roommates. Even though the roommate might be curious about the intervention and want to use it to change their behavior if they do not feel the responsibility, the curiosity might not be enough to establish the habit.

### 5.4 Ethical guidelines

Several ethical guidelines were established for the intervention: (i) the intervention must give the user enough room for autonomy, (ii) the intervention must give the user enough room for autonomy, (iii) the intervention must not give the user the feeling being under authority, (iv) privacy must remain with the intervention.

## 6 EVALUATION PLAN

The evaluation plan focuses on how the final set of user tests should be done and, more specifically, which parts of the theory can show if the desired goal has been achieved. The habit theory is the focus of this intervention; therefore, the ultimate goal is to add a new habit to the user's routine.

### 6.1 Intervention level

#### *6.1.1 Goals*

Self-efficacy is integral to gaining a new behavior and maintaining it. It gives the user the confidence and motivation to keep using the intervention and work towards the target behavior. The ultimate goal of the intervention is for the user to unplug their device every time they leave their room for a more extended period. In the end, the intervention should not be needed anymore. The goals are specified as followed: (i) Self-efficacy should be at a level where the user can maintain their new routine; (ii) Unplugging devices before leaving their room should become part of the user's routine (without needing the intervention).

#### *6.1.2 Determinants*

To determine the self-efficacy level, questionnaires should be focused on using questions with 'can do' and 'will do' statements where a scale is used to supply an answer [S. Orbell and B. Verplanken 2020]. To determine if the target behavior has been reached, questions should be asked, such as how many times they unplug their devices, how much they still need to use the intervention, and how high their self-efficacy level is.

### 6.2 Interaction level

#### *6.2.1 Goals*

The intervention should be used as much as possible to generate a new habit. Building a new habit takes time and needs to be done consistently [S. Orbell and B. Verplanken 2020]. Every time the user leaves the room for longer than one part of the day, the intervention should be used. The goal of the intervention is to add a habit to the user's routine. Keeping the interaction simple is essential since this can affect the user's self-efficacy. The interaction itself should fit the related target behavior. The look of the cue/intervention should be related to the target behavior. The goals are specified as followed: (i) The user should interact want to interact with the intervention when they leave the room for a longer period of time; (ii) The interaction itself should be simple and fit logically with the desired targe behavior.

#### *6.2.2 Determinants*

Different methods are used to determine if the goals are being reached on the interaction level. For the first goal, a technical method can be used. The intervention can measure with sensors how many times the user has used the intervention per day. For the second goal, a constructive approach should be used. At the beginning of the testing process, a questionnaire can be sent, or an interview can be held to see how the user feels about the interaction of the intervention.

### 6.3 User testing

The testing of the final version of the intervention should take around 13 months in total, in an ideal setting. According to the Transtheoretical Model (TTM) [J.O. Prochaska et al. 2008], the preparation phase takes about a month, the action and maintenance phase both take around 6 months each.

The participants will be gathered from different universities and schools. Their ages should be somewhere between 18 and 28. And they should live in a student house where they have their own room. To accurately test the intervention, the participants should already be in the preparation phase in regard to wanting to lower their energy consumption at home.

#### *6.3.1 Phase one*

The phase takes place for one month where the participant prepares to go to the next phase. In this phase the test is explained, and tools are given to make it easier for the participant to turn unplug their devices. They should also set up their home to successfully use the intervention.

*6.3.2 Phase two*

When the necessary preparations have been made, the participant moves on to the second/action phase. When this phase starts the participant uses the intervention. Once a week the participant fills in a questionnaire to keep track of their activities with the intervention. An example questionnaire can be found in Appendix G. The researcher can use these to track the participants progress, combined with the data from the intervention on how much the intervention is used. After 6 months the participants will have an interview with the researcher to talk about their progress and interaction with the intervention. If applicable the participant moves on to the next phase. Some determinants that can assess if the participant can move to the next phase are the level of self-efficacy, the amount of time the intervention is used compared to the number of times the participant unplugs their devices before leaving.

*6.3.3 Phase three*

This phase relates to the maintenance phase from the Transtheoretical Model. Here the participant tracks their progress every two weeks instead of one. When their self-efficacy level is high enough, unplugging devices has become part of their routine and the user does not need the intervention anymore, the test can be completed. This may take around 6 months.

*6.3.4 Phase four*

This phase serves as a check in moment after 6 months to ascertain if the behavior change is still in place. If not, then the researcher can question what the reasons are and if the intervention can/should be changed.

## 7 PROTOTYPE AND EMPIRICAL EVALUATION

For evaluation purposes, a lo-fi prototype (figure 2) was made to study the effectiveness and appropriation of the final design concept at both interaction and intervention levels. Due to the difficulties in assessing the prototype in users' natural environment, a lab-approach study was conducted in the research. Within the test, the aim was to investigate if participants were able to fulfil the interaction level goals: (i) the affordance of the prototype, (ii) understanding and ability to relate it to the energy consumption, and intervention level goals: (iii) the noticeability of the prototype and the ability to serve as a cue, and (iv) the willingness to use by participants. To conclude if these goals were reached, determinants can be used such as the visibility of the cue, the level of affordance, ease of use of the intervention and if the participant would use the intervention in their own home.

### 7.1 User test set-up

A meeting room on the Eindhoven University of Technology campus was reserved for creating an environment similar to student rooms. The prototype was stuck next to the exit door inside the room. A pilot test and eight user tests were carried out with the presence of one of the researchers in the room as observer and facilitator, and one outside the room to explain the consent form to participants before the test and answer questions regarding the questionnaire afterwards. The participants were all university students aged 18 to 28 who were randomly recruited in person or via social communication platforms.

Along with this, short information on the scope of the study was explained before the testing began. The information involved the explanation of phantom energy, the test set-up, and that the test room should represent a student room. Once the aforementioned steps were completed, participants entered the room, and as a relaxing activity, they were asked to work on a sudoku for five minutes. Next, they were asked to leave the room with the prototype in their confrontation and fill in the questionnaire.

For practical reasons, the user study was set up by means of self-report instrument [S. Orbell and B. Verplanken 2020]. A questionnaire was designed to assess the participants' feedback and look at how the goals are achieved. The questionnaire contains 12 statements (three for each goal) in Likert-scale, which the participants are asked to rate, and two open questions

for more general feedback. The questionnaire results are collected and assessed through Microsoft Forms anonymously. The content of the questionnaire is available in Appendix H.

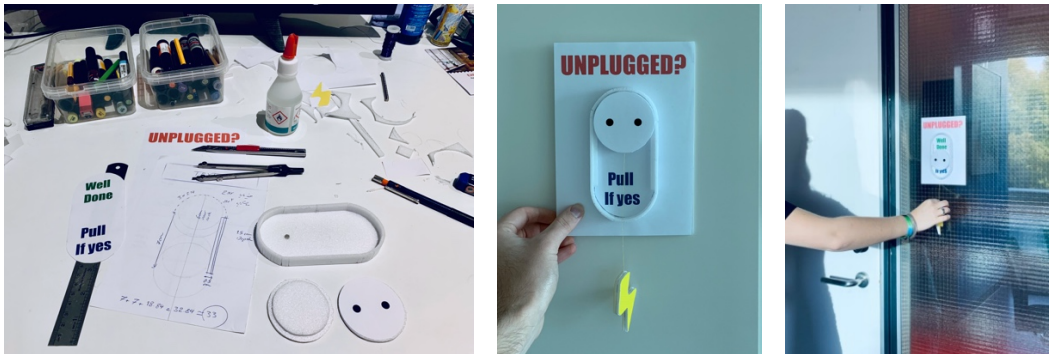


Figure 2: respectively from left to right, the prototype-making process, the end prototype, and the prototype in use

### 7.2 Test Results

#### *7.2.1 Interaction Level*

Participants appeared relatively optimistic about the interaction with the prototype. All questions got at most two negative values, while most answers were positive. An overview of all the results is included in Appendix I. The results show that i) most people understood the relation between the prototype and energy saving; ii) even though a few felt the relation between the cord and the switch was ambiguous, all participants found it easy to understand and manipulate the interaction.

#### *7.2.2 Intervention Level*

The results show that participants had a generally positive impression of the intervention. To be more precise, i) almost all participants see the prototype and see it as a cue, but around one third of them were not instructed to take further actions; ii) participants generally see the potential to use this, while about one third thought it still needs improvement to significantly raise their awareness.

## 8 DISCUSSION

The intervention was carefully designed and tested as explained in this report. However, there are still some remarks that will be discussed here.

First, during this project a behavior change intervention was designed. Even though the timespan of the project did not allow for testing a fully realized prototype, a low-fi prototype was used to confirm aspects of the intervention. Therefore, it is worth mentioning that the findings discussed in this report argue that several elements could work for a behavior change intervention. However, it is not confirmed that the intervention as a whole could change behavior as a longer testing period is necessary for this because it takes time to form and maintain a habit [J.O. Prochaska et al. 2008].

Secondly, users will always be able to ignore the intervention and leave the room without any action, but this intervention was designed for people in the preparation, action or maintenance stage of the Transtheoretical Model [J.O. Prochaska et al. 2008] meaning that users want to change, keep or maintain their (new) habit and are determined to change.

Thirdly, during one test session the prototype was not on the default stage, so it already showed ‘Well done’. From communication with this participant some interesting insights were gathered but not included as they cannot be generalized. However, the participant mentioned that a positive feeling was experienced because of the ‘Well done’. As explained in chapter 4, the intervention includes a social actor. Future research could focus on researching the impact of the congratulating text, and what the best text for this purpose could be to strengthen the social actor element in the intervention.

Lastly, even though it was communicated that the context of the intervention is in a student room, it cannot be confirmed that the intervention will attract the same amount of attention in a personal space. Alongside this, it can also not be confirmed that the intervention will be too distinctive from the personal space, resulting in that people potentially will not want to place it in their personal space.

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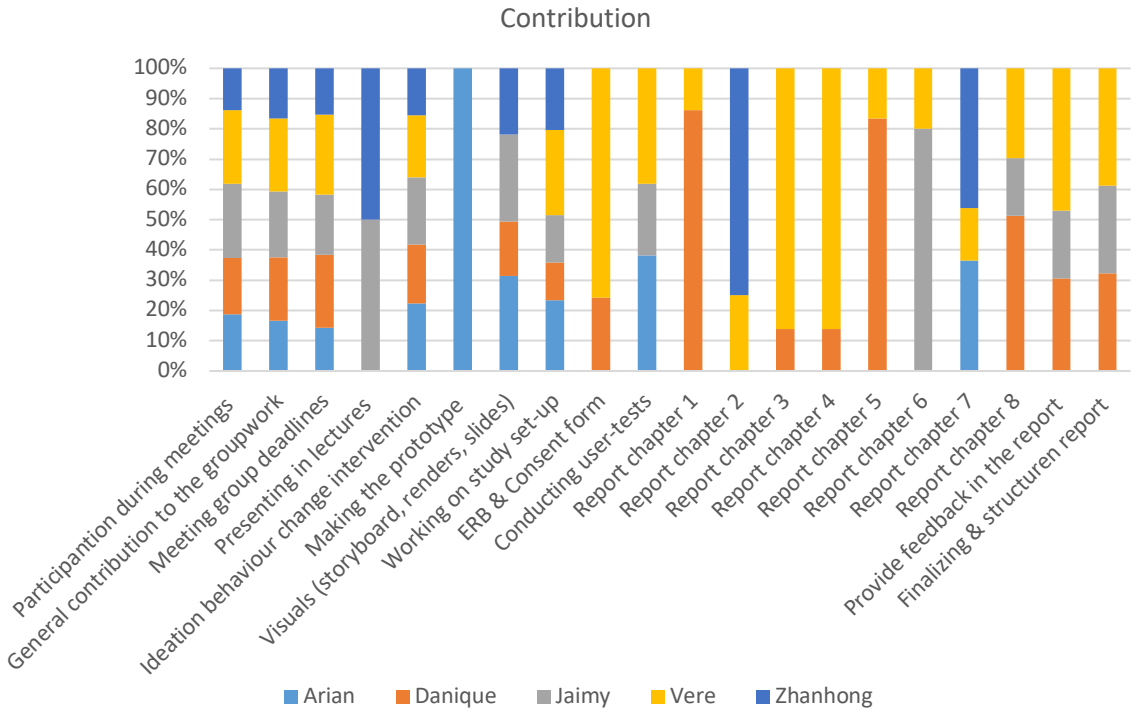
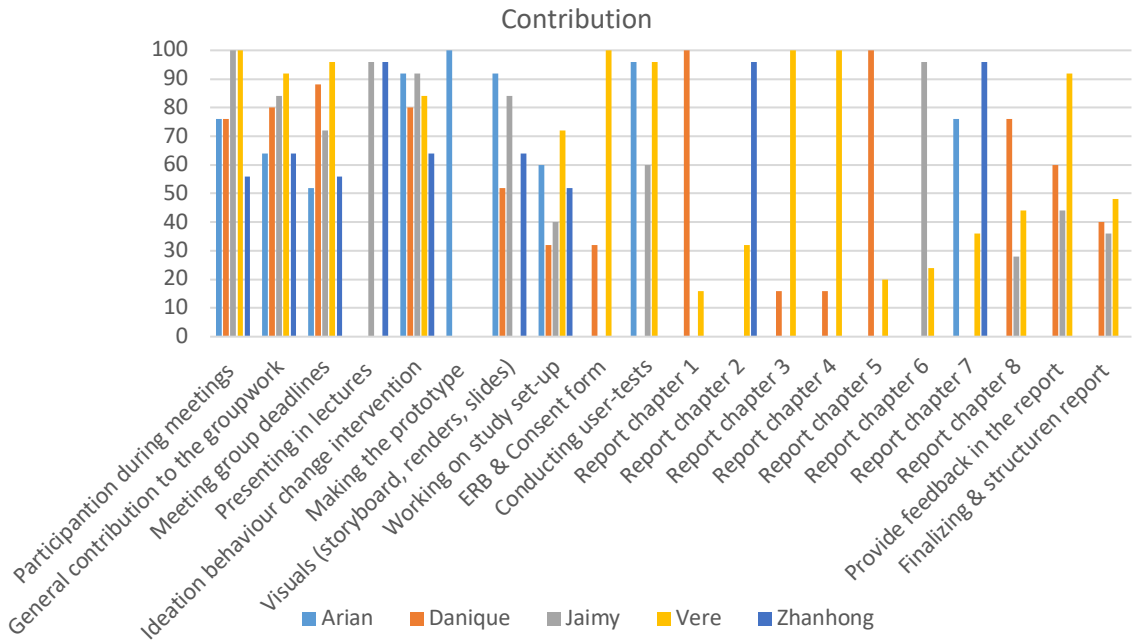
**APPENDIX A: INDIVIDUAL CONTRIBUTION**

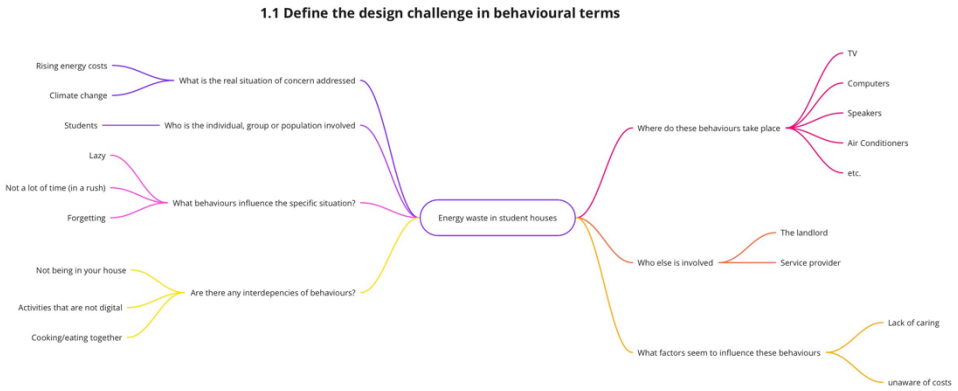
To illustrate the distribution of work throughout this course an image is made. All group members peer-reviewed each other which is translated into the graph below. All group members agreed with this graph.




The same data is used for another visualization as it was not known which one is preferred.



## APPENDIX B: DESIGN BRIEF MIND MAP



## APPENDIX C: TARGET BEHAVIOR SELECTION

**1.2 Select Target Behaviour**

New table

| Assessment ranking | Target behaviours | Impact | Likelihood | Spillover | Measurement |
|---|---|---|---|---|---|
| 2 | turning off the lights when you leave the room for a short time (15 min) | Worth considering | promising | worth considering- promising | Very easy |
| 3 | unplug your devices | Promising | worth considering | worth considering | Easy |
| 1 | Do more non-electronic activities | Promising | worth considering | very Promising | medium |
| 5 | use energy together | Promising | | Promising | medium |
| 5 | Cook together | | unpromising (really depends on environment) | promising | easy |
| 4 | Use alternatives for electronic devices | Promising | worth considering | worth considering | medium |
| | Total assessment | Promising/Unpromising/Unacceptable | Promising/Unpromising/Unacceptable | Promising/Unpromising/Unacceptable | Promising/Unpromising/Unacceptable |

## APPENDIX D: TARGET BEHAVIOR SPECIFICATION

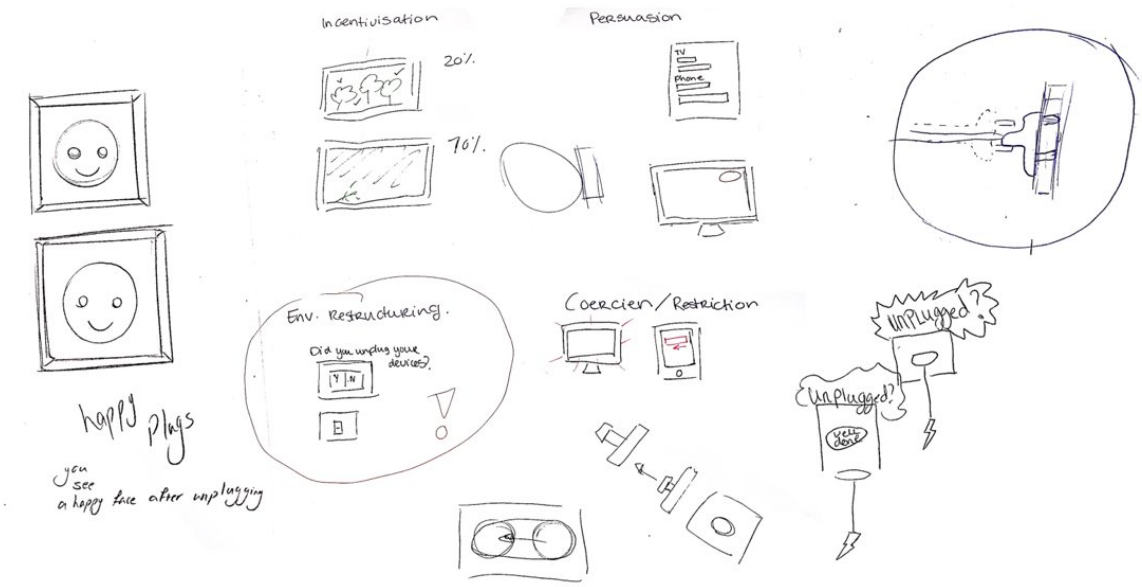
1.3 Target behaviour specification

| Target behaviour | Unplugging Electronic Devices When Leaving the Room |
|---|---|
| Who needs to perform the behaviour? (Characteristics) | student |
| What do they need to do differently? | Unplugging (unnecessary) electronic devices |
| When do they need to do it? | When they leave the rooms, usually in the evenings or during weekends |
| Where do they need to do it? | At home, in their room |
| How often do they need to do it? | On a daily basis, depending on how many times they leave the rooms for a long time |
| With whom do they need to do it? | Individually, but also with your roommates |

**APPENDIX E: COM-B ANALYSIS**

| Com-B components | What Needs to happen for the behaviour to occur | Is there need for change? |
|---|---|---|
| Physical Capability | Be able to do something else | No change needed |
| Psychological capability | Know how to unplug your devices. | No change needed |
| Physical opoportunity | Make it easy to unplug devices. Plugs should be in easy reach. | Change needed, some rooms have outlets that are not easy to reach. |
| Social opportunity | Have the social support. | No change needed |
| Reflective Motivation | Believe that it will help with your energy consumption. | Change needed, be aware of how much energy plugged devices can use and that changing their behavior will help. |
| Automatic Motivation | Establish a routine and/or habits of unplugging devices. | Change needed, to establish routines and find activities you enjoy |
| Com-B diagnosis | Reflective and automatic motivation is needed to be established. Physical opportunity should also be a sub focus of the intervention. Psychological capability as well as social opportunity. | |
| Determinants | Strength of habits / Motivation to change habits | |

**APPENDIX F: CONCEPT ITERATION AND CATEGORIZATION**



## APPENDIX G: EXAMPLE QUESTIONAIRE

### Questionnaire

1. How many times have you left your room for a longer period of time?
2. How many times have you interacted with the intervention?
3. How many times did you unplug your devices?
4. How easy was it to unplug your devices? (7-point scale)
5. How easy was the interaction with the intervention? (7-point scale)
6. What is your level of self-efficacy now? (0 to 100% scale)
7. What is your level of affordance? (0 to 100% scale)

Any other comments? (open question)

## APPENDIX H: USER TEST

Place: A meeting room in Atlas (or other buildings on campus) with sockets
Time: 10 min
Number of participants: 9

**Process**

1. Participants are invited into the room and fill in the consent form.
2. Participants are asked to perform a random task given by the researchers.
3. After a short period of time, participants are asked to leave the room, with the prototype in their confrontation.
4. Participants decide themselves whether to do anything with the prototype or take any further actions.
5. Participants fill in the questionnaire regarding the intervention.

**Questionnaire**

2. I realized that the prototype is referring to the shape of a switch. (7-point scale)
4. I understood that the lightening sign had a meaning. (7-point scale)
3. I understood that pulling the cord down referred to energy saving. (7-point scale)

7. I understood that the prototype should be triggered by pulling the cord. (7-point scale)
5. I understood that pulling the cord is equivalent to turning the switch. (7-point scale)
6. The prototype is easy to manipulate. (7-point scale)

7. I found that I noticed the cue when I was going to leave. (7-point scale)

If this is not the proper place, where would you put it? (Open question)

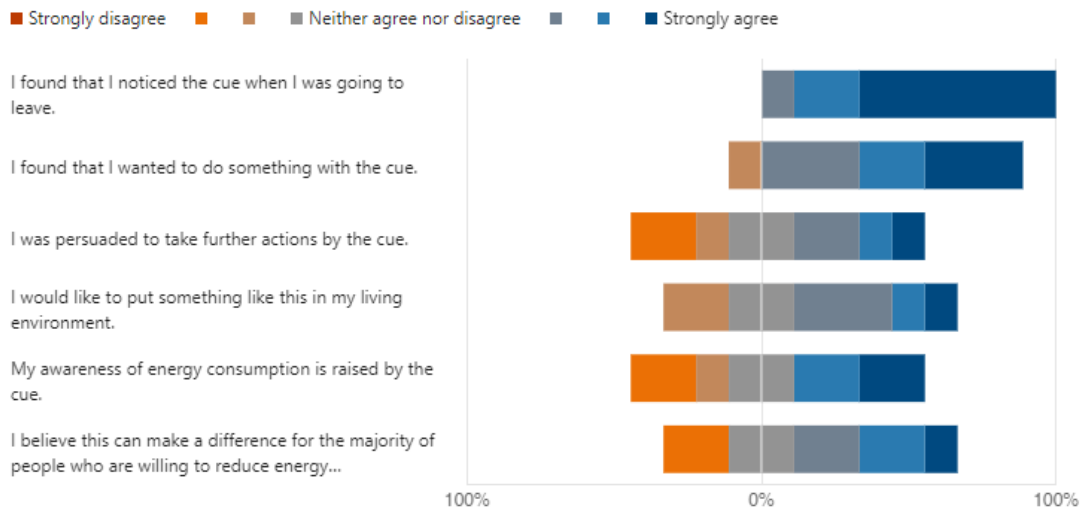
8. I found that I wanted to do something with the cue. (7-point scale)
9. I was persuaded to take further actions by the cue. (7-point scale)

10. I would like to put something like this in my living environment. (7-point scale)
11. My awareness of energy consumption is raised by the cue. (7-point scale)
12. I believe this can make a difference for the majority of people who are willing to reduce energy consumption. (7-point scale)

**APPENDIX I: USER TEST RESULTS**

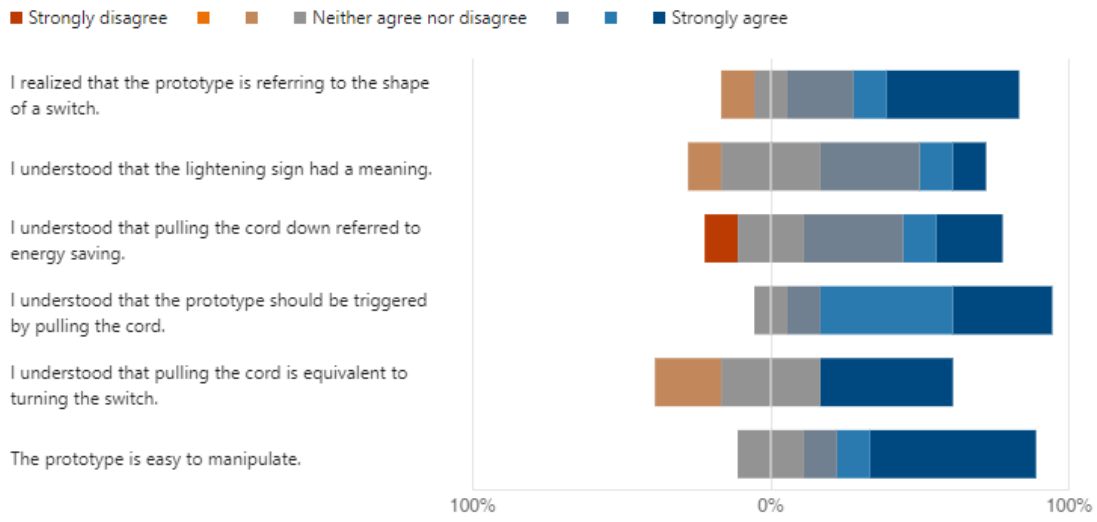
1. About the intervention

Meer details




2. About the interaction

Meer details



3. If putting the cue next to the door is not the proper place, where would you put it?

7 Antwoorden

| ID ↑ | Naam | Antwoorden | Taal |
|---|---|---|---|
| 1 | anonymous | I think this is a great place but otherwise i would put it somewhere in the living room (like the thing for temperature) | English (United States) |
| 2 | anonymous | It is the proper place. perhaps the bedroom also is good, because you can turn off devices when you go to sleep | English (United States) |
| 3 | anonymous | I think next to the door is the best choice to mutify it as a switch. If I have to chose and other places, I would say near by my computer. | English (United States) |
| 4 | anonymous | Not a bad place, but it could possibly be integrated around the door lock. Like putting off the lights is the same kind of action as locking your house. | English (United States) |
| 5 | anonymous | Before the kapstok or shoe rek | English (United States) |
| 6 | anonymous | found the placement fine, either on the door itself to really be in view | English (United States) |
| 7 | anonymous | I thinks next to the door is good. Otherwise you forget when you leave. Feels like a reminder | English (United States) |

4. Any other comments or suggestions?

6 Antwoorden

| ID ↑ | Naam | Antwoorden | Taal |
|---|---|---|---|
| 1 | anonymous | Having something that shows wether or not you've already used it | English (United States) |
| 2 | anonymous | No, thank you | English (United States) |
| 3 | anonymous | It a quite an interesting cue, when I first came into the room, I didn't notice it. But when I want to leave I notice it, it is very easy to interact with. | English (United States) |
| 4 | anonymous | some devices you don't want to unplug when you leave the house, how do you make that difference? | English (United States) |
| 5 | anonymous | Only because it was a test i was more looking at my surroundings, otherwise I would probably not have noticed it. I have no idea if pulling the cord actually did something, I would like if it actually turned all devices of at once. But if it was meant to first unplug all devices manually before turning the cue then I did not do that. | English (United States) |
| 6 | anonymous | The lightning took my attention | English (United States) |

**APPENDIX J: ERB FORM**

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# Ethical Review Form Education

**(Version 17.07.2020)**

This Ethical Review Form should be completed for every research study that involves human participants or personally identifiable data. The form should be submitted and approved by your supervisor before potential participants are approached to take part in the research study.

## Part 1: General Study Information

| | | |
|---|---|---|
| 1 | Student name and email | Vere Vreeswijk – v.vreeswijk@student.tue.nl<br>Danique de Vries - d.c.c.d.vries@student.tue.nl<br>Jaimy de Kok - j.d.d.kok@student.tue.nl<br>Zhanhong Su - z.su@student.tue.nl<br>Arian Ettefaghpour - a.ettefaghpour@student.tue.nl |
| 2 | Supervisor name and email | Panos Markopoulos - p.markopoulos@tue.nl |
| 3 | Degree Program | Industrial Design |
| 4 | Bachelor/master | Master |
| 5 | Bachelor/master end project? | No |
| 6 | Course name and code | DDM110 Design for behavioral change |
| 7 | Project title | Reducing energy consumption by unplugging devices before leaving the house |
| 8 | Research location | In a room at the campus of Eindhoven University of Technology |
| 9 | Research period (start/end date) | 22/10/2022 until 1/11/2022 |
| 10 | [If Applicable] Proposal already approved by (external) Ethical Review Board: Add name, date of approval, and contact details of the ERB | No. |
| 11 | Research question | Will a cue-contingent intervention support creating the routine of unplugging devices and therefore, help reducing energy consumption. |
| 12 | Description of the research method | Students between the age of 18 until 28. |
| 13 | Description of the research population, in- and exclusion criteria | Participants of this research should be a student between the age of 18 and 28. The participant should be living in a student house or studio. The participant should also be motivated to reduce their energy consumption. |
| 14 | Number of participants | 8 |
| 15 | Explain why the research is socially important. | We are currently having an energy crisis in the Netherlands. Also, it is more and more known that extensive energy consumption is bad for the environment. Therefore, it is important to being more carefull with our energy consumption and try to reduce it as much as possible. A lot of the energy consumption is done by having devices off, but not unplugged. Therefore, there is a gain in changing this behaviour. |
| 16 | Describe the way participants will be recruited | As the researchers are students, they will look within their own network to find participants. Recruitment will be done by sending text messages or approaching people in real life. A brief explanation will be done of the research. |

1

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# Ethical Review Form

| | | |
|---|---|---|
| 17 | Provide a brief statement of the risks you expect for the participants or others involved in the research and explain. Take into consideration any personal data you may gather and privacy issues. | There are no expected risks in this research. The only data asked from participants is their age group and if they live in a student home and if they are willing to save energy. All this information will not be able to trace back to the participants. |

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# Ethical Review Form

| | Part 2: Checklist for Minimal Risk | | |
|---|---|---|---|
| | | **Yes** | **No** |
| 1 | Does the study have a medical scientific research question or claim (see definition below)<br><br>*Medical/scientific research is research which is carried out with the aim of finding answers to a question in the field of illness and health (etiology, pathogenesis, signs/symptoms, diagnosis, prevention, outcome or treatment of illness), by systematically collecting and analysing data. The research is carried out with the intention of contributing to medical knowledge which can also be applied to populations outside of the direct research population.*' | ☐<br>If yes or maybe:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | ☒<br>If no:<br>Continue with question 2 |
| 2 | Does the study involve human material (such as surgery waste material derived from non-commercial organizations such as hospitals)? | ☐<br>If yes or maybe:<br>This is only allowed if your supervisor has consulted with the medical coordinator. Continue with question 3 | ☒<br>If no:<br>Continue with question 3 |
| 3 | Will the participants give their explicit consent – on a voluntary basis – either digitally or on paper? Or have they given consent in the past for the purpose of education or for re-use in line with the current research question? | ☒<br>If yes:<br>Continue with question 4 | ☐<br>If no:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval |
| 4 | Will the study involve discussion or collection of personal data? (e.g. name, address, phone number, email address, IP address, BSN number, location data) or will the study collect and store videos, pictures, or other identifiable data of human subjects? | ☐<br>If yes:<br>The handling, storing and de-identification of the personal data should be discussed with your supervisor. Continue with question 5 if you met all requirements for handling personal data (see …) | ☒<br>If no:<br>Continue with question 5 |

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# Ethical Review Form

| | | Yes | No |
|---|---|---|---|
| 5 | Does the study involve participants who are particularly vulnerable or unable to give informed consent? (e.g. children, people with learning difficulties, patients, people receiving counselling, people living in care or nursing homes, people recruited through self-help groups)? | ☐ | ☒ |
| | | If yes:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | If no:<br>Continue with question 6 |
| 6 | May the research procedure cause harm or discomfort to the participant in any way? (e.g. causing pain or more than mild discomfort, stress, or anxiety) | ☐ | ☒ |
| | | If yes:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | If no:<br>Continue with question 7 |
| 7 | Will the participants receive any compensation for their participation? Such as a coupon or a chance to win a prize? | ☐ | ☒ |
| | | If yes:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | If no:<br>Continue with question 8 or 10, depending on the type of study (see red text below) |
| **The following questions 8-9 are for *observational* research (e.g. (semi-)structured interviews; focus groups; (participatory) observations). If your research is *experimental*, then skip questions 8-9 and continue with question 10** | | | |
| 8 | Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g. covert observation of people)? | ☐ | ☒ |
| | | If yes:<br>This is only allowed when observing behavior in public space. If so, continue with question 9.<br>If you observe people in non-public space without their consent, your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | If no:<br>Continue with question 9 |
| 9 | Will participants be asked to discuss or report sexual experiences, religion, alcohol or drug use, or suicidal thoughts, or other topics that are highly personal or intimate? | ☐ | ☒ |
| | | If yes:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | If no:<br>Continue with part 3 |

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# Ethical Review Form

| | | | |
|---|---|---|---|
| **The following questions 10-13 are for *experimental* research (e.g. measurements on yourself or another person; testing a prototype/device; influencing behavior through manipulation (e.g. light or temperature). If your research is *observational*, then skip questions 10-13 and continue with part 3** | | | |
| | | **Yes** | **No** |
| **10** | Is the study invasive (i.e. it affects the body such as puncturing the skin; taking blood or other body material (such as DNA) from the participant)? | ☐ | ☒ |
| | | If yes:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | If no:<br>Continue with question 11 |
| **11** | Does the device have a medical purpose sucs as diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease or injury? | ☐ | ☒ |
| | | If yes or maybe:<br>Your supervisor should submit the study to the ERB. You cannot get automatic ethical approval | If no:<br>Continue with question 12 |
| **12** | Will the experiment involve the use of physical devices that are 'CE' certified for unintended use (meaning you will use existing CE certified devices for other things than they were originally intended for? | ☐ | ☒ |
| | | If yes:<br>This is only allowed if they are completely harmless. They should have a harmless voltage of <5V and hazardous waste (fumes/gas/substances) should not be released. You should discuss with your supervisor whether you need to have the device tested for safety | If no:<br>Continue with question 13 |
| **13** | Will the experiment involve the use of physical devices that are not 'CE' certified? | ☐ | ☒ |
| | | If yes:<br>This is only allowed if they are completely harmless. They should have a harmless voltage of <5V and hazardous waste (fumes/gas/substances) should not be released. You should discuss with your supervisor whether you need to have the device tested for safety | If no:<br>Continue with part 3 |

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# Ethical Review Form

| Part 3: Enclosures and Signature | | |
|---|---|---|
| 1 | Enclosures (tick if applicable):<br><br>☒ Informed consent form (link to template);<br>☐ The survey the participants need to complete, or a description of other measurements (such as interview questions or a description of the prototype);<br>☐ Text used to find participants (such as brochures, flyers, etc);<br>☐ Approval other research ethics committee; | |
| 2 | I hereby declare that I have completed this form truthfully<br><br>Signature(s) of the student(s)<br><br>Date |  |

Discuss this form with your supervisor. If any of the boxes your ticked in Part 2 suggest that your supervisor should submit your study to the ERB for ethical approval, try to change your research design in such a way that your supervisor can approve it instead. If this is not possible, ask your supervisor to submit the proposal to the ERB. It will take two to five weeks before you receive a decision from the ERB.

| Part 4: Review by supervisor | | | |
|---|---|---|---|
| | | **Yes** | **No** |
| 1 | Does the data storage adhere to all requirements of responsible data management (link toevoegen)? | ☐ | ☐ |
| | | If yes:<br>Continue with question 2 | If no:<br>Discuss with your student the necessary steps to adhere to the requirements |
| 2 | Does the research proposal adhere to all requirements for automatic approval? | ☐ | ☐ |
| | | If yes:<br>Please skip the questions 3-6 and sign the form | If no:<br>Discuss with your student if any alterations can be made in order to adhere to the requirements for automatic approval. If you decide that the study cannot adhere to the requirements, then you as a supervisor need to submit the proposal to the ERB. Please answer the following additional questions (3-6) |

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# Ethical Review Form

| Additional questions for ERB approval | | |
|---|---|---|
| 3 | Elaborate on the topics from part 2 that do not allow for automatic approval. Describe how you safeguard any potential risk for the research participant for each topic. | |
| 4 | Describe and justify the number of participants you need for this research, taking into account the risks and benefits | |
| 5 | Explain if your data are completely anonymous, or whether they will be de-identified (pseudonymized or anonymized) and if so, explain how | |
| 6 | Who will have access to the data? | |

| Part 5: Signature by supervisor | | |
|---|---|---|
| | I hereby declare that I have completed this form truthfully<br><br>Signature of the supervisor<br><br>Date | |

## APPENDIX K: CONSENT FORM



# Subject information for participation in scientific research

### Energy consumption in student houses

*Official title: Energy consumption in student houses*

### Introduction

Dear Sir/Madam,

You are asked to take part in a scientific study.
Participation is voluntary. Participation requires your written consent. Before you decide whether you want to participate in this study, you will be given an explanation about what the study involves. Please read this information carefully and ask the investigator for an explanation if you have any questions. You may also discuss it with your partner, friends or family.

### 1. General information

This study has been designed for the course Design for Behavioural change and is being carried out by 5 master students Industrial Design.

### 2. Purpose of the study

In this study, the researchers are testing several elements of the designed behaviour intervention.

### 3. What participation involves

During the study, the following will happen:
- data is collected about your age group and motivation for saving energy
- You are asked to fulfil a task
- You are asked to fill in a short questionnaire

### 4. What is expected of you

In order to carry out the study properly is important that you follow the study instructions.

It is important that you contact the investigator:

- if you no longer want to participate in the study.

### 5. If you do not want to participate or you want to stop participating in the study

It is up to you to decide whether or not to participate in the study. Participation is voluntary.

If you do participate in the study, you can always change your mind and decide to stop, at any time during the study. You do not have to say why you are stopping, but you do need to tell the investigator immediately.
The data collected until that time will still be used for the study.

If there is any new information about the study that is important for you, the investigator will let you know. You will then be asked whether you still want to continue your participation.

## 6. End of the study

Your participation in the study stops when

- you choose to stop
- the end of the entire study has been reached
- the investigator considers it best for you to stop

The study is concluded once all the participants have completed the study.

## 7. Usage and storage of your data

No personal data will be collected, used and stored for this study. Non personal data such as your age group and motivation for saving energy will be collected.

**Confidentiality of your data**

To protect your privacy, your data will be given a code. Your name and other information that can directly identify you, will be omitted. Data can only be traced back to you with the encryption key. The encryption key remains safely stored in the local research institute. The data that is sent to the course supervisor will only contain the code, not your name or other data with which you can be identified. The data cannot be traced back to you in reports and publications about the study.

**Access to your data for verification**

Some people can access all your data at the research location. Including the data without a code. This is necessary to check whether the study is being conducted in a good and reliable manner. Persons who have access to your data for review are the course supervisors.

**Retention period of your data**

Your data must be kept for 3 years at the research

**Withdrawing consent**

You can withdraw your consent to the use of your personal data at any time. This applies to this study. The study data collected until the moment you withdraw your consent will still be used in the study.

**More information about your rights when processing data**

For general information about your rights when processing your personal data, you can consult the website of the Dutch Data Protection Authority.

If you have questions about your rights, please contact the person responsible for the processing of your personal data. For this study, that is v.vreeswijk@student.tue.nl
If you have questions or complaints about the processing of your personal data, we advise you to first contact the research location. You can also contact the Data Protection Officer of the Eindhoven University of Technology or the Dutch Data Protection Authority.

## 8. Any questions?

If you have any questions, please contact v.vreeswijk@student.tue.nl

## 9. Signing the consent form

When you have had sufficient time for reflection, you will be asked to decide on participation in this study. If you give permission, we will ask you to confirm this in writing on the appended consent form. By your written permission you indicate that you have understood the information and consent to participation in the study. The signature sheet is kept by the investigator. Both the Investigator and yourself receive a signed version of this consent form.

Thank you for your attention.

## Subject Consent Form

Energy consumption in student houses

- I have read the subject information form. I was also able to ask questions. My questions have been answered to my satisfaction. I had enough time to decide whether to participate.
- I know that participation is voluntary. I know that I may decide at any time not to participate after all or to withdraw from the study. I do not need to give a reason for this.
- I give permission for the collection and use of my data to answer the research question in this study.
- I know that some people may have access to all my data to verify the study. These people are listed in this information sheet. I consent to the inspection by them.

- I want to participate in this study.

Name of study subject:
Signature: Date: __ / __ / __

---

I hereby declare that I have fully informed this study subject about this study.

If information comes to light during the course of the study that could affect the study subject's consent, I will inform him/her of this in a timely fashion.

Name of investigator (or his/her representative):
Signature: Date:__ / __ / __

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