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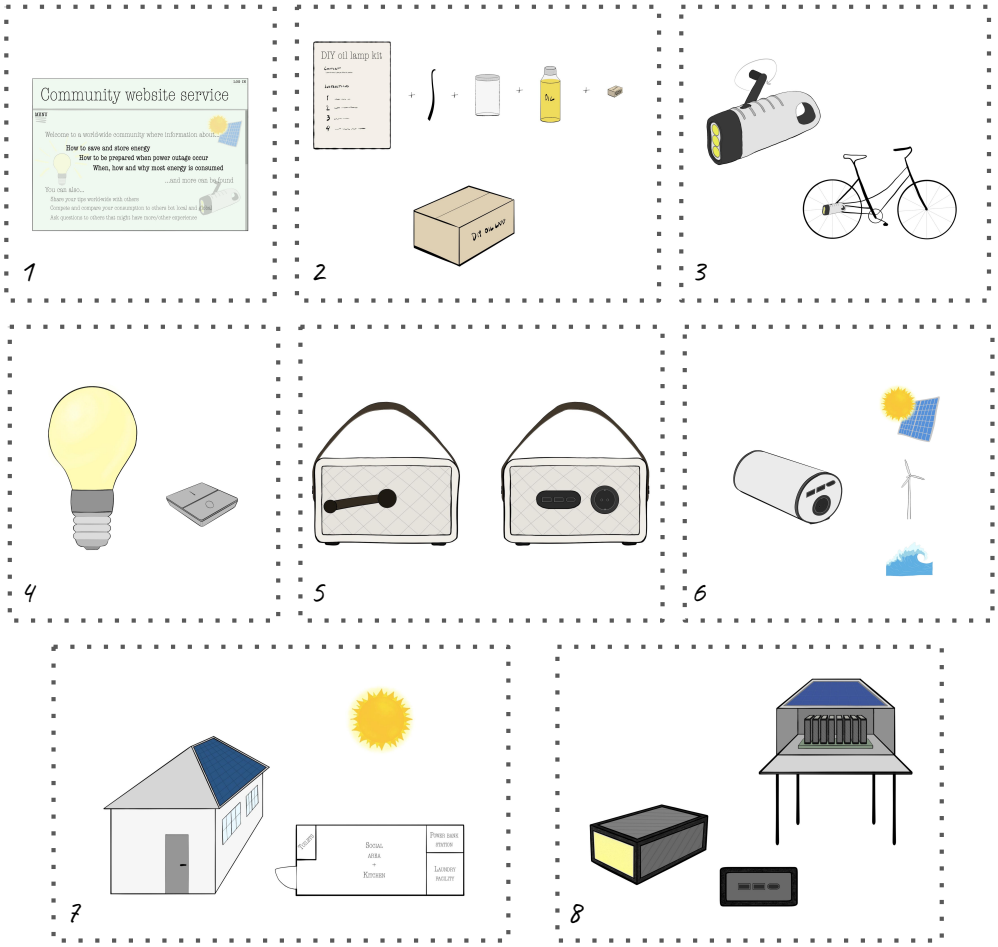

Energy Resilient Design for All Income Economies

Exploring backup system and lighting needs when experiencing power outages

Master's Thesis in Industrial Design Engineering

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Department of Industrial and Materials Science
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022
www.chalmers.se

Master's thesis 2022

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Master's Thesis 2022
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Cover: An overview of the eight developed concepts within the area of lighting and backup system when experiencing power outages, influenced by low and lower-middle income economies.

Typeset in LaTeX
Printed by Chalmers Reproservice
Gothenburg, Sweden 2022

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Abstract

Due to a transition towards sustainability and a growing dependency on electricity, disturbances and limitations in electricity supply are expected to increase. Already, an insecure electricity supply exists in low- and lower-middle-income economies. Therefore, the first aim of this master's thesis was to investigate everyday life in low- and lower-middle-income economies regarding energy resilience. The second aim was to explore the possibility of a design proposal for all income economies within a narrowed down area, which came to be lighting and backup systems when experiencing power outages.

Practice-oriented exploration and analysis were performed, investigating the first aim, mapping household practices in low- and lower-middle-income economies concerning energy resilience. The second aim was explored through a Research through Design approach, which commenced with an idea generation and elimination process, resulting in eight design proposals created through individual brainstorming and two co-creation sessions with participants from different income economies. Lastly, the design proposals were evaluated through a survey and interviews, where the answers were quantitatively and qualitatively thoroughly analyzed.

From this study, many of the practices performed in low- and lower-middle-income economies were already energy resilient. However, practices such as communicating, entertaining, and educating were generally not as energy resilient; how lacking depends on the household's habits, general meanings, and competences. The result of the study indicates that a design proposal for all income economies is possible, while there is a plurality of individual factors affecting when designing within the area. Also, unity in the households from all investigated income economies was found, where all seem to prefer easily accessible and implemented solutions that function with a small effort. This result is affirmed through two concepts being preferred in all income economies. Thus, this master's thesis contributes to one way of preparing for the dilemma of future disturbances and limitations in households' electricity supply.

Keywords: energy resilience, income economies, power outages, backup system, lighting, future design, sustainability, design for all, research through design.

Acknowledgements

First of all, I would like to thank my supervisors, Helena Strömberg and Hanna Hasselqvist, with whom I have had very good discussions and received feedback on how to take the project further. As well, a thank you to Helena for being my examiner.

I want to send a special thank you to my husband, who has motivated me, helped discuss different paths throughout the master's thesis, and helped me take this project forward. Extra valuable since the master's thesis has been performed individually.

I had great pleasure working as part of the project group, which has given help and tips along the way. I would also like to acknowledge the effort of several within Engineering Without Borders who extended assistance throughout the project.

Thanks should also go to Swaroop, who participated in interviews and a workshop throughout the master's thesis and helped spread the survey. I want to extend my sincere gratitude to Ola and Mary, who helped spread the survey; I am very thankful. Also, many thanks to Sofia, who helped initially in the project when understanding the context of low- and lower-middle-income economies.

I would also like to acknowledge the help from all survey respondents, interviewees, and participants in the co-creation workshops for an invaluable contribution to the master's thesis.

Lastly, I would like to extend my deepest gratitude to family and friends who encouraged me along the process and helped in responding and sharing the survey. Additionally, thank you, whoever you are, for all the encouraging kicks from inside the stomach.

Nelly Sevelius, Gothenburg, April 2022

Contents

1
Introduction

This chapter introduces this master's thesis, including an exposition of the project's background and aim.

1.1 Background

In today's society, we are transitioning towards a more sustainable future [1, 2], with more usage of renewable energy instead of finite resources, which is likely to result in disturbances in our energy systems as renewable energy sources are more unreliable [3, 4]. Additionally, limitations and interruptions in energy supply will be present due to climate changes [5]. At the same time, we are more than ever reliant on a secure and stable electricity supply with more and more technology dependent on electricity as well as the habits people have developed being dependent. Furthermore, according to data from the International Energy Agency [6], the energy usage in 44 years, between 1970 and 2014, increased by 44 % all over the world. Meaning an annual average increase of 1 % throughout the whole world.

The Swedish Energy Agency has developed four probable scenarios due to the energy system in Sweden will be facing significant changes both in the near future and beyond [7], which further underlines what is written yet. The scenarios range from 2020 to 2050, and each describes a probable development of society and the energy system. These different scenarios mean there are different paths possible in being chosen when going forward in this transition. There are several ways to face this issue, e.g., expanding the electricity supplies; expanding power grids; better use of energy resources; accepting and reducing electricity habits; developing new electricity independent technology or preparatory technology; or accepting and managing both technology and people. Where a combination of some or all presented suggestions are a probable and a good path to head.

One way of preparing for this is currently being investigated in the project *Designing everyday energy resilience*, in which this master's thesis will be a part. Further, this will be referred to as "the main project". The main project investigates how to be less dependent on reliable electricity supply. Namely, what type of activities are done, how they are performed and possible alterations, and how the products in our everyday life can manage or become more resistant to disturbances in access to electricity. This, in short, is referred to by the project team as more *energy resilient*.

1.1.1 Definition of Energy resilience

There are many different definitions of energy resilience, so this master's thesis will define what is meant when referring to energy resilience. As brought up by the main project [8], the common definition of Energy resilience is about ensuring the energy supply in a broader context and is typically referred to from an infrastructure point of view [9, 10] and thus, where the infrastructure is to be resilient. In the main project, the authors define a new concept called household energy resilience, focusing on households and how they can secure a good life in the expected future of disturbances in electricity due to renewable transitioning. The main project defines *energy resilience* as the following.

> *"As an interwoven part of everyday life, household energy resilience is to ensure a good life through adjusting what activities that are performed, when they are performed and how they are performed in the face of expected and unexpected power outages and shortages as well as to prepare for future adjustments of activities and to more fundamentally change to reduce the need for adjustments."* [8].

Resilience, according to Svenska Akademien [11] is defined and translated to English as an ability to recover or resist various disturbances. Resilience, according to dictionary.com [12] is *"the ability of a system or organization to respond to or recover readily from a crisis, disruptive process"*. In this master's thesis, *Energy resilience* is defined as an adaptation to the definition of what resilience is with inspiration from the main project; to be able to respond, recover or resist various disturbances in regards to energy, in the context of everyday household practices.

Furthermore, a definition of a household being energy resilient also needs to be clarified and expressed. A household is thus energy resilient when it in any way can respond to, recover or resist various energy disturbances. Disturbances may be power disruptions or power outages. Also, no access to the grid or no access to electricity is counted as a "disturbance" in access.

1.1.2 An interest in low- and lower-middle income economies

The World Bank [13] divides the world's countries into four income economies based on different levels of GNI per capita: low-, lower-middle-, upper-middle- and high-income economies (LIE, LMIE, UMIE, HIE). An insecure electricity supply already exists in some income economies, especially LIE, where the electricity supply may vary and be non-existing in some geographical areas. In 2019, merely 41 % of the total population in LIE had access to electricity [14]. Additionally, the same countries often experience power outages, as much as 5 to 95 power outages per month [15]; confirmed in a lot of articles [16, 17, 18, 19, 20]. Thus, in such countries, it may already be of necessity to utilize some form of energy resilience. In LMIE, almost 88 % have access to electricity, still with power outages [15]. While 100 % have access to electricity in UMIE and HIE [14], still also experiencing power outages but considerably less. Hence, UMIE and HIE are not as constrained to being energy

resilient today. Therefore, UMIE and HIE may learn from LIE and LMIE how to be energy resilient.

Furthermore, in an article about household energy-use patterns in Nepal, it is argued that the path of how today's both developed and developing countries have to emerge into being sustainable developed countries [21]. The terms "developed" and "developing" are an alternative to the income economy classification of dividing countries. A designation used by United Nations since 1996 and *"intended for statistical convenience"* [22]. The article further states that both developing countries have to take a future path instead of revering developed countries as an example and that developed countries proceed into sustainable developed countries. This is visualized in the recreation of the articles figure [21] in figure 1.1. According to the authors, in the future, all countries should be sustainably developed countries, where: both rural and urban areas are sustainably divided and developed; our energy use are at optimum levels without limiting our quality of life; as well as instead of using fossil fuels or biomass, reliance on renewable energy is the future.

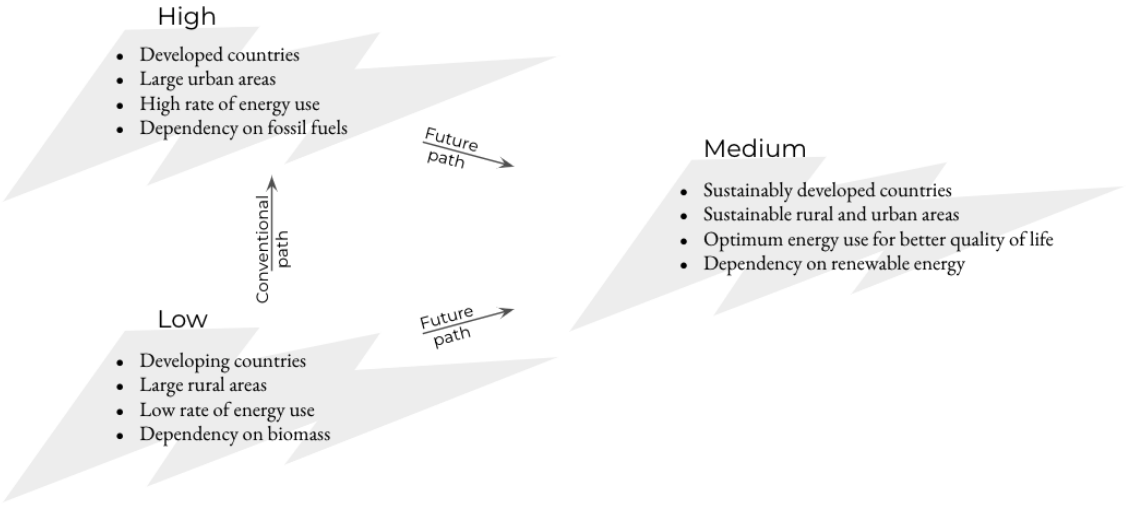

Figure 1.1: A recreation of a graphic in the article [21], showing *"the general trends of energy use both in developing and developed countries at present and also the future goal to be designated"* [21].

1.2 Aim

This master's thesis will investigate everyday life regarding the use of energy in countries classified as LIE and LMIE; and how their lifestyles and products can influence development for energy resilience. The thesis will then develop and evaluate the possibilities of a design proposal on an energy resilient product suitable for all income economies. A proposal that encompasses the union of all income economies through an exploratory study; thus, a proposal that contributes towards reduced dependence on reliable energy systems, in accordance with the main project. Additionally, by designing for all income economies, this master's thesis investigates the

possibilities of designing for the emerged "medium" as in the model in figure 1.1 of future paths for all income economies.

In short, the aim will be to:

- Investigate everyday life in LIE and LMIE regarding energy resilience;
- Explore the possibility of a design proposal for all income economies;

1.2.1 Research questions

The main research questions which ought to be answered through this master's thesis are:

- What types, parts and interrelations of practices connected to energy resilience in LIE and LMIE exist; and which aspects may be relevant for HIE?

- What is learned through creating and evaluating a design proposal with the intention of being suitable for all income economies?

2
Research Context

In this chapter, the research context which will be presented, including more specifically which will be the countries of investigation.

2.1 A main focus on low- and lower-middle income economies

The World Bank [13] divides countries in four income economies, low- (LIE), lower-middle- (LMIE), upper-middle- (UMIE) and high-income economies (HIE). A division made according to different levels of GNI per capita, i.e., the gross national income per capita and year converted in U.S. dollars using the World Bank Atlas method [24]. Table 2.1 shows the income economies with each GNI per capita.

Table 2.1: Income economy classification in regard to GNI per capita. [13]

Income Economy Classification	GNI per capita ($)
Low	<1045
Lower-middle	1046 - 4095
Upper-middle	4096 - 12 695
High	>12 696

According to IEA's [6] latest available data from 2014, the energy usage per capita in HIE is around ten times more than in LIE and LMIE together, while HIE versus UMIE is around two times more. Further, between 1970 and 2014, the energy use in UMIE has increased by almost 300 %, while in LIE the increase was only 16 %. This shows that with increasing standards, energy usage increases, and accordingly, a need for sustainable and more energy resilient solutions are required to tackle this.

Insecure electricity supply already exists in some countries, especially in LIE, where the electricity supply may vary and be non-existent in some geographical areas. The World Bank explicates that *"individuals' access to electricity is one of the most clear and un-distorted indication of a country's energy poverty status"* [14]. In 2019, merely 41 % of the total population in LIE had access to electricity [14], while 30 % in rural areas of LIE [25]. Furthermore, even when having access to electricity, a LIE country may have between 5 to 95 power outages [15] per month. Many articles

address this fact [15, 16, 17, 18, 19]. Thus, it is already necessary for these countries to utilize some form of energy resilience. While in a LMIE, almost 88 % have access to electricity, still with power outages [15]; while 100 % respond to UMIE and HIE [14] having access while also experiencing power outages but considerably less. Hence, today UMIE and HIE countries are not as constrained in being energy resilient.

In summary, LIE and LMIE use immensely much less energy than a HIE, and not even half of the population in a LIE have access to electricity, which is very insecure. Further, LMIE are some distance away from all of the population having access, also with insecurity due to outages. Therefore, an interest points towards exploring these two income economies regarding if and how energy resilient they are. This, as a country that uses less energy or does not have access at all or not secure access is more likely than a HIE or UMIE in already being energy resilient. Still, HIE will also be included in the research but as a comparable reference and in the later part of the study. Also, as all income economies are in need of being sustainable developed countries in the future, this reference point of a country using more energy and having 100 % access to electricity are of interest. In addition, as earlier mentioned, a HIE in a future may also need to be prepared for more insecure access due to climate changes and clash in demand and supply or the transmission of electricity.

2.2 Countries of investigation

Which countries in the above-stated income economies LIE and LMIE are of interest are first of all chosen in regard to the lowest energy use. Thus, as seen in Figure 2.1, countries in South Asia and Sub-Saharan Africa are of interest. Seven LIE and LMIE countries were chosen to be investigated concerning everyday household energy resilience. Three from Asia: Nepal, India, and Bhutan; and four from Africa: Rwanda, Uganda, Tanzania, and Kenya. These countries were chosen owing to being in a variety of poverty levels, as can be seen in table 1.2, where GNI per capita ranges from 0,780 $ to 2,860 $ [24]. Also, in figure 2.2 where the lower and upper limits of LMIE each are visualized with a red line. Thus here is seen the spread of the countries in the income classification defined by World Bank [24]. Additionally, countries in two different continents are considered beneficial as the cultures, lifestyles, and products may differ. The countries were also chosen because the possibility for contact is more probable as initial contact paths existed to the mentioned countries. Still, other countries in the income economies LIE and LMIE can be of interest when gathering complementary information. Furthermore, Sweden is chosen to be explored as a HIE as this is where the master's thesis is written; in Sweden the GNI per capita is equal to 53,800 $ [24]. Exploration in a HIE will be done to have a comparative reference in the first parts of the study and for the later parts when designing and evaluating a design proposal intended for all income economies.

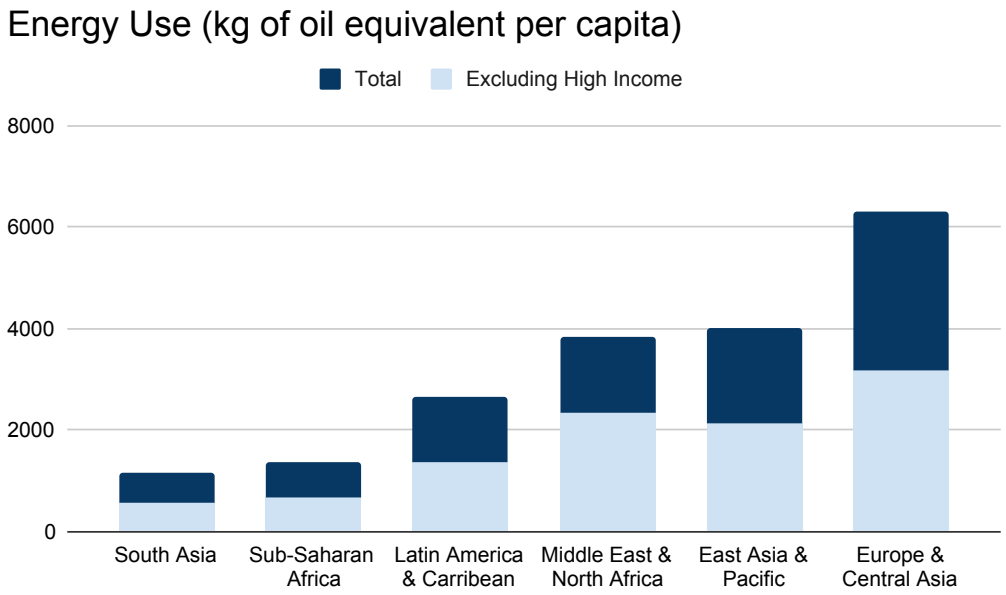

Figure 2.1: Use of energy in 6 different divisions of the world, visualized as kg of oil equivalent per capita with data from IEA's latest data from 2014 [6].

Table 2.2: Countries with their respective income economy classifications and GNI per capita [24].

Country	Income Economy	GNI per capita ($)
Rwanda	Low	0,780
Uganda	Low	0,800
Tanzania	Lower-middle	1,080
Nepal	Lower-middle	1,190
Kenya	Lower-middle	1,760
India	Lower-middle	1,900
Bhutan	Lower-middle	2,860
Sweden	High	53,800

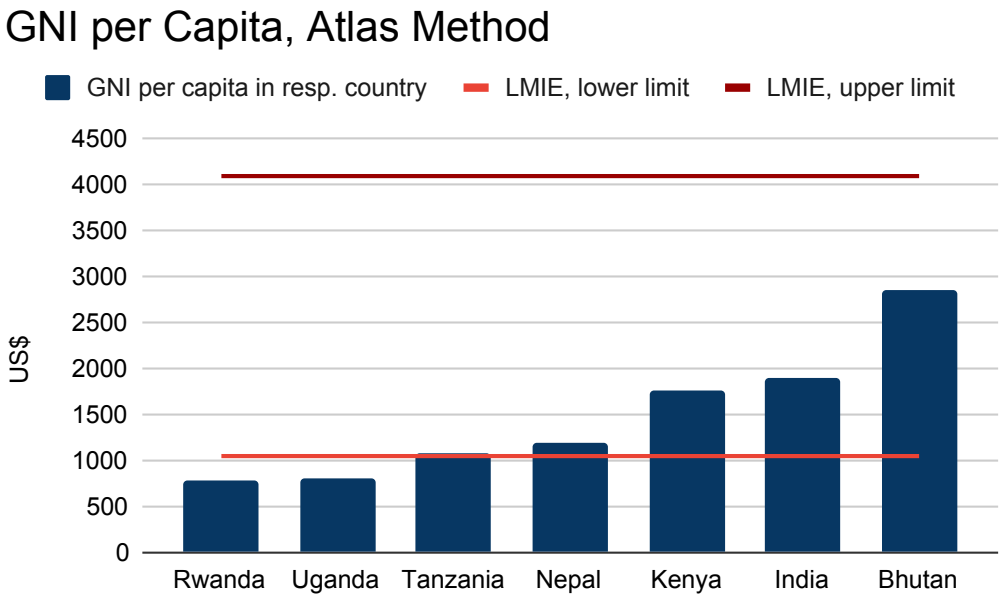

Figure 2.2: GNI per capita, as per the Atlas method, of each chosen country and visualized with two read lines of the lower and upper limit of LMIE. Graphics created with data from World Bank [24].

3

Theoretical Framework

When investigating a topic through a design research study, a theoretical framework is favorable to use in order to facilitate a trustworthy and cohesive starting point, both when exploring and analyzing. One of several is Practice theory, providing a theoretical and conceptual framework when gaining knowledge about a specific topic and with the purpose to help see patterns in practices in different contexts. In this master's thesis, Kuijer's [26] interpretation of what Practice theory is will be used; *"an interpretation [...] relevant to design and sustainable design in particular"*, as in this study. The chosen theoretical framework is practice-oriented due to the practice being *"the main unit of analysis"* explained by Kuijer [26]; which is further explained as *"an inclusion of multiple products and people and a turning away from looking into people's minds, towards a main interest into what people do and the rationales they offer about this"*. More specifically, practice theory has been favorably used in a plurality of different studies when investigating energy usage in everyday life [27, 28, 29, 30, 31], similarly to the topic investigated through this master's thesis. Bartiaux et al. express how *"practice theories help to shift the focus towards more collective approaches and practices, rather than towards individuals"* [28], which is appropriate when creating knowledge about everyday life in general, as in this master's thesis regarding household energy resiliency. Furthermore, Practice theory is a tool in explaining the complexities in everyday life, e.g., argued by the researchers Kuijer and Backer as taking practices as the unit of analysis instead of interactions between product-user help in doing so [32]. Further, the researchers address some benefits of using this theory collected from several different researchers where some precious qualities connecting to this master's thesis is the following; where practice theory aids in: understanding *"the dynamic relation between things and those who use them"* [33], *"help think beyond the individual"* [34] and understanding *"the dynamics within and between households, the practices consumption is implicated in, and shifting expectations of normality"* [35].

In order to describe and understand the practice of interest, three different elements of a practice are defined: materials, competences, and meanings, from Shove and Pantzar [36] which Kuijer [26] was inspired by when elaborating on the topic. A visualization of the practice can be seen in Figure 3.1. The definition of the elements is the following. Materials include *"things, technologies, tangible physical entities and stuff of which objects are made"* as put by Shove et al. [37]. The element competences include *"skill, know-how and technique"* and meanings include *"symbolic meaning, ideas and aspirations"* as explained by Shove et al. [37]. The authors further argue that the practice does not exist until links between the elements ex-

ist. This linkage is an ongoing process where the different elements may continually exist in different practices. Further, there may thus be connections between different practices, where one or more of the three elements may be shared between two or more practices. This is visualized in Figure 3.2 where the element materials is shared between two practices. Kuijer [26] also presents a more detailed visualization of how multiple elements are being shared or share links, visualized in a recreation of Kuijer's model in figure 3.3.

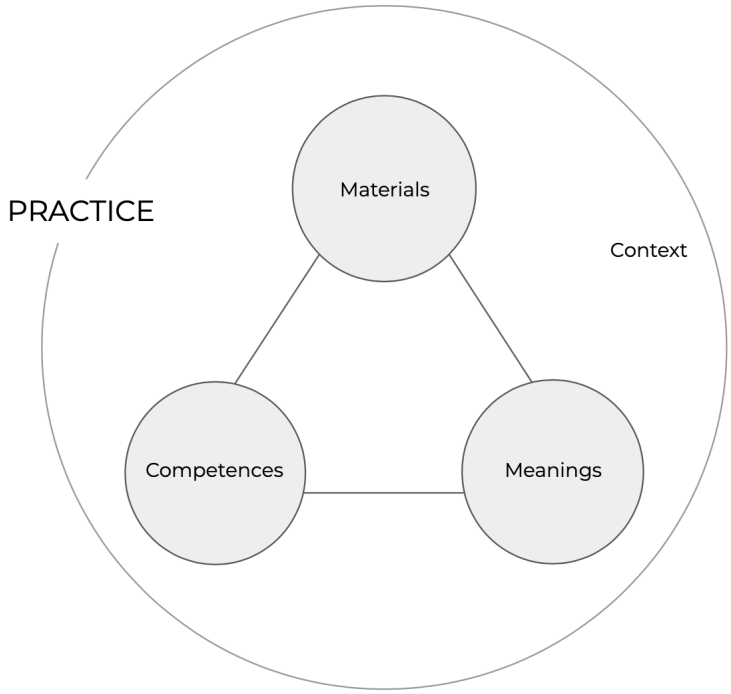

Figure 3.1: A visualization of a practice with the three elements materials, competences and meanings, and the surrounding context. The lines between the elements visualize links between them. A model adapted from Shove et al. [37].

When referring to people in a practice-oriented framework, Kuijer [26] explains how people are viewed as body/minds, carriers, or performers of a practice. Thus, one never refer to people as "having" a practice, this as practices are shared between all as further explained by Kuijer.

Before performing a study, a target practice should be decided; wherein this master's thesis study, an adaptation of Kuijer's [26] recommendations on the selection of a target practice is made. First, the target practice can be broad, and later through a study, this can be narrowed down to either one or more types, parts, or interrelations of a household practice area.

After selecting a target practice, the practice should include the following in its analysis according to Kuijer [26]. First, quantifying resource consumption indicators, where average, varieties, history, and target levels should be analyzed. Thenceforth, it is suggested to trace historic carrier and similar practices; lastly, the target prac-

tice should be mapped before opportunities are defined to make change through a future design. In this master's thesis study, an adaption of Kuijer's suggestions will be made; and historical research will be included in the study as far as information is found, relevant, and time is available. Mapping a practice implicates two paths being done. First is mapping *"an overview of relations between resource consumption and the constitution of the practice"* and secondly, following this overview, is creating *"a list of core characteristics regarding opportunities for change in less resource intensive directions"* [26]. In this master's thesis, the first path is considered the main priority in creating an understanding of the practices in everyday life regarding energy resiliency. From this mapping, Kuijer describes how conclusions of which links are the strongest and between which core elements these exist [26]. Additionally, threats and trends in the resource consumption are to be concluded in the mapping, as well as give indications of where the practice has weak links or problems.

Accordingly, practice theory is chosen due to enabling an understanding of *"social life through the synthesis of societal structures and a person's individual dispositions"* [38]. Practice theory will therefore help this master's thesis give the methods and tools to create this understanding for household practices in everyday life. The theoretical framework will also help see patterns, connections, and interrelations between and within household practices.

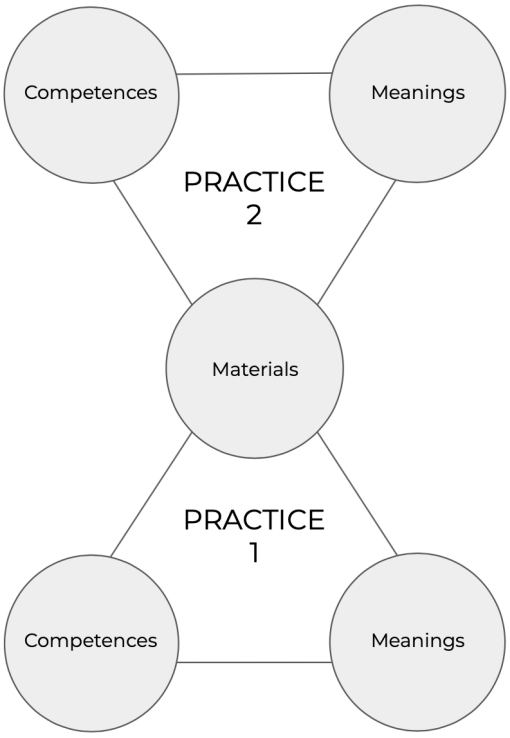

Figure 3.2: A visualization of two practices sharing the element materials.

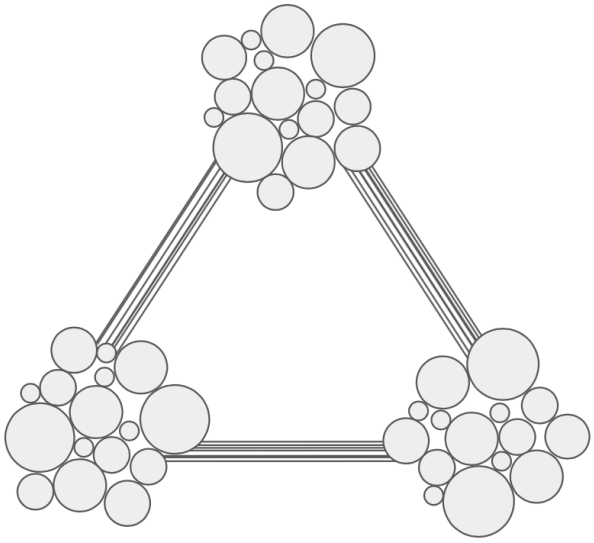

Figure 3.3: A recreation of Kuijer's [26] visualization of how multiple elements are shared or share links.

4
Methodology

In this chapter, the overall workflow of this master's thesis is presented, the research approach being explicated as well as the methodology used is being discussed. Thus, throughout this chapter, an understanding of how and what has been performed in this one year performed, master's thesis study is sought to be given.

4.1 Research approach

This master's thesis has adopted the research approach Research through Design, an approach initially coined by Frayling [39, 40]. The authors Stappers and Giaccardi [41] later partly frame it as *"[...] activities that introduce prototypes into the world, and reflect, measure, discuss, and analyze the effect, sometimes the coming-into-being, of these artifacts"*. Further, Research through Design most often has a research outcome that may be used elsewhere, as concluding general principles are appraised. More specifically, in this master's thesis, a context has been explored, concepts have been developed and later evaluated; *"using the prototype as a 'physical hypothesis' to prove the feasibility of a proposition"* as exemplified by Stappers and Giaccardi [41]. In this master's thesis, the physical prototype is exchanged for conceptual sketches to enable an evaluation together with all income economies.

In Research through Design an artifact, i.e., the conceptual sketches, *"places a central role in the knowledge-generating-process"* where *"it creates the possibility for people and products to engage in interactions that were not possible before, and these can come into existence—indeed, become observable—through the design"* [41]. As in this master's thesis' aim and research questions; to see what can be learned with the help of LIE- and LMIE-created design proposals about designing for all income economies when experiencing power outages. So, to answer the second research question, something had to be created and investigated how it was perceived in a context. In addition, as the artifact is unknown for all and so is the experience of a power outage, especially for HIE, it is much easier to perceive and reflect how it would be experienced if an example is available that may be visualized into one's everyday life.

This approach enables the investigation of the second research question in this master's thesis by creating and evaluating artifacts where knowledge is gained about the effects of these artifacts. Hence, resulting in knowledge about what has been learned when performing this creation and evaluation.

4.1.1 Connecting to practice theory

Practice theory was used in the investigation of the context of LIE and LMIE in regards to energy resilience, where the context was explored, as phase 1, and defined as phase 2, seen in figure 4.1. Here practice theory influenced which questions were asked and set a basis in the analysis of the collected information. Then commenced the main parts of the research approach, the creation, and evaluation of the artifacts, as phase 3 and 4 in figure 4.1, based on what had already been gained about the context. Apart from creating knowledge about the LIE and LMIE context, hence knowing what to design for, the result from the practice theory analysis was also used in shaping the ideas as well as helping in how to eliminate the idea space. More specifically, dimensions created from practice elements were used in the idea generation and elimination process. Additionally, practice theory was further applied in the evaluation when investigating what would be altered in the household practices using the concepts.

4.1.2 Design for LIE, LMIE and for all

Additional approaches had to be utilized throughout the master's thesis and this overall research approach. When not living as for the one designing for, it is hard to know what, if and how something would work. So, when designing for all as intended in this master's thesis, a designer with principal experience of a HIE context, as the author has, additional information, more than usual, about this unfamiliarity is required. When exploring this new context, practice theory has been used, as previously described. As for designing for LIE and LMIE, a completely new context differs in many ways from a HIE perspective. Therefore, it is of high importance that this context is thoroughly explored in order to create an understanding for this unfamiliarity [42, 43, 44]. Additionally, it also stands as a recommendation to use co-creation as a tool [42, 44, 45, 46]. Thus, co-creation has been included in the study, specifically in the idea generation of solutions.

While some of the researchers [43, 44, 46] within the same area of designing for LIE address approaches, e.g., as co-creation and user-centered, instead of guidelines or methods which also are needed. So, when designing for all or LIE, there are also more specific recommendations and tools to use in the development process. A researcher, Whitehead et al., recommends [42] a design tool in the development process of designs, especially for LIE. The tool includes eight different so-called assessment indicators: affinity, desirability, reparability, durability, functionality, affordability, usability, and sustainability, by which a design should be designed and evaluated. However, as the design proposals in this master's thesis are only to be developed on a conceptual level, this is not considered relevant in a first evaluation/development stage and will thus not be utilized but instead recommended as a next step. The same goes for the use of *The 7 Principles of Universal Design*, which was originally developed by a multidisciplinary team in 1997 [47]. These seven principles were developed to enable guiding for *"design of environments, products and communications"* in order for the designs to function universally and complement the design tools described above. Similarly, while a bit more specific, the principles are

the following: equitable use; flexibility in use; simple and intuitive use; perceptible information; tolerance for error; low physical effort; size and space for approach and use [47]. Additionally, there is also a foundation, Design for All, which is also presenting criteria and strategies in order for *"[...] anyone, including future generations, regardless of age, gender, capacities or cultural background [...]"* to *"[...] participate in social, economic, cultural and leisure activities with equal* opportunities" [48]. These criteria are similar to the earlier presented but with different wording and complementing, where the design should be: respectful, safe, healthy, functional, comprehensive, sustainable, affordable, appealing. All three sources of recommendations: tools, principles, and criteria are therefore recommended to go through to enable and ensure the design is indeed being designed for LIE, LMIE, and *for all*.

4.2 Overall workflow

An overview of the master's thesis workflow is presented in figure 4.1, consisting of four phases: Explore, Define, Create and Evaluate, each having several sub-phases. Two gates in the Define-phase are marked with a thicker line; it is possible to move on to the next intended sub-phase when reached. Thus, iterations were being performed throughout the project, both planned and unplanned when needed. This is visualized with arrows back and forth between the phases. Unlike the others, one arrow between phase Create and Explore is dashed, meaning there was no planned iteration; instead, this was done when needed.

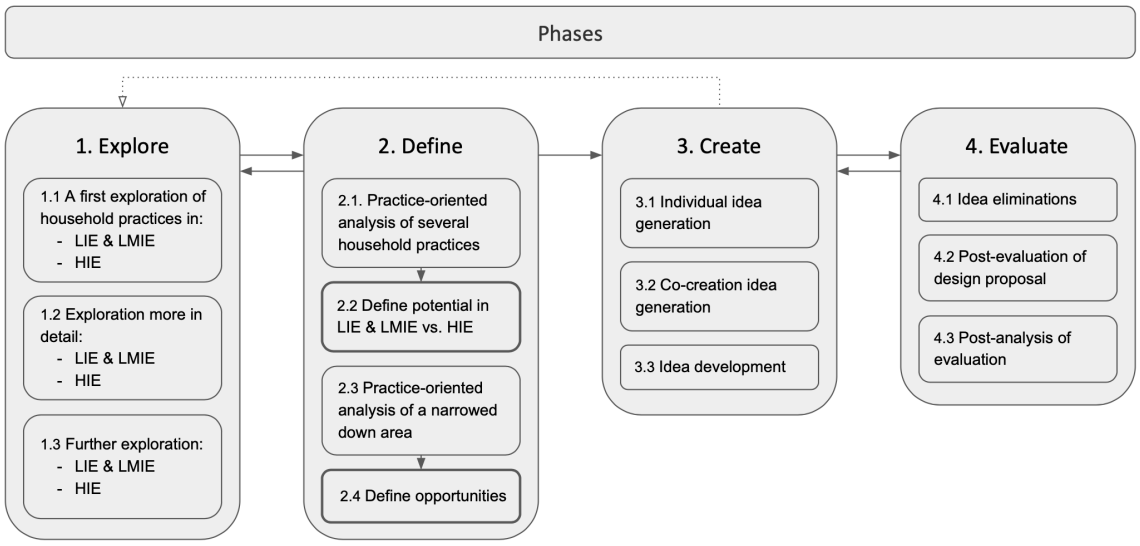

Figure 4.1: The overall workflow of the master's thesis, visualizing the project's phases and respective sub-phases.

4.3 The process in chronological order

In this section, what has been performed is presented in chronological order. The master's thesis was executed in one year, divided into two halves where a half-time report was performed. In the first half, iterations between the explore-phase and define-phases were made. In the second half, first, an iteration between create-phase and define-phase was made and then commenced the main parts of the second half, iterations between create-phase and evaluate-phase. A figure, see 4.2, of the master's thesis' performed timeline is visualized in chronological order to easier follow along when reading the descriptions of the process, where thus an overview of when each sub-phase was performed can be seen.

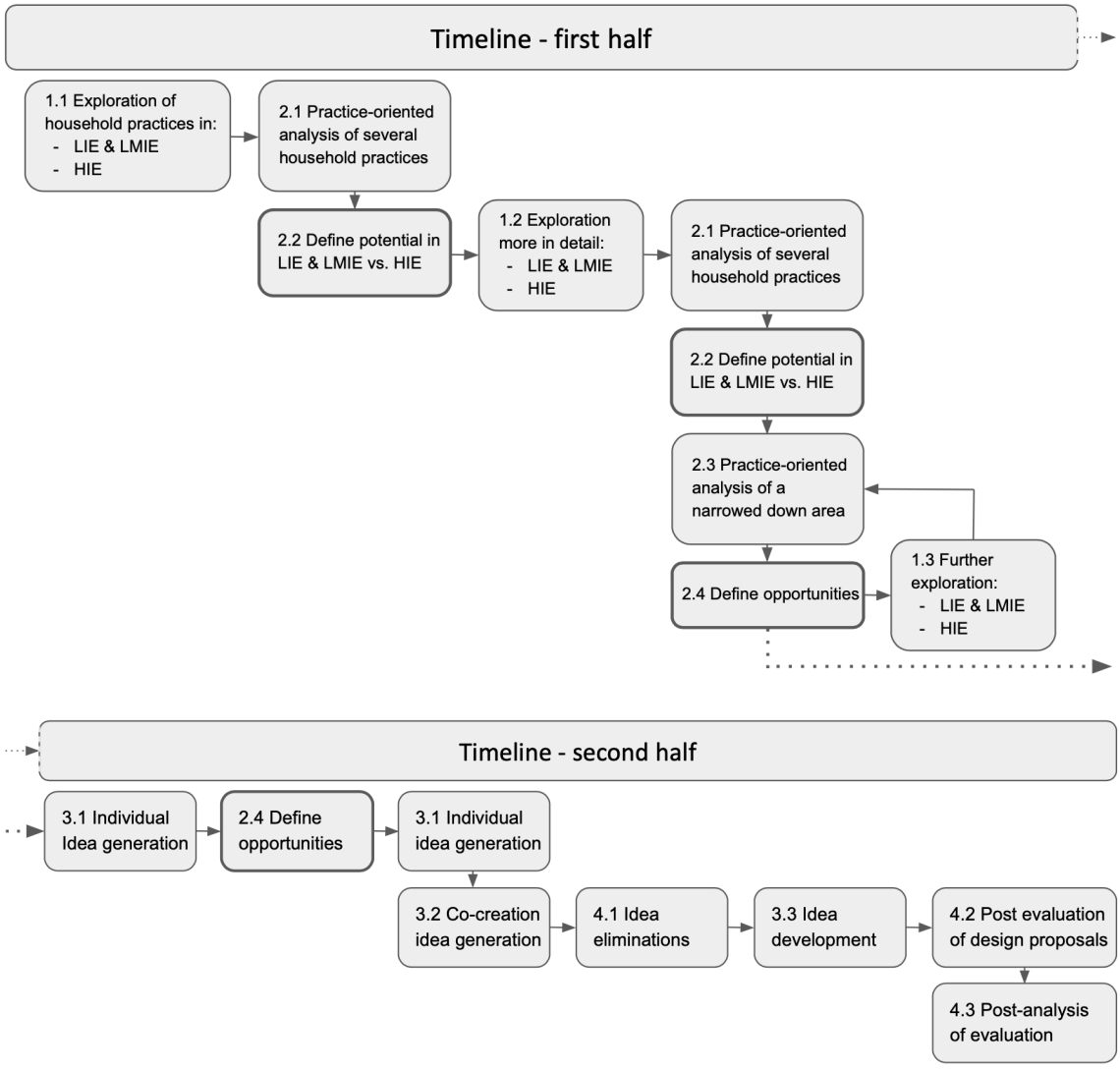

Figure 4.2: A visualization of the timeline of this master's thesis, including all sub-phases in the performed order.

All methods performed are visualized in figure 4.3, which serves as an overview of the methods performed in this master's thesis. These are also presented in chronological order and where the same sub-phase numbering, as in figure 4.2 of timeline, can be found in each square.

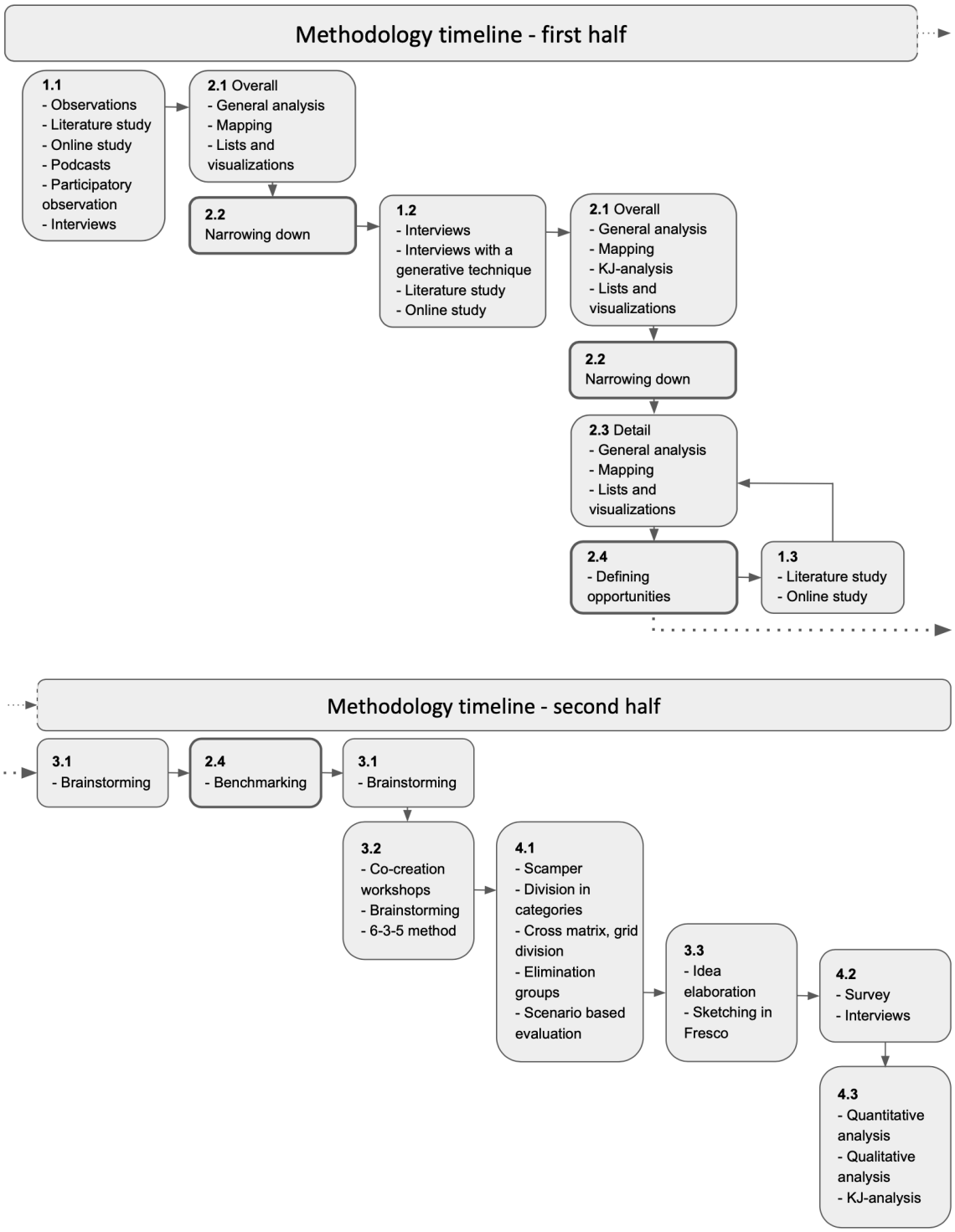

Figure 4.3: Workflow of the master's thesis, with all methods visualized in order of when performed.

4.3.1 Sub-phase 1.1 - First exploration

In this section the first performed sub-phase in the exploration phase is presented, sub-phase 1.1, visualized first in order in figure 4.1 and 4.2. In order to cover all types of knowledge: explicit, observable, tacit, and latent, when in the exploration sub-phases, complementary methods are suggested as by the authors' Sanders and Stappers [49]. Sanders and Stappers [49] divide different methods into three different categories in order to reach all levels of knowledge: Say, Do and Make tools that complement each other. Thus, a plurality of methods have been performed in the investigating throughout the explore-phases, explained later according to when they have been performed.

In this first exploration, the method utilized was mainly observations, a so-called Do-method according to Stappers and Sanders [49], videlicet watching relevant documentaries and movies on the topic in order to reach an overview of the household practices. The movies and documentaries were searched for on Google, Svt-Play, and Netflix, where they were chosen regarding being close to the topic of this study, decided by reading a resume or watching the trailer. Here, the seven specified countries of interest, as well as general information about other LIE and LMIE, were of interest. An overview of what movies and documentaries watched can be seen in table 4.1. The table includes when they have been watched and if a specific country was specially brought up in each movie/documentary, as well as the year of release. While watching the movies and documentaries, notes were made according to different household practices and the different elements: materials, competences, and meanings, as well as other interesting observations noted about the overall context. Questions in mind when watching the movies and documentaries were thus: What type of materials do the households own and use; what type of competences do they hold; what meanings do the people in LIE and LMIE have; as well as how does the context of LIE and LMIE look like, what is explicitly brought up as examples?

Commonly in design research, contextual research is favorable if performed in situ. However, in this study, this has not been possible due to Covid-19 outbreaks, first on the ground of being impossible due to Covid-19 restrictions in the early stages of the study and later due to recommendations from the Swedish authority Folkhälsomyndigheten [50] and own stances about health and ethics. More discussion on this can be found later in the thesis in section 6.3.1.

In addition to observations, a literature study, as well as an online study, was done, functioning as gathering different types of knowledge through say- and do-methods as explained by Sanders and Stappers [49]. In the literature study, research articles were explored from the database Google Scholar by searching keywords such as "everyday life in low income economies" and "low income economy households". However, this literature study felt a bit early on as not much knowledge had been achieved about the contexts. Therefore, most of the literature study was postponed until later explore sub-phases. On the other hand, through the so-called online study existing information online was searched through sites such as Gapminder [51], The World Bank [52], Sustainable Energy for All [53], et cetera. Much knowledge about

Table 4.1: An overview of the movies and documentaries watched throughout this master's thesis study.

No.	Title	Released	Country
1	Waterschool	2018	India, Uganda
2	Tänk om - avsnitt 5. Tänk om alla världens rikedommar delades lika	2020	General
3	Does being born poor mean you will stay poor?	2012	General
4	Why Poverty? Welcome to the World	2012	General
4	Why Poverty? Land rush	2012	Mali
5	The boy who harnessed the wind	2019	Malawi
6	Why Poverty? Solar mamas	2012	Jordan, India

the context and the household practices was gained through this. Especially Gapminder and The World Bank gave much input to this master's thesis. Gapminder visualizes both through pictures and in texts about households in the contexts of interest. Filters could be selected, first of all, according to a selection of countries where the seven countries of interest were chosen, and then different income levels within the countries as well as according to different household practices or specific types of the element material. All these filters were applied when performing the online study through Gapminder. On the other hand, the world bank is an organization and a website containing open data and statistics about the world in many different fields and areas. While searching on The world Bank, selections were also made according to different income economies and a search of interest. For example, poverty, access to electricity, and power outages were found through this site.

Hence, in this sub-phase, data gathering regarding several household practices was performed, i.e., insights into how LIE and LMIE already tackle energy resilience was achieved and general information about the context being explored. Several household practices, such as bathing, cooking, cleaning and entertaining, et cetera, in LIE and LMIE in an energy resilient way, were investigated. As adapted from Kuijer [26] a Practice-oriented exploration was performed, where: resource consumption indicators; Shove and Pantzars' [36] three elements: materials, competences, and meanings, for the several household practices, were explored. Resource consumption indicators in this study were, for example, how often a practice is performed or the number of power outages that are experienced by a household and in the contexts in general, et cetera. However, historical careers or similar practices as recommended by Kuijer [26] was not yet explored as the scope was extensive and heavy as well as time was limited.

Furthermore, also some podcasts were listened to as a complementary say-method step, where the contexts of interest were explained. These worked more as a compliment in gathering a more general understanding of the context, and thus no data gathering, summarizing, or analyzing were made other than performed indirectly by listening.

Additionally, a participatory observation was executed in the south of Sweden together with 12 other people, living two days on an uninhabited island and without access to water and electricity. Through this, it was investigated how to cope without accessing these essential and habitual needs. Also, five short interviews were followed to gain the other participant's thoughts and feelings around the topic.

4.3.2 Sub-phase 2.1 - First overall defining

As previously explained about the explore-phase, the structure and analysis in the Define-phase also adapt practice theory and the practice-oriented approach explained by Kuijer [26]. More specifically, in sub-phase 2.1, several household practices in LIE and LMIE were analyzed. The household practices were defined and analyzed regarding the resource consumption indicators and mapping of the target practices with the elements, materials, competences, and meanings within. Meaning the analysis consisted of interpretations of the different resource consumption indicators overall. Further, in each household practice, division in the elements materials, competences, meanings, and practices were seen concerning each other where connections between elements or practices were investigated. Also, analysis of the exploration of an overview of similar practices in HIE was made based on personal experiences, where a comparison of HIE versus LIE and LMIE was made.

4.3.3 Sub-phase 2.2 - First narrowing down

The next sub-phase, 2.2 in the Define-phase, consists of identifying and defining the potential to narrow down from several to either one or more types, parts, or interrelations of a household practice, as earlier mentioned. As also earlier mentioned, this sub-phase 2.2 was performed two times. The first time performing this narrowing down, a minor narrowing was made, where the households regarded as most poor and richest were considered not of further interest. This as the needs of those living in the most poverty differ considerably, do not use any electricity at all, and are mainly struggling with having enough food to survive. Nor were the wealthiest households in LIE and LMIE considered further as these too differ a lot from the average. Additionally, they differ considerably less from the average in a HIE household, and all could not possibly be covered through this master's thesis study. Hence, the focus onward was on collecting information mainly about the average LIE and LMIE households and those around, with the average based on each country's GNI per capita.

4.3.4 Sub-phase 1.2 - Second exploration

In sub-phase 1.2, as seen in 4.2, a somewhat smaller area was explored, now focusing on the average LIE and LMIE households. Practices had now been defined, and an overview of the LIE and LMIE household had started to form. However, the narrow-down was not as narrow as initially planned. Instead, a continuation in width of the explored area was considered beneficial to understand the contexts and the performed household practices.

Similarly, as in the prior sub-phase 1.1, Kuijer's [26] practice-oriented approach was adapted when exploring in sub-phase 1.2. Overall this exploration was performed more in detail, unlike the prior phase; still, historical careers were not explored due to not being a prioritization when still having a broad scope and due to limitations in time. Resource consumption indicators and the three practice elements explained by Shove and Pantzar [36]: materials, competences, and meanings were explored. Lastly, also similar practices, as recommended by Kuijer [26], was explored: the HIE context Sweden was investigated in order for getting a comparative overview of the household practices in a context with other conditions and opportunities. The HIE exploration consisted of searching for information as an online study on Gapminder [54] as well as summarizing of own experiences as living in the HIE, Sweden, all life.

In order to gather explicit knowledge, the Say-method, online interviews were used, as suggested by Sanders and Stappers [49]. Nine interviews were performed and were semi-structured to allow for adjacent discussions that may be of interest. After the interviewees were introduced to the master thesis topic, they were asked to briefly talk about themselves and their experiences of LIE and LMIE contexts. Then questions regarding more specific experiences: power outages, electricity habits and prerequisites, and household practices. If further interest in specific questions, the interview script is found attached as appendix A. The interviewees were people both born and living in LIE and LMIE and other individuals and individuals working in organizations with knowledge about the investigated contexts. The interviewees were found both reaching out to organizations connected to LIE and LMIE contexts and through friends and relatives. In table 4.2 an overview of the interviewees in this study can be seen, where later in the study, interviewees will be referred to through each interviewees number from this table.

Table 4.2: An overview of the interviewees in sub-phase 1.2.

No.	Age	Sex (M/F)	Country of origin	Country of Experience	Country currently living in (since # years)	Living in urban/rural	Experience of rural vs urban	Generative session
1	60 - 79	M	Bhutan	Bhutan, Nepal, India, Malaysia, and more	Nepal (5)	Urban	A lot of both	-
2	40 - 59	F	Sweden	Tanzania, Kenya, Uganda, Rwanda	Sweden (birth)	-	A lot of both	-
3	40 - 59	F	Sweden	Nepal, India, Malaysia	Nepal (10)	Urban	A lot of both	-
4	40 - 59	F	Tanzania	Tanzania, Kenya, Burundi, Rwanda	Sweden (27)	-	A lot of both	-
5	20 - 39	F	Kenya	Kenya	Kenya (birth)	Rural	A lot of both	x
6	20 - 39	F	Kenya	Kenya	Sweden (9)	-	Both, mostly rural	-
7	20 - 39	M	India	India	Sweden (1)	-	Both, mostly urban	x
8	20 - 39	F	Uganda	Uganda	Sweden (3)	-	A lot of both	-
9	40 - 59	M	Nepal	Nepal, India	Nepal (birth)	Urban	A lot of both	x

Also, an interpretation of one of Sanders and Stappers [49] Make-methods, a generative session was also performed in order to gather possible tacit and latent knowledge. Sanders and Stappers [49] bring up several generative techniques, wherein this study photos collected by the interviewees was used during three of the performed interviews. Which of the interviewees may be seen to the right in table 4.2, where three interviewees are marked with an "x". The interviewees were asked to either take new photos or show existing in the online interview depicting the inside of the household the interviewee had an experience of living in. No limits were set for the interviewee not to feel pressure to show their whole home. The pictures were then incorporated to be shown and talked about when asked the same questions as the interviewees, not in the generative sessions. The interviewees for the generative sessions were thus somewhat the same people as explained earlier; people with experience of *living in* LIE and LMIE, instead of only people with knowledge about the investigated contexts.

In sub-phase 1.2, a literature study was also used for overall data gathering, collecting different types of knowledge levels, namely explicit, observable, tacit, and latent knowledge through existing studies. Here, research articles about the everyday life of people living in LIE and LMIE were investigated more in detail, about the LIE and LMIE contexts regarding the household practices and the specific elements, and general information about the contexts of interest. Keywords such as "everyday life in low-income economies", "energy poverty households", "power outage low income", and "backup equipment households low income" were used to search for research articles on Google Scholar and through Chalmers library's database. Mainly the seven chosen countries were of interest when choosing articles, but also other articles about LIE and LMIE countries were read and collected information from when these were considered particularly interesting. The number of citations of each article found was also noted and the year of publication; where the latter was considered more important as new information as possible is considered most relevant. The basis and the size of the study were also observed in order to be able to make decisions about relevance.

In addition, a further continuation of the online study, described in 4.3.1 about the first exploration, was performed, where already existing information online on mainly the websites of Gapminder [51] and The World Bank [52] was used. Here complimenting information to what had been found to the household practices and LIE and LMIE contexts were gathered.

4.3.5 Sub-phase 2.1 - Second overall defining

Once more, practice theory was adopted in the analysis, and Kuijer's [26] practice-oriented approach was adapted. The second time around performing this sub-phase, the performed interviews were all transcribed. Thenceforth, the gathered data was analyzed through the thematic analysis method KJ-analysis [55], finding relevant citations from the interviewees and areas of what to narrow down to, and also through organized lists and visualizations according to the different practices. Again, all

household practices in LIE and LMIE were further analyzed. The household practices were further defined and analyzed regarding resource consumption indicators and mapping the practices with the different elements. Again, the analysis consisted of: interpretations of the different resource consumption indicators overall and in each household practice; division in the elements materials, competences, meanings; and practices were seen in relation to each other where connections between elements or practices were investigated.

4.3.6 Sub-phase 2.2 - Second narrowing down

The second time around performing sub-phase 2.2, the narrowing down was made and chosen in regard to being one of the most necessary areas to continue with, according to the study. This, as here was where the LIE and LMIE had an electricity dependency, the opposite to most household practices where they were completely independent of electricity. Additionally, the narrowed down area being truly important in meeting necessary needs for someone experiencing power outages and disruptions. Additionally, the narrowed down area was seen both as a problem for LIE, LMIE, and in a HIE future.

4.3.7 Sub-phase 2.3 - Detailed defining

Sub-phase 2.3 includes practice-oriented analysis about the narrowed down area, with similarities to sub-phase 2.1 but more in detail and with additional analysis points. First, resource consumption indicators were quantified and followed up from the second performed analysis in sub-phase 2.1. Also, mapping the target practice regarding the three elements was done, where materials, competences, and meanings were analyzed and defined regarding the chosen practices, this time more in detail and along the narrowed down area. Lastly, the similar explored practice in the HIE context Sweden was also analyzed, where a comparison of HIE versus LIE and LMIE was made in the narrowed down area.

4.3.8 Sub-phase 2.4 - Define opportunities

Lastly, in the Define-phase, sub-phase 2.4 was performed, where opportunities were identified and defined. However, this sub-phase needs to be re-done as before performing this sub-phase, more exploring in sub-phase 1.3 is required, and the next big phase, Create, needs to be initiated.

4.3.9 Sub-phase 1.3 - Continuation of exploration

As sub-phase 1.3, exploring according to what was necessary to complement with was done. A continuation of the literature study and overall gathering of facts was executed when more information was found needed.

4.3.10 Sub-phase 2.4 - Define opportunities

As a further step in defining the opportunities, these were explicated through summarizing what was to be designed further, why, and to what purpose, functioning as a short design brief to the following master's thesis half.

4.3.11 Halftime report

A halftime report was written between the two halves where all investigation and generated knowledge from the first two phases was compiled and explicated.

4.3.12 Sub-phase 3.1 - Individual idea generation

In this sub-phase, 3.1, the method brainstorming was performed individually with the purpose and tool in commencing the idea generation and see what types of ideas were possible within the narrowed down area.

4.3.13 Sub-phase 2.4 - Define opportunities

As sub-phase 2.4, definition of the opportunities, a market analysis in terms of benchmarking was performed to see what types of existing solutions within the narrowed down area are possible. Through this, the idea area was somewhat more specified as to what is already available at the market, but this does not entail the ideas being similar.

As the last step in defining the opportunities, so-called dimensions were chosen and formed from meanings and competences found in the earlier sub-phase, 2.3 Detailed defining, seen in section 4.3.7, through the Practice-oriented analysis of the narrowed down area.

4.3.14 Sub-phase 3.1 - Individual idea generation

A second time around performing this sub-phase individual idea generation was performed, also functioning as a pilot test before the next sub-phase, where the method brainstorming with the chosen dimensions was performed.

4.3.15 Sub-phase 3.2 - Co-creation idea generation

In this sub-phase, 3.2, two online co-creation workshops were performed, one with HIE-experienced and one with LMIE-experienced participants. The purpose of the workshops was to create as many ideas within the area as possible according to the design brief resulting from the master's thesis first half. Additionally, the purpose of performing co-creation sessions with people with HIE- and LMIE-experience separately was to enable idea generation with people with experience from each context the designing is intended for.

In the first workshop, three HIE designers and the author of this master's thesis, all four with experience living in HIE and designing for HIE, participated. The second workshop consisted of three persons with experience of LMIE contexts, where the author of this master's thesis functioned as a facilitator. In table 4.3, all participants can be viewed with information about gender, experience, and from which country the participants origins and mostly has experience. In the second LIE/LMIE workshop, four participants were first intended to take part, while unfortunately one could not participate and is therefore omitted from the table referred to above.

The online workshops were performed through a Zoom meeting and using the virtual whiteboard tool Miro to visualize information, facilitate idea generation, and share ideas. The Miro board which the workshop began with can be seen in figure 4.4, where prepared information material to read and boxes to write and sketch in during the workshop can be seen.

Table 4.3: Table visualising the participants for both workshops performed.

Workshop	Gender	Experience	Country
1	Female	HIE, Designer, Researcher	Sweden
	Female	HIE, soon finished Designer student	Sweden
	Female	HIE, soon finished Designer student	Sweden
	Female	HIE, soon finished Designer student	Sweden
2	Male	LIE/LMIE, engineering student	India
	Male	LIE/LMIE, engineering student	India
	Male	LIE/LMIE, engineering student	Pakistan

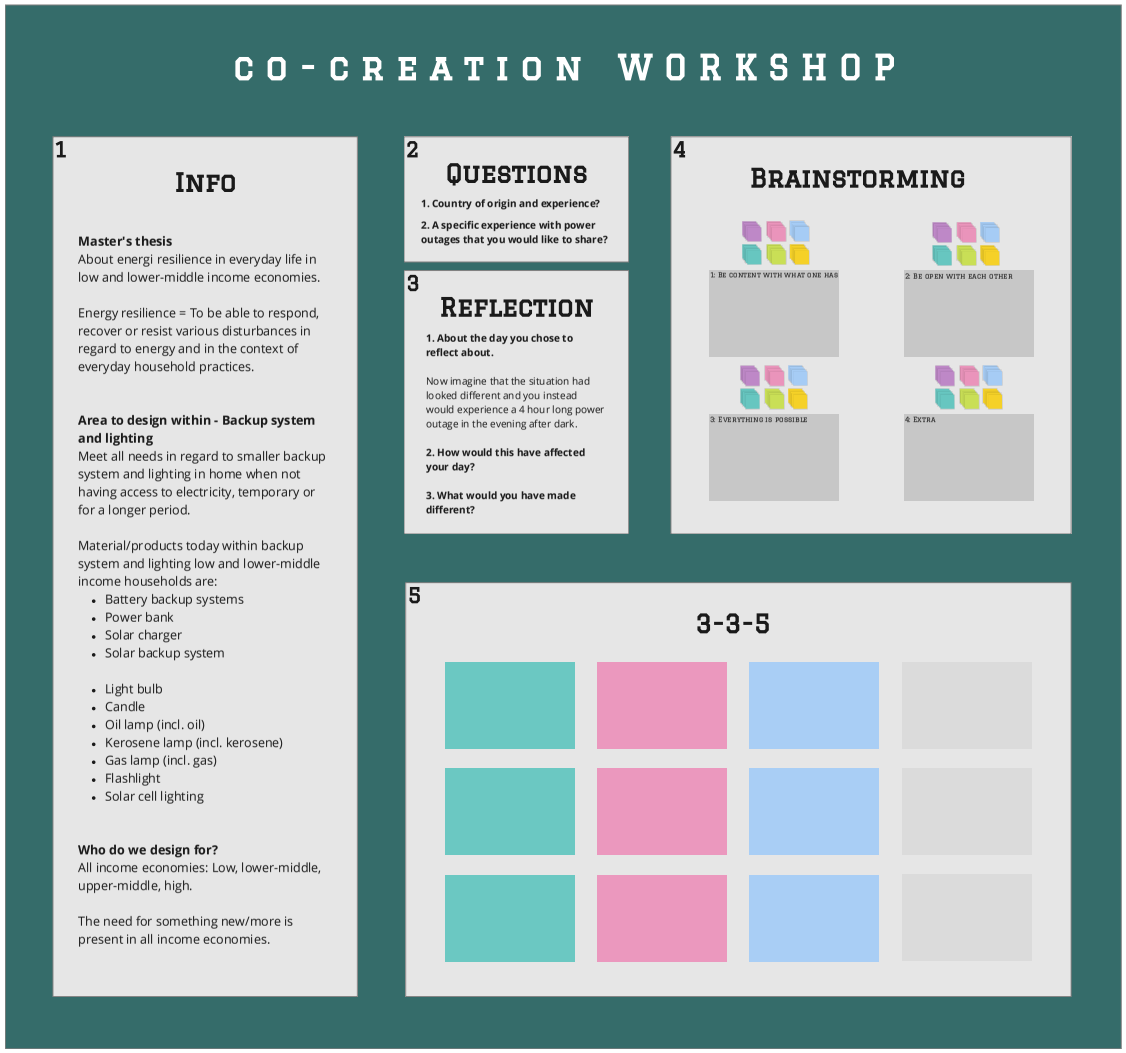

Figure 4.4: An overview of the workspace board in Miro which the workshops began with.

Before both workshops, a preparatory PDF, which can be viewed in appendix B, was sent out one week in advance, giving and preparing the participants with practical information together with a Zoom invitation to the workshop. Also, general information about the master's thesis and the area to design for was included in the PDF. Lastly, in the preparatory PDF, the participants also received a request for a preparatory task in the form of a reflection question. This, to put the participants in the proper mental preparation, especially for the participants with HIE background who did not have the same experience of power outages as those with LMIE background. The reflective question asked the participants to choose an evening to reflect on. Then this day was altered by them imagining that the situation had looked different and that they instead would experience a 4-hour long power outage in the evening after dark. After that, they were asked to think about and write down how this would have affected their day and what they would have made different and bring this with them to the workshop. Lastly, in the PDF sent out to the LIE/LMIE's workshop participants, preparatory information about the methods to perform during the workshops could be found. Due to these participants did not have the same experience with either a co-creation workshop or the idea generation methods.

The workshops were initiated with five minutes of information given about the workshops' agenda and a recap about the general info about the master's thesis as well as the area to design within and who were the target group intended to design for during the workshop. Then followed ten minutes of questions and reflections. In the LIE/LMIE workshop, each participant told the group about where they were from and was asked to share a general or a memorable experience with power outages. Afterward, each person's answers to the reflective question were presented by each participant and discussed by the group.

Then commenced the actual idea generation methods. First, the method Brainstorming was performed, and later a version of the 6-3-5 method, both inspired by the explanations of these made by Wikberg-Nilsson et al. [56]. Three brainstorming rounds were executed, each performed from one analogy as defined in the earlier sub-phase 2.4 Define opportunities in section 4.3.13, with room for one more extra round if a need of this would have existed. In each round, 5 out of 15 minutes were spared to individual brainstorming. So, in silence, each person could google, sketch, think and write down on notes. When five minutes had passed, all ideas were shared and written on post-it-notes on the Miro-board, and the rest of the time of this round, the group continued with brainstorming together. The ideas generated through the brainstorming sessions could either solve whole or a part of the narrowed down area. This method resulted in many ideas, partial solutions and more conceptual in both a part of the narrowed down area and complete.

Before the next idea generation method, a pause of 10 minutes allowed the participants to clear their minds and relax before continuing with the next. The second idea generation method during the workshops was, as earlier declared, a version of the 6-3-5 method. Normally, six persons will ideate three concepts each in five

minutes; then, in a second round of five minutes, one continues on another participant's concepts and do so until all participants have gone through all ideas. In the figure 4.4 the method is instead called 3-3-5, as three instead of six persons were participating in the LIE/LMIE workshop. While it will still be referred to as the original name 6-3-5 method.

In total, 30 minutes were given to this method to be performed. During five minutes of silence, as the last number in the methods name, each participant wrote, sketched, copied in pictures on three different ideas, as the middle number, on each assigned colored boxes, as seen in 4.4. When five minutes had passed, all participants would switch color, one notch to the right, and continue to further develop on these already initiated ideas by someone else. All continued to switch colors until all had performed 5 minutes on each of the colored boxes. The rules of this method were, as suggested by the authors Wikberg-Nilsson et al. [56]: do not criticize, neither yourself nor the ideas of others; aim for crazy and wild ideas; combine and improve ideas, further develop; aim for quantity over quality. This method resulted in three times the number of participants as the number of generated concepts, 12 in the HIE workshop and 9 in the LIE/LMIE workshop.

4.3.16 Sub-phase 4.1 - Idea eliminations

Before initiating the evaluative phase and the idea elimination process, after finalizing both the individual brainstorming and the two workshops, all ideas were compiled in a new Miro board document. 144 ideas were generated through two rounds of individual idea generation and the two performed workshops. During this step, the questions from Scamper, explained by Wikberg-Nilsson et al. [56], were utilized in order to support the development of the ideas further; hence a modified way of using the original method Scamper was done. This step commenced the elimination process as when ideas were compiled, many ideas were also eliminated. In total, the elimination process was performed in four steps, visualized in figure 4.5 as the number of ideas in each step. The idea space started at 144 ideas and concluded in 8 remaining ideas.

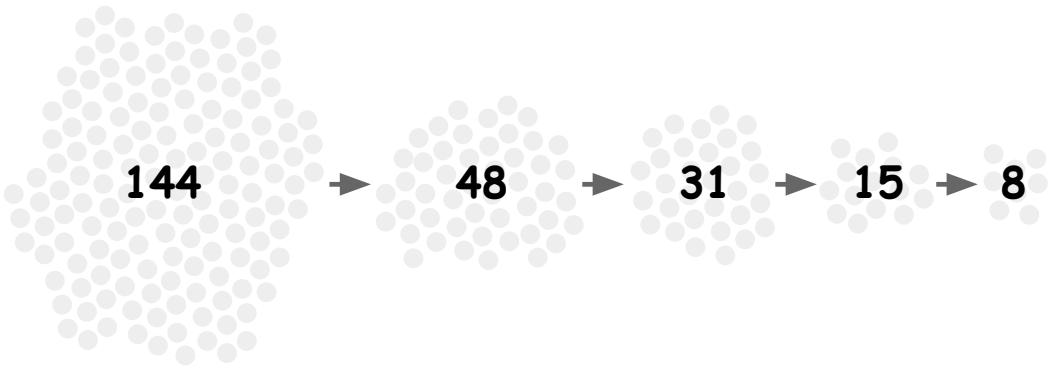

Figure 4.5: Visualization of the elimination process. Its stages, the arrows, and the amount of ideas left before and after each stage.

In this first compilation and elimination step, all ideas were divided into three categories: one with complete ideas/concepts, another with partial solutions or ideas that may be applicable to other solutions, and a third where ideas were discarded. Ideas were eliminated based on being completely disconnected from the chosen narrowed down area, for example, ideas regarding heating in the house or too large solutions that would meet a greater need. Ideas that were limited to specific countries and the conditions that exist only in some contexts were also removed. E.g., ideas connected to the use of financial grants from the state or one's employer. Finally, also duplicates of ideas were removed. This resulted in, in total, 48 remaining ideas, where still some ideas were more similar to each other than others.

In the second step of the idea elimination, the decision was made to place the ideas in a grid to see the spread of ideas according to two criteria. Namely, the dimensions, from defining the opportunities in 4.3.13 and utilized in the idea generation process, which originates from the practice-oriented analysis and the meanings and competences found connecting to the narrowed area. The cross matrix can be seen in figure 4.6. This cross-division and matrix were done in order to comprehend an overview of how different the ideas were. Through this division, 31 ideas were included as these are sought further. The other 17 ideas consisting of the non-complete concepts and partial solutions will be read through later when the final narrowed-down ideas will be elaborated.

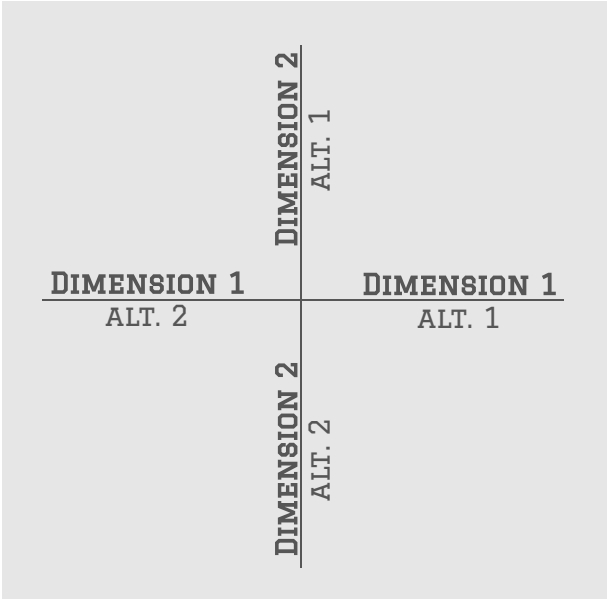

Figure 4.6: The cross matrix where the grid division of ideas was made according to the dimensions.

After the grid division was made, the ideas were written in idea elimination groups. As the next step in this idea elimination, the ideas were eliminated based on being too similar and each idea's feasibility, resulting in 15 remaining ideas. After that commenced the fourth and last idea elimination process. This functioned as an additional way to get as wide a distribution of the remaining ideas as possible; thus,

the ideas were marked according to four categories of solutions; electrical backup solutions, lighting solutions, complete solutions (both electrical backup and lighting), and lastly non-physical solutions. Ideas were eliminated again based on feasibility and similarities, innovativeness, and interest in the ideas were also taken into account to narrow the idea space further. Some ideas were merged, including parts from some eliminated ideas in some remaining ideas. This last stage of elimination resulted in eight remaining ideas to be further elaborated and developed before initiating the next phase in this master's thesis, the evaluation phase. Hence, iterating back to phase 3 Create and, more specifically, sub-phase 3.3 Idea development.

Additionally, and as a part of the idea elimination, the ideas were throughout the above-described elimination process last two stages, investigated based on different scenarios, i.e., the different income economies. As inspired by Wikberg-Nilsson et al. [56] explanation of Scenario-Based Evaluation, the different ideas were regarded from four different scenario points of view: from the perspective of a household in an urban apartment in a HIE; from the perspective of a HIE household living in a more rural setting in a house, third was from the perspective of a LIE urban apartment; and lastly with the perspective of a rural LIE household living in a house.

4.3.17 Sub-phase 3.3 - Idea development

After sub-phase 4.1 followed sub-phase 3.3, where elaboration of the eight remaining concepts in text first was performed. The ideas were generally formulated from what had already been generated about the ideas through the idea generation process. Thenceforth, all ideas were elaborated and further developed through explicating the ideas more in detail along with sketching all eight concepts in Adobes sketch program Fresco, used on a tablet. This resulting in both verbal and visual explanations of the concepts for in the next evaluative sub-phase.

4.3.18 Sub-phase 4.2 - Post evaluation of design proposals

In order to evaluate the concepts thoroughly, both a survey and interviews were made to exhaust the future users on information and perceptions about the concepts. The survey with the intention to collect many answers from different income economies, while how exhaustive answers one may obtain from a survey was unclear in advance. The interviews with the purpose of gathering more in-depth thoughts either confirming or contradicting the result from the survey and thus also serving as a complement to the survey's result if additional questions arose.

Survey
The survey was created containing big but simple questions, with questions inspired by the Kano model, as explained by Wikberg-Nilsson et al. [56]. This in order to cover the purpose of what was intended through evaluations about the concepts. That is: how well suited the design proposal fits in the different contexts; how the design proposal, intended for all income economies, is received and perceived by the future users; and thus also is a design proposal for all income economies possible within this area?.

First, questions about the respondent were asked, then some questions about their experience with power outages, followed by the central part of the survey: the concept evaluation with the same seven questions asked about each concept. Two of the following questions were with a scale and the remaining with text responses. Questions regarding: their first impressions with the concept; if the concept was perceived as simplifying an everyday with power outages; if they would use the concept; if the concept would change their everyday life in any way; and if they saw any problem with the concept. Also, if they had any additional comments on the presented concepts were asked. Two versions of the survey were made, one in Swedish and one in English. The questions from the English version of the survey can be seen in appendix C. Before the survey was considered finished, it was tested through three pilot tests. The first entailed a few linguistic changes and the survey being slightly shortened. Afterward, two additional pilot tests through which the survey was considered okay, and the survey was thus considered finished and ready to send out.

In order to get as many answers as possible, the survey was shared in numerous ways, especially the majority of targeted ways to LIE and LMIE. The survey was shared with all in the summarized table 4.4, a combination of private connections, the previous interviewees in the project, organizations, and universities all over the world. In total, this entailed 77 respondents.

Interviews

What was intended to be evaluated through the interviews remains the same as the survey. That is: how well suited the design proposal fits in the different contexts; how the design proposal, intended for all income economies, is received and perceived by the future users; and thus also is a design proposal for all income economies possible within this area?. The interviews also served to gather more in-depth thoughts, either confirming or contradicting the survey result, as well as complementing the survey if additional questions arose.

In total, 12 interviews were conducted. In order to gather participants for the interviews, the last question in the survey was a question about interest in a follow-up interview. More than 12 persons registered interest, and interview participants were thus selected to get as much spread as possible on the participants according to age, gender, and location of accommodation. An overview of the interviewees in the evaluation phase can be seen in table 4.6. Here, information about the interviewees' age span, gender, country of origin, countries of experience, experience of income economies, accommodation type, location of accommodation, experience of rural or urban, and their experience with power outages can be seen.

Table 4.4: Table of how and to whom the survey was shared.

Type	**Description**	**Amount of times shared**
Personal contact	Facebook	Open share + 14 re-shares
Project contacts	Interviewees from project	10
Organisation	Engineering without boarders	4
Personal contact	Experience with LIE and LMIE	6 + # re-shares
Organisation	Chalmers (International collaborations and Reality Studio Course)	2
University	Kathmandu University	2
University	Tribhuvan University	1
University	Indian Institute of Technology Bombay	2
University	Indian Institute of Science Bangalore	2
University	Royal University of Bhutan	1
University	Strathmore University	2
University	University of Dar Es Salaam	1
University	Mbarara University of Science and Technology	1
University	University of Rwanda	1

In order to describe the interviewees' location of accommodation, a table clarifying the definition of each location type was made and can be seen in table 4.5. The location of accommodation is divided into five categories ranging from the biggest to the smallest location type in the following order: big city, city, town, rural village, and rural area. This definition is based on The World Banks' definition in order to measure urbanization around the world, where they define cities, towns, and rural areas [57].

Table 4.5: An overview of the definitions of the locations of accommodations.

Location of Accommodation	**Inhabitants**	**Inhabitants / km^2 [57]**
Big City	>300 000	
City	50 000 - 300 000	>1 500
Town	5 000 - 49 999	>300
Rural Village	500 - 4 999	<300
Rural Area	<500	

Table 4.6: An overview of the interviewees in sub-phase 4.2, Post evaluation of design proposals.

No.	Age	Gender (M/F)	Country of origin	Country of Experience, >1 year	Experience of Income Economy (secondary)	Accom-modation Type	Location of Accom-modation	Experience of Rural/ Urban	Experience with Power Outages (None/Low/ Mean/High)
1	20-29	M	Sweden	Sweden	HIE	Apartment	Big City	Urban	Low
2	20-29	M	India	India, Sweden	LMIE (HIE)	Apartment	Big City	Urban & Rural	High
3	30-49	F	Sweden	Sweden	HIE	House	City	Urban & Rural	Low
4	50-69	F	Sweden	Sweden	HIE	House	Rural Area	Rural	Low
5	20-29	M	India	India	LMIE	Apartment	Big City	Urban	High
6	50-69	F	Sweden	Sweden, India	HIE (LMIE)	House	Big City	Urban	Low
7	50-69	F	Sweden	Sweden	HIE	House	Rural Area	Rural	Low
8	30-49	F	Sweden	Sweden, Senegal	HIE (LMIE)	House	Rural Village	Rural & Urban	Low
9	20-29	M	India	India, Sweden	LMIE (HIE)	House	City	Urban & Rural	High
10	30-49	F	Sweden	Sweden, USA	HIE	Apartment	Town	Urban & Rural	Low
11	20-29	M	South Africa	South Africa, Sweden	UMIE (HIE)	House	Rural Area	Rural & Urban	High
12	50-69	M	Cameroon	Cameroon, Nigeria	LMIE	Apartment	Big City	Urban & Rural	High

Before the interview script was considered finished, the first out of the 12 performed interviews comprised a pilot test where some alterations in formulations were made and afterward considered finished. The interviews were semi-structured; thus, all questions were prepared in advance and decided what order they should be asked. Still, with this type of interview, it is "allowed" to form more questions or discussion along the way depending on how the interviewees' answers. Semi-structured interviews allow for an open dialogue and are not as strict as reminding of an interrogation.

The interviews were initiated with a short welcome and recap about what the master's thesis is about, followed by a question of the respondents' approval of sound recording of the interview. As all interviewees had responded to the survey, no general question was asked about getting to know the respondent, but instead a short opening about where they were from and their experiences with power outages. Then the concepts were shared, and a shorter recap about each of the concepts was explained if desired. Before each interview, the interviewees' responses from the survey were compiled, summarizing the interviewees' impressions and views about each concept. Thus, the first concept evaluation part of the interviews connected back to relevant survey answers. The interviews were as the survey inspired by Kano model [56], but also the same authors take on Scenario-Based Evaluation. Usually, a Scenario-Based Evaluation as described by the authors [56] entail presenting different scenarios where the target group evolve/change over time; instead, in these interviews, scenarios were made depending on the time of day and variations of the household practices, which has been seen connected to the narrowed down area. The Kano model evaluates a perceived value for users and therefore entails questions about their basic, conscious, and unconscious needs in each scenario. If further interest in specific questions, the interview script can be found attached as appendix D.

4.3.19 Sub-phase 4.3 - Post-analysis of evaluation

The survey answers and interviews were analyzed through both quantitative and qualitative analysis. How this was done is described in this section.

In the analysis of both the survey answers and the transcript of interviews, what was sought to find was: how well suited the design proposal fits in the different contexts?; how the design proposal, intended for all income economies, is received and perceived by the future users; and is a design proposal for all income economies possible within this area?.

Analysis of survey

First, the survey data was compiled and organized in Google Sheets, with headings and different colors of the information gathered from LIE/LMIE and HIE, respectively, to distinguish different answers from the income economies more easily.

More specifically, when analyzing the survey answers, what was sought was the following: how were the respondents' first impressions about the concepts?; did the respondents think that the concepts would simplify an everyday life with power outages?; would the respondents use the concepts?, why?, why not?; how many and what type of problems did the respondents notice?; how many of the respondents were first positive in their response but later noticed problems?; did the respondents think the concept would change anything in their everyday life, and vice versa what would they have to change in their life?; How did the respondents perceive sharing a concept?, what reasons in connection to this were stated?.

Additionally, the following questions were asked when investigating the above stated: do the different income economies differ in their responses?; are there more characteristic groups from the answers?, e.g., according to age, accommodation type, location of accommodation, et cetera.

All data were analyzed through a quantitative analysis where diagrams and tables of both information about the respondents and the two questions on each concept answered with scale were made. Thus, the following types of graphical diagrams, charts, and graphs were made to visualize the data: a geographical diagram with markers, pie charts, bar charts, stack bar charts, and distribution graphs. Through this analysis, insights about the spread of respondents regarding age, gender, accommodation type, location of accommodation, and from which countries the respondents had experienced were gained. By analyzing the questions answered on a scale, insights about the overall picture of how the concepts were received through the survey were gained.

Afterward, qualitative analysis was performed using the method KJ-analysis [55] of two of the survey answers on the four questions asked about each eighth concept. First, this data was compiled and organized in Google Sheets, as described earlier. Regarding the surveys' first question, about the respondents' first impression, subcategories were formed to differentiate the answers from each other, where different types of answers formed the same opinion and were marked and written. Afterward, three categories could be formed, grouping the sub-categories in the following: positive, negative, and no clear opinion; by reviewing all opinions. Then a quantitative analysis of the qualitative analysis just performed was also done. This was done by compiling the number of answers of each category from the thematic analysis of the survey's first and third questions and visualizing this in a stacked bar chart and a chart bar, respectively. Through this analysis, insights were gained about the respondents' first impressions and an overview of the total number of respondents that noticed problems. Also, other information was visualized in charts along the analysis process but regarded redundant or not interesting to present and discuss further. The two remaining questions in the survey about each concept were analyzed by simply going through the answers one by one and compiling and summarizing in a text document the responses regarding each concept. Also, throughout the analysis of all survey questions, interesting, summarizing, or differentiating opinions were marked and compiled to be used as citations in this master's thesis report.

Analysis of Interviews

After 12 interviews had been performed, all interviews were transcribed. Also, a table with information about each interview participant was made, presenting an overview of the interviewees. Then a read-through of all transcriptions was made by starting with the first question of each performed interview, followed by the second, then third, and so on. In this read-through, a qualitative analysis of each question was made by comparing the answers from each interviewee, noting down the responses in a text document, and gathering interesting, summarizing, or differentiating opinions made by the interviewees to be used in this master's thesis report.

More specifically, what was sought beyond the bigger questions mentioned in this section's beginning, when analyzing the interview transcript was the following: more about the interviewee's perceptions about the concepts?; more about if and how the interviewee thought the concepts would change their everyday life; if and what they would have to change in their life in order for making the concept work?; how the interviewee thought about the concept of sharing?, how many the interviewee would have liked to share with?; how the interviewee thought about walking/transporting to a concept and if they had a limit in distance?; where there factors changing if one or more of the concepts actually would have been used?, did the interviewees think the concepts were enough or did they need to be complemented in different scenarios?; what with or which of the concepts was seen as being unnecessary or superfluous?.

Additionally, the following questions were asked when investigating the above stated: do the different income economies differ in their responses?; are there more characteristic groups from the answers?, e.g., according to age, accommodation type, location of accommodation, et cetera.

5
Results

In this chapter, the master's thesis result and analysis are presented. First, energy access in the studied countries is brought up, followed by the household practices being presented and the energy dependency of all investigated household practices. Thence, the narrowed down area of the master's thesis, backup system, and lighting, regarding the household practices and a description of the mapping of the materials, competences, and meanings within this area and connections in between. Then, a comparison to HIE is presented; and concluding the first half of the performed master's thesis, a design brief is presented. Afterward, market analysis is brought up, and the idea generation and elimination process result. This is followed by a presentation of the eight developed concepts and the evaluation of those regarding different aspects and from various angles. Lastly, different factors affecting within the narrowed down are when designing for all is presented.

5.1 Energy access in the studied countries

Here the research context will be further elaborated through descriptions of the countries regarding poverty, access to electricity, and power outages. These facts are some in this master's thesis investigated resource consumption indicators as indicated by Kuijer [26] to investigate. The data in this section was gathered through the online study and literature study.

5.1.1 Poverty

The chosen countries are visualized in regard to poverty in figure 5.1 and 5.2. Here, it can be seen that the four chosen countries in Africa have more poverty than those in Asia; and Sweden has remarkably lower poverty. So has Bhutan, despite being a LMIE, and stands out from the rest of the LIE and LMIE countries.

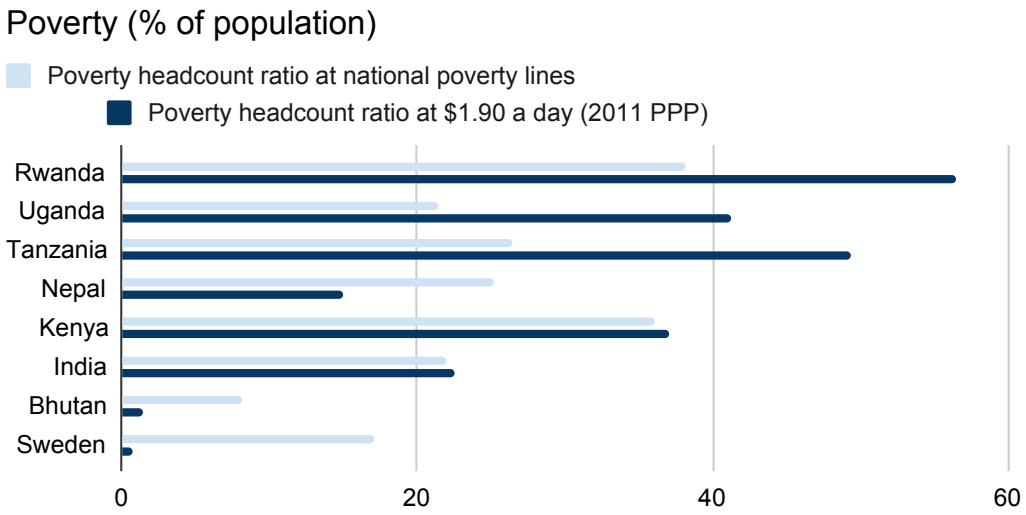

Figure 5.1: Poverty in percentage of population regarding the chosen countries national poverty line and World banks at $1.90 a day [58, 59].

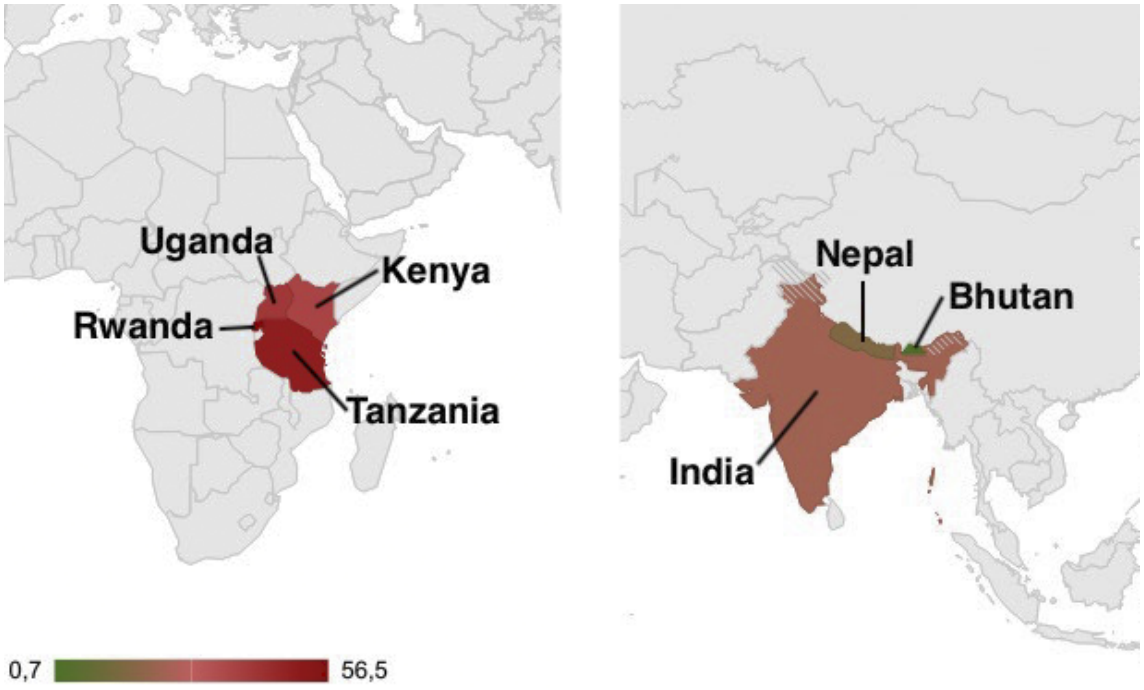

Figure 5.2: Poverty visualized in tonality from dark red - country with the most poverty, to green - country with least poverty. Graphics created with data from World bank [59].

5.1.2 Access to electricity

The chosen countries' access to electricity are summarized in figure 5.3, wherewith the exception of Tanzania, the countries' access to electricity follows the GNI per capita in respective country as seen if comparing figure 2.2 and 5.3. When comparing the total and rural population of each country, the difference is more noticeable in Rwanda, Uganda, and Tanzania, after that Kenya, while Nepal, India, and Bhutan

have close to the same percentage of access in total as rural. In Sweden, the rural and total population percentage is 100 %. It can also be seen that Tanzania is behind when compared to the average access in its income economy LMIE and Kenya being slightly lower than the average in LMIE as well. Apart from Tanzania, which stands out from these graphs, the difference in LIE tends to be bigger than in a LMIE and HIE, so the higher the income economy, the less the gap between total (i.e., also urban) and rural there is.

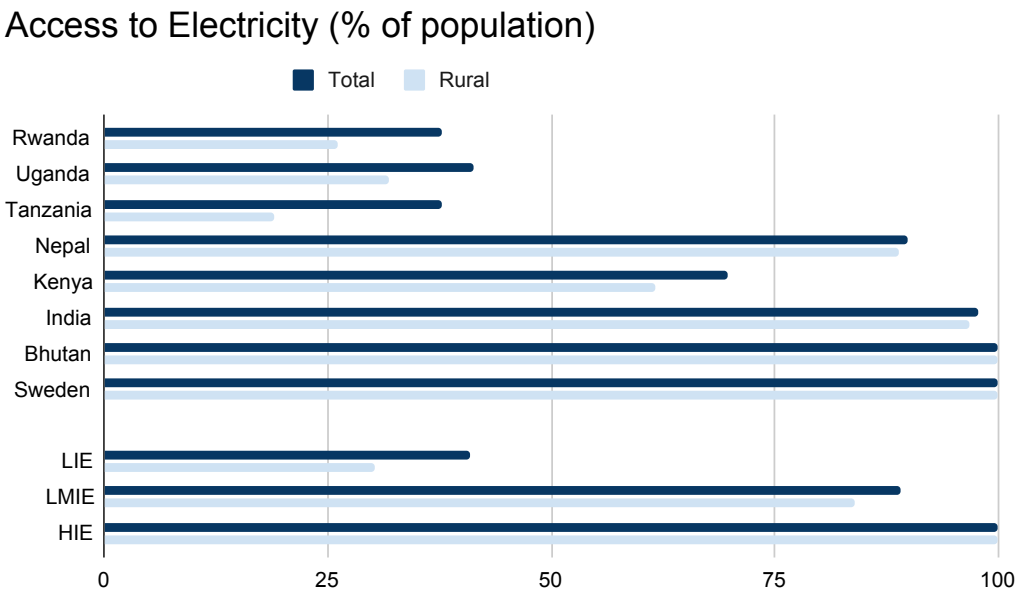

Figure 5.3: Each country's, as well as the investigated income economies, access to electricity both in percentage of total population [60] and percentage of rural population [61].

5.1.3 Power outages

A power outage is when there is *"an interruption in the supply of electricity"* [62] which are most common to occur due to *"natural causes, human error and overload"* [63]. A power outage can also be called load shedding, which is the response when in need of shutting down the system partly because of an unplanned event to secure from a complete blackout in the whole system. These power outages are examples of so-called unscheduled outages, while a power outage can be scheduled as well [16]. For example, this may happen when the income economy has higher demand than supply or something needs to be maintained, repaired, or inspected. A power outage may also be called disruption, commonly if shorter outages also interruption are common words, either when unscheduled or scheduled.

The typical amount of power outages that occur in firms in the chosen countries during a month can be seen in figure 5.4. Here, Sweden stands out with a zero, not as surprising as Bhutan's low result of being close to zero. However, India has the highest result, surprisingly despite being the second-highest country in LMIE and near 100% access to electricity as seen in figure 5.3.

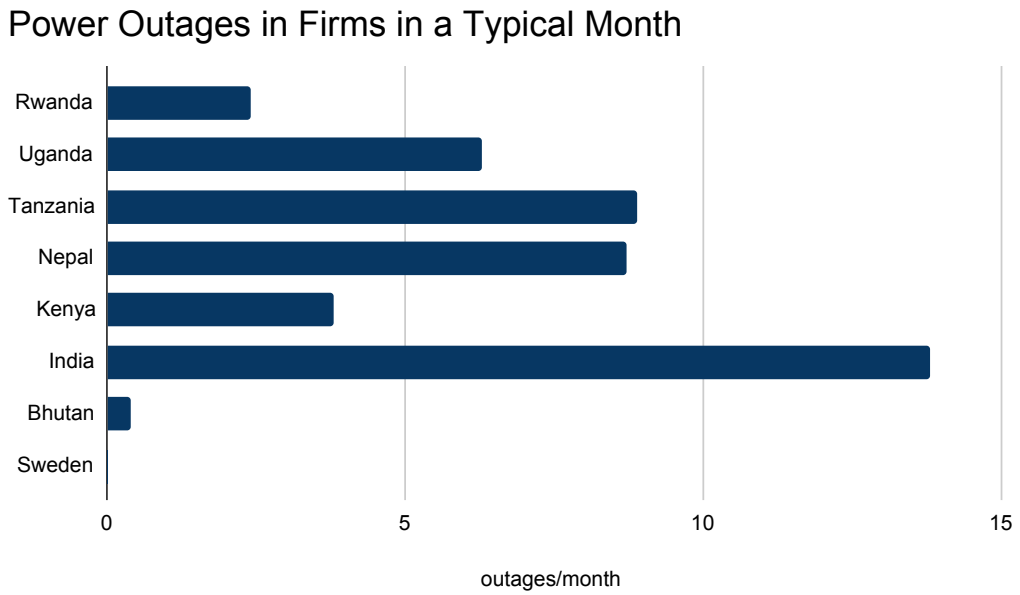

Figure 5.4: The amount of power outages that occur in firms, in a typical month [17].

From a study, [16] the amount of average power outages in a Nepali household is presented, where 76.8 outages per month in the worst month, while in a typical month 40 outages are expected. The mean value differs significantly from the median, 76.8 versus 63 relative 40 versus 22.5. Meaning the distribution is skewed to the right; thus, the distribution is uneven as it seems, and the result of the mean value might be somewhat misleading. Still, the median value of the studies' insight on typical values is high, meaning an outage occurs three out of four days. These facts related to those presented of Nepal firms in figure 5.4 are a lot higher. 8.7 [17] in a typical firm versus 40 in a typical household. Hence, the figure 5.4 should not be translated directly to how many power outages occurs in the countries of interest. Nevertheless, this figure may indicate typically how many outages the countries expect in relation to each other.

Further, in Sub-Saharan Africa, videlicet including Rwanda, Uganda, Tanzania, and Kenya, among others, countries are experiencing power outages every fourth day on average, and some are experiencing outages daily [18], which is slightly higher than the average presented in firms in a typical month as the data presented in figure 5.4. Still, Sub-Saharan Africa is a truly large area, and as the countries investigated except Kenya are below the average of Sub-Saharan Africa's GNI per capita of 1480 $ [64], it is more likely those countries are experiencing daily than as rarely as every fourth day. Still, every fourth day is also a high value.

From this above information, it can be concluded that interruptions are o lot more common, with Bhutan as an exception from the found data, in LIE and LMIE than in a HIE. Also, the amount of outages that occur in LIE versus LMIE does not differ distinctly. Therefore the prerequisites regarding power outages may be seen as similar in the LIE and LMIE countries explored.

5.2 Energy dependency of household practices

In this section, thoughts about not having electricity are elaborated, and the energy dependency of household practices in the explored countries are presented. Where energy dependency in terms of electricity dependency is being investigated. Lastly, the household practices regarding energy resilience and a compilation of energy dependency are concluding this section.

5.2.1 About not having electricity

Experiencing power outages is very common in countries classified as LIE and LMIE. As mentioned in section 5.1.3, in the explored countries, there is typically a power outage ranging from daily to every fourth day. Thus, the households are indeed used to having power outages. One interviewee, no. 5 in table 4.2, said the following when asked about her experiences with power outages: *"Oh yeah. Oh God, I wouldn't really call it experience. I will call it a way of life. [laughter] You know, funny thing is, it becomes so common for you, when something is so common like, you wake up and you brush your teeth."*

One interviewee, no. 6 in table 4.2, describes the feeling when not having electricity as: *"Maybe you don't have electricity... You live with anxiety. You're not sure if you'll have power at night to read"*. When not having electricity, both when experiencing disruptions or if the household does not afford to have it the entire day, many households live by the sun, which was understood through interviews and observations. That is cooking food, educating, and performing other household practices only when there is light outside, and then just before it gets dark, they would go to bed and sleep until just before the sunrise. Thus the LIE and LMIE households try to be as independent of electricity as possible.

Another interviewee, no. 8 in table 4.2, spoke of having electricity as:

> *"It's a whole different thing who doesn't know, who has never had electricity will never know what it feels like. But I think when they also have it, one time they'll really feel they need it. It becomes a necessity, like part of life. Like I really need to have this thing. I feel it's comfortable. I think everyone wants to be comfortable in life, it's this peace of mind."*

This shows that electricity enables new opportunities and helps in being comfortable in life, and when provided with or exposed to electricity, a household experience a continued need for this considering what it gives. If able to access electricity, all interviewees agreed on a light bulb being a priority to own. One interviewee, no. 1 in table 4.2, with experiences of a plurality of countries in Asia, meant that a light bulb, mobile phone, and a rice cooker were first of prioritization. Most of the interviewees also brought up the mobile phone as being in close second place when getting access to electricity. So by gaining access to electricity, a household will feel comfort in being able to have lighting and use a mobile phone. Interviewee

no. 2 in table 4.2 also concluded that if there is stable electricity, then it will by time be used by habit. However, if there is unstable electricity or only access to electricity sometimes, then the households will continue to have parallel techniques that they alternate between. This may be the reason for LIE and LMIE households, on average, still being more independent of electricity than a HIE household, which will be further elaborated and presented throughout this section.

5.2.2 Household practices in a material perspective

In this subsection follows a description of the household practices found in the explore phase of LIE and LMIE households in the countries of interest regarding energy dependency. This knowledge was gathered from watching several movies, and the online/literature study [65, 16, 66, 67]. The household practices explored are the following:

- Bathing
- Visiting Toilet
- Cooking (incl. storing food)
- Doing Dishes
- Laundering
- Cleaning
- Entertaining
- Communicating
- Socializing
- Retrieving water
- Staying warm/cold
- Educating

All these household practices have been investigated in LIE and LMIE, where more specifically, what types, parts, and interrelations of these practices are connected to energy resilience have been explored. Worth mentioning is that there are more household practices not mentioned and explored through this study due to limitations in time. The energy dependencies in the household practices are mediated by being presented first and foremost from the element material's perspective. The material element is principally impacting the electricity dependency and is, therefore, the most relevant when explaining. Meanings are not considered directly connected to electricity dependency, while competences do make a direct impact, where *know-hows* and *techniques* may impact the dependency. Still, whether a practice is using electricity or not is decided by the element material using the electricity or not, thus, making the main impact. Additionally, knowing what is used within the practice, i.e., the materials, creates a great starting point in understanding the practice further. Therefore, the description includes the element materials in the practices and a depiction of the context regarding each household practice. Additionally, resource consumption indicators are mentioned in some household practices when needed and of interest to illuminate.

The household practices differ between the investigated countries, more or less depending on which practice and this as the habits and prerequisites differs over the world. The household practices also differ within the countries owning to different economic situations, habits, rural versus urban, et cetera. More specifically, how and if they differ are brought up in each household practice affected. Also, in the following description of the household practices, the average and thus the most common from each practice are brought up from the investigated contexts. Meaning all found from the study is not included, nor is a complete coverage in this description, as that would entail a too large section of this master's thesis and require a much more extensive study to thoroughly and correctly cover and reflect all differences within all investigated countries.

Bathing

Bathing is made with a bucket and scoop. The bucket may either be standing on the ground, or a suspension has been made so the water may run from above. See Figure 5.5 for reference picture. In all found about bathing, this household practice is considered as independent of electricity, as no energy of this type is used within the practice. However, for some a bit more wealthy, they use some sort of energy to heat the water a bit, but in this section, it is not included when referring to energy dependency as electricity is the main focus.

Figure 5.5: Pictures of the practice bathing. Photo to the left: Global Exploration for Dollar Street 2018 (CC BY 4.0). Photo to the right: Omar Havana for Dollar Street 2019 (CC BY 4.0).

Visit Toilet

When visiting the toilet, they do their needs through a hole in the ground, either inside or outside. The "hole" may either be literally a hole in the ground or a ceramic hole with surfaces on both sides of the hole to put one's feet at, as seen in Figure 5.6. Visiting toilets is energy independent in most households in LIE and LMIE. However, when visiting the toilet at night, some light is needed; therefore, some type of energy source for this may still be used. Either a flashlight, candle,

some type of fuel lamp, or in some cases, the households have a light bulb running on electricity.

Figure 5.6: Pictures of toilet. Photo to the left: Global Exploration for Dollar Street 2018 (CC BY 4.0). Photo to the right: Luc Forsyth for Dollar Street 2015 (Free to use under CC BY 4.0).

Cooking (including storing food)

Cooking food is done using a gas burner; it is also common for the household to cook over an open fire made with either firewood or charcoal sticks if the household is poorer, as seen in Figure 5.7. The households only own and use a few pots and tools, and usually, no kitchen has electrical appliances. The food is either dried or fresh from the garden, farm, harvest, or local market/community. The richest have a refrigerator, but not middle and low in the countries explored. The ownership of a refrigerator differs between the countries, where less than 1 % have a refrigerator according to a study about Rwandan [68]. While a refrigerator seems to be more common in South Asian LIE countries [66, 69, 70], which is also seen through this study's interviews. Possibly in some areas in Asia in the middle and up, referring to the economic situation, one prioritizes a rice cooker if having access to electricity, both as this keeps the food warm and the smooth cooking process. One might also have a pressure cooker in some countries in Asia [69]. The richer may also have a juice blender, and some have a mixer in their household.

Cooking may be done in a shared room, where entertaining, socializing, and educating are also performed, that is, if the household is cooking with gas. Then, electrical lighting is essential for making this practice possible for other hours than the sun enables. If cooking over an open fire, this in itself generates some light and may serve as a compliment. Still, it has been acknowledged that cooking is often avoided in hours when the natural light is no more regardless of how and with what type of material element the practice is performed with. In total, the household practice of cooking is seen as being energy independent, still with the exceptions of lighting if

cooking after sundown or as in some a bit wealthier household a rice cooker, blender or pressure cooker may be used.

Figure 5.7: Pictures of the household practice cooking. Photo to the left(printscreen of video): Omar Havana for Dollar Street 2019 (CC BY 4.0). Photo in the middle: Luc Forsyth for Dollar Street 2015 (CC BY 4.0). Photo to the right: Omar Havana for Dollar Street 2019 (CC BY 4.0).

Doing Dishes

The dishes are done by hand with a small bucket and a cloth or sponge, seen in figure 5.8. The water is poured into the bucket, or a plastic jerrycan is used with a tap. The water used when doing the dishes may be second used for something else. This household practice is seen as completely energy independent as no electricity is used within the practice.

Figure 5.8: Picture of doing the dishes. Photo: Omar Havana for Dollar Street 2019 (CC BY 4.0).

Laundering

The laundry is done in a similar way to doing the dishes. By hand with a small bucket and either with a washboard in wood or entirely by hand. The water is either already poured in the bucket, or a plastic jerrycan is used with a tap; sometimes, the laundry may be done at the community's manual pump. The water used when doing the dishes may be second used for something else. See figure 5.9 for reference pictures. Some households, considered among the more wealthy, in a LIE and LMIE country may have access to a washing machine, but this is counted as an exception, and in the middle and low within LIE and LMIE, one does not own a washing machine.

Therefore, the household practice of laundering is considered being independent of electricity.

Figure 5.9: Pictures of doing laundry. Photo to the left(print screen of video): Omar Havana for Dollar Street 2019 (Free to use under CC BY 4.0). Photo to the right: Omar Havana for Dollar Street 2019 (Free to use under CC BY 4.0).

Cleaning

Cleaning is done with a broom made from dried grass tied together, see Figure 5.10. If the household has a floor that is possible to clean with water and soap, this is done by scrubbing the floor with a brush lying on one's knees and taking water from a bucket next to the person doing the cleaning. From this it can be seen that the household practice is completely independent of energy in LIE and LMIE households.

Figure 5.10: Pictures of the household practice cleaning. Photo to the left: Omar Havana for Dollar Street 2019 (CC BY 4.0). Photo to the right: Luc Forsyth for Dollar Street 2015 (CC BY 4.0).

Entertaining

As entertaining either a book, each other in the household, radio, a mobile phone or another hobby is common. Also, one may watch television or use a computer/laptop if the household is slightly better off financially. If the households own a computer also seems to differ a lot between the different countries investigated, as seen through the interviews. The use of a mobile phone for entertainment purposes depends on the household's financial situation. A household may have either one or more mobile phones, and the phone may be a more simple phone or an up-to-date smartphone, depending on the family's prioritization and financial situation. The household may also have a laptop if slightly well-off financially. Depending on what the households are performing within the practice of entertaining, it may be dependent as well as independent of energy. However, this household practice is counted as dependent as the average households in LIE and LMIE nowadays have at least one mobile phone and often a television, which is commonly used for entertaining purposes. However, the practice might as well be independent of energy sometimes when reading a book or performing another hobby without the need for electricity.

Communicating

For communicating, a mobile phone is commonly used, see figure 5.11 for two examples of mobile phones. Almost everyone has one regardless of how poor the household is. Nowadays, this is a priority for everyone as soon as one basically has food and a roof, then the next priority is owning a mobile phone. Of course, verbal face-to-face communication is also done in this practice, that is, between family members and people living in the nearest community of the household. Therefore this household practice may be independent as well as dependent on electricity. However, it is counted as dependent as in the average LIE and LMIE households owning one or more mobile phones is common and is frequently used when communicating with others than those in the same room.

Figure 5.11: Two pictures of a mobile phone, used in the household practices communicating and entertaining. Photo to the left: Omar Havana for Dollar Street 2019 (Free to use under CC BY 4.0). Photo to the right: Global Exploration for Dollar Street 2018 (Free to use under CC BY 4.0).

Socializing

A practice nudging to the household practices entertaining and communicating is socializing. The families socialize together in the main room where they also sleep, eat, study, et cetera; or for a wealthier household, the family may have a living room where they eat, socialize, watch or listen to some sort of entertainment. Socializing is spent talking to each other either when doing chores, eating, or simply socializing and talking as a family solely as one practice being performed. Socializing may also be done through the mobile phone when communicating with family, old or new friends. As socializing is most commonly understood to be performed within a household, it is concluded to be a mainly energy-independent household practice but may also be dependent when socializing with people through the mobile phone.

Retrieving Water

Either a household has to go to a water source with a jerrycan, or the water is delivered from a truck which is then pumped up on the roof in overhead tanks in order for the household to have running water. In some cases, the household may have a manual pump to pump up the water, or it may also be pumped to overhead tanks by electricity. Some wealthier households have an electric water dispenser. The water is always in need of filtering; most households also boil and cool the water before use. Some have an electric filtering pump with a container always filled with water. For warm water, the household is most common to cook the water, and this is done with cooking gas or over an open fire. A solar heating system may be used for those who are better off financially. Through this explanation, it may be understood that this household practice may be counted as both independent and dependent on electricity, depending on how wealthy the household is. However, it is most common in the average household to be independent of electricity through this practice.

Cooling and Heating

In homes with access to electricity, an electric fan is probable for the household to have, and many households even have more than one fan, while an AC is more unusual for the very most in the lower sections within LIE and LMIE. Otherwise, one has blankets or sweaters to keep them warm. This practice is counted as dependent on electricity, still with exceptions as the more accessible alternative of using blankets or more or fewer clothes may be seen as a solution for the average household.

Educating

Lastly, in households consisting of a family with school children, the practice of doing one's homework is highly prioritized by the household. In this practice, the children have their books from school and a pen to study. Something that is also relevant in this practice is the need for lighting to be able to study, and some type of artificial light is essential to perform this practice after daylight has passed. As the children are in school during the day, the most common time to study is sometimes during the evening. Thus, for this purpose, lighting is brought up as being very

important for households. Therefore this study is counted as dependent on energy as lighting is needed, and the typical time to study is in the evening.

5.2.3 Competences and meanings in the household practices

The competences [37] found permeates most household practices. The following list summarizes what has been discovered to be mostly general competences in the LIE and LMIE households. These competences and meanings have been found throughout the study, in interviews, through observations, and from the online and literature study.

- Always have a plan B
- Build up life to be independent on electricity
- Follow the sun
- Family and friends getting together
- Trust in communities and collaborations
- Knowledge together
- Create together
- Build from what one has and repairing

The household always has a plan B, and that is in all areas possible. If the household has access to electricity and a power outage occurs, they have solutions for this with additional alternatives if something is dependent on electricity. However, most households have built up their life to be as independent of electricity, especially grid electricity, as they can be. Additionally, if a household does not have electricity, either temporary or no access, they are likely to follow the sun: by mostly doing chores and the household practices when the sun is up; and thus by going to bed right before it gets completely dark, then sleep until right before sunrise when dawn sheds some light again. In the households, they also seem to have an overall trust in communities. Where communities may include family, friends, neighbors, and people in the villages; in these communities, they collaborate by helping each other by exchanging knowledge, services, and resources. E.g., how to build or repair the house, help with repairing something, and exchange building materials or food supplies from the neighbor's land. The households also generally hold the competences of building with what one has and how to repair. If their broom, used when cleaning the house, breaks, then it is repaired; if the water container with tap, used when doing the dishes as seen in 5.8 then that is repaired, et cetera.

Likewise, the meanings [37] found are mostly general and manifest in more or less all household practices. Due to time limitations, no specific research in the meanings behind each household practice was investigated. A list below summarizes the found meanings.

- Survival and essential needs trumps all
- Open to people around them
- Repair instead of buy new

- Use few resources
- Content with the current
- Independent of electricity
- Having electricity becomes a necessity and comfort

Principally, what is done in the households is first and foremost done for survival and essential needs. The people in the households are also open to people around them because they know that here is where help exists when needed. What characterizes LIE and LMIE households, in general, is their aspiration to repair with what one has and to use the resources that are the cheapest and thus most easily accessible. Additionally, one strives to use as few resources as possible, mainly for economic purposes or the thought of others having a need and for some also out of habit, when they maybe have reached a more wealthy economic state in the household. Another discovered meaning was the idea of the households being content with what they have. This is both due to economic reasons and because one does not know how it is to live in another way. Further, the LIE and LMIE households were found to have an aspiration to try to be as independent of electricity as possible, mainly through adapting to when there is daylight and using less electricity, e.g., in the practice of cooking. At the same time, the meaning of having electricity becomes a necessity, and comfort was found through the interviews in this study, this especially regarding lighting for different practices and being able to have a mobile phone.

5.2.4 The household practices in regard to energy resilience

A lot of the household practices in the explored contexts can be counted as energy resilient, as most of the household practices are indeed independent of electricity. See table 5.1 for an overview of how independent each household practice is of electricity. However, it must be taken into consideration that this compilation may differ in many ways depending on many different factors seen through this study. What differentiates households in being more or less dependent on energy is summarized in a list below for an overview of the factors found.

- Income economy classification (both of country and household)
- Different countries
- Different regions
- Household prerequisites
- Household habits
- Time of day

Income economy classification both of country and household refers to that the practices have been seen to differentiate due to the type of income economy classification the country is and the household's specific income economy, i.e., how wealthy the household is. Also, due to different habits and customs in different countries and regions and what they are indoctrinated in by living in a specific country/region. Prerequisites and households depending on each household were found to be factors; where it is situated and what they choose to own and use matters. Lastly, what

time of the day it is, has also been found to alter the energy dependency of the household practices. Thus, table 5.1 should not be seen as strict showing how it is but merely and rather as a direction of how it has been understood to be in the average households explored through this study.

As brought up in the description of each specific household practice, there are some exceptions within the household practices counted as independent of electricity. This as some appliances requiring electricity are not used by the very most as seen through this study. These households practices thus have exceptions and are marked with "with exceptions" in the table 5.1. More specifically, e.g., in cooking, it may differ how independent of electricity the practice is depending on which region/country the household is situated in, how wealthy the households are, and what habits they have. For example, a household in the explored countries in Asia is more likely to own a rice cooker even if they are a poor household, while in the explored countries in Africa, it is highly likely that the household does not own and use any electrical appliances. This is one of some examples found through this study's performed interviews, observations, online, and literature study. In the household practice entertaining, many use a mobile phone or television when performing the practice, while others may talk to each other or play games which on the other hand is independent of electricity; this depends on the household's habits and prerequisites. Regarding communicating, one may be temporarily independent of electricity if talking to the neighbor by walking there or communication between household members, while some use the mobile phone more frequently even when talking to someone within walking distance. Therefore, it is impossible to compile and say that the list is fixed, but rather the list should be considered variable when exploring such a large context and may therefore be seen as a direction of how it, through this study, have been understood to be in general and in the average LIE and LMIE households.

With that said, most household practices are considered to be energy resilient, as they are often not performed with electricity. While areas which are considered to be electricity-dependent are entertaining, communicating, staying warm/cold, and educating, as seen in table 5.1. Nevertheless, the households still may be energy resilient, while highly varying in how much as some are and have the opportunity to be more prepared than others. The opportunity in how to be prepared chiefly depends on how well-off the household is. Also, four household practices are marked in table 5.1 as independent but with exceptions where these practices in some cases may be seen as dependent.

Table 5.1: Overview of household practice versus independency of electricity.

	Independent of electricity while performing the household practice?
Bathing	YES
Visiting Toilet	YES (with exceptions)
Cooking (incl. storing food)	YES (with exceptions)
Doing Dishes	YES
Laundering	YES
Cleaning	YES
Entertaining	NO (with exceptions)
Communicating	NO (with exceptions)
Socializing	YES (with exceptions)
Retrieving water	YES (with exceptions)
Staying warm/cold	NO (with exceptions)
Educating	NO (with exceptions)

Lastly, being energy resilient in a LIE and LMIE household has been found to occur in four different ways. This is compiled through the following list, summarizing what has been said throughout this subsection.

1. Completely disconnected to electricity. - *Independent of electricity.*
2. Partly disconnected to electricity. - *Partly independent of electricity.*
3. Alternative way of enabling electricity. - *Not dependent on grid electricity.*
4. Have a plan B when disruptions occur. - *Partly independent of electricity, and most importantly being prepared in any way.*

5.3 Narrow down to backup system and lighting

In this section, the project's scope is narrowed down, what area is of further interest is presented, why that area is chosen, and the household practices of further interest relating to the area.

5.3.1 Why backup system and lighting?

In the first half of the master's thesis, the whole household as-is and all household practices performed were explored in LIE and LMIE contexts. Before going into the second half of this master's thesis study, the scope was as intended in narrowing down. When going through the material from the interviews, observations, literature study, and the online study, a plurality of areas of what to narrow down to was suggested, where the chosen area came to be backup systems and lighting. The narrowed down area thus entails shifting the focus from a plurality of practices towards an elemental area, as both lighting and backup systems are counted as an elemental area of the type material. The more narrowed down scope was chosen in regard to being one of the most necessary to continue with, according to the study. This, as

here is where the LIE and LMIE have electricity dependency, the opposite to most household practices where they are entirely independent of electricity. Further, the area is important as it meets the necessary needs, excluding food, for someone who experiences power outages and disruptions and is or would like to be living energy resilient. Moreover, this is a problem for both LIE and LMIE and HIE as the future is most likely to entail these types of disruptions according to the future scenario mentioned at the start of the thesis. Thus, the area is highly relevant for HIE as well.

In addition, it is still a broad area in order to be open to solutions covering broader needs. However, to slightly narrow down one step further, the area of the backup system is intended to be somewhat smaller, where complete backup reserves for an entire home are excluded. Hence, solutions suiting large appliances such as refrigerators, fans, AC, et cetera, are excluded. Also worth mentioning, the element area of lighting will include both electrical and non-electrical materials to cover aspects of both dependencies and in-dependencies of electricity. However, backup systems only include backup for electrical purposes and therefore exclude all non-electrical needs in the area, e.g., water backup, spare parts, extra gas for cooking, et cetera.

Further, as the area still are a somewhat broad area, a possibility is that the solution will solve a partial need within the chosen scope. Thus, in continuation, the solution is said to solve and live up to facilitate and accommodate a household's needs in an energy resilient way within the backup system and lighting areas. Furthermore, the solution is open to be technical, social, physical or non-physical, or a combination.

5.4 Element area lighting and its connections

In this section, the element area lighting and its connections are explained. The information gathered from the study, including from literature study, online study, observations, and interviews, was analyzed from a practice theory perspective. Meaning the three elements: materials, competences, and meanings, were mapped out from the gathered information. Here this mapping is verbalized and visualized in accordance with the narrowed down area.

5.4.1 Household practices connected to lighting

The element area lighting has the potential to further include all but staying warm/cold of the investigated household practices if including natural light as a light source. Namely: bathing, visiting the toilet, cooking, doing dishes, laundering, cleaning, entertaining, communicating, socializing, retrieving water, and educating. However, to narrow down the scope among the household practices where natural light is the main source and dependency these will not be included. Hence, the following household practices are eliminated due to this: bathing, doing dishes, laundering, cleaning, retrieving water. Left are visiting the toilet, cooking, entertaining, communicating, socializing, and educating. Still, natural light may be the common source depending on how financially well-off the household is. These household practices are found to be visiting the toilet, cooking, and socializing. But, it may

as well be the other way around that the average household use other than natural light when doing these household practices. Especially within cooking lighting may be prioritized, that is if cooking with gas and thus being inside; or the household may use some sort of electrical appliances if they are more well-off. Also, lighting may be of interest when visiting the toilet at nighttime or socializing after sundown.

- Communicating
- Entertaining
- Educating
- Visiting toilet
- Cooking
- Socializing

5.4.2 Lighting as a material element

The element Materials include *"things, technologies, tangible physical entities and stuff of which objects are made"* as put by Shove et al. [37, p. 19]. Materials within the element area lighting are summarized in a list below and explained in the following paragraphs. The materials brought up are found through interviews and observations and confirmed in the articles [16, 66, 21]. Worth mentioning again, the element area of lighting includes both electrical and non-electrical materials.

- Light bulb
- Candle
- Oil lamp (incl. oil)
- Kerosene lamp (incl. kerosene)
- Gas lamp (incl. gas)
- Flashlight
- Solar cell lighting

For a wealthier household, it is common to invest in solar cells, as described by an interviewee, no. 4 in table 4.2,: *"If you had a little economy, then you bought a small solar cell plate so that you had a bright spot in any case."*.

Lighting in LIE and LMIE income economies most commonly consists of a light bulb in the ceiling, and usually, the bulb is connected to the grid and hanging in the kitchen area if cooking food inside. According to a study about energy use in Nepal [21] 100 % of the households investigated had electric lighting. While in the rural areas, additional alternatives were also owned and used. The household may also have either as a complimentary, backup, or only light source the following as a light source: a candle, an oil lamp, a kerosene lamp, or a gas lamp. For example, according to [16], in Nepal, only 13.52% have a kerosene lamp, while candles are much more common in the households, as seen in this master's thesis study. Nevertheless, all households have some sort of lighting backup.

A household with a much higher income may have a solar system either as a backup

or an extra source. According to an article [16], only 1.43% had a solar home system, while almost 18% had a more simple solar lighting in any form. With higher income comes material preparedness more than those who are poorer. Nevertheless, all are prepared somehow as described in the next section about the element competences.

Lastly, a wish connected both to lighting and mobile phones was expressed by one interviewee, no. 2 in table 4.2: *"I wish that [...] telephone and lighting were less dependent on electricity because that is where there will be a disturbance."* This expresses a want and a need for some sort of solution in this area.

5.4.3 Competences connected to lighting

The element competences include *"skills, know-how and technique"* as declared by Shove et al. [37, p. 19]. The competences found within the area lighting within households in LIE and LMIE are explained in the following paragraphs and summarized in a list at the end of this subsection.

A LIE and LMIE household have skills, know-how, and different techniques in how to be prepared when an outage occurs. As outages and disruptions occur frequently, this is necessary to be prepared for, and thus, all are in some way prepared.

> *"You have to have plan B, have plan B, yes. Have plan B for water, have plan B for electricity and for lighting, have plan B for food. [...] Have always a plan B for your basic needs."* Said by no. 5 in table 4.2.

Households in LIE and LMIE have mechanisms of how to deal with power outages and disruptions. All have some sort of lighting backup and all interviewees agreed that one always has to make sure to have candles, a flashlight, or a fuel-driven lamp in the households. One interviewee, no. 6 in table 4.2, explained that *" it's rare to find someone who's gonna be in extreme darkness when there are outbreaks or these outages"*. So, most households in LIE and LMIE have some sort of backup, where sometimes the backup solution for some might be the only solution for the more poor households.

One competence in a LIE and LMIE that differs from a HIE is the habit of doing something new and fixing with what is available in the home, instead of buying new when something is broken. A household build from what is available at home and tries to take advantage of everything. This is clearly depicted both from interviews and the online study. On the same note, one creates together in communities to survive. So the meaning behind what is done clearly differs from HIE. Also, knowledge is something often created together, as often it is not possible to search on the internet whatever comes to one's mind; instead many have the habit of asking someone living in the household or maybe a neighbor. The study has also shown that there are overall more collaborations, both in and between communities and co-operations between people, households, and villages.

Many households have built up their everyday lives not to be so dependent on electricity. Some, often the poorest, have routines that follow the sun. E.g., going to bed right before it gets dark not to waste fuel or candles, and in the end, always to be economically frugal.

A list summarizing the competences found throughout this study:

- Always have a plan B.
- Always make sure to have candles and flashlights at home.
- Life in general is built up as to be as independent on electricity as possible.
- Follow the sun.
- Have knowledge together.
- Create together.
- Build/fix from what one has, try to take advantage of everything.
- Repair instead of buy new.
- More communities and overall collaborations.

5.4.4 Meanings connected to lighting

The element meanings include *"symbolic meaning, ideas and aspirations"* as explained by Shove et al. [37, p. 19]. In the following paragraphs, meanings found, through interviews, observations, online and literature study, corresponding to the narrowed down area of lighting, is presented and lastly summarized in a list.

When comparing a LIE and LMIE to a HIE, the overall meaning of what is the primary thought often differs a lot. First of all, the poorest survival and essential needs are more on the line. Essential needs are always the first thought, evident through a plurality of examples in the following paragraphs. While in a HIE, the thought of survival-ability and essential needs is important but more secondary thoughts as this is much more easily fulfilled.

When a LIE or LMIE is thinking about lighting, this is only considering necessity, as explained by all interviewees. Lighting and education are often brought up at the same time by the interviewees. With lighting comes the opportunity of enabling children to read their homework when coming home from school; this is often brought up by the interviewees when not having access to electricity in one way or another. One interviewee, no. 7 in table 4.2, with experience of both Sweden and a LMIE country, said: *"they [Swedes] use a lot of electricity, like for decoration purposes, not even like, you know, for necessities"*. In the LMIE country, India, of which this interviewee had experience, lighting is not a declarative purpose, only for some *"luxurious"* people. For most, lighting is only for lighting up the necessities in their home. This also reflects the overall mindset of using resources; in a country classified as LIE and LMIE one always uses resources with a thrift. A household do not take what is around them for granted in the same way as in a HIE. Also, the interviewees describe people of LIE and LMIE as being more content with what they have. That this is needed and eventuate in being happier.

People in LIE and LMIE households are open to people around them. One interviewee, no. 2 in table 4.2, meant that *"The fact that I live here and the neighbors are over there, does not work in that context [low-income context]."* Instead, in a LIE and LMIE context, one both gives and takes advantage of the households around them regarding knowledge, contacts, utilities, and food. As earlier described, about competences and more overall collaboration between villages, communities, households, and single people, there is an aspiration to be open to the people around them. Overall, there is both an aspiration and a need in both helping and being helped by others.

Something the interviewees explained that has changed in recent years is that there is not the same aspiration and reliance for grid arrival as it has been back in the days. This is due to new technologies that can compensate or even replace the need of the grid. However, it is still an aspiration, a need, and a way away from poverty and a basic necessity that this is something everyone should have access to. As described by one interviewee, no. 8 in table 4.2: *"The world we're living in now, it's very, very important to have electricity."* This importance is due to many reasons, first and foremost because having light whenever is an essential step when being poor; information spread is through the internet; enables better and more accessible communication; many technologies is dependent on electricity nowadays; and these technologies enable the poorest to take "shortcuts" in being less poor through the access of, e.g., a phone. Also, the importance of having electricity is related to lighting and communication. In a case study about Haiti [71] it is brought up the primary needs for having electricity in Haitian households as being for lights, refrigerator, and small electronics.

A list summarizing the meanings found throughout this study:

- What is done is done for survival and essential needs.
- Lighting enables education.
- Open to people around them.
- Compare brush teeth with amount of power outages.
- Seeing is believing, without electricity you live in the dark.
- When not knowing, you don't know what you're missing.
- Lighting is only for necessities, not as a decoration purpose.
- Having electricity becomes a necessity and comfort.
- Everyone should be comfortable - about having electricity.
- Wishes that telephone and lighting is less dependent on electricity.
- A sense of enough and sufficiently. To be more content.

5.5 Element area backup system and its connections

In this section, the element area backup systems and its connections is presented. Same as regarding the element area lighting, the information gathered is from the

study's performed interviews, observations, literature, and online study. This information was also analyzed from a practice theory perspective, where the three elements within and connecting to the area were mapped out.

In this narrowing down, backup systems do only include backup for electrical purposes and therefore exclude all non-electrical needs in the area, e.g. water backup. Furthermore, the area of backup systems will not include big backup systems such as a backup reserve for a whole home, as earlier mentioned.

5.5.1 Household practices connected to backup systems

The household practices which will be further explored in connection to backup systems are discussed in this subsection. The area backup system could, as lighting, have the potential to include many of the explored household practices further. However, as a backup system is directly connected to practices where electricity is being used, household practices where the average household does not use electricity are not considered further interest in connection to backup systems. Namely: bathing, visiting the toilet, doing dishes, laundering, cleaning, or retrieving water. In the borderland of using electricity or not are cooking, where this depends on how wealthy the household is and their priorities. Also, socializing depends on the household habits and prerequisites as this may include using electricity, but as well may not. Therefore cooking and socializing will be further included as household practices in backup systems. Additionally, as the area of backup system is intended to be somewhat smaller, complete backup reserves for an entire home are excluded, and hence solutions suiting for large appliances such as fans, AC, et cetera, are excluded. Meaning staying warm/cold will not be further explored as this is no longer is related to the chosen area. Therefore the household practices of further interest concerning backup systems are:

- Communicating
- Entertaining
- Educating
- Cooking
- Socializing

5.5.2 Backup systems as a material element

Here the materials elements consisting of the area of backup systems are presented. How many of the so-called materials the household owns depends on its economic situation and what types of solution they choose.

- Battery backup system
- Power bank
- Solar charger
- Solar backup system

- Diesel generator

In LIE and LMIE, the amount of power outages that is occurring is in general between daily and every fourth day, as earlier mentioned in section 5.1.3. While most of the interviewees were very well aware of how often power outages occurred, one interviewee did not. 3 in table 4.2, did not really know. *"I don't really know how often we have power outages right now, because as my batteries go in, I do not notice it, but it is probably every day at some point and sometimes it can be several hours. Sometimes it can be completely dark on my street for several hours in the evening."* It is quite unusual for households in LIE and LMIE to have extra batteries to cover when there is a power outage. However, some fortunate have this luxury that is better off economically. In a study about Nepal [16] it is stated that approximately 70% of the Nepali households do not have any sort of backup equipment. While almost 26% responded having rechargeable batteries for lighting, including backup for appliances; and 34% had rechargeable batteries for lighting but not any backup for appliances. When having a mobile phone, it is possible for the households also to have a power bank. This is a precautionary measure to have as power outages often happen.

Further, in this study, it seemed not to be so common to have a diesel generator in the households, same as in another study [71], only some have this as a backup. However, a diesel generator *"entailed a cost in fuel, noise and air quality (due to exhaust)"* [71] and is thus not the best alternative due to several reasons. From an article about facts from Nepal [16] it is brought up that households in Nepal have energy backup or storage in the shape of *"e.g., small diesel or solar generator, power inverters, and batteries"*.

5.5.3 Backup systems and connections to other material element

The following materials are not directly included in the area of backup system: mobile phone, tablet, router/modem, computer, television, and radio. These are important to bring up as they are indirectly linked to the area and thus necessary to mention as they may be used when having some sort of a backup system.

- Mobile phone
- Tablet
- Router/modem
- Computer
- Television
- Radio
- Above stated material element in the area of lighting

A mobile phone is regarded as expensive even for a HIE household, but as one interviewee said, no. 3 in table 4.2,: *"It's often quite surprising, it's a bit like, no matter how poor people are, there's always a cell phone."* Nowadays, a mobile phone

is a high priority for households in all income economies; despite no or very little electricity access, a household seems to prioritize a mobile phone in order to keep up in the world. This is further strengthened and confirmed in a study about another LMIE country, Haiti [71]. Also, according to [72] as seen in Figure 5.12. The mobile phone is used both for the household practices communicating and entertaining and transferring money et cetera. Thus, this material is now considered necessary in all income economy households. Further, in the Haitian study, the following was explained about the use of mobile phones: *"[...] Haitians are regular users of text messaging, Facebook, e-mail, and chat applications. Heavy uses of online bandwidth, such as videos, were avoided due to their cost."* [71]. The same was found through this study, where communication was often the main reason, but depending on access to the internet, more "heavy uses" were also used and sometimes also prioritized despite having a lack of internet. Further, Facebook is brought up as a *"extremely well engineered to handle intermittent low-bandwidth connections"* [71]. The features and advancement in the phone differs, where a basic mobile phone is much more common than a smartphone. E.g., in the LIE Uganda 57 % have a basic mobile phone while 34 % have a smartphone [73]. Another source state that in Rwanda 58 % have a mobile phone of any kind [68]. While in rural India, around 80 % of the households are said to own a mobile phone.

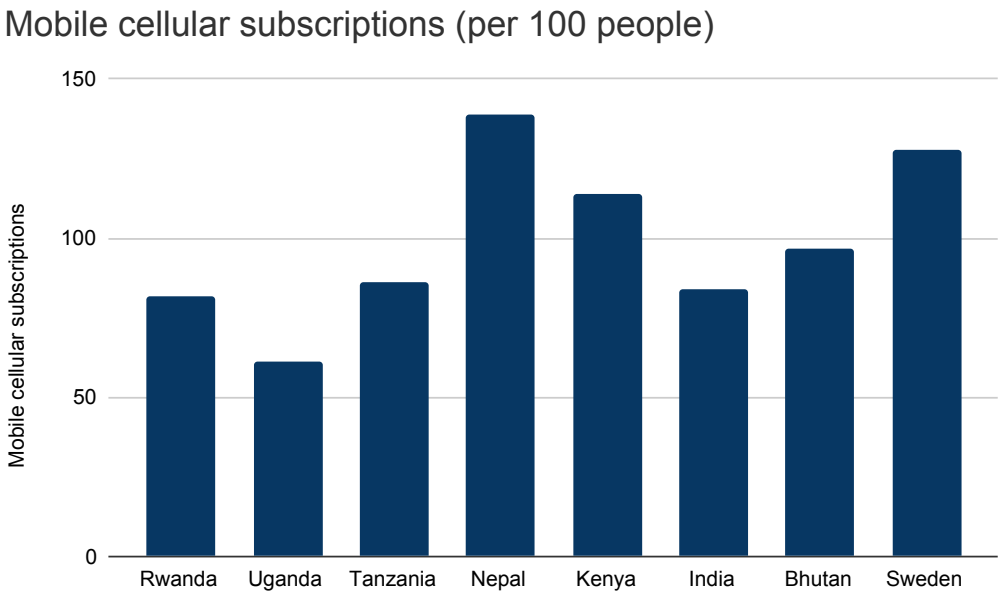

Figure 5.12: An overview of statistics of mobile cellular subscriptions per 100 people in the countries of interest.[72]

A computer is not that common for LIE households to own. According to International Telecommunication Union [74], only 7 % was estimated to have a computer at home in the least developed countries and 36 % in developing countries. In this classification [22], all countries of interest counts as being developing countries, while Rwanda, Uganda, Tanzania, Nepal, and Bhutan account for being a least developed

country. Thus it can be assumed that around 7-36 % of the population in the countries of interest are expected to have a computer. While another source states [68] that in Rwanda, an average of 2,1 % owned a computer, even lower than what was estimated in the previously mentioned source.

When having a computer, it is likely for the households to have some kind of router/-modem. When looking into internet access in the LIE and LMIE households, it differs between 4-42 % of the populations having internet access, Bhutan corresponding to 42 % and Uganda to 4 %, while 25 % is a mean value in the countries of interest [75]. While another source [74] estimates the mobile-broadband subscriptions to be 33 % average in the least developed countries and 65 % average in developing countries. Thus, according to this source, it seems as if internet access is slightly higher.

Lastly, all above, in subsection 5.4.2, stated material elements within the area of lighting might also be seen as to be included in the area of backup systems. As a light bulb indeed uses electricity and may need to be replaced with a backup system. In many ways, households are prepared for this by, e.g., owning candles, fuel lamps, or a flashlight. However, these have already been specified in subsection 5.4.2 and are therefore not brought up more in detail.

5.5.4 Competences connected to backup systems

In this subsection, competences connected to the area of backup systems are described, where some competences are brought up in detail and some more on the surface as many already have been explained in the earlier section of competences connected to backup systems in 5.4.3.

Surprisingly two interviewees, one living in a LIE and the other in a LMIE, both had a power bank but usually did not make sure to keep it fully charged. One interviewee, no. 3 in table 4.2, said that *"[...] it's just that you have to have it charged as well, you often don't think of it until you're in need of it."* So, even in the context of LIE and LMIE, where one always thinks about one's plan B and has some sort of backup in all contexts, it is not self-evident that one has the power bank fully charged.

One interviewee, no. 7 in table 4.2, described the scenario of not having or having less access to electricity: *"The good habits are, that you know we don't have access to electric televisions or something. So, every family, people, you know, gathered together, they talk to each other."* So, not only are LIE and LMIE prepared for outages, but they also have habits of having less electricity or being frugal with what they have. Even better-off people have somehow built up their everyday lives not to be so dependent on electricity.
Same as for the area of lighting, the households always have a plan B, e.g., meaning they have competences in how to cope when a power outage occurs. Therefore, even when not having an electrical backup system, many somehow manage to cope. Also,

having knowledge together and creating together are competences acknowledged in the area of backup system as well. In this area, meaning they rely on each other, communities and overall have collaborations if in need of some backup. Further, which was also found in the area of lighting was that one build with what one has at home and repair instead of buying new. So, instead of buying a new power bank if the one owned breaks, this is something the households try to fix before considering to throw away their old, either by themselves or with the help from others.

In summary, the competences found are the following:

- Not remembering to have the power bank charged, despite often experiencing power outages.
- Family and friends getting together.
- Life in general is built up as to be as independent on electricity as possible.
- Always have a plan B.
- Have knowledge together.
- Create together.
- More communities and overall collaborations.
- Build/fix from what one have, try to take advantage of everything.
- Repair instead of buy new.

5.5.5 Meanings connected to backup systems

Here the element meanings connected to backup systems are brought up. Here only on the surface of the meanings are described as the same has been brought up in 5.4.4 when bringing up meanings connected to the area of lighting.

As earlier mentioned, survival and essential needs are of the highest priority in LIE and LMIE. The interviewees through this study meant that people in LIE and LMIE are, in general, very open to people around them.

The interviewees explained that nowadays, grid-arrival are not the same aspiration as before; due to new technologies that can compensate or even replace the need of the grid. However, it is still considered a need and a way away from poverty and a basic necessity that this is something everyone should have access to. Also, having electricity is compared to being comfortable and safe as well as by having electricity a household have access to what is needed nowadays; e.g., as information spreads through the internet, it is easier to communicate and many technologies are dependent on electricity nowadays and may facilitate the life of LIE and LMIE. At the same time, the interviewees wished for mobile phones and lighting to be less dependent on electricity. The LIE and LMIE households were found to have an aspiration to try to be as independent of electricity as possible. At the same time, they still had the meaning that having electricity becomes a necessity and comfort, especially regarding lighting for different practices and being able to have a mobile phone.

A list summarizing the meanings found throughout this study:

- What is done is done for survival and essential needs.
- Open to people around them.
- Compare brush teeth with amount of power outages.
- Seeing is believing, without electricity you live in the dark.
- When not knowing, you don't know what you're missing.
- Having electricity becomes a necessity and comfort.
- Everyone should be comfortable - having electricity.
- Wishes that telephone and lighting is less dependent on electricity.
- A sense of enough and sufficiently. To be more content.
- Independent of electricity.

5.6 Connections between lighting and backup system and their relating household practices

There are many similarities in the competences and meanings found in the two areas, lighting and backup systems; videlicet most of the competences and meanings can be found in both areas. Regarding the element materials within the area of lighting all of these brought up that is non-electrical would be included in the area of backup systems if including non-electrical backup within the elemental area. Therefore lighting may be concluded in serving as an extension to the area of backup system as defined in the narrowing down.

Further, in figure 5.13 an overview of the connections between the household practices still of interest and specific elements may be seen. Exactly what types of materials that may be used as lighting are not mapped through this study but are visualized in those household practices where each material has been seen being used. Neither type of backup system used in the different household practices has been mapped through this study. The competences and meanings visualized in the figure 5.13 are not always specific to each household practice but often more general for all practices performed in LIE and LMIE as seen through the interviews, observations, online and literature study.

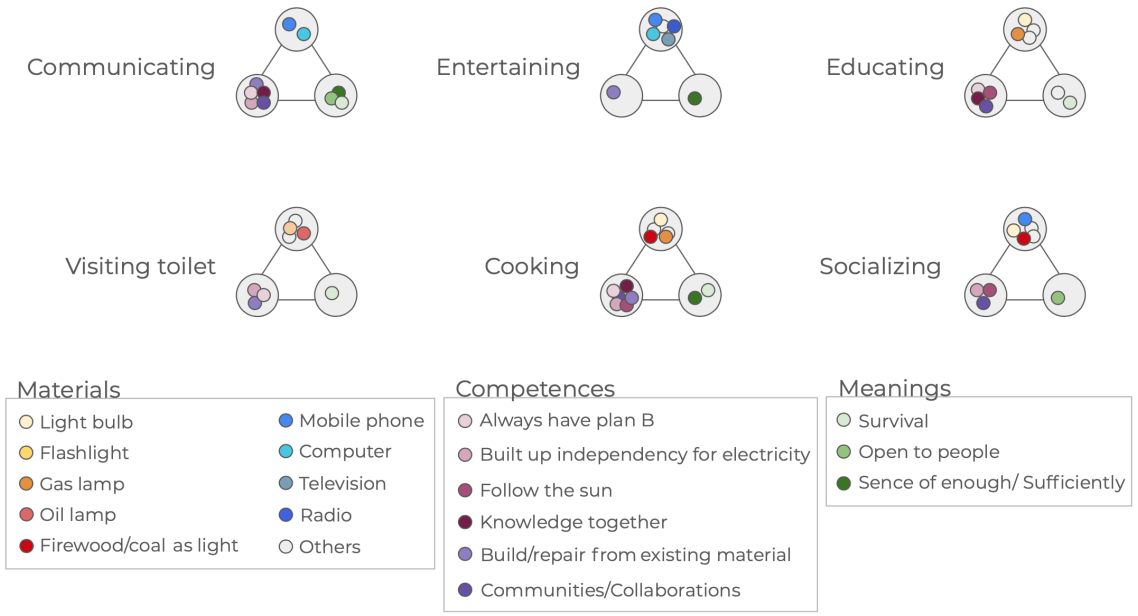

Figure 5.13: An overview of the connections between household practices and specific elements.

In the figure 5.13 a material specifically distinguishing is the mobile phone which is used in communicating, socializing and entertaining. While in entertaining, if using a mobile phone for entertaining also varies depending on prioritizing in the household and economic situation. While any type of light is only essential in the household practices educating, visiting the toilet, cooking, and socializing after sunset.

It may also be seen that the competence build/repair from existing materials can be seen in almost all household practices. Further, all practices are seen as having some sort of dependence on electricity. Also, the competence of always having a plan B can be seen throughout all but entertaining and socializing as here it was not specifically found relevant through the study. Lastly, regarding meanings, surviving is the only distinctive as it is included in four household practices: educating, cooking, and visiting the toilet. This as entertaining and socializing was not characteristic in being essential in being performed.

5.7 Comparison to HIE

Compared to LIE and LMIE, the homes in HIE are on average bigger [76] where fewer people are living in a bigger area. The households have more money to spend and thus also bigger opportunities to save money each month, unlike many of the investigated LIE households where they hoped of enabling their children to go to school and dreamed of saving for a larger home.

First of all, the household practices differ in a way that a HIE household includes a lot more of the element materials than the average LIE, and LMIE households have

been understood to own. This is also confirmed through another research article [21]. For example, in the practice cooking, a HIE households generally have a lot of electrical kitchen appliances. They may have a hand blender, a second bigger blender, a juice press, an electric mixer, a coffee maker, a microwave oven, a refrigerator, a freezer, an oven, a stove, et cetera. The list could go on, but the point may have been proven with this fairly long list. In the practices communicating, entertaining, and socializing, a mobile phone is used in a HIE. While a LIE may share or have less advanced mobile phones, a HIE most likely would have one advanced smartphone each in a household, and with high certainty, the phone is exchanged regularly.

Regarding competences, the average households in HIE are not prepared as LIE and LMIE have been understood to be, as, in the latter context, one must always have a plan B due to frequent power outages or economic situations. In HIE, that has not yet become a necessity, but may as well if the future scenario becomes a reality, as mentioned in the introduction of this thesis. Furthermore, in most households in a HIE as Sweden, survival needs are not of priority to always think about as the economic situation is overall better. Still, for example, cooking is as essential in a HIE as households in this income economy are as much in need of food as in LIE and LMIE.

As the household practice cooking is characteristic for a HIE having a lot more electrical appliances, i.e., more of the element materials, while the general competences and meanings have not seemed to differ in amount, this is visualized in figure 5.14 as a depicting picture of a HIE household having other wherewithals than a LIE. In the same figure, it can be seen that in the LIE context, the element material contains no material, where only electrical is included, thus showing a remarkable difference in the practice performed in a LIE versus a HIE. In a HIE household, the practice is generally always dependent on electricity while compared to a LIE, the practice is independent of electricity, still with exceptions for some financially better-off households that own a refrigerator then it may be considered partly independent of electricity or if the household possibly uses electrical lighting, i.e., a light bulb. Moreover, and an important mention, a LIE and LMIE household still have material elements within the practice of cooking; while these are independent on electricity, they also own and use much less. This depicts a main difference found between HIE versus LIE and LMIE, as a HIE household generally has more things, i.e., materials, in their home.

Interesting is the fact that both LIE, LMIE, and HIE bring up cooking and their mobile phone (communicating/entertaining) as two areas (households practices) considered the most important. This was seen through all interviews performed in this study regarding LIE and LMIE as well as those regarding HIE, confirmed according to the main project's study [77].

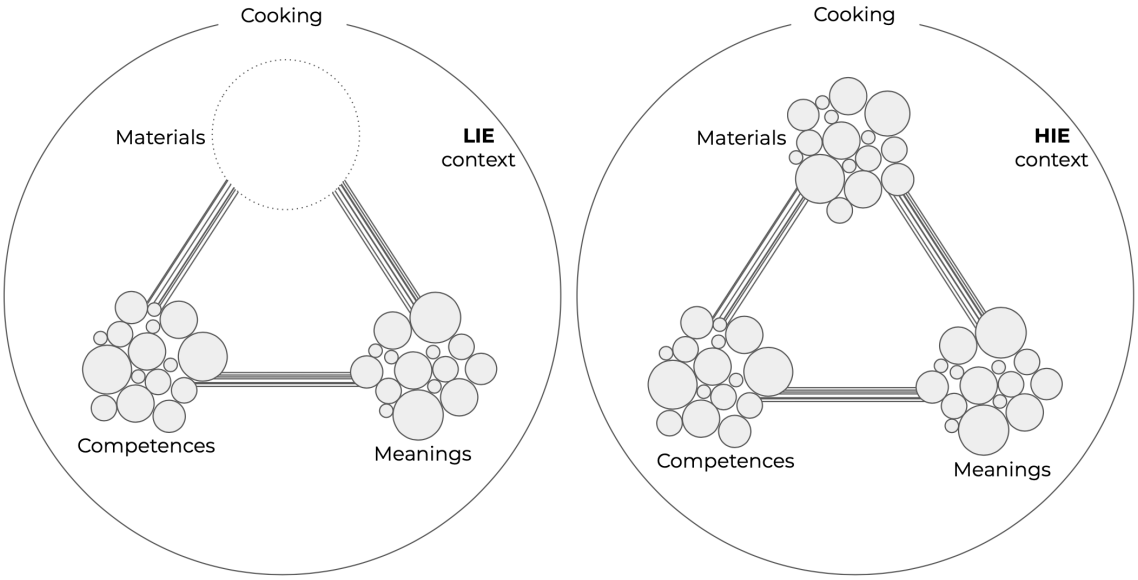

Figure 5.14: Comparison of the household practice cooking in LIE and HIE, where the element material can be seen differing a lot. In materials only electrical kitchen appliances are included

Hence, the following conclusions through a comparison of a HIE versus LIE and LMIE can be made. There are many differences between the income economies regarding the different practices, differences in wherewithals and other prerequisites, differences in competences such as preparedness of a household, et cetera. Despite HIE having more of the element materials than the average LIE and LMIE in connection to the practices, the most important practices brought up of the households' basic needs when experiencing a power outage remain the same regardless of what type of income economy. That is cooking and communicating, where the mobile phone within communicating and entertaining is why those practices are the most important. Therefore this may point towards a possibility of a solution, the same for all income economies helping a household when experiencing power outages. While this will be further investigated and concluded through the rest of this master's thesis study.

5.8 Design brief

A design brief was compiled from the first half of the master's thesis, from the defining of opportunities. Saying, a design within the narrowed down area of backup system and lighting which help a household when experiencing a power outage and in being energy resilient, either temporary or for a longer period. It should more specifically help with being energy resilient before or in the event of a power outage; thus, as the master's thesis definition of energy resilience, a design aimed to help a household respond to, recover or resist various disturbances in the context of everyday household practices. The idea generation should result in one or more design proposals as concepts with the intention of being designed for all income economies. Where designed for all income economies mean being able to work and help in the four income economies, low, lower-middle, upper-middle, and high, separately. As stated in the master's thesis aim: *"A proposal that encompasses the union of all*

income economies through an exploratory study; thus, a proposal that contributes towards reduced dependence on reliable energy systems". Hence, the design can be verbalized as intended to be designed for the sought future emerged "medium" as in the model in the earlier presented figure 1.1.

The design output aims to visualize and evaluate energy resilient solutions with potential future users, i.e., different types of households in all income economies. It should therefore result in visualizations as conceptual sketches and descriptions of the concepts. Additionally, the solution is open for being technical, social, physical, or non-physical, or a combination.

As a help in the design brief, lists of the materials within the narrowed down area in LIE and LMIE and the practices connected to the area are included. While these also can be seen and described in the sections 5.4 and 5.5. These are included as this serves as a compilation of the needs the designs should meet and functions as an inspiration for how LIE and LMIE already use material in being energy resilient.

Material today within backup system and lighting in LIE and LMIE households helping to be energy resilient are:

- Battery backup system
- Power bank
- Solar charger
- Solar backup system
- Candle
- Oil lamp (incl. oil)
- Kerosene lamp (incl. kerosene)
- Gas lamp (incl. gas)
- Flashlight
- Solar cell lighting

Also, materials not directly included in the narrowed down area and helping in being energy resilient, but instead connecting to and comprising of other types of material being used in connection to the area are:

- Mobile phone
- Tablet
- Router/modem
- Computer
- Television
- Radio
- Light bulb

The household practices in connection to backup system and lighting are:

- Communicating
- Entertaining
- Educating
- Visiting toilet

- Cooking
- Socializing

5.9 Dimensions

As the last step in defining the opportunities, dimensions were chosen and formed from the meanings and competences found in the earlier sub-phase, 2.3 Detailed defining, as described in the methodology section 4.3.13. These dimensions helped shape the ideas generated throughout the ideation and later when eliminating the idea space. The dimensions are individual versus shared and old material versus new material together with futuristic. Derived from the meanings and competences listed below, which also can be found described in sections 5.5 and 5.4.

Individual versus Shared:

- Competences
  - Family and friends getting together
  - Have knowledge together
  - Create together
  - More communities and overall collaborations
- Meanings
  - Open to people around them

Old material versus New material/Futuristic:

- Competences
  - Build/fix from what one has, try to take advantage of everything
  - Repair instead of buy new
- Meanings
  - A sense of enough and sufficiently. To be more content.

5.10 Market analysis - Benchmarking

Before the main idea generation was performed, market analysis in the shape of benchmarking was made. The benchmarking collected solutions available for online purchase both in LIE and LMIE, as well as HIE. Hence, all may not be available for all income economies financially or practically. The benchmarking gives an overview of what has been found to be available on the market today before presenting the ideas generated through this study.

There are variations of backup systems and lighting solutions and might be products with one or more functions: radio, battery backup, flashlight, solar cell charging, grid charging, or crank charging. The backup system variations are, e.g.: portable battery backup with grid charging; battery backup with a built-in lamp and only charged with solar power; crank radio with built-in power bank and flashlight. There is also something called Uninterruptible Power Supply (UPS), which is essentially a battery backup connected between a grid outlet and one's selected appliances.

These appliances are not to be affected when a power outage happen as the UPS takes over the supply in such an event. Another complement and backup system available is a foldable solar panel to be used when charging appliances or enabling light without grid electricity. Lastly, on the market, there are portable sun-powered lamps or flashlights running on both rechargeable and not batteries.

Connecting to the presented dimensions, all found solutions are both *new material* and *individual*. Hence, all solutions are new products that are newly manufactured factory made. Also, all build on individual energy resilience instead of being shared in a community or society. No solutions with the intention of being shared were found in the market analysis.

Out of all presented solutions, a flashlight with batteries and a small power bank suiting for charging a smartphone is most common in a HIE household, while owning bigger battery backups or advanced backup systems is less common. UPS is more common in a LIE and LMIE household than in a HIE, according to the interviews when exploring the context in the study. Still, having extra batteries to cover when there is a power outage was found to be unusual in LIE and LMIE, and is more common for households that are better off economically. Hence, many of the solutions found are too expensive for many, if not most, of LIE and LMIE households. On the other hand, all are most likely available and possible for the vast majority in a HIE household.

5.11 Result from idea generation and elimination

In this section, the results from the idea generation process are presented. First, an overview of the compilation of all ideas and the elimination of ideas. Then the eight remaining and final concepts are presented, and lastly, a summary of factors found when designing for all.

5.11.1 Compilation of all ideas

An overview of the compilation of all generated ideas throughout the individual brainstorming sessions and the performed workshops can be seen in figure 5.15. In total, 144 ideas were generated throughout the ideation. They comprised both complete concepts and partial solutions and ideas outside the narrowed-down area. An interesting observation of the ideas generated in the separate co-creation workshops, LIE/LMIE versus HIE, was that they were not seen as different as perhaps one would have thought, but instead, many ideas were somewhat similar to each other.

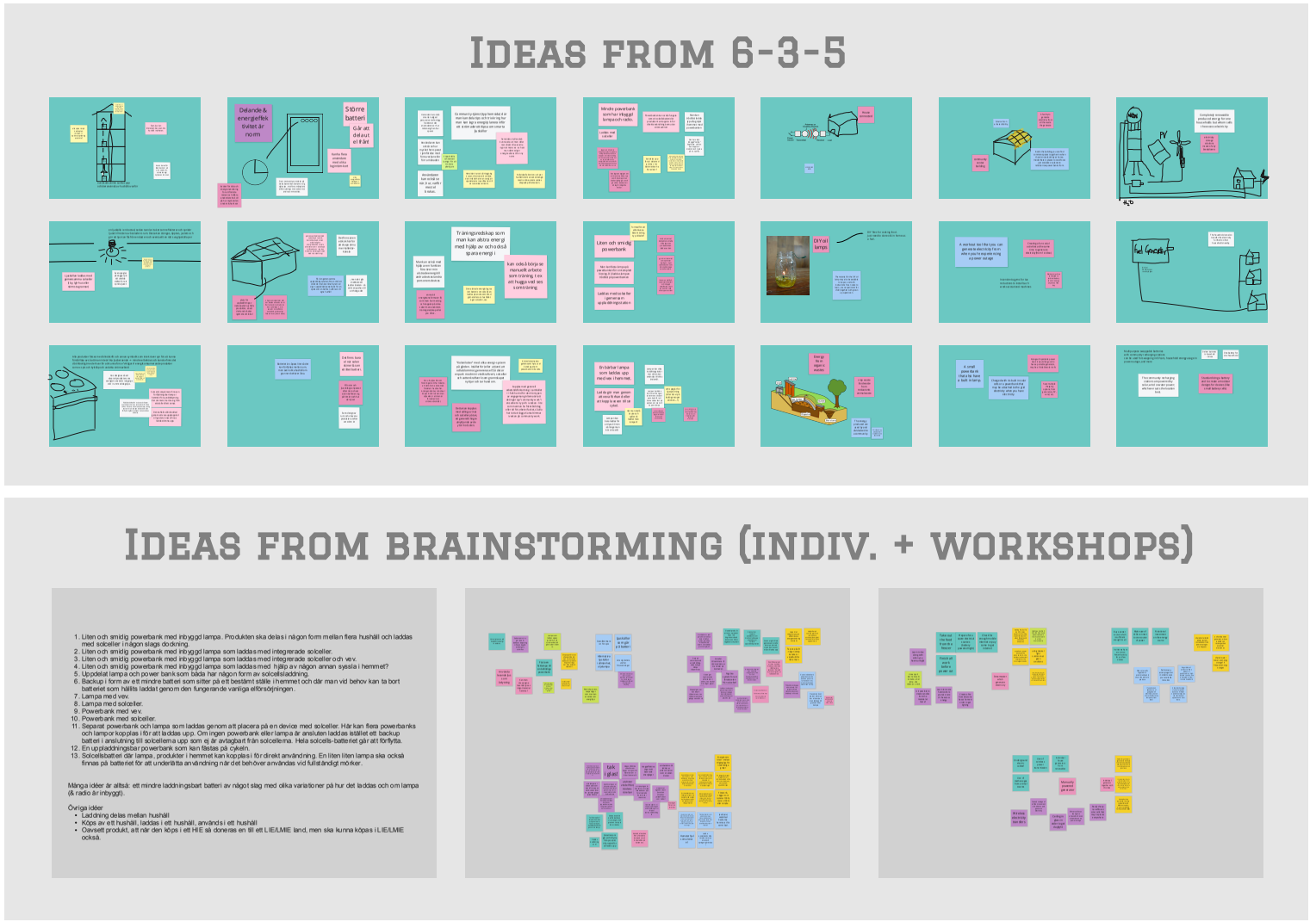

Figure 5.15: An overview of the compilation of all generated ideas throughout the idea generation process.

5.11.2 Elimination of ideas

In the elimination of ideas, the idea space started at 144 ideas and concluded in 8 remaining concepts.

Categorisation

Different categories were investigated to base the categorization of the ideas. This was to eliminate the ideas according to as big variation as possible in the idea space once the elimination was done. The categories are formed of different idea sizes, different types of ideas, and the two dimensions shared versus individual and novelty, i.e., old material versus new material. A figure visualizing an overview of the utilized categories can be seen below in figure 5.16.

The following categories were considered in the elimination of ideas: if the concepts were small or big scaled; if the concepts were a product, service, or both; shared or an individual household concept, if made out of old material, new material as well as futuristic; and lastly if the type of ideas covered electricity backup, lighting or both areas as well as if the concept were non-physical. The last-mentioned category, non-physical, is thus not ideas directly helping in a power outage situation but indirectly through some sort of information source, unlike the other three mentioned in the same category area. Further, the category "shared" is divided into four different subcategories to more easily decide how shared a concept is. These subcategories are: create energy together; distribute energy together; do energy-intensive chores together; and lastly, share information about energy. If a concept falls under more than one of the subcategories, it is considered more shared. Also, if compared with each other to share information about energy are considered less of a shared concept than the other three subcategories, as this requires fewer requirements of the users both in time and by and between each other.

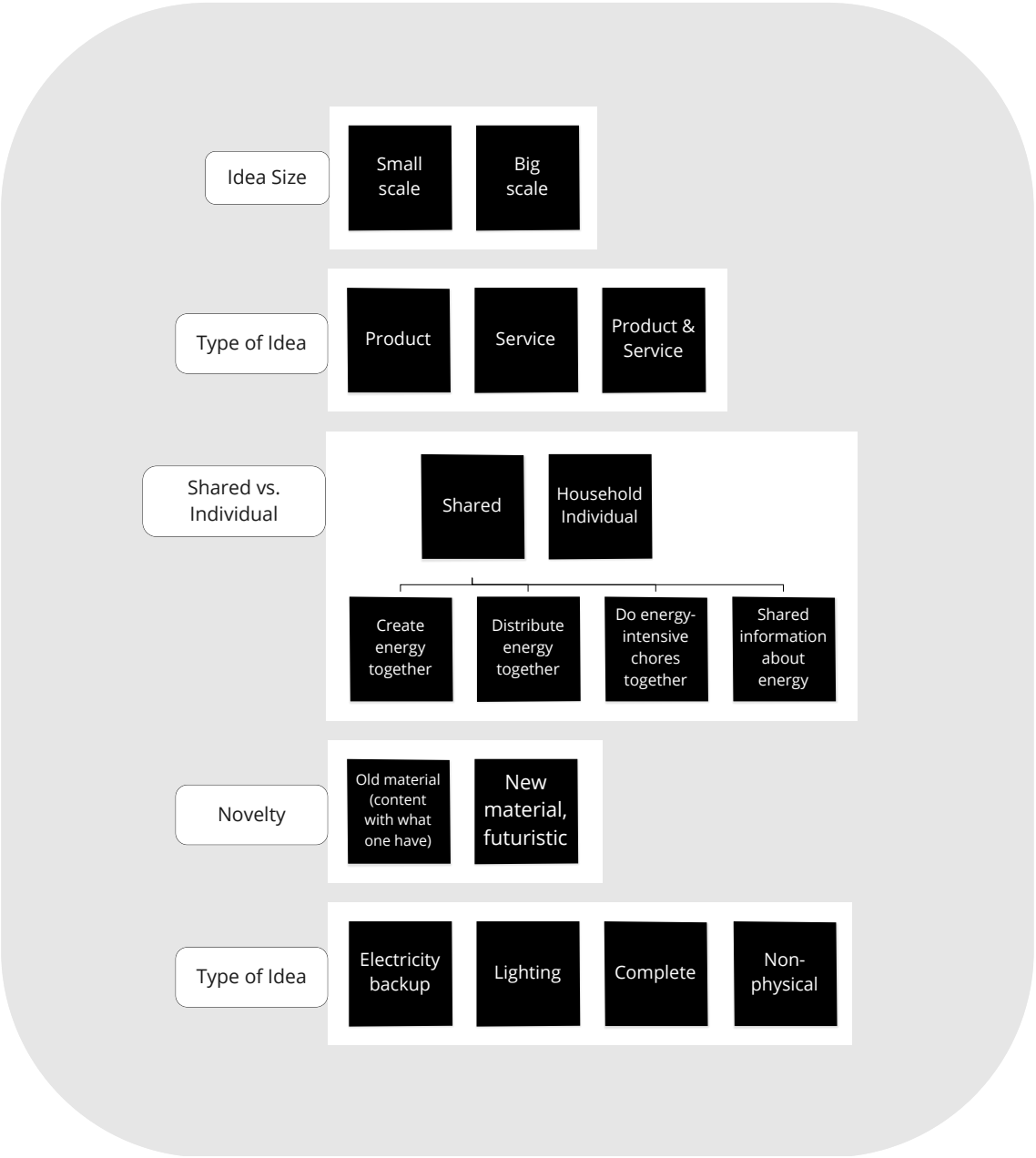

Figure 5.16: Different categorisation used throughout the idea elimination process in order to divide the ideas generated.

Cross matrix

In the second stage of the idea elimination, the cross-division, the ideas were visualized of their differences through a cross matrix with the dimensions on each axis. They range from individual to shared on the x-axis and new material or futuristic to old material on the y-axis. The dimensions functioned as important main tracks in differentiating the ideas. An overview of the cross matrix can be seen in figure 5.17. As shown in the figure, the ideas are distinct individual, if considered individual, while the shared ideas are more spread throughout the axis. The individual ideas are spread throughout the old/new-material axis, while the somewhat shared ideas

are more clustered and almost solely in the fourth quadrant, shared and new material/futuristic. This makes the least amount of ideas generated in the first quadrant, only two ideas considered to be both shared and old material.

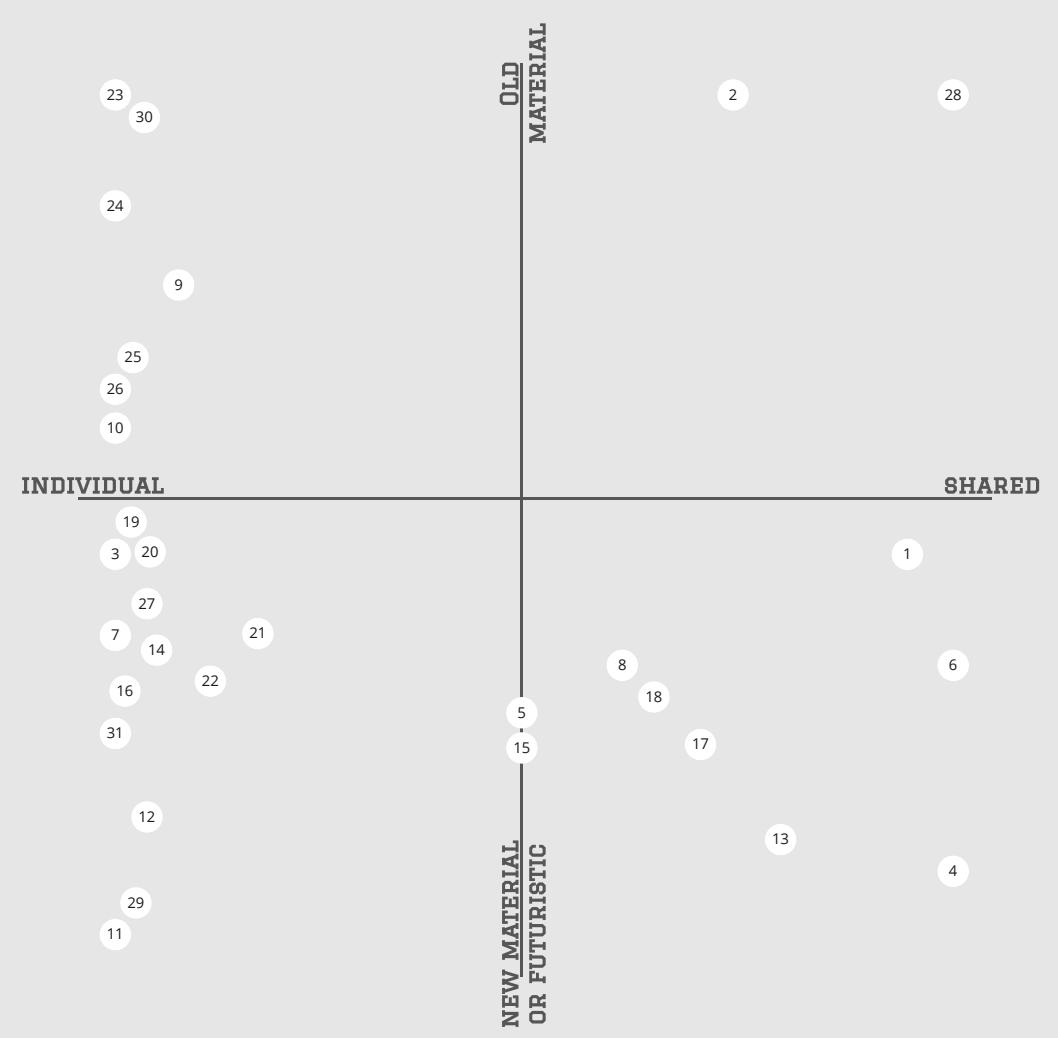

Figure 5.17: An overview of the cross matrix, where with the use of the dimensions on each axis help in visualizing the distribution in ideas.

Final elimination of ideas

Lastly, in the idea elimination process, eight ideas remained, which resulted in a wide range of ideas throughout the different categories as earlier presented in figure 5.16 and finally, these concepts circled in figure 5.18. Two electricity backup solutions, three lighting solutions, two complete solutions, and one final non-physical solution. The ideas are considered to constitute a wide range throughout the earlier categorization groups.

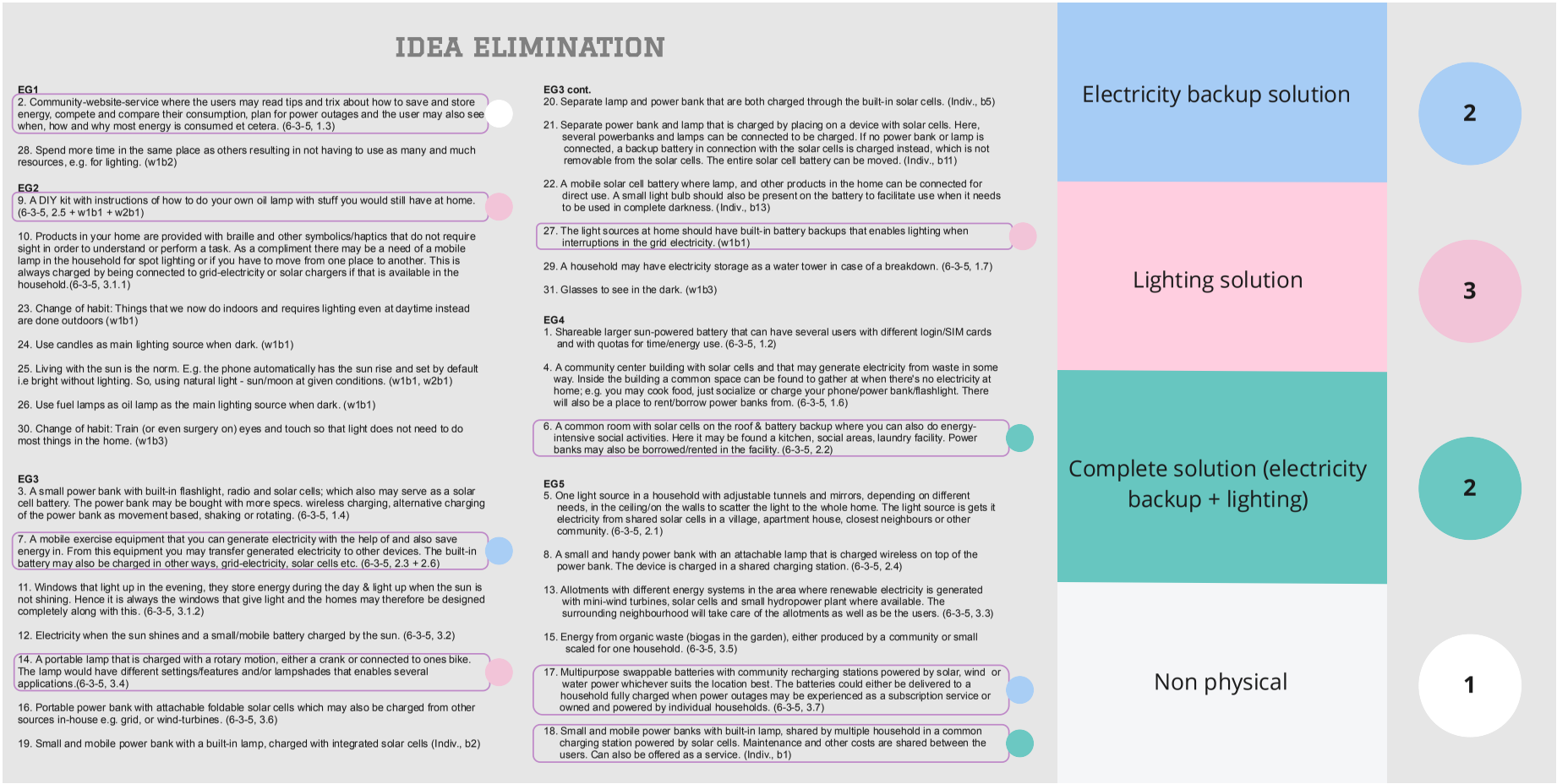

Figure 5.18: An overview of the final idea elimination stage. Here the categories of as well as in which elimination group from the cross division each remaining concept belongs to can be seen. Also, the amount of ideas in each category of type of idea can be seen in the circles to the right.

5.12 The eight concepts

In this section, the eight remaining concepts are presented. The idea space resulted in these eight concepts due to constituting as a comprehensive wide range of the different categories utilized throughout the elimination process. Thus, the number of eight concepts was not set in advance but instead ended up at this number when the concepts did not overlap too much or too little in the different categories.

An overview visualizing all eight concepts can be seen as figure 5.19. Concept 1 is a community website service. Concepts 2, 3, and 4 are solely lighting solutions, where concept 2 is a DIY oil lamp kit, 3 is a portable lamp with a crank, and 4 is a light bulb with a built-in battery. Concepts 5 and 6 are electricity backup solutions, where 5 is a self-owned battery backup, and 6 is a battery backup subscription. Lastly, concepts 7 and 8 are complete solutions, thus combining both electricity backup and lighting solutions. Concept 7 is a community center building, and lastly, concept 8 is a shared battery backup station.

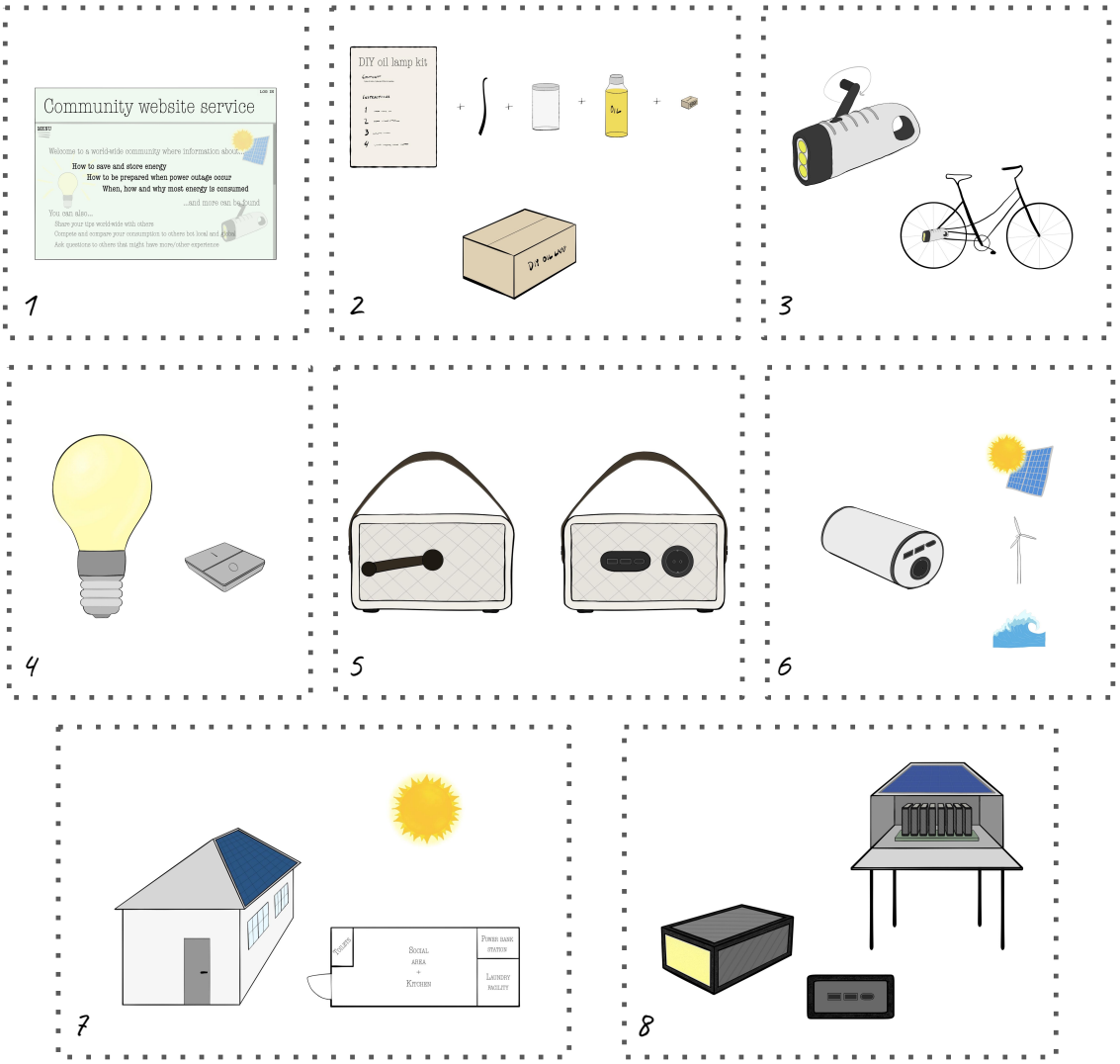

Figure 5.19: An overview of the eight remaining concepts.

In the following subsections, explanations of each concept are given. In these explanations, all possible details are not given, but rather details and all important aspects that have been seen as important to include in the first steps of the concepts. Important details that are not thought to be changed with a concept are mentioned, but varying factors, e.g., the size of the concept, design appearance, and exact capacity of a battery, are either not definitive or unsaid. Hence, more development, elaboration, and tests should be done if continuing with any of the concepts.

5.12.1 Non-physical solution

In this subsection the non-physical concept, concept 1, is presented.

Concept 1 - Community website service

A community-website-service with information, tips, and tricks connected to energy usage constitutes concept 1, helping households when experiencing a power outage and being energy resilient. Hence, the concept can indirectly help prepare a household to respond, recover, or resist disturbances. It serves as both a website and an app where users can log in to enable specific tips according to location and personal preferences. When the user has logged in, he or she can download information to his or her mobile phone, computer, or tablet, to use in an offline mode.

In figure 5.20 a visualization of the concept can be found. The information, tips, and tricks found through this site are: how to save and store energy; how to be prepared when power outages occur; when, how, and why most energy is consumed. One can also share tips worldwide with others, compete and compare one's consumption to others both local and global, and ask questions to others that might have more or other experience.

Figure 5.20: Visualization of concept 1, a community website service.

The website or app is indented to be used in advance of the next power outage, enabling the readers to prepare and be more prepared before the next. Nevertheless, it can also be used when experiencing a power outage if a user has prepared for offline mode or uses one's mobile data. This concept thus creates a new practice in being prepared in advance or searching for information once it happens. Also, the concept intends to work for all income economies, while many households, mainly LIE, still use a simpler non-smartphone type of phone. For that reason, the concept does not work for everyone in all income economies. However, the households that this solution does not work for at the same time are most likely not the ones most in need of this solution.

5.12.2 Lighting solution

In this subsection, concepts being only lighting solutions are presented, consisting of explanations of concepts 2, 3, and 4.

Concept 2 - DIY oil lamp kit

Concept 2 is a DIY (do it yourself) oil lamp kit, including all supplies and instructions on how to assemble the oil lamp with stuff you would still have at home. The kit is visualized in figure 5.21. This concept intends to show that it is possible to create light with small means and things common for many to already have at home. There is not always a need to buy new things but instead use what is already in one's household. A household may buy this kit themselves, or it may be donated to some areas with the purpose of spreading this mindset. Hence, through spreading a mindset, more people without buying or receiving could create an oil lamp of their own with things they have at home.

The oil lamp kit is intended to be assembled and tested before a power outage occurs to prepare a household in advance of the next power outage. However, a household may as well have the oil lamp kit at home still boxed and assembled when the outage occurs. This concept is creating new practices of preparing and assembling the kit that the user needs to do. Still, the kit can also be used for demonstrative purposes of showing one may as well cope with what is already available at home. Thus, the concept is intended for all income economies showing with small means a household can prepare or cope when experiencing a power outage and in being energy resilient. Hence, the concept may help a household respond to and resist various disturbances.

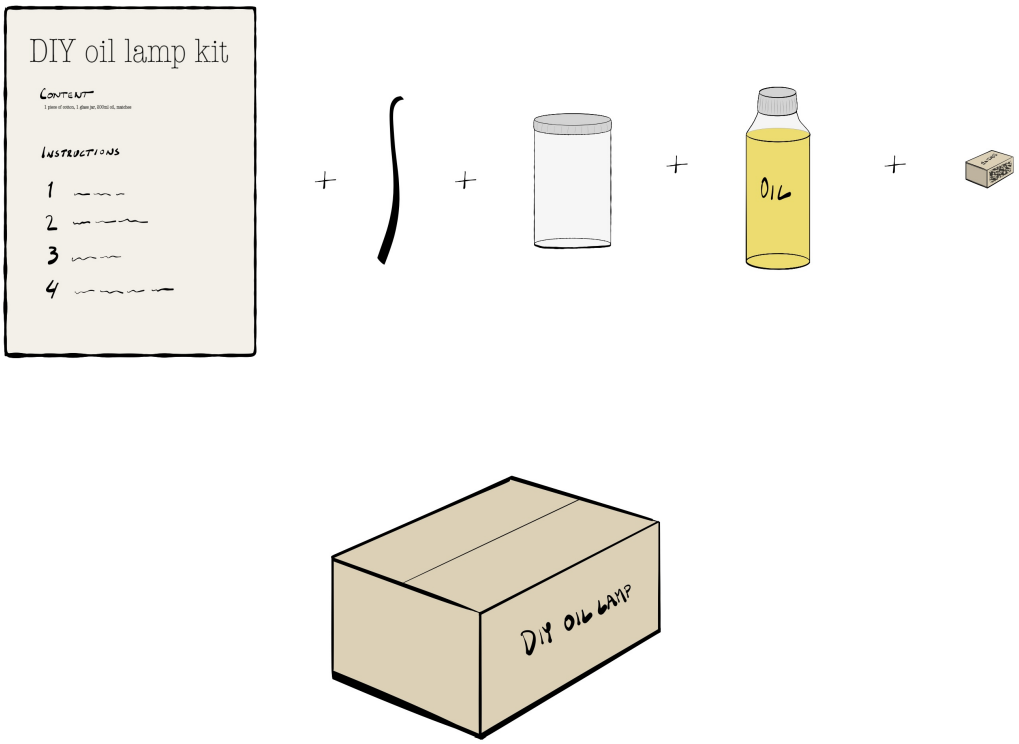

Figure 5.21: Visualization of concept 2, a DIY oil lamp kit.

For this DIY Oil lamp, it is important to mention that aspects of avoiding kerosene instead, using some sort of vegetable oil should be recommended. This, as a Kerosene oil lamp, entails breathing in toxic fumes [78, 79, 80]. Vegetable oils do not produce toxic byproducts, and cheap olive oil is the best recommendation to use, while also, e.g., sunflower oil is cheap and can be used; however, this produces some smoke [80]. As for the wick, it should be in cotton, and it is ideal if it is braided [80]. Still, any cotton is possible, e.g., an old shoelace, strips of old clothing, or a string.

Concept 3 - Portable lamp with crank

Concept 3 is a portable motion-charged flashlight, where visualization of this concept can be seen in figure 5.22. The flashlight should be small enough in order for it to be handheld. The lamp is a LED light, as LED lights have less power consumption, produce less heat, and can accommodate more battery space [81].

The flashlight has a battery or other type of storage of energy which is charged with a rotary motion, principally through rotating a crank that is attached to the lamp, while the lamp can also be connected to one's bicycle in order for it to be fully charged at a faster pace. This connection to one's bicycle is possible through an adapter, but exactly how the adapter is designed is left indefinite. According to a study where patterns regarding bicycle ownership were investigated globally, household bicycle ownership ranges from 20 % to 80 % according to a study where

patterns regarding bicycle ownership were investigated globally [82]. Where the seven chosen LIE and LMIE in this study ranges from 20-40 % households having bicycle ownership, while the HIE Sweden has one of the highest ownership percentages with over 80 % [82]. Nevertheless, the concept does not require owning a bicycle, while it could entail the concept being less appreciated in countries with lower ownership rates.

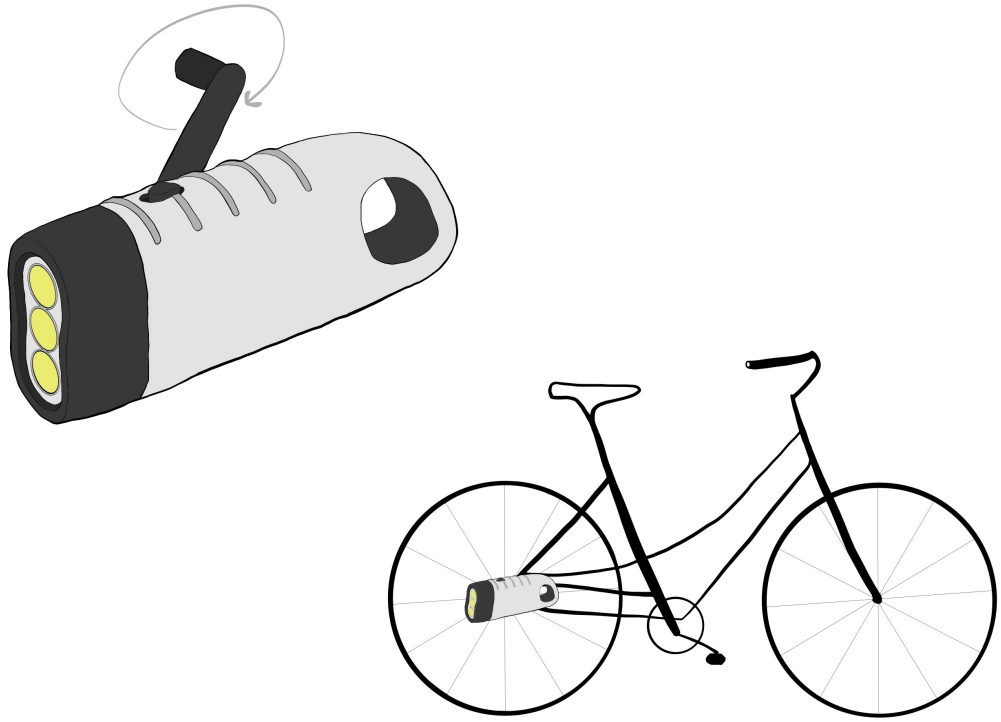

Figure 5.22: Visualization of concept 3, a portable lamp with crank.

So, this concept is to be used in a power outage, enabling a household to have light and be energy resilient. Hence, the concept may help a household respond to and resist various disturbances. This concept is intended to work for all income economies, including households not having access to electricity. Also, the concept entails a new, or for some, a developed, form of practice, meaning one has to crank to create light. While a developed practice as some usually use candles or oil lamps to create light, that can also be considered "some work" to create light, other than simply pushing a button.

Concept 4 - Light bulb with built-in battery

The fourth concept is a LED light bulb with a built-in battery backup. A visualization of the concept can be seen in figure 5.23. The lamp is a LED light as this type is energy efficient, produce low heat, and can accommodate more battery space [81].

The light source enables lighting because of its built-in battery for a certain period of outages or interruptions in the regular electricity supply. This is as it is kept charged through its normal placement, and no user requires charging it as

preparation. Therefore, no new practice is created through this concept, but simply continuing “as normal” regarding lighting when experiencing a power outage. The LED light may automatically dimmer somewhat to enable a longer duration of time it lights up on the built-in battery. There is a corresponding remote control for the light bulb to be powered on and off.

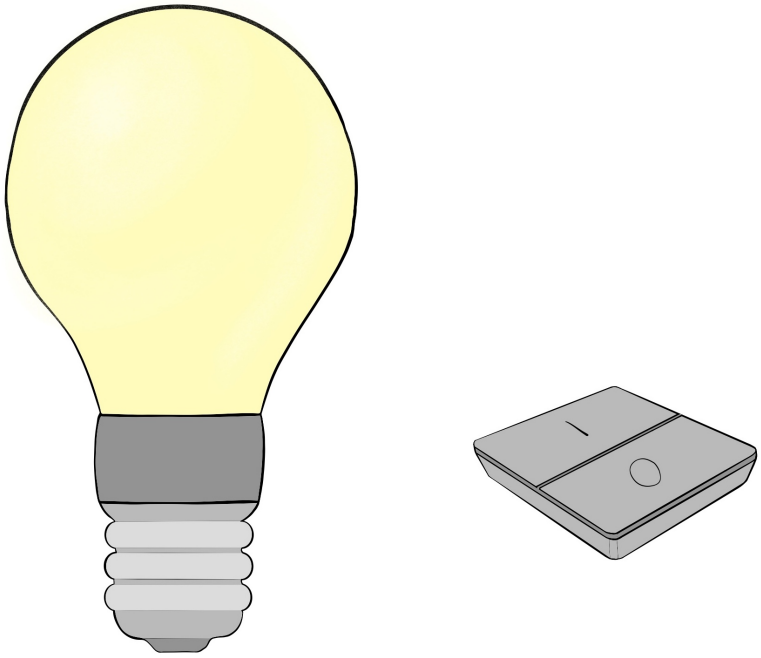

Figure 5.23: Visualization of concept 4, a LED light bulb with built-in battery enabling lighting when temporary not having access to electricity through the households normal supply.

This concept intends to be able to work for and help all income economies households when experiencing a power outage and in being energy resilient. Hence, the concept help a household respond to and resist various disturbances automatically. Still, only those households have access to some form av electricity in the first place, grid electricity or individual solar-powered do not matter.

5.12.3 Electricity backup solution

In this subsection, concepts being only electricity backup solutions are presented, consisting of explanations of concepts 5 and 6.

Concept 5 - Self-owned battery backup

Concept 5 is a mobile battery backup with a detachable motion charging through rotating a crank. The concept can be seen in figure 5.24. Electricity can either be generated to the battery through motion charging by rotating the crank or be charged through grid electricity as preparation before experiencing a power outage. At the same time, the best utilization of the concept will probably be to have it charged in advance of a power outage and use the crank as a complementary

method in charging the battery. This concept creates a new practice as the household needs to prepare the battery backup either by having it charged or using the crank to charge the battery. While when using the concept in the event of a power outage, no new practice is created.

The battery backup outlets should potentially be USB-3, USB-C, and the standard socket from the country where the concept is used. In this battery, one may, in turn, e.g., plug in a lamp, charge one's phone, tablet or run a smaller computer for a shorter while.

Figure 5.24: Visualization of concept 5, a self-owned battery backup with an detachable motion charging crank.

The concept is bought and utilized by one individual household and intends to be able to work for and help all income economies households when experiencing power outages and in being energy resilient. Hence, the concept may help a household respond to, recover from and resist various disturbances. Depending on the efficiency of the crank charging, the concept may work for a household that usually is without access to electricity. While this type of household, commonly a poorer household in a LIE, do not have a need and may not afford it; it still could open doors in utilizing a more sustainable and especially more healthy option enabling light together with a light source, without fumes from firewood or bad oil lamp which compromises with the household's health.

Concept 6 - Battery backup subscription

The sixth concept consists of multipurpose swappable battery backups charged and stored through community recharging stations, visualized in figure 5.25. A multipurpose battery powered by solar, wind, or water power, whichever suits the community recharging station's location the best.

The batteries are still small but sufficient for the smaller needs when experiencing power outages, such as enabling necessary lighting, charging a phone tablet, or possibly charging a smaller computer for a shorter while. Same as concept 5 the

outlets on the battery backup should therefore potentially be: USB-3, USB-C, and the standard socket from the country in question.

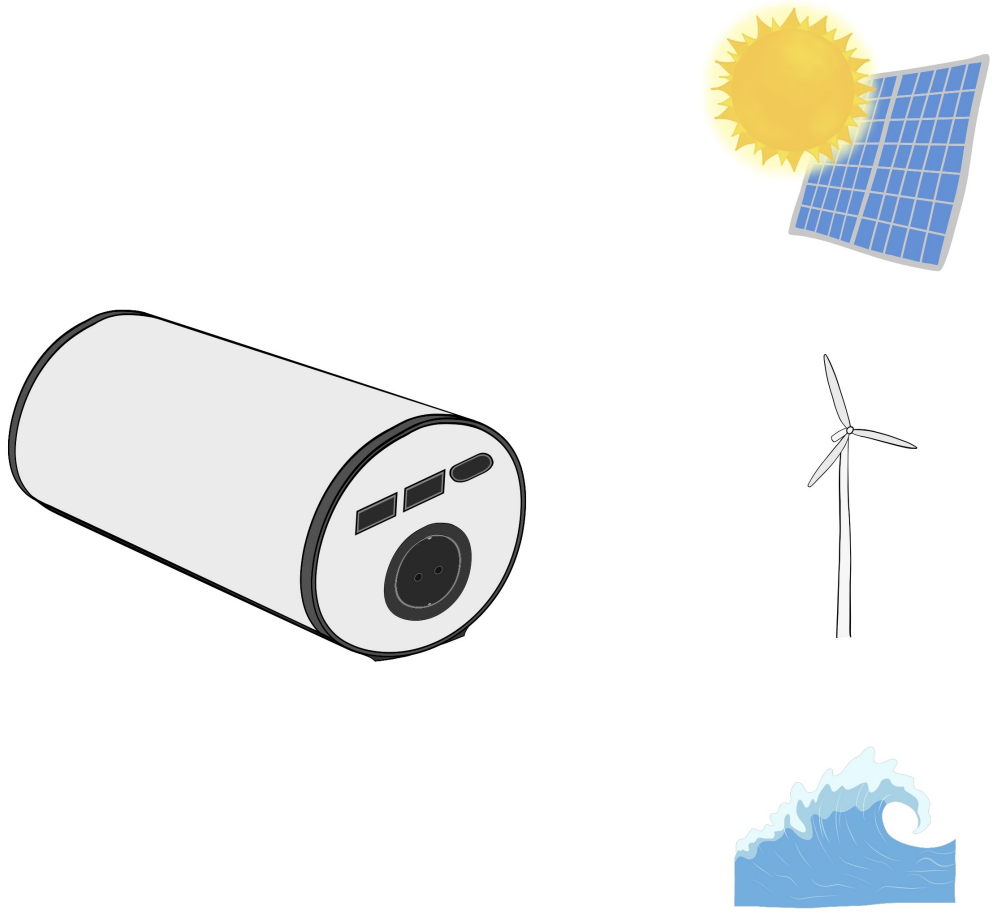

Figure 5.25: Visualization of concept 6, a battery backup subscription.

The batteries could either be delivered to a household fully charged when power outages may be experienced as a subscription service or also owned and powered by a smaller community, e.g., a few neighbors collaborating. Either way, the concept is considered shared between users. Hence, the concept may help a household respond to, recover from or resist various disturbances, depending on when the solution is delivered. The concept intends to be able to work for all income economies, while affordability is of priority for especially LIE and LMIE. If the concept is to be able to work there, it needs to be cheaper than other solutions. Further, the same stands as with concept 5, a household normally without access to electricity, commonly a poorer household in a LIE, does not have a need and may not afford it. Still, this concept could open doors in utilizing a more sustainable and especially more healthy option, enabling light together with a light source, without fumes from firewood or bad oil lamp, which compromises the household's health.

5.12.4 Complete solution

In this subsection, concepts being complete solutions are presented, where both lighting solutions in combination with electricity backup solutions are presented. In this category, concepts 7 and 8 are therefore included and explained.

Concept 7 - Community center building

Concept 7 is a community center building with battery backup powered by solar cells on the building's roof. The concept can be seen in figure 5.26. In this building, one can normally also do energy-intensive activities, but first and foremost, it is created as a space when experiencing power outages. The concept is thus helping a household when experiencing power outages and in being energy resilient for both a temporary or longer time. Hence, the concept may help a household respond to, recover from or resist various disturbances, depending on when arriving in connection with the disturbance. The community center building functions as a common room, where a kitchen, social areas, laundry facility, and toilets/bathrooms can be found. Also, power banks may be borrowed or rented in the facility. Thus, this concept creates an alternative way of performing one's household practices.

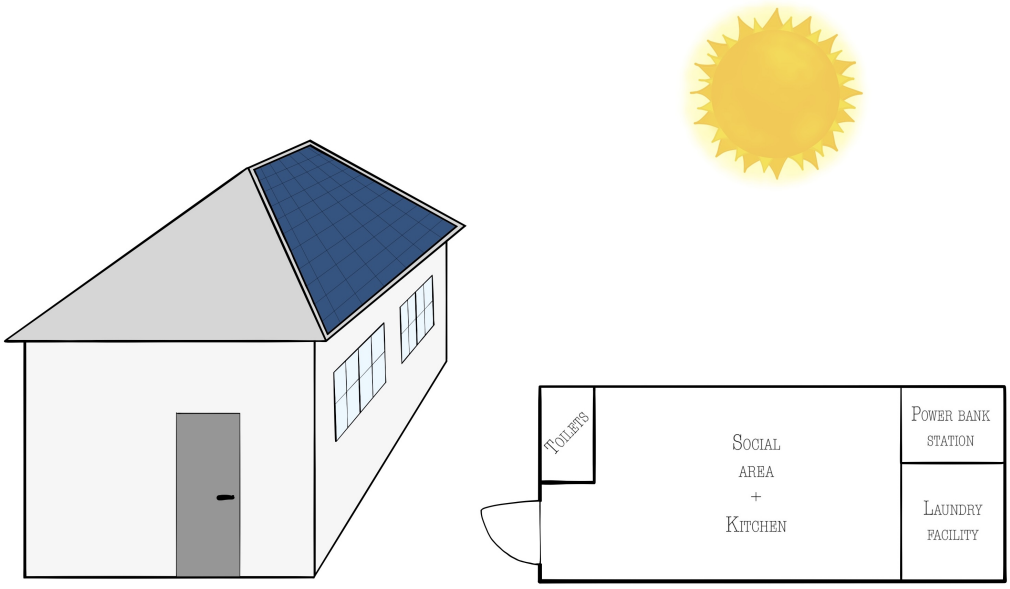

Figure 5.26: Visualization of concept 7, a community center building.

Either the community center is owned by a company or a certain number of neighbors; this depends on what suits the location best. The distance from the users to the community center is undecided, and how many users may share the concept. The concept is intended to be used in all income economies and utilized by all within each; still, the affordability of using this concept is of importance for it to be possible for all.

Concept 8 - Shared battery backup station

The last concept, concept 8, is a shared mobile battery backup with an integrated LED lamp, which can be seen in figure 5.27. Multiple households and neighbors share the battery backup. It is placed at a common self-service charging station powered by solar cells. When the battery is discharged, it should be returned to the charging station again. The distance from users to the charging stations is undecided, and how many users share the concept. Thus, additional practice is formed through this concept of getting to the place where the battery backups are being located. Otherwise, when a household gathers the battery backup, the practices can be performed as normally performed in the household.

Maintenance and other costs are shared between the users. The concept can also be offered as a service by a company instead of owned by neighbors, depending on what suits the location the best.

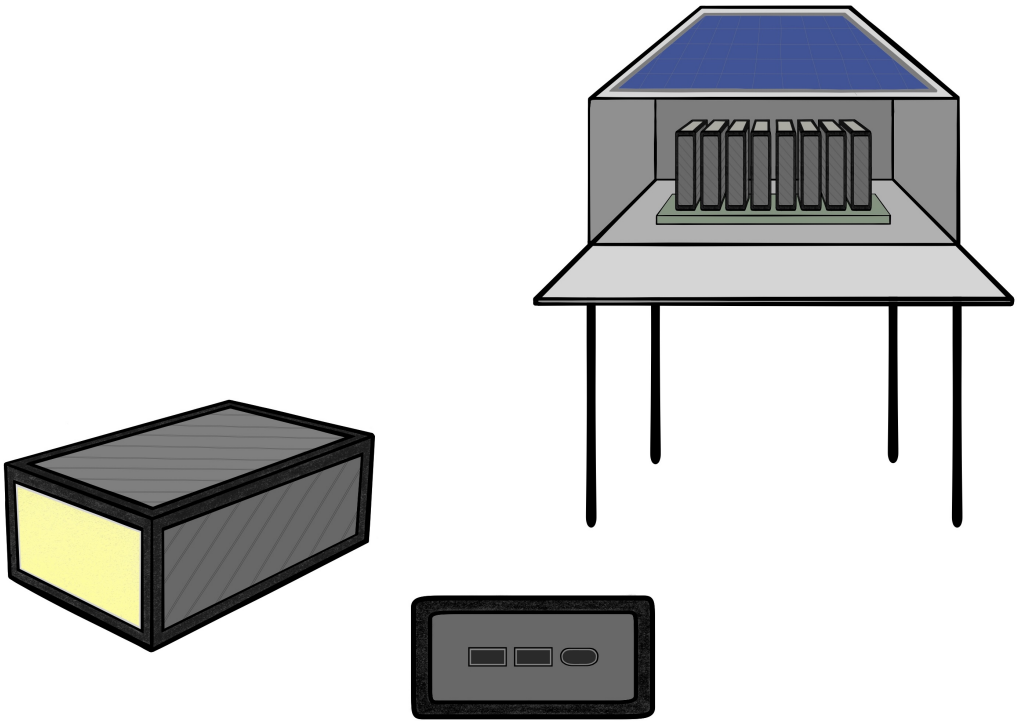

Figure 5.27: Visualization of concept 8, a shared battery backup station.

Same as the other concepts with battery backup, the batteries are still small but sufficient for the smaller needs when experiencing power outages, such as enabling necessary lighting, charging a phone, tablet, or possibly charging a smaller computer for a shorter while. Therefore, the outlets on the battery backups should be USB-3 and USB-C. Thus the concept has the potential of helping a household when experiencing power outages and in being energy resilient. Hence, the concept helps a household respond to, recover from, or resist various disturbances, depending on when collecting the battery backup in connection with the disturbance.

The concept is intended to be able to work for all income economies, while with this, as with the other concepts, the affordability is of high prioritization for especially

LIE and LMIE. Additionally, a household normally without access to electricity, commonly a poorer household in a LIE, does not need it. While still, this concept could open doors in utilizing a more sustainable and especially more healthy option, enabling light together with a light source, without fumes from firewood or bad oil lamp, which compromises the household's health.

5.13 Evaluation of concepts

This section presents the result of the evaluation of the concepts. First, the survey respondents are presented, then the survey respondents' first impressions of the concepts are presented. This followed by a description of the respondents' opinions of if the concepts would simplify everyday life and if they were to be used in everyday life. Then, the number of respondents who noticed problems are presented. Next, are all concepts discussed one by one. This followed by a presentation of if and how the concepts would entail changing their everyday life, the collected thoughts about sharing the concepts, and walking or transporting to a concept. Then the scenario-based evaluation is presented. Lastly and concluding the evaluation of concepts follows a summary of the concept evaluation performed through survey and interviews.

Noticeable from the survey result was that overall the responses were surprisingly exhaustive from both LIE and LMIE as well as HIE respondents. Meaning the respondents were generous in their explanations through the text answers about each concept. The respondents were thus engaged and took their time responding to the survey.

5.13.1 The survey respondents

In this subsection, the demographic of the survey respondents are presented. This is important to be able to connect answers to different categories and discover potential patterns in and between these categories. Also, to show how distributed the answers are when it comes to validity in the results. So, when investigating if the concepts would work in all income economies, the demographic distribution is important to assure.

In total, 77 respondents answered the survey, while in total 81 text responses of the survey were collected and 77 responses in number responses. Meaning four of the respondents living in a HIE also had an experience of a LMIE context: Tanzania, Senegal, and India; and answered in the text responses from both perspectives separately. In total, 51 respondents came from a HIE and 26 people respondents from a LIE and LMIE.

The responses were collected worldwide, specifically from respondents with experience in 28 different countries. A map presenting an overview of the respondents' countries of experience can be seen in figure 5.28. Many of the respondents with experience from a HIE also had experience living in a LIE or LMIE and vice versa.

Additionally, many originating from a LIE or LMIE also had an experience of one or two more LIE's or LMIE's.

Figure 5.28: An overview of the respondents countries of experience, bigger dots meaning more answers from that specific country.

The respondents' distribution in age can be seen in figure 5.29, where the distribution among HIE were more spread than in LIE and LMIE. In the responses from LIE and LMIE no responded with an age of 70 or above. Neither did anyone under 19 years old respond in either one of the income economy groups.

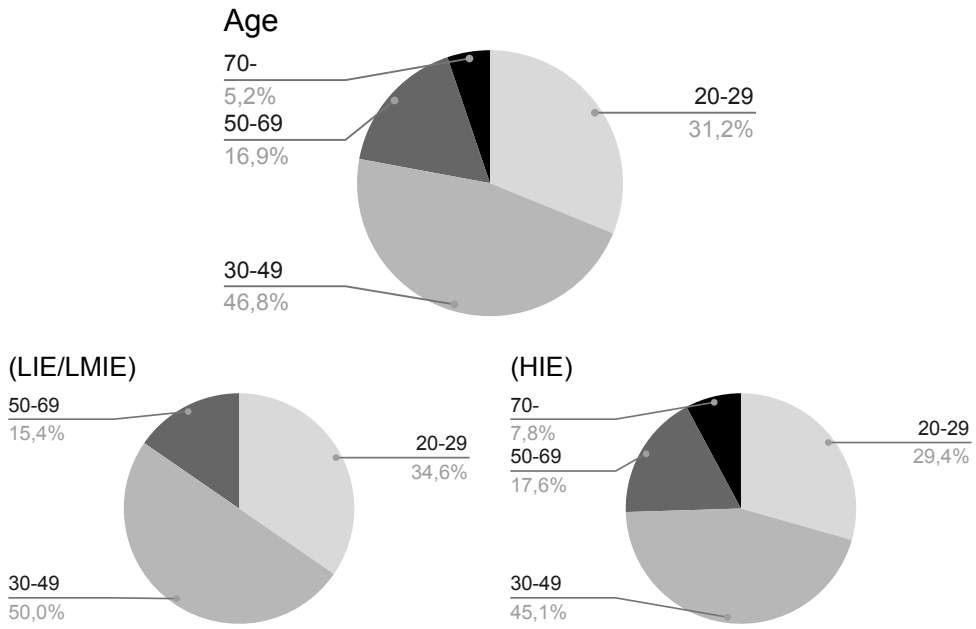

Figure 5.29: The survey's respondents distribution in age. In the first pie-chart total distribution can be seen, while only LIE- and LMIE-respondents to the bottom left and only HIE-respondents to the bottom right.

In both the LIE and LMIE as well as HIE answers, the distribution of the respondents' gender was obliquely distributed. 70,6 % female was the majority in HIE respondents, and 61,5 % male constituted the majority in LIE and LMIE respondents.

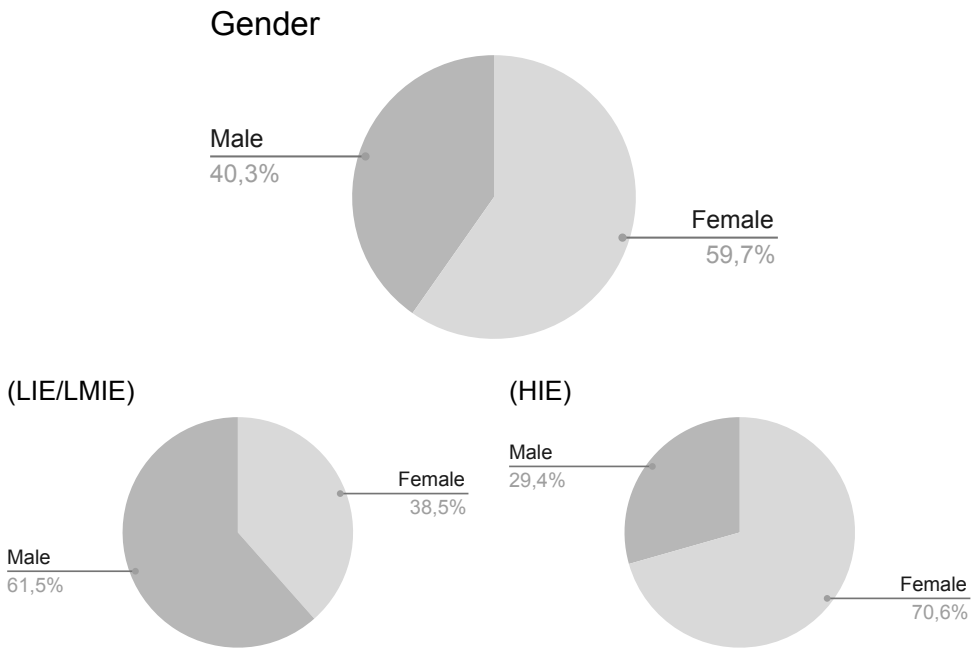

Figure 5.30: The survey's respondents distribution in gender. In the first pie-chart total distribution can be seen, while only LIE- and LMIE-respondents to the bottom left and only HIE-respondents to the bottom right.

In Sweden, 52 % of the population are living in houses while 42 % are living in apartment buildings [83]. Where also most of the HIE respondents come from. The statistics in Sweden are similar to statistics about the mean population in Europe, where 42 % lives in apartment buildings and 57 % live in houses [84]. From figure 5.31 we can see that 74,5 % of the HIE respondents live in houses while 25,5 % of the respondents live in apartment buildings, meaning more responses from people living in houses constituted as higher than the average distribution in Sweden and Europe. Further, it is generally more common to live in a smaller house in LIE's and LMIE's, and that more people share a smaller space and a space of fewer room than in a HIE [85]. Meaning it would indicate it is more common living in houses in LIE and LMIE than in HIE. Therefore, the survey answers from LIE and LMIE would indicate being less close to the actuality than the HIE responses. While updated data justifying this about LIE and LMIE are harder to find. Globally, in 2020, 56 % of the population lived in urban settings and 44 % in rural [86] and *"the urbanisation trend is having an impact on the types of dwelling people live in"* [87]. The number of apartment dwelling households was 36,3 % in 2013 and is the most increased form of housing [87].

If the survey respondents' answers on their location of accommodation are compared to the reality, the distribution looks not far from being similar. Globally, 56 % of

the population lived in urban settings and 44 % in rural according to data from 2020 [86]. While the total respondents account for 36 % in rural and 64 % in urban, meaning 8 % more respondents from urban than compared to the global percentage was collected. However, when looking into LIE/LMIE and HIE separately 38 % of the LIE and LMIE population live in an urban context while 82 % in HIE [88, 89]. This would mean the responses in HIE were skewed, with only 51 % urban answers instead of close to 82 % as it normally is in a HIE. The LIE and LMIE responses were even more skewed, where 88,5 % of the urban population responded, wherein the reality should be as low as 38 %. This needs to be taken into account in the analysis. In both the LIE and LMIE as well as HIE answers, the distribution of the respondents' gender was obliquely distributed. 70,6 % female was the majority in HIE respondents, and 61,5 % male constituted the majority in LIE and LMIE respondents.

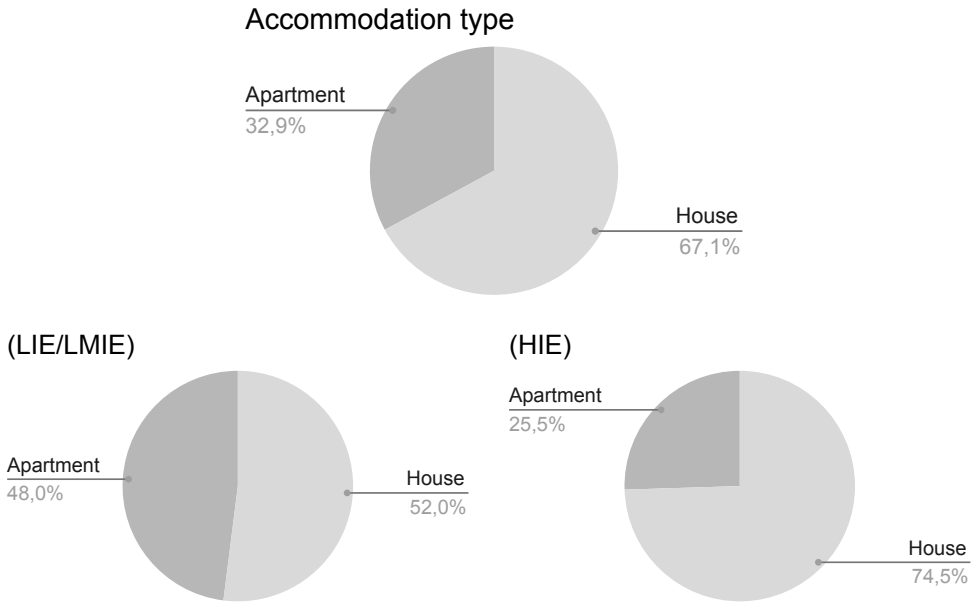

Figure 5.31: The survey's respondents distribution in accommodation type. In the first pie-chart total distribution can be seen, while only LIE- and LMIE-respondents to the bottom left and only HIE-respondents to the bottom right.

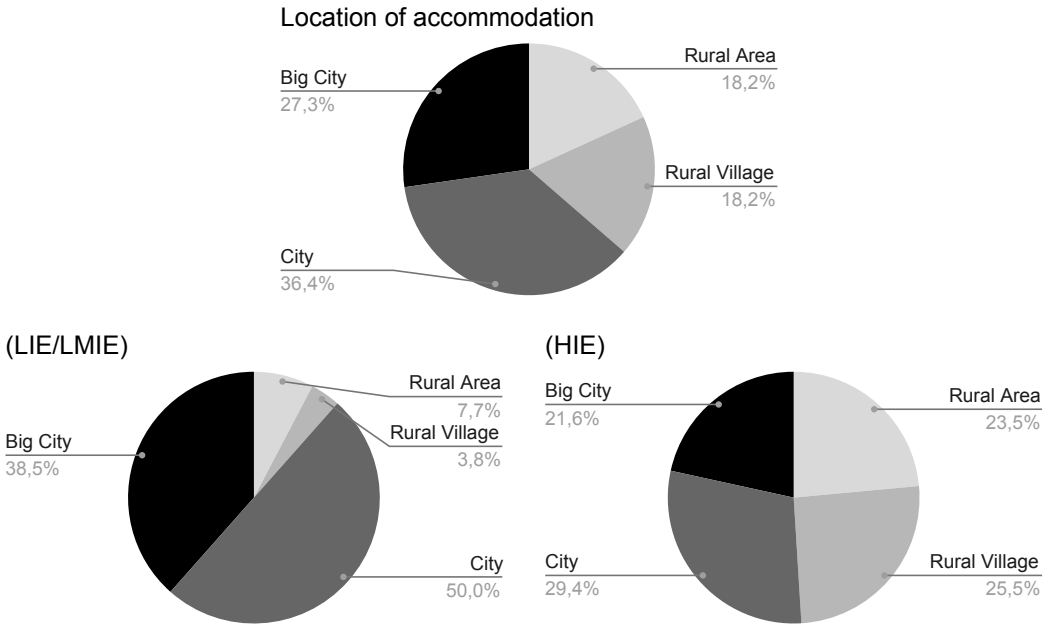

Figure 5.32: The survey's respondents distribution in location of accommodation. In the first pie-chart total distribution can be seen, while only LIE- and LMIE-respondents to the bottom left and only HIE-respondents to the bottom right.

5.13.2 First impressions

In the survey, the first question about each concept collected the potential future users' first impressions about the concepts, written as text answers. Through a thematic analysis, the respondents' answers were divided into different subcategories, which in turn were divided into three different main categories: positive, negative, and no clear opinion.

There were three subcategories in the category *positive*. First, generally positive, where the answers were not as depicting or did up any specific but were more a general positive. The following subcategory was respondents who felt a need, meaning all who in some way expressed that they would need this or said this is something they would use directly. The last subcategory was respondents who acknowledged potential in the concepts, where this was more specifically expressed opinions about something positive about the functions or in the technology being used.

The *negative* responses comprised as more subcategories, namely eight. First, some expressed opinions simply being negative towards the concept or technology and pointing this out. Some respondents acknowledged specific problems with the technology. While some expressed they did not feel a need, respondents expressed that they simply did not feel the need for the concept or that the concept is not something they would use. Another subcategory was respondents mentioning that the concept would not be possible for everyone, either personally or they spoke on behalf of someone else. Some commented that the concept was not effective, whereas some respondents were uncertain about some of the concepts making an impact. Espe-

cially regarding the first concept, some respondents pointed out that some users would not be internet literate enough or at all to be able to use the concept or need this type of concept. Another subcategory was that the concept would not work due to usage and devices differing worldwide or regionally, and the concept could therefore not be the same for all. The last subcategory in the negative opinions was that the concept would not work due to economic reasons, meaning a concept would be too expensive for some in purchase or usage.

There were three subcategories in the category *no clear opinion*. First, some responses were neutral, meaning they explicitly pointed this out or mentioned both positive and negative opinions. Second, some mentioned that they had seen similar and did not say any clear opinion due to this. Third, some respondents did not understand the concept and pointed this out.

The thematic categories and subcategories are summarized as the following:

- Positive
  - Generally positive
  - Feel a need
  - Acknowledge potential in concept (functions/technology)
- Negative
  - Negative to concept/technology
  - Problems with technology
  - Do not feel a need
  - Not possible for everyone
  - Not effective
  - Not internet literate
  - Would not work due to usage and devices differing worldwide/regionally
  - Would not work due to economical reasons
- No clear opinion
  - Neutral
  - Have seen similar
  - Did not understand concept

The categories were then counted comprising of a stacked bar graph which can be seen in figure 5.33. The respondents were the least negative to concept 5, followed by concept 4 and subsequently concept 3. These subcategories will be connected back to later when discussing each concept, in sections 5.13.6 to 5.13.13.

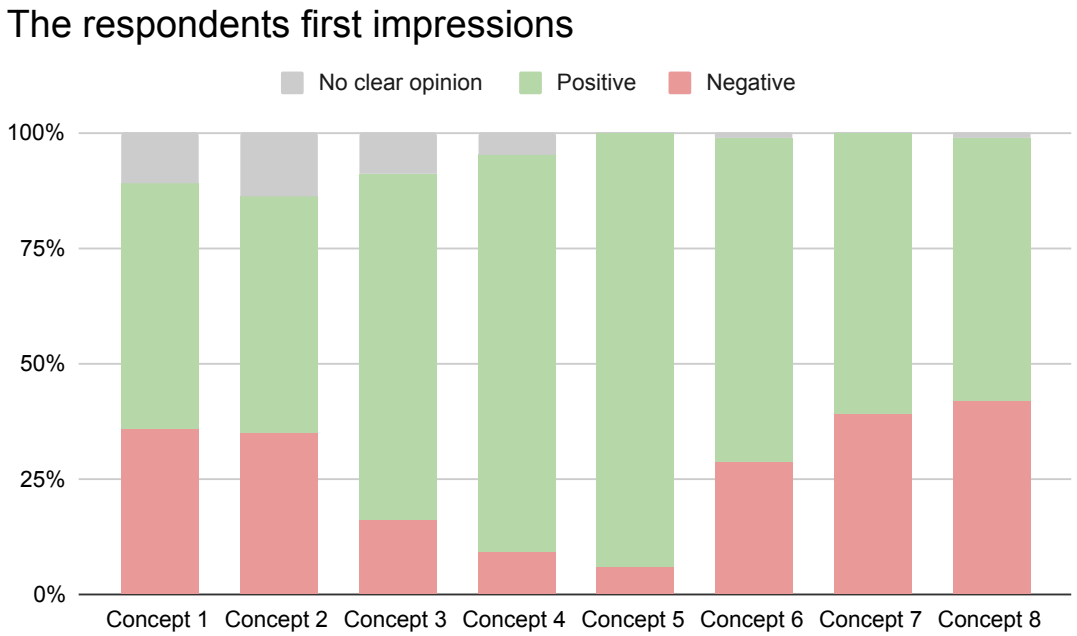

Figure 5.33: An overview of the first impressions of the concepts. The percentage share of respondents with positive, negative and no clear opinions can be seen.

5.13.3 Simplify everyday life

The respondents in the survey were asked if they thought the concept would simplify an everyday life with power outages and to rate their response on a scale from 1 to 7. The result from this constitutes a distribution graph, seen in figure 5.35. A good outcome, meaning a concept that would be considered simplifying an everyday life with power outages, would result in an increasing curve. Meaning more and more people rate it high, resulting in as many high ratings as possible. Concept 5 is a great example of such a response, being the concept that would simplify everyday life with power outages the most. Also, concept 4 is almost as good as an example, followed by concept 6 being slightly less. Concepts 3, 7, and 8 have a relatively slight increasing curve, meaning they are not distinctive. The concepts with the worst outcome are concepts 1 and 2, with high responses on low ratings and a mostly decreasing curve.

In figure 5.34 the mean values of the responses of the same question: if the concept would be considered to simplify everyday life with power outages, can be seen. This graph gives a good overview of the result where the same result can be read. The different mean values from the LIE and LMIE, as well as the HIE respondents, can also be seen, giving a possibility to compare the income economies with each other on this question.

In the bar chart, the responses from the income economies are similar to each other in most concepts. While concepts 6 and 8 distinguish LIE and LMIE as more positive towards these shared concepts. Also, concepts 3 and 7 indicate the same response but slightly less.

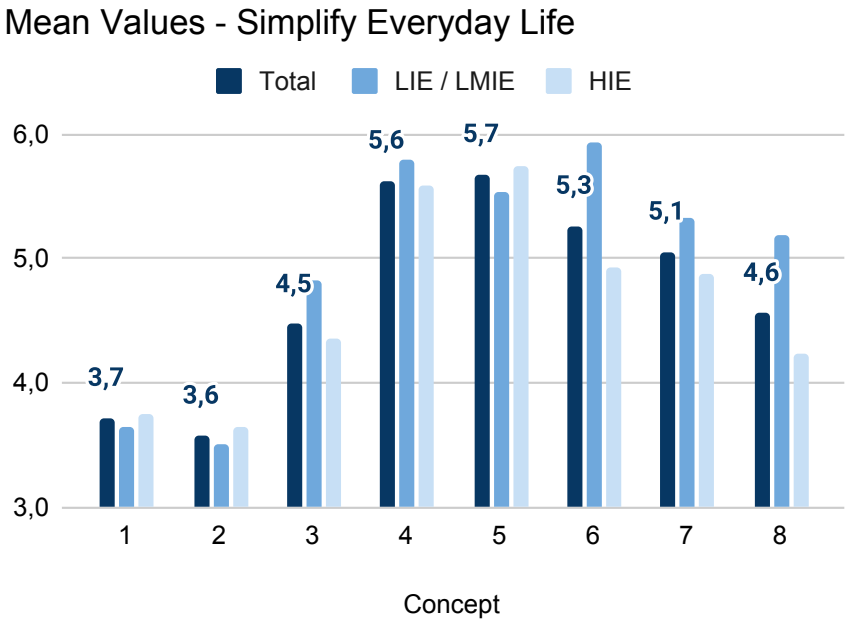

Figure 5.34: The mean values from the survey respondents answering the question: "Do you feel that the concept would simplify an everyday life with power outages?".

5.13.4 Use in everyday life

The survey respondents were asked how likely they would use the concepts in everyday life with power outages and to rate their response on a scale from 1 to 7. The result from this constitutes a distribution graph, seen in figure 5.36. Same as the previous question about simplifying everyday life, a good outcome would result in an increasing curve in the graph. Still, concepts 4 and 5 are the best example of a good response, and thus the concepts the users would use in the event of power outages. Now concept 6 stands out in differing from the outcome in the previous explained question. By comparing concept 6 curves in figures 5.35 and 5.36, we can conclude that concept 6 may be considered being slightly better perceived than actually being used during an outage. Concept 2, followed by concept 1, are still the concepts with the worst outcome and decreasing curves. Meaning these concepts would be the least to be used when experiencing a power outage.

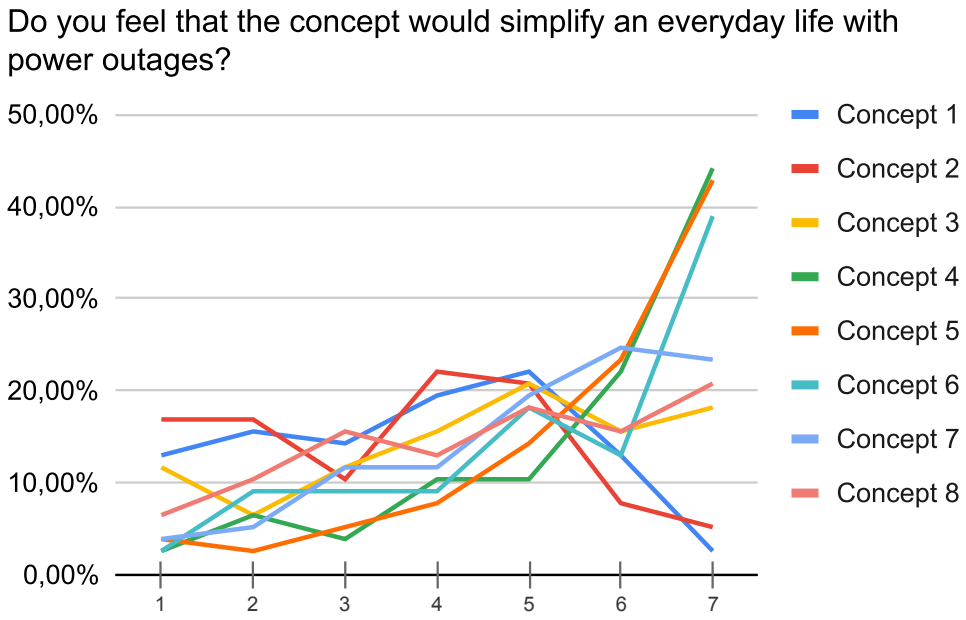

Figure 5.35: An overview of the distribution of the survey respondents answering the question: "Do you feel that the concept would simplify an everyday life with power outages?".

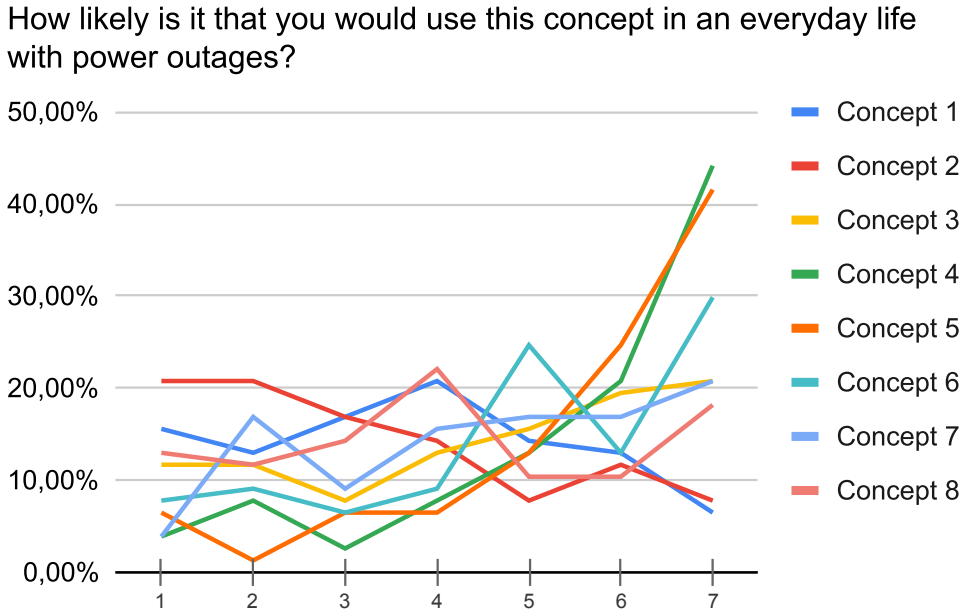

Figure 5.36: An overview of distribution of the survey respondents answering the question: "How likely is it that you would use this concept in an everyday life with power outages?".

In figure 5.37 the mean values of the responses of the same question: "How likely is it that you would use this concept in an everyday life with power outages?", can be seen. Presenting a good overview of the result was the same result as described

above. Also, the mean values from LIE and LMIE respondents, as well as HIE respondents, can be seen, enabling a comparison of the income economies responses to this question.

In the bar chart, the responses from the income economies are similar to each other in most concepts. While concepts 6, 7, and 8 distinguish the most, with LIE- and LMIE-respondents being more positive towards using these shared concepts than the respondents from HIE's. Also, concepts 1 and 7 indicate the same result but slightly less.

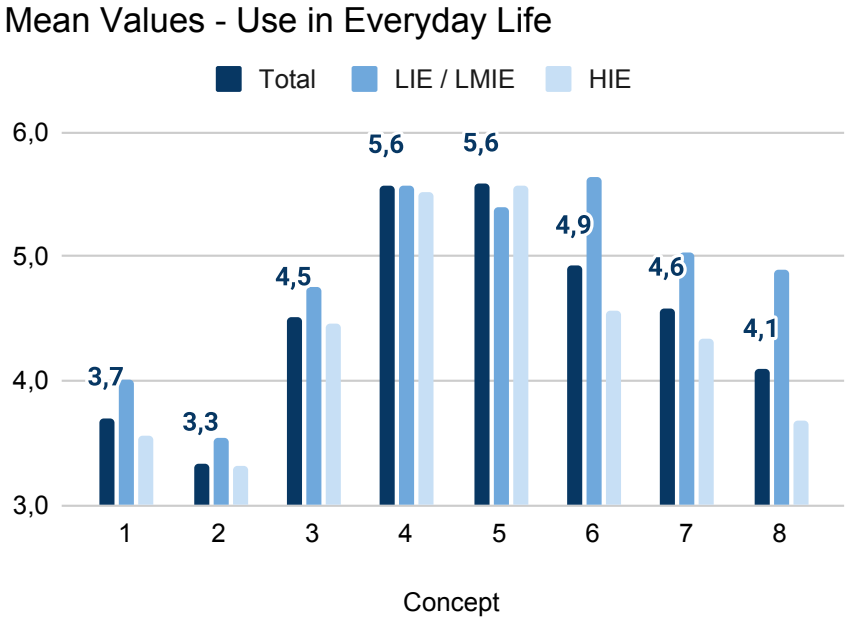

Figure 5.37: The mean values from the survey respondents answering the question: "How likely is it that you would use this concept in an everyday life with power outages?".

5.13.5 Amount who noticed problems

The total percentage amount of respondents who noticed problems with the concepts through the survey are visualized in figure 5.38, also the LIE and LMIE respondents and HIE respondents separately. Overall, it can be seen that the number of respondents from LIE and LMIE noticed problems significantly more often than the respondents from HIE, apart from concepts 6 and 7. Also, concept 1 differentiates the most between the income economies.

From the chart, it may also be seen that the least amount of people noticed problems with concept 5. However, this bar chart does not visualize the number of problems found, but only the amount of respondents who noticed problems. Therefore, some of the concepts may have many respondents noticing the same problems but visualized in this graph as having many problems. More specific information about the problems noticed in each concept is brought up in the following sections when discussing each separately.

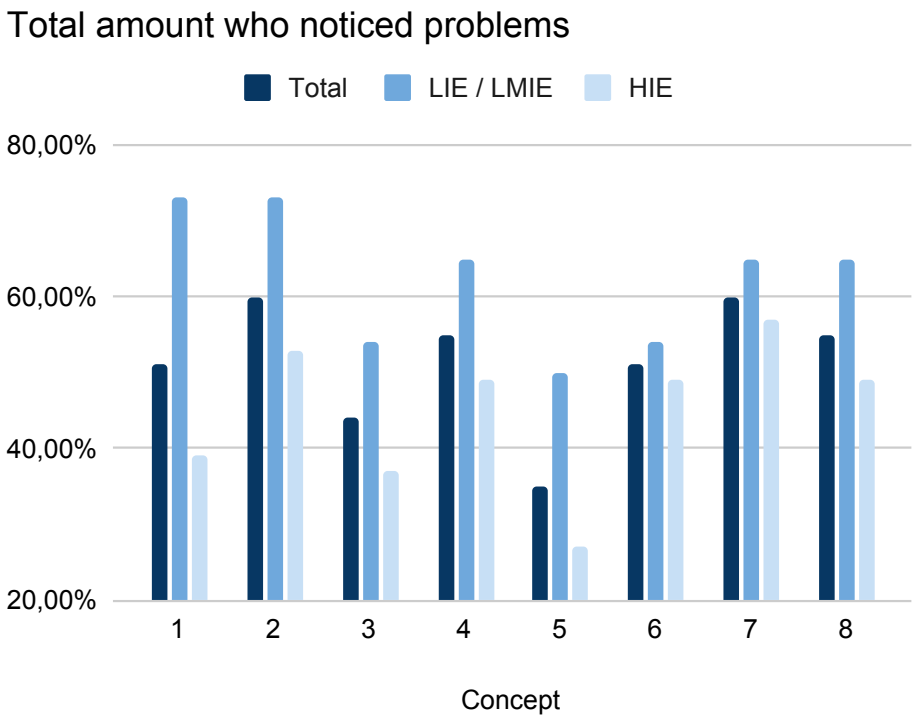

Figure 5.38: Amount who noticed problems noticed by the survey respondents. Total amount, LIE/LMIE as well as HIE respondents answers visualized separately.

5.13.6 Concept 1 - Community website service

52 % of the respondents were positive to this concept in regard to their first impressions, while 24 % of the responses were positive at first but later stated problems. As many as 33 % directly were negative and only noticed problems with the concept.

Positive

Some survey respondents would feel a need for the website/app when and if experiencing long outages. A male respondent from Ghana, with much experience with power outages, wrote: *"Great, speaks to an existing need and leverages a community of shared concern to build and foster relevant information/solution sharing"*. The concept was perceived as proactive, easily accessible, useful, and educational. An opinion was also that it was good to compare to others and utilize the power of competitiveness to make a change. A female respondent from Peru though: *"The way people use the internet varies a lot, based on their education and interests. We need more engagement and consciousness in countries like Peru. Therefore communication is a key issue."*. Thus, she was very positive about a community website service where more engagement and consciousness would be possible. One interviewee pointed out that the concept would be even better if it also could predict and tell when an outage would occur, even so-called unplanned due to storms or wind. Accordingly, the respondents from the survey saw different benefits with a concept like this.

Negative

In total, 51 % saw some problems with the concept. First of all, the fact that the website does not help directly with the core problem of not having electricity but instead consists of, e.g., tips and tricks which is not making a direct impact, and only potential of an indirect impact, was stated by some of the respondents. Apart from that many different problems were noted.

An opinion from respondents from India, Peru, South Africa, Kenya, and Cameroon was that the concept would not work because of usage and devices differing worldwide, also stating that it would not be possible for everyone. Further, these respondents also illuminated that many in LIE and LMIE countries are not internet literate and thus would be a big problem with the concept. A respondent from India with much experience of power outages meant that *"[...] when the population is not so internet literate then there is zero use of having websites and apps. For example, at my home, 95% will not benefit from this concept"*. Another respondent stated that the concept is *"not applicable in rural areas and impoverished households in most African countries"* said a male living in Cameroon. A respondent from France and multiple Swedish respondents in the age group "70-" also noted the absence of or low internet literacy. Indicating this would be a problem in all income economies.

A few respondents believed that they would rather have this kind of information from an official source, e.g., their electricity supplier. However, then the concept of worldwide would be lost. While some respondents thought having the website connected to one's electricity company's information would be superfluous. Also, some did not think that the community part of the concept would facilitate. Two respondents questioned *"why this instead of other social platforms?"* and did not think that a site like this would become widespread and would be a site requiring many active users. They meant that this site would only become one in the crowd in today's information society. Also, the people interested in this would find the information; therefore, this type of respondent did not find a need for the concept. Another questioned "why at all?", by stating: *"It would be better to give my community advice on how to get off the grid rather. That would assist them more."* said a male respondent from South Africa.

Some were skeptical about using mobile, tablet, or computer for this purpose when experiencing a power outage due to battery consumption. Many were unsure they would prepare with a read-through or download the information beforehand. *"Humans are not good at being prepared, however, we are good at acting when needed"* was a response from a male from Sweden with low experience with power outages. A few did not feel a need for the concept and expressed that they would not use it, where *why* would not be clear. Furthermore, respondents also pointed out that it is not good to let each user share tips since potentially bad advice could be shared, also concerning one's integrity when sharing private information. Also, information overload and information stress can compound anxieties of not finding information at all were some respondents' opinions. Lastly, one respondent also pointed out the cost of the equipment and the energy storing all information and wondered who would pay for that.

What would the concept change in everyday life?

Mostly, the respondents answered when they thought it would change anything in their everyday life that the concept, in general, would help in being more prepared before the next power outage. Some thought that it would change the anxiety about unreliable energy supplies, it would give them better holistic thinking, and they could save money through tips on how to use energy more efficiently. Some would learn ways to store energy which would benefit everyday life in multiple ways, saving time and money. While some thought they would find ideas also for "normal life" and not just when experiencing power outages. However, most of the respondents thought the concept would not change anything, mainly on the ground of them not experiencing enough power outages or the concept not being used.

Conclusion to concept 1

Through this exposition, it is clear that the problems seen with this concept or a concept similar to this are many and that there are quite a few obstacles if this concept were to work for some, and for some it would simply not work at all. Nevertheless, the concept would probably not be used according to the result from the survey.

5.13.7 Concept 2 - DIY oil lamp kit

Similar to concept 1, 51 % of the respondents were positive about concept 2 regarding their first impressions. 24 % of the responses were generally positive to the concept at first but later stated problems. While as many as 33 % directly were negative and only noticed problems with the concept.

Positive

The positive respondents were generally positive for two reasons. Positive towards the concept as they already owned a factory-made oil lamp which they thought was a nice solution both when experiencing a power outage and when not. The other large part meant that the concept was positive towards the rudimentary aspects, that it would be simple to use, and that it would work in very rural areas. Still, aspects of safety risks were brought up by many of the same respondents. On the same note, many also stated this it would be suitable for some, but not for all.

It was suggested by a respondent that instead of a new product like this, one could instead print a short infographic on, e.g., the packaging for cooking oil, with the same info as would be conveyed through the kit. One respondent, a Swedish female with low experience of power outages, said it would be a *"good thing to have in the basement just in case"*, while another expressed it to be perfect as a gift.

Negative

In total, 59 % saw some problems with the concept. Many were negative to the concept and noticed problems, while still, many of the problems seen were the same. The concept was seen more as a fun and creative concept than actually being used

and being effective. Many, especially respondents from LIE and LMIE, thought it was an old-school idea, felt as going backward, and that the concept was retrogressive. A lot of people from HIE did not see the benefits of this concept instead of simply buying a finished oil lamp from a manufacturer.

Some would prefer using candles instead and thought it would be more cumbersome or expensive than candles, a flashlight, or their already owned not self-made oil lamp. Some thought purchasing and using oil would be inconvenient. Interesting is that a lot of the respondents saw problems with putting the DIY kit together when there was an outage and did not think of preparing this beforehand. *"Hard to assemble all the parts in the dark"*, wrote a male from Sweden. Another male from Sweden meant that it would be *"advanced to do this when power outage occurs"*. Many questioned if it would be safe to make a homemade oil lamp and stated that they would not be comfortable using a self-made oil lamp. On the same note, many also noted the risks of accidental fires. Also, the risk of taking "the wrong oil" and that it would not be good to use if you do not have proper ventilation in your home; if taking "the wrong oil", then smell, smoke, and serious respiratory health issues may await. Some were also unsure whether the homemade oil lamp would meet the household lighting needs in any measurable quantity without polluting household air quality. One respondent from Liberia wrote that the concept was *"not too far from the regular kerosene lamps in villages in Africa"* and meant that this is not what you want to strive for when going forward.

What would the concept change in everyday life?

When asked if and how the concept would change anything in their everyday lives, not many respondents thought it would change anything in their everyday lives. Those who thought it would change anything wrote it would facilitate when in darkness. One respondent thought they would have all the supplies at home always to be able to make or use an oil lamp like this. Some would use the oil lamp even when not experiencing power outages. A lot of the respondents thought the risk of fire would increase. Thus, the concept would entail both positive and negative changes to one's everyday life.

Conclusion to concept 2

Based on these responses from the survey, concept 2 had a lot of negative aspects while still some positive opinions suggesting it would work for some but not for all. However, this response, together with the quantitative analysis of the concept, points towards the concept not working in everyday life for the very most.

5.13.8 Concept 3 - Portable lamp with crank

Generally, the respondents were positive towards this concept in their written first impressions. As many as 71 % of the respondents were positive about the concept regarding their first impressions. 27 % of the responses were generally positive to the concept and later stated problems. While 16 % directly were negative and only noticed problems with the concept.

Positive

The positive comments from respondents who acknowledged potential in this concept consisted of somewhat scattered opinions. Many thought it was good with an easily implementable invention and a light concept not dependent on grid electricity. *"We should have many more dynamo-powered lamps!"*, said a female from Sweden. Another respondent, a male from Sweden, said: *"I use a flashlight so rarely, so when I need one, the batteries are often exhausted"*; therefore, this would be good for him. Many agreed with this respondent and thought it would be an excellent alternative to a conventional battery flashlight, but how good would depend on how fast it discharges.

One respondent suggested it would be good if the concept would have a somewhat bigger battery so one could use it also as a small power bank, not only for lighting purposes. Some were very positive that it could be attached to a bike, and some thus stated that it was a good idea for people who own a bike. Some stated that it was a really good concept if it would be cheap.

Negative

In total, 43 % noticed some problems with the concept, where many agreed on a whole lot. They meant that it might store too little energy and for a too short period. Also, it would require the users' physical input to work was noted as a problem. They would not use this concept because it takes too much energy for a relatively small effect. The same respondents meant that people need simplified and comfortable solutions, not things where they have to work more. Some respondents illuminated that this concept would be difficult or even impossible for some to crank due to age, weakness, or illness. *"Ok for younger people"*, meant an older female from Sweden. Also, some noticed the noise while struggling to rotate the crank to charge and that it would be stressful and annoying.

Several respondents also stated that there are already good, probably better or cheaper, options on similar solutions on the market. Also, it was interesting that some respondents said they would rather use a regular flashlight with chemical batteries instead, and thus when the concept had rechargeable batteries and a crank, the concept was not considered as good. Some said it would not stand the economic competition to what solar-powered lamps readily offer and with just a button click. Moreover, several responded that all do not own a bike and that it would be a much more annoying concept for all those who do not own or use a bike that often. Some

of the responses meant that it would be a good concept but thought it would be less utilized in the long run.

What would the concept change in everyday life?

When asked if anything would change in their everyday life with this concept, as much as 60 % did not think it would change anything. Those who thought it would bring up that it would light up the road when on the bike and produce extra power for a lamp to be used in the household. The concept could provide light for reading or doing routine chores in "normal life". The concept would save money on non-rechargeable batteries for a flashlight. Also, the concept would make a household worry less about running out of batteries or living in complete darkness when experiencing power outages. Some respondents thought it would help be more environmentally friendly and that the concept would entail more self-sufficiency. One respondent also said that if power outages had been more common, referring to a HIE respondents' environment, the respondent would have used the bike more to have a secured light source.

Conclusion to concept 3

Accordingly, concept 3 is good, especially for being a concept not dependent on grid-electricity and always giving a possibility in creating light through the crank as long as it can store enough energy and would not be too cumbersome to charge. While still, some would think this is not the solution for them, it is considered a good concept that would also work in rural LIE and LMIE areas where access to electricity is bad or non-existent.

5.13.9 Concept 4 - Light bulb with built-in battery

As many as 81 % of the respondents were positive to concept 4 regarding their first impressions. While 41 % of the responses were generally positive to the concept at first but later stated problems. Only 8 % directly were negative and solely noticed problems with the concept.

Positive

In general, the respondents were very positive about this concept. The thought of a small, simple solution solving a big problem is the main reason for the very most and that the problem with lighting when experiencing power outages basically was solving itself through this concept. One respondent mentioned it was a good concept because it would not require the user to make any big changes but only replace the light bulbs where there is a need for lighting in a power outage. *"Novelty at its best"* said a male respondent from Ghana. *"Like it a lot! Feels like a concept that would have changed a power outage from a very special situation where you change all your behaviors to a slightly more normal state"* said a Male respondent from Sweden. Two of the respondents had seen something similar to this solution before

and were positive about the concept. Some wrote that this should be standard in light bulbs nowadays.

Negative

Still, with 81 % of the respondents being positive towards this concept, 55 % raised opinions that might be or would be a problem. However, most of the respondents mentioned the same opinion, videlicet, the duration of the battery.

Several respondents also brought up the lifespan of the built-in battery and a light bulb in general. *"Like all bulbs, disposal after lifespan is a serious environmental concern"* wrote a male respondent from Kenya. Also, it was brought up that built-in batteries generate chemical waste; thus, it is hazardous waste. One respondent from Tanzania was concerned with what to do with the battery once it would stop working, as it would be thrown directly into nature or at the dump in their country. However, that is still a problem with the current batteries and light bulbs being used and in all other concepts as well.

Two respondents noted that it would not work for everyone, referring to all households not having electricity. Another meant it would probably be too expensive for some. While some respondents still would prefer using candles, oil lamps, or a flashlight with batteries instead and considered this concept unnecessary.

What would the concept change in everyday life?

When asked about what the concept would change in their everyday lives, the responses varied. Many agreed that the concept would make everyday life less annoying and frustrating while experiencing power outages. They would be getting light without any hustle and discomfort. Some would have a lot less anxiety about not having light when a power outage happens. Some also mentioned that the concept would reduce panic when in need of finding candles or a flashlight when experiencing an unexpected power outage.

Some respondents wrote about the possibility of always ensuring their children would be able to read no matter if a power outage occurs. One respondent said that a power outage would not be a problem anymore (apart from cooking food). Lastly, a male respondent from South Africa wrote that the concept *"[...] would mean that some community members may not need to invest in large solar installations, inverters, and batteries to be grid independent if lighting is all they want"*.

Conclusion to concept 4

Hence, the responses about this concept indicate that it would simplify everyday life and be used by the very most; only the duration of the battery is long enough. For all to be able to use this concept, all households with electricity, that is, the concept is still in need of being cheap and the disposal after lifespan to be facilitated.

5.13.10 Concept 5 - Self-owned battery backup

The concept most respondents were positive towards was concept 5, with 92 % of the respondents being positive in their first impressions. 29 % of the responses were generally positive to the concept at first but later stated problems. While 7 % directly were negative and only noticed problems with the concept.

Positive

All but four respondents in the survey had good first impressions of this concept, while two more were neutral in their response. Thus, in general, all were very positive about the concept and thought it would be very good to have when experiencing power outages.

Concept 5 was distinctive among all concepts in getting a lot of superlative, e.g.: *"Very good idea!"; "Great!"; "Smart!"; "Awesome!"; "Really cool!"; "Excellent"; "Would have loved to have one like that!"; "The future!"; "Want one now!"; "Such a one everyone should have."*.

Some illuminated that the concept had different charging methods. *"I like that it can be both prepared by charging through a normal outlet and acting as a generator"*, said a male from Sweden. A Swedish female wrote: *"I could have basically continued as usual in the event of a power failure if I had one like this (and such cool light bulbs for light [Concept 4])"*. The respondents thought it was good with a more advanced power bank to have as a backup and also that the concept was specifically adapted for mobile phones, computers, and other smaller products in the home.

Also, two additions to the concept were suggested both through the survey and interviews. First, it would be good if the concept had solar cells or could be attached to portable solar cells in order for it to be charged. Secondly, it would be good with different variants in battery sizes to meet the needs of different households. Suggesting the concept could be in two sizes, one bigger for bigger needs and one smaller for computer, tablet and mobile phone.

Negative

In total, 35 % saw some problems with the concept. Regarding the problems stated, the respondents were overall unanimous. They were skeptical about whether the crank would generate sufficient energy and the duration of the battery. Also, the battery's longevity would be an essential factor in the concept's success. Further, one respondent brought up the uncertainty of if it would wear out the battery to always have it connected to an outlet in order for it to be charged, or conversely to forget to charge the battery every once in a while if power outages are not frequent. Another respondent addressed that the concept would entail a high failure rate; however, why and what the person referred to is unclear. Other problems that were brought up were the cost, weight, and size of the battery backup, as well as what type of mechanism would be used to generate power.

What would the concept change in everyday life?

Several respondents agreed that the concept would simplify everyday life in an unexpected power outage. One would be able to manage everyday life with this concept at hand, and the concept would cushion the effect and frustrations associated with power outages. Some said it would improve the overall quality of life, work, and chores, especially with the possibility of powering appliances to a great extent even when experiencing power outages. One even said everyday life could continue if the respondent had this concept. Some respondents thought the concept would change their everyday lives at an economic and self-sufficient level. One respondent specifically said the concept would reduce the fear that the battery in the phone would die. A few noted that they would need to secure that the battery backup would be charged all time. Lastly, it was mentioned by some of the respondents that they would use the battery backup even when not experiencing power outages, whereas two respondents would use the concept when camping with a motorhome.

Conclusion to concept 5

Concept 5 is the concept the very most were positive towards, and the survey answers indicate it would both simplify and be used in everyday life with power outages. So, if the obstacles of the crank generating sufficiently with energy, if the longevity and disposal of the battery would be facilitated, and the concept would not be too expensive or heavy, the concept could indeed be the future solution when experiencing power outages for the very most. Still, it would be an even more appreciated concept if it would be available in various sizes in battery capacity.

5.13.11 Concept 6 - Battery backup subscription

68 % of the respondents were positive to concept 6 regarding their first impressions. 25 % of the responses were generally positive to the concept at first but later stated problems. While 28 % directly were negative and only noticed problems with the concept.

Positive

The respondents were generally positive toward the concept as renewable energy would be used; thus, the concept would entail more inclusive access to cleaner energy. Where one respondent specifically meant that the inconvenience of the concept needs being distributed is worth it as the respondent thought people value the use of renewable energy. Some were positive towards the concept when experiencing longer power outages, and some when experiencing frequent power outages. A few respondents mentioned a positivity towards the concept being delivered to their home as they would not be required to prepare the battery backup by themselves. One female respondent from Sweden but with much experience from power outages in Tanzania stated that it would be a *"great idea, to create a business around the concept"*, creating possibilities for employment in the area of where the concept would be introduced.

Negative

In total, 49 % saw some problems with the concept. Significantly more respondents with experience from HIE than LIE and LMIE were negative in their first impressions towards this concept. In the negative comments, the respondents somewhat agreed about the reason, the main being that the concept would be shared and or distributed. The other common reason was that the concept would not work for economic reasons. The problems regarding the concept being shared or distributed were due to three different sub-reasons. First, it would not work in rural areas, in the countryside, where distances between neighbors were too far due to having few neighbors. The second is that the respondents from HIE's thought that HIE countries required one or more of the concepts per household, and thus they could just as well own one or more by themselves. Third, some respondents from LMIE questioned why one would subscribe to a battery backup when instead it could be owned by the household directly as everyone needs this when experiencing a power outage.

More problems that the respondents saw with the concepts were that the concept felt superfluous if a smaller size, but some thought it could have potential if the battery was bigger, e.g., big enough to power one's entire household. Also, some were negative towards the concept being delivered as it would be better to have a stationary bigger shared between a few households. Two respondents from HIE pointed out why instead of this concept not only connect the renewable power source directly to the grid and charge a battery backup through that in each household. *"New norms of sharing community resources may be associated with potential conflicts with power, authority and interest - converging and diverging. Success may depend on the economic model of subscription costs"* wrote a male respondent from Ghana. One respondent from LMIE thought it would be good only if housing companies or electricity network companies managed all with the concept; thus, the concept would not work for all. One male respondent from South Africa meant that he *"would not invest in this infrastructure unless I had ownership and was sure to have access when I needed it"*. A female respondent from Kenya wrote that *"there could be a problem with neighbors who do not want to make their payments"*, meaning it would be hard to implement in many areas. More opinions were also stated about difficulties in cooperation and unity of community members in order for this concept to work.

Also, some respondents pointed out problems about whether there would be enough batteries to supply an entire community, the delivery time, cost and system, and the batteries' longevity, durability, cost, size, and weight. One respondent specifically pointed out that the concept would need being a bigger battery in order for it to be worth it. While some respondents wrote that they would rather cope without electricity during shorter power outages or have their own solution, without stating any more explanations.

What would the concept change in everyday life?

When asked if the concept would change anything in their everyday life, the response rate was low; only 30 % of the respondents answered something that would change. Mainly the responses were that it would reduce the problem and frustrations caused by power outages to some extent, and the need to be always prepared to deal with it. It would also reduce the fear of losing one's mobile phone's battery power. Some would use the concept even when not experiencing a power outage. A male respondent from Cameroon thought he would team up with his neighbors to install this and have a more secure energy supply. A female respondent from Sweden deemed that maybe the price of electricity would have been lower, at least secure what it has been the last months, then this would give her better space in her economy. In general, the concept was also thought to help be more environmentally friendly regarding energy.

Conclusion to concept 6

The problems with concept 6 are quite a few, and there is great uncertainty about how many people would have used this concept or if it would work at all. While it can be seen that this concept is perceived as being used more by respondents from LIE and LMIE than respondents from HIE, this may indicate it could be better suited for those income economies. However, there is no significant clarity in this.

5.13.12 Concept 7 - Community center building

61 % of the respondents were positive about concept 7 regarding their first impressions. 40 % of the responses were generally positive to the concept at first but later stated problems. While 39 % directly were negative and only noticed problems with the concept.

Positive

In general, the responses were positive towards using solar power in a community house. Many stated that it would be a good concept when experiencing longer power outages, especially if they were longer and frequently recurring.

Some respondents said it would work well in India and be possible to be implemented there. One respondent from Ghana said the concept was *"relevant, timely and informed innovation that would work with sun-fed Africa in particular"*. Some believe and are very positive in the concept regarding apartment buildings where already shared spaces are common. Moreover, some stated that maybe the concept would work in region-specific areas and some countries. Some were very positive that the concept would work for tenants and households with small resources. A Swedish female respondent with experiences from Lebanon meant *"if it can build this on tenant associations or daytime activities that already exist as an institution, and have capacity for quite a few users, then the concept would be good"*. A few of the respondents brought up that they were positive towards the social part of the concept and that it would entail them being more social than now.

Negative

In total, 59 % saw some problems with the concept. An interesting thought from the survey is that many are still positive towards the concept but think it will not work in their neighborhood, community, or society while suggesting it might be good for someone else. *"Not viable in our current society. [...] Can be a solution in areas with low incomes where individual solar cells are not possible from an economic perspective"*, said a male respondent from Sweden. While a respondent from Tanzania with experiences from living in Sweden said that *"in Sweden, the idea would work, but if I then compare with the country Tanzania, everything in the house would eventually disappear, or decay"*, which is an answer similar to many of the responses from other African countries as well. A respondent from Peru thought that the concept is *"very good but not easy to manage in every neighborhood here"*. A male respondent from Sweden illuminated the fact that *"applying this only for expensive new housing can increase social inequality during power outages if some have access to better infrastructure than others"*.

A male Swedish respondent pinpoints a lot of the respondents' thoughts: *"It would certainly be useful, while many would have preferred to have easier access in their home"*. Many of the respondents also have questions or are negative towards the following: who is managing it?; the use of the concept, generally about sharing, sharing with strangers, sharing with neighbors, maintenance, vandalism distances to the concept in rural areas. Also, many are negative towards having co-ownership in general and with neighbors as finance together often will be a problem. It is also brought up that it seems expensive and thus it would not be worth it. Further, the building is also believed to be often left unused, which would be an actual waste of resources. Costly to maintain for a neighborhood collaboration while expensive for companies with very little return on investment.

One female respondent from Sweden was *"not sure if it would be used 'right' and instead be used 'wrong' by criminals and homeless"*. A female respondent from Liberia wrote: *"In my region security issues can be a thing, so people are always careful when it comes to exposure of gadgets/appliances in social gatherings, especially in cities, except in local communities of course"*. Thus respondents were unsure if it would be safe to use this community center building.

An answer that differs from the rest about rural experiences is the following: *"Very interesting concept - could suit the inhabitants of the countryside"* meant a female respondent from Sweden who lives in a rural setting. Otherwise, the responses from people living in rural settings are very skeptical of sharing a community building. First and foremost due to the distances between the neighbors. Also, a female respondent from Tanzania meant that in many places where this is needed *"the population lives very distributed, and the inhabitants do not move in the area after dark"*. Additionally, people living in houses in the cities do not think they would need this but that it would suit apartment buildings better. At the same time, a female respondent living in an apartment building said: *"I really do not want to share this concept with everyone in our residential building (60 people). Prefer*

to have my own solution in my home, with only my family. Alternatively, if you had shared with close friends, family and relatives". Thus, conclusions regarding opinions about this concept can be made according to accommodation types or different locations of accommodation in such a way that the opinions from those living in respective types and locations are most often negative towards the concept of them sharing something themselves.

What would the concept change in everyday life?

When asked if the concept would change anything in their everyday life, the respondents, 63 %, did not think so or also did not have an opinion on this. Those who thought it would change anything had scattered opinions.

The concept would make people worry less about power outages and improve livelihood when experiencing power outages. The concept would secure access to power and allow for socialization within the community. One respondent said he would probably have gotten more social through this concept. Some thought the concept would help save money, while some thought the opposite.

A male respondent from Cameroon thought that *"this concept would change many things in everyday life as light would be constant, business would flourish, people would be happy. A lot would be achieved because light is life".* Some responses thought this concept would enable more knowledge sharing, e.g., through having book clubs.

Conclusion to concept 7

It can be concluded that concept 7 would neither work for nor be used by everyone. Mostly, these conclusions can be made according to accommodation types, different locations of accommodation, and safety aspects in some areas. While still, the concept has potential in working for some, experiencing longer and frequent power outages; that is, if the concept is not being co-owned by the users, not being too costly, and the maintenance is well taken care of.

5.13.13 Concept 8 - Shared battery backup station

Regarding concept 8, 57 % of the respondents were positive about the concept regarding their first impressions. 29 % of the responses were generally positive to the concept at first but later stated problems, while 43 % directly were negative and only noticed problems with the concept.

Positive

The positive responses about the concept were many times similar. The respondents thought it was good to use energy powered by solar cells. The concept could entail good accessibility for many. Several thought it was very positive with a concept where the battery backups were ensured of being recharged when in need. The

respondents were also more positive towards the concept if owned by a company and not co-owned by users.

Negative

In total, 55 % saw some problems with the concept. Several of the respondents' first impressions were negative, and many noticed problems from the start. Many respondents did not see any other benefits besides the battery backups being charged with solar power. Some thought the concept would be cumbersome. A male respondent from South Africa said: *"Why shared? When individual, cheap power banks are already on the market"*, which many more respondents agree. Some are not positive about sharing the concept if the power bank would be of small capacity; they also question, *"why share?"*. Also, some respondents pointed out that poor people most likely would not be able to afford a concept like this.

The respondents who are negative to the concept are, e.g., unsure towards co-ownership, find challenges in administering ownership and maintenance when shared, afraid of theft risks, and that the supply is enough for everyone or that it would not be abused. Many questions whether people would remember putting back the battery backups after use, and overall who would take on responsibility for the equipment?

Some are negative to the concept due to living in rural areas where long distances and neighbors are few. Again as with the two earlier shared concepts, 6 and 7, there are divided opinions about sharing. Many are positive towards the thoughts of sharing but not sharing a concept themselves. Some think it works in smaller communities where everyone knows each other, some are positive about sharing with all, and some would like to, no matter what, own the devices by themselves instead. An opinion from a respondent from Tanzania with experiences from Sweden clearly states her opinion: *"In Sweden it would work but not in Tanzania. It would probably be stolen, and maintenance of the station and the power banks would not be carried out. Everything is falling apart in Tanzania, there is not even a word for maintenance in Swahili."*. A female respondent from Peru also deemed that there would be major problems with theft in her community; hence, this would not work there.

What would the concept change in everyday life?

When asked if the concept would change anything in their everyday life, the response rate of stating changes was at its lowest, whereas many as 73 % did not think anything would change anything or did not have an opinion on this.

Those who thought it would change something were quite in agreement with how. The concept would reduce frustration when experiencing power outages. The concept would prolong how much time one has to interact and communicate with the world through mobile phones in power outages. It would create security in always being able to reach the world. One would be able to power appliances and gadgets

in any situation. Some also stated that the concept would lead to conflicts.

Conclusion to concept 8

In conclusion, many questions why one would share a concept like this when it would probably be cheaper and less cumbersome to own a backup battery yourself and charge with grid electricity. Also, the theft risk and vandalism with such a concept. It would certainly not work in rural HIE areas, while it is also unlikely to work in LIE and LMIE as it would probably be too expensive for many and due to theft risk and lack of maintenance in many areas. For the concept to work for some, neighbors cannot be few, and the distances between them are too long, safety aspects of the concept are in need of being secured, and especially in LIE and LMIE, the expense of using the concept requires being as low as the electricity normally cost in the area. In other words, this is a concept with high uncertainty to work.

5.13.14 Change in everyday life

Connecting back to the survey and the question *"Would any of the concepts change anything in your everyday life?"*, the interviewee was asked to elaborate on this question. Then was asked: *"Would you be in need of changing any habit or practical thing in your home in order for any of the concepts to work?"*. The question was asked to get more answers in general about all concepts about what they thought they would change in the situation of a power outage.

This question was hard for the very most interviewees to answer. The interviews acknowledged that this was due to the interviewee not being able to test the concept when experiencing a power outage. While further and especially for the HIE interviews with Swedish interviewees of they not having high experience of power outages making it even more difficult. Also, the fact that the interviewee had to regard as many as eight concepts may have affected this.

Still, the responses from the interviews emerged in themes: one needs to keep track of the product, one needs to prepare it, and perhaps some maintenance is required to be done. E.g., with concept 5, the self-owned battery backup, they would keep it plugged in, in an outlet to ensure batteries were kept fully charged when needed. With concept 4 an interviewee stated that he would keep track of the batteries but was hoping this would be implemented in the product, so one did not need to do any controlling tasks with that concept. Another interviewee illuminated the need to be prepared for using the concepts so that there is no misunderstanding or uncertainties when a power outage occurs. However, interviewee number 10 in 4.6 distinguished herself by stating she would not prepare anything before a power outage other than having the product at home. E.g., with concept 5, she would not prepare anything before but crank up the battery backup in the event of a power outage.

One interviewee, number 5 in 4.6, stated that he would require *"reducing the comfort at least to a little level to when it occurred"* with any of the concepts when experiencing power outages. Also, interviewee number 9 agreed on this by mentioning he

would compromise normal habits as to what is possible with what one has access to during the power outage. These responses came from two interviewees with much experience of power outages in India who were well aware of the situation that arises when a power outage occurs and what they normally do. Still, with the concepts at hand, something else needs to be altered that they cannot be aware of before testing a concept in the environment when a power outage occurs. One interviewee, number 6 in 4.6, distinguished herself from the other interviewees by stating that: *"I don't think I would change my way and prepare, it might be stupid, but maybe it makes a difference if you live in a more rural area or experience more power outages than I do"*. Interestingly, the same interviewee clearly explained through another question later how she would alter her habits if a power outage occurred. E.g., if the plan were to watch TV, she would instead read a book. While she stated she would probably not use any of the concepts, it would be inevitable that some solution would need to be used to solve the light issue when performing this task instead. This shows the importance of the scenarios being implemented in the interviews and having a high experience of or being exposed to a power outage when trying a concept in order for the answer to be truthful.

5.13.15 Sharing concepts

The questions regarding the evaluation of sharing were regarding concepts 1, 6, 7, and 8. All of the interviewees were positive about sharing concept 1 and did not bring up any problems or opinions as to why they would not like this to be a shared community website.

The feeling towards sharing a concept and the concepts in question was mixed. Many are positive about the idea, but many would not like to do it themselves, and the reasons differ. The following quote reflects how most of both the interviewees and respondents say: *"To share can be very smart. However, I don't imagine that would happen in my life situation."* , said interviewee no. 1 in 4.6. Thus, the reason why they would not like to share when it comes down to it sometimes stands unknown.

In the interviews, it was investigated as to how many one would be comfortable sharing the concepts with, and the views on this were widespread. One interviewee would be open to sharing with about ten houses. If the concept is taken good care of, another interviewee did not see a limit on how many she would be comfortable sharing with; while still unsure about sharing with unknown people as households have different rules and visions of how it should be taken care of. A third would not like to share with anyone due to living in a rural area in Sweden. The same goes for interviewee no. 11 from South Africa, living in a rural area, with their closest neighbor 2 kilometers and next closest 20 kilometers; hence, it would not be possible to share a concept with anyone. Another interviewee was open to sharing with no specific limit of the number of people, as long as it is not co-owned by the users. Still, the most important aspect is that the supply should be adapted to the number of connected users. Lastly, reflecting the thoughts of many survey respondents, one interviewee, no. 10, living in an apartment in a Swedish village, first stated she

should be comfortable with sharing with people and that she probably would be using concept 7 if she needed for an essential task. While later in the discussion, when asked more specifically to say with whom or how many she would be comfortable sharing with, the opinion completely swayed in another direction as to not to be probable to be using any of the shared concepts. As earlier stated, this reflects the thoughts of many survey respondents as many in the survey were positive towards the concept at first but did not think they would use it. Rather that it would probably suit another household, area, or country. The same indication can be seen with concept 6.

More specifically, how many people they would be comfortable sharing with differed between concepts 7 and 8. Regarding concept 8, the interviewees were much more open to sharing with no specific amount of people. The whole world meant one interviewee, and as there is no people interaction, they thought that people would generally be fine with sharing this concept with whomever, only that it would not be emptied on battery backups when needed.

On the other hand, concept 7 ranged from 0 to 100 people, but all answered that they would like to know or be acquainted with almost all users if they were to use this. According to two interviewees, the reason for sharing with fewer people was being introverted. Moreover, those not wanting to share with anyone lived in houses in cities and rural areas and from different income economies. The reasons would be: *"I will manage in my own house"*, the geographical distance between neighbors and that often when power outages occur today it is in connection to heavy snow or strong wind; meaning it would be too long of a distance or due to not wanting to go out in bad weather. Furthermore, the user's age would also affect, as when the interviewee would get older, she would not like to walk a longer distance to retrieve something heavy as a battery backup possibly. *"In principle, I do not mind sharing, but it should not be an aggravating circumstance."* , said interviewee no. 4 in 4.6.

In other words, concluding these widespread opinions as to why not to share, no conclusion can be made if it would be possible with such concepts. Neither can anything be concluded about whom or where sharing is better suited as this differs a lot too. However, fewer and longer distances between neighbors generally make users more negative towards sharing. The ranking questions in the survey could potentially also mean that LIE and LMIE are more open towards a concept being shared. Further, it may be concluded that people in general think sharing is considered a good idea, but many would not be open to sharing themselves as it would probably be cumbersome and an aggravating circumstance. Also, the fact that one does not prefer co-owning something with neighbors can be concluded.

5.13.16 Walking or transporting to a concept

The interviews also investigated what was thought about walking or transporting to be able to use or collect a concept. All interviewees agreed it needed to be within walking distance, while this distance varied. Maximum 2 kilometers and down to

100 meters, thus everything between 1 minute to 20 minutes walking distance [90]. Some also thought the distance would vary according to the time of day. Three interviewees described a distance but in the same sentence said that they would not use it due to living in a rural area. People in rural areas would be more comfortable having the concept at their home instead due to few neighbors and long distances between neighbors. Accordingly, it can be concluded that a concept needs to be within walking distance, while the opinion of the range of this distance differs too much to conclude something precise. It can also be concluded that the fewer the neighbors and the longer the distances between these neighbors, the more negative towards walking to a concept the user would be.

5.13.17 Scenario Based Evaluation

In the interviews, the interviewees were given three different scenarios and asked three questions in each scenario about the concepts. Where the scenarios are based on the practices, presented in 5.4.1 and 5.5.1, found being included in the narrowed down area of lighting and backup systems. While also differentiating in time of day, day in the week, and power outage duration. This is to cover as much of everyday life as possible with the three scenarios stated below.

1. It is morning, a weekday and it is a 3h long power outage. You will be eating breakfast and doing your morning routine as you do on a weekday.
2. It is an early Saturday night and you were just about to do something but unfortunately a power outage occurs. You do not know for how long the power is gone.
3. It is night and you wake up because you are in need of going to the toilet and you realize a power outage has occurred.

The first question was if they would use any of the concepts in the presented situation, the next was if they would like to add anything to the concepts, and the third was if and what they thought was superfluous about the concepts. Below, the responses to these questions are compiled by describing what would be used, added, or considered superfluous.

Scenario 1 - Morning

About half of the interviewees responded they would maybe like to use concept 4 depending on if it were dark outside, the rest would not like to use any in this situation. While the majority, eight of the interviewees, would maybe like to use concept 5 to make coffee, tea, porridge, or charge one's mobile phone. Otherwise, in this situation, the interviewees would like to add candles, an oil lamp, and a few potentially a bigger battery backup.

Scenario 2 - Early Saturday night

Concepts 4 and 5 were said to be used by all interviewees, while two interviewees also pointed out that concept 3, and one interviewee said to maybe use all. In this scenario, four interviewees, two from HIE and two from LMIE, discussed that

depending on length, they maybe would use concept 7 also. Additionally, some interviewees would like to add a bigger battery backup to connect the refrigerator and freezer or a water pump for those who own and use a well. If not adding the bigger battery backup, two interviewees would instead use diesel generators. Moreover, all interviewees would normally use candles, an oil lamp, flashlights, or a mobile phone for light.

> *"It is a huge difference if it is a recurring outage as well, like there are two occasions like this [scenario 2] a month. Because I think if it is only once a year or once every six months on an evening, then you may as well just adjust to how it is and then you can either sleep, take out the guitar or read a book or something."* - Interviewee no. 4 in 4.6.

This shows the significance of depending on how recurring the outages would be responses about habits and which concepts would be necessary and used may be altered a lot.

Scenario 3 - Night

All but two interviewees agreed on using concept 4. Two interviewees would not use any of the concepts, but nothing or maybe a flashlight or their mobile phone would be used. A mobile phone and a flashlight were also mentioned to be used by more interviewees today and still in the future, even though they sometimes would use concept 4. Additionally, through two of the interviews, an idea that emerged was having a light with a small solar panel system would be very good to put in the window during daytime and use at nighttime. Otherwise, they felt no need for anything else in this situation, except that one interviewee would like to add a holder for the remote control always to know where it was.

Conclusions from Scenario Based Evaluation

Thus, by evaluating all scenarios, the earlier presented survey scale responses were once more validated, that the interviewees actually would use concepts 4 and 5. Still, other solutions would be used in addition to the concepts, and some users would still probably use none of the concepts.

The responses in scenario 2, when experiencing longer outages thus a bigger need, were also pointing towards concepts 3 and 7 as being discussed in maybe being used by some. While concept 8 was almost not mentioned at all, and concept 6 would only be used by some if the outage would be scheduled. It was also clear that in an early shorter power outage, as in scenario 1, almost all concepts felt superfluous for all interviewees, all but 3, 4, and 5, while in a longer outage, 2, 3, and 6 were considered superfluous for the most.

5.13.18 Conclusions of the evaluation of concepts

It can be concluded in this evaluation through both the survey and interviews that concepts 4 and 5 are the concepts the most are being positive towards and think

they would use. Still, the concepts would not work for all, rather all but people living without access to electricity where all would thus not have the need. Next, concept 6 followed by 3, 7, and 8 showed pretty similar responses in being okay and with overall more varying responses. The analysis pointed out a cohesive result in concepts 1 and 2 being the least appreciated concepts. This is because the least respondents would use these concepts; these concepts focused on preparation, would not make an impact, and better alternatives simply are available. Most differing problems were noticed about concepts 1, 6, 7, 8, while concept 5 was the only concept where only 35 % of the survey respondents noticed problems, while 40-60 % of the respondents noticed problems among the other concepts. While concept 4 stood out in having the least differentiating problems by a margin, despite being a concept where 55 % noticed problems.

Overall, the survey answers and interviews indicate that people prefer easily accessible solutions; thus, the concepts not being shared but instead self-owned. The majority are still positive towards the thought of sharing a concept in some way, just that it maybe is not the right choice for them. Still, some are positive towards both sharing with whomever and whenever, while this is only a few. Additionally, the solutions are preferred to be easily implemented and function with a small effort.

Lastly, through both the survey and the interviews, it was understood that all concepts were perceived as covering everything in the topic of power outages, while some still would need some self-owned bigger battery backup solutions, especially people living in rural areas.

5.14 Different factors affecting within the area when designing for all

Both the interviewees' and survey respondents' answers would differ due to multiple reasons, depending on where the interviewee would live, while the needs and opinions of a person living in a rural area differ more from the rest. This connected to sharing versus individual concepts, where respondents living in these areas were more positive towards individual solutions. Also, depending on how recurring the outages would happen and the length of them alters the responses about a person's habits and preferences and thus which concepts actually would be necessary or not. Also, personal traits of a character affect a lot; some, for example, like to be connected to the internet while some do not or do not care. Further, regarding the internet, internet literacy is also affecting concept 1, where the user needs to understand an online website or application on mobile. Where especially, some in LIE and LMIE would not be internet literate enough to be able to use this type of solution. Internet literacy was also brought up regarding older age groups in different HIE's. Age groups were also seen as affecting in another context, namely the use of a crank and thus using motion and strength of the user. Some users, especially in the older age group of 70+, were brought up not being able to use solutions where this is needed. Additionally, age groups alter the needs and habits of the user, e.g., as users above

the age of 70 do not work anymore, they expressed themselves to have other needs than a user in need of going to work at a specific day and time.

If lighting is needed depends on the time of the day and when it is sunrise and sundown; thus, where in the world the users are located has an impact. Generally, about the concepts solving only lighting needs, some respondents were more negative because it only solves a small part of the problem. Also, a few considered lighting to be the least important problem when experiencing power outages, while most said that was probably one of their main needs, this in regards to personal habits and needs, as well as traits of a character. Some are simply not comfortable living in the dark.

Further, both worldwide and regionally, usage and devices differing were seen as affecting the solutions; in choice and perception and directly in the solutions' appearance. E.g., HIE uses many types of electrical appliances when cooking food, while LIE and LMIE often do not, or some prefer using grid-connected solutions while some do not. Additionally, the sockets differ depending on where the user is located in the world. So may also the electricity network, wherein some countries it is common to have different voltages or the network being located either above or below the ground. Hence, this would either alter the solutions directly in the design or indirectly through differentiating the need of using the solutions.

The analysis did not indicate any significant differences or patterns in the perceptions about the concepts between different income economies. Instead, more specific factors on an individual level can be concluded to impact the respondents' perceptions. E.g., the economic aspects of people living in LIE and LMIE affect the solutions, while still people living in HIE also have economic aspects impacting, and a person living in a HIE also may be the least as poor as a person living in a LIE or LMIE. Thus, indicating individual factors being the main affecting reasons. Still, some quantitative data from the survey indicated that the respondents from LIE and LMIE could potentially be more open towards sharing concepts. However, the text responses and interviewees did not show the same result but instead brought up negative opinions and uncertainties regarding the feasibility. Also, LIE and LMIE noticed more problems in general with the concepts. Through the interviews, the responses from income economies did not seem to have a big impact, other than LIE and LIME interviewees would bring up more examples about when experiencing outages. Further, it can be concluded that all interviewees were open to changing their habits and mentioned that they would probably be in need of compromising their original plan and habits in times of an outage.

Finally, it can be stated that the interviewees were confirming the responses through the survey and vice versa about pointing out concepts 4 and 5 as being the best, most preferred, and used among all the concepts. While still, these two concepts are not possible for all, but only where access to electricity is available. As still 11 % in LMIE and 59 % in LIE do not have access to electricity [60] these solutions do not work for just as many percentages. While people living in households without

access to electricity, neither need such concepts as no access to electricity means no electricity consumption. For that reason, access to electricity is seen as the biggest factor affecting if and what solutions are needed or possible when experiencing a power outage.

So, when performing this study, several factors have been found to affect when designing for all within the area of lighting and backup systems. The factors found are at different levels of detail and are intertwined and linked in different ways. From the above descriptions, it can also be said that some factors can always be applied while some only sometimes. Additionally, the factors may either affect the solutions directly in needing different functions and alterations or the usage of a solution, where it may be used, used in alternative ways, or not at all. All factors are summarized in the following list:

- Access to electricity
  If a household have access to electricity or not.
- Habit of power outages
  How common it is or has been for a household to experience power outages.
- Electricity consumption habits
  What habits a household has regarding consuming electricity.
- Usage differing worldwide or regionally
  How something is used differs.
- Accommodation type
  What type of accommodation the household are living in.
- Location of accommodation in country
  Where the accommodation is located within the country.
- Location of accommodation in world
  Where the accommodation is located in the world.
- Income economies
  What type of income economy a household is located in.
- Age groups
  What age the user would be.
- Socioeconomic factors
  E.g., occupation, education, income, family size.
- Personal habits in everyday life practices
  Specific personal habits.
- Traits of character
  What type of traits a character has.
- Internet literacy
  How internet literate the user is.
- Strength of user
  The physical strength of a user.
- Devices differing worldwide or regionally
  What type of devices is used differs.
- Different sockets
  What type and standard of sockets differ in different countries.

- Electricity network
  How the electricity network is constructed differs, as well as the voltage being used.
- Economic aspects
  A households wealth, income, or economic priorities.

6
Discussion

In this chapter, aspects affecting the project outcome are discussed, where the result, sustainability and ethics, the methods performed as well as future research is included. Lastly, a conclusion is given.

6.1 Result

This master's thesis investigated one way to meet the probable dilemma of more future disturbances in our energy systems together with a growing need and dependency on electricity. Thus, an energy resilient way of managing this has been examined through this study. The initial purpose of this master's thesis study was to investigate everyday life in LIE and LMIE regarding energy resilience and, through this, develop an understanding of these explored contexts. Additionally, relevant aspects for HIE and a comparison of HIE versus LIE and LMIE were intended to be gathered. In the later part of the study, the aim was also to develop and evaluate a given design proposal as well as explore the possibility of a design proposal for all.

The first research question connected to the first half of the master's thesis is: *"What types, parts and interrelations of practices connected to energy resilience in LIE and LMIE exist; and which aspects may be relevant for HIE?"*. The world's households are provided with different starting points and prerequisites. Compared to a HIE, the average LIE household is 60 % less likely to have access to electricity; in addition, a LIE household may experience power outages daily to every fourth day while a HIE instead is around zero. Through this study, it was understood that most of the household practices in a LIE and LMIE could be counted as energy resilient. LIE and LMIE households already being energy resiliency are seen as positive. However, this could potentially have a negative impact if the current energy resiliency is in need of change. It may be harder to change a habit of an existing energy resiliency compared to creating a new one, while this has not been investigated. LIE and LMIE household practices are seen as energy resilient as they are mostly independent of electricity, or else the households are prepared *if*, or rather *when*, losing the electricity by always having a plan B. However, the independency in electricity has been found to vary between household practices and depending on which countries, regions, or income economies, what time of day or simply due to a household's habits and prerequisites. When investigating a large context, as in this study LIE and LMIE, it is therefore important to illuminate that the results should be considered as indications rather than "depicting how it is in all LIE and LMIE",

that would indeed require a much larger study. Further, the practices communicating, entertaining, and educating have been found to be the average exceptions in being energy resilience. Still, with an additional exception within each household practice depending on the time of day and household habits. Furthermore, the master's thesis narrowed down area, backup system and lighting, which are considered highly relevant for HIE as well, as seen to corresponding HIE households practices in a combination of what the future is likely to hold. Therefore the aim of investigating everyday life in LIE and LMIE regarding energy resilience is considered to have been fulfilled, as well as the possibility to answer the first research question connected to the first half of the master's thesis.

Additionally, the second part of the study's aim has been fulfilled, and it is possible to answer the master's thesis's second research question: *What is learned through creating and evaluating a design proposal with the intention of being suitable for all income economies?*. Through the creation and evaluation of eight different design proposals, it seems possible with a solution for all income economies within the area of backup system and lighting. However, the same solution *for all* is not possible. Neither is there one single solution solving all problems when experiencing power outages for the very most, but instead, there seems to be a need for multiple and different solutions which may differ from household to household. Still, there is unity among the different income economies responding about which types of solutions are the best and what is most important and appreciated. The households seem to prefer easily accessible solutions; thus, the concepts not being shared, but instead self-owned. Still, many are positive at first toward sharing, just that for them, it might not be the best or right choice. Additionally, on average, households also prefer easily implemented solutions that also function with a small effort. This resulting in concepts 4, the *Light bulb with built-in battery*, and 5, the *Self-owned battery backup*, being the most appreciated. Further, the most prominent factor when designing for all is not the income economies, but on a more individual level, if a household has access to electricity or not; due to this changing the practices and a household's habits the most.

Designing for all income economies regarding energy resilience or similar within the area of power outages, and more specifically lighting and backup systems, has not been found in any research. Nor has any information where inspiration is to be taken from a LIE or LMIE and then using the knowledge to create solutions for everyone within the area. Hence, this study fills the specific gap regarding this research and contributes towards a better understanding of designing for all income economies within the area of lighting and backup system. More specifically, within the area the gap includes researching a design for the emerged "medium", finding differences and similarities within the investigated countries, as well as looking at the practices from a material perspective.

6.1.1 Specific result - First half

Overall, the findings, mainly through the online study and the interviews and movies watched, are confirmed in the literature study, performed in the early parts of the master's thesis, as similar findings were made. E.g., lighting as a material element brought up in interviews and observations was confirmed in articles [16, 21, 66]; also, the importance of electricity in today's society was brought up in this study as well as in a Haitian study [71]; the same goes for the priority about having a mobile phone [68, 71, 72, 73]. The fact that articles confirm what was found in the online study, the interviews, and the movies watched are considered both a successful outcome and proceeding in doing so.

In LIE and LMIE, the household practices investigated in this study were overall considered energy resilient, as they are independent of electricity or the households have a prepared plan B when losing the electricity. However, the independency has been found to vary due to several factors: countries, regions, income economies, or simply personal habits and prerequisites. The practices communicating, entertaining, and educating were found in being exceptions of energy resiliency, while still, some households can be energy resilient in these practices as well. In other words, the study did not conclude in a single-tracked result but rather with the knowledge of how versatile the household practices may be depending on who the performer might be and are situated. Further, the main project group have acknowledged three strategies, based on insights created from a study with 21 households' past and present experiences as well as future thoughts of being energy resilient in Sweden: *"(1) response diversity, i.e., diversity in ways of carrying out normally electricity-dependent practices, (2) creating opportunities to develop resilience, and (3) building community energy resilience"* [29]. Where these strategies are considered a start in how to deal with everyday limitations in households. This is also connecting to what has been found through this study as tracks in how LIE and LMIE households are being energy resilient today.

It was unexpected that even a LIE household living on the bare minimum, struggling with money for food, and living in a one-room household are still most likely to own one or more mobile phones. Today, mobile phones are a high priority for all income economies due to their versatility in being a communication device, wallet, entertainment, camera, et cetera. This fact and interest in the topic led to the phone, among others, being included in the narrowing down. Thus, the household practices communicating and entertaining was one of the most similar when comparing LIE, LMIE, and HIE. Furthermore, it was indeed interesting that both LIE, LMIE, and HIE see their mobile phone (i.e., communicating/entertaining) and cooking as two as the most important areas and household practices, this which was both confirmed in the main projects study [77] as well as in this study's smaller participatory observation on an uninhabited island. This indicates that LIE, LMIE, and HIE being similar in their thoughts and habits despite having completely different prerequisites due to income economy levels.

The LIE and LMIE household's preparedness in that one always have to have a

plan B for one's basic needs was not that surprising. While a mobile phone being included in that basic need was more of a surprise. However, it was acknowledged that in a LIE and LMIE it was still not certain the power bank, if owning one, was charged, despite this being the main plan B for many. This implies that more research is needed to strengthen or deny that LIE and LMIE households are always prepared for power outages. Still, the fact that LIE and LMIE households are in a greater need than today's HIE in being prepared can be concluded, as well as a LIE and LMIE in the average households are more prepared than an average HIE household.

It was quite surprising that Bhutan stands out in having nearly 100 % access to electricity, experiencing way fewer power outages, and that it is a country with way less poverty than the other LMIE countries. In retrospect, it would be interesting to explore more about this fact. However, this is considered somewhat outside the scope; to investigate why the different countries of investigation differ. At the same time, understanding this and overall having detailed knowledge about the context designing for are considered favorable [91]. Still, time was not enough in this study to do these types of explorations.

6.1.2 Specific result - Second half

Through the evaluation of the different design proposals, different factors seen to affect within the area of backup system and lighting were found. An interesting finding among these is that not only and not primarily did the income economy affect but instead more individual differences. Where above all, if a household has access to electricity is affecting the most as these types of households do not need any electrical backup systems. Also, where the respondent would live, in a rural or urban setting, was seen to affect much, as well as personal traits affecting the habits in the households.

Research about designing for all income economies are indeed hard to find; however, there is all the more focusing on designing for "the base of the pyramid", "developing countries", "people in poverty" and "resource-poor", in general, and within specific areas as brought up in a review about design and poverty by the researcher Jagtap [92]. While still nothing within the specific area of lighting and backup system has been found. If the factors found instead are compared to findings within all areas focusing on designing for LIE and LMIE; Jagtap brings up that broad contextual aspects need to be considered: e.g., "income of poor people, rural or urban region, design sector, specific developing countries, and gender aspects" [92]. Where the author brings up urban versus rural regions as differentiating in *"geographic-spread of poor people, their occupation, and resources available to them"*, similar to what was found making an impact through this study, where this was also seen within HIE. Further, the same researcher also brings up how the social networks of poor people living in rural versus urban areas as making a difference [92]. Where the social networks are considered better in rural areas. A more specific discovery than in this master's thesis study, where this was found to be more general when com-

paring LIE and HIE, as LIE, in general, utilizes social networks in their everyday life more than HIE. Additionally, Jagtap also illuminates how *"poor people living in urban slums typically face the problems of social unrest, crime and related violence"* [92]; which similarly but on a more general note was illuminated by some respondents with experience of LIE through this study as some of the shared concepts not being able to work due to crime and violence in some LIE contexts. The same author has also more specifically compiled typically cited design requirements when designing for low income as a need for: *"simplicity, low-cost, use of locally available materials, small-scale, energy efficient, labour intensive to enhance employment opportunities, maintainable by local communities, and suitable for cultural and social contexts"* [92]. Where these requirements can be translated to the factors found through this study: *low-cost* refers to economic aspects; and where *simplicity, use of locally available materials, labor-intensive to enhance employment opportunities, maintainable by local communities* have been brought up particularly by some with experience of LIE and as being important due to some traits of character. While *suitable for cultural context* and how that would affect within this are have not been found. Another article brings up *"regulatory environment, physical infrastructure, knowledge and skills, and access to financial services"* [93] as issues in need of being addressed when designing product-service systems for low income. These issues are also similar to the factors found through this study; e.g., physical infrastructure is translatable to the electricity network and, more specifically, different sockets, while knowledge and skills may be translated to the factors internet literacy and strength of the user. Other researchers bring up the appropriate technology movement where technology originally designed for *"Western contexts"* could not be transferred to LIE in the 1950s and 1960s *"due to differences in social, political, material, environmental, organizational, and other contextual conditions"* [94]. Still, these arguments are valid and brought up through the factors found in this study, while many more on a specifically defined level. Further, and within the same area of power outages, the researchers in the main project group [29] as well as a researcher named Lovell [95] also points out social, geographical, and technological contexts to be of importance to regard in especially some locations *"as they set frame for new energy practices which do not necessarily transfer well to other contexts"* [29]. Where the main project group brings up *"island communities with stronger bonds"* such as Isle of Tiree and Orkney Islands as being examples of this. Aspects similar to what was found in a more general area by the other researchers were brought up and more specifically through this study. The articles found within broader respect also point towards more differences on a more individual and specific level rather than only on a general level between the income economy levels, LIE versus HIE et cetera, as in this study. If acknowledging these differences, it is through this study regarded possible to design for all income economies within the area of backup system and lighting. Still, no articles have been found agreeing that designing for all income economies to some extent is possible.

Regarding sharing, many are positive but have notions that it would not work for them, and instead, it may work for someone living in another country, accommodation type, location of accommodation, et cetera. Hawlitschek, a researcher within

the area of sharing economies, bring up trust towards other users as the most important prerequisite in order for sharing to entail long-term success [96]. A problem also brought up through this study as being impeding according to the respondents. Additionally, one of the main reasons to why households would be negative towards sharing was sharing ownership and the economic problems this could (would, according to the respondents) entail. While the main project brings up trust among users when sharing as challenging and suggests *"community ownership of items to share, rather than individual"* being *"one way of addressing trust issues"* [29]. While agreeing with this fact, there are other problems seen through this study this would entail and need to be regarded. Hawlitschek also brings up factors that may impede sharing as *"[...] the independence of private ownership, effort expectancy, and perceived process risks"* [96], thus agreeing with some of the problems seen in the shared concepts in this study. Further, it was indeed concluded through this master's thesis study that households, in general, want easily accessible and implemented solutions that function with small effort. Sharing a concept for many and to a large extent entails a compromise on these arguments; hence, the fact that many respondents are negative is not strange. A researcher within the area partly discusses reduced trends of sharing and that *"the boundaries of what is done with others have simply changed"* through households sizes being smaller, and the *"trends towards the 'domestication' and 'privatisation' of provisioning"* [97]. This meaning less users would be open to sharing due to this reason. Regardless, why is it that many were seen through this study first to be positive, but then when it comes down to it, they are instead negative? Why do some think that other people might want to share and that it would work for others but not think the same about themselves and their situation? Why would it work or work better for someone else? This study indicates some people are positive towards the idea of sharing due to positive aspects it would imply, but as it still would be an aggravating circumstance when it comes down to it, they would not like to share. However, more answers and conclusions regarding these questions can be made. Also, one might wonder if there is something in psychology implying a reason or pattern as to why one believes someone else would be better suited. However, no information confirming this has been found.

The design proposals created through this master's thesis were seen by most of the respondents and interviewees to cover everything needed when experiencing a power outage. If compared to the market analysis of what type of existing solutions are found, the design proposals are first of all testing new ways to own and share the products and share information. Particularly regarding concept 4, the *Light bulb with built-in battery*, this is a much easier, accessible, and implemented solution than the existing one for the user where he or she basically can continue everyday life as normal. There are no slightly bigger batteries with a crank among the Benchmarking products, only UPS-variants, thus adding an alternative to the existing through concept 5, the *Self-owned battery backup*. Thus, the design proposals differ from what was found through the market analysis.

6.2 Sustainability and Ethics

In this section, discussion points regarding sustainability and ethics are brought up.

6.2.1 Energy resilience, sustainability, and environmental friendliness

Being energy resilient is not directly equal to being environmentally friendly. How one responds to, recovers, or resists defines exactly how sustainable and environmentally friendly the household is. Through the investigation of everyday life in LIE and LMIE, some households were found to have a diesel generator to resist power outages, which is not counted as environmentally friendly as they thus are dependent on fossil fuels. While the households having solar backup systems are considered sustainable as these utilize the renewable energy source solar power. Further, in the early stages of the study, it was understood that many utilize gas when cooking which is completely independent of electricity, thus considered energy resilient. However, neither is this sustainable, as fossil fuels are utilized. It is still cleaner than coal regarding environmental friendliness, which is also regarded as an energy resilient way of cooking [98, 99]. In addition, cooking with coal is bad for the performer of the practice as inhaling the oozing smoke is not healthy. Through these examples, it is evident that being energy resilient is not equal to being sustainable and environmentally friendly. Also, through this discussion, it is suggested either that sustainability always is brought up when referring to something being energy resilient as the notion may hint inevitable about sustainability. Alternatively, the definition of energy resilience could be redefined in including sustainability; that may be what truly being energy resilient could be, thus giving this notion a consistently positive meaning.

All concepts created through this study are considered improving a household's energy resiliency. This through enabling a household to respond to, recover or resist the event of a power outage. While depending on how, *if*, the concepts are further developed and later used, they have the potential also to be sustainable. In a potential development, it is important to ensure sustainable and suitable choice of materials and longevity in the concepts as well as designing for circularity in order for the concepts to be recyclable or reused. While ensuring a concept being sustainable depending on households' use is more difficult when grid electricity is aimed at being used through the concept.

6.2.2 Transitioning towards sustainability

As earlier stated, from the article about energy-use patterns in Nepal [21] it is brought up that in going forward, all countries, both developing and developed, will have to transition towards the same goal. The goal in being a sustainable developed country where: both rural and urban areas are sustainable; our energy use is at optimum levels without limiting our quality of life; as well as instead of using fossil fuels or biomass, reliance on renewable energy is the future. While agreeing with

the authors on this topic and that this summarizes a sustainable future path, it is also believed that this master's thesis is one micro-step in this future path that might help pave the way for this change. Since this master's thesis study has the potential to design a sustainable solution for all income economies helping in being more energy resilient, where designing for all income economies may help to design for the emerged "medium" as in the model in the earlier discussed figure 1.1.

An interesting thought was illuminated in the same article [21]:

> *"In general, people tend to believe that the more one uses energy, the better his/her quality of life becomes and so-called energy saving simply decreases the quality of life. However, it is important to seek the way of life that can realize the reasonably better quality of life with the least possible rate of energy use in dwellings."* [21]

As this citation implies, quality of life can instead be increased while decreasing one's energy use, and for some, exchanging habits in relying on more sustainable resources. This is an important position in arguing for the need for this study, as well in a similar project and in going forward if developing the concepts further.

6.3 Methodology

This section discusses the implementation and execution of the methods performed, where advantages and disadvantages impact the reliability and validity of the study's outcome are addressed.

6.3.1 Observations and online study

The observations performed, i.e., mainly movies and documentaries watched, have been favorable in exploring and gaining general understandings about the context of LIE and LMIE. They were not the most important source in finding and exploring the household practices; as such, video sources where this in detail was depicted were hard to find. However, if observations had been performed in situ, as recommended by many researchers [91, 100, 101, 102, 103], the outcome of the observations could have been completely different. While this was not possible to perform in this study, due to Covid-19, it would be recommended that a Contextual Inquiry and direct observations, as described by Salazar [100], would have been performed as this could have been more beneficial than the observations performed. *These methodologies [surveys and interviews] rely on the users' ability to recall and explain a process that they are removed from in that moment.* By instead being at the location of the practice being performed, this is avoided, and *reasoning, motivation, and underlying mental models* [100] are more likely to be perceived. In this study, the online study replaced the visual part of the observations on-site due to an incredible amount of information which nowadays have been gathered and compiled through Gapminder [51]. That information, together with interviews, is perceived to have worked rewarding for the study. Still, it may have been even better to perform a Contextual

Inquiry. However, it is hard to state if it is either-or. The study discovered a gap in the findings, i.e., about the element meanings. However, this could also be due to a too big scope and time limitations in this study. As recommended by Kuijer [26], the target practice should not be too big when utilizing a practice-oriented approach.

A recently published research paper discusses benefits, drawbacks, and new opportunities with performing a field study from a distance due to Covid-19 brought up [103]. By having online interviews instead of on-site, it was seen through a study that more interviewees wanted to keep in touch and help post-interview. This was also observed in this study, as the majority of the nine performed interviews voluntarily urged in helping with more if in need later. In the article, *"a flexible and adaptive design, management, and implementation of research projects"* is one recommendation as well as *"fostering open access to research data and publications and, more importantly, the inclusion and empowerment of local research partners in multiple ways for a more just, ethical, and sustain- able research landscape"* [103]. This which have been utilized through this master's thesis where open access to research data, especially Gapminder [65] together with complementing research articles have been very helpful, as well as three of the interviewees having a connection through either own local research or currently working on-site for communities making great changes. Additionally, as mentioned in [103], by not performing an on situ field study, resources such a long travel would entail are beneficial if avoided when not really needed. This, which might be the case nowadays with more than ever available data and research online and "being online" actually exist in rural areas of LIE countries. Thus, the online study served as one of the excellent complement to being on-site when understanding the household practices and contexts of LIE and LMIE. Principally due to the website Gapminder [65], where numerous researchers and photographers have contributed in covering pictures and describing texts of the world's home, in a variety of income economies.

6.3.2 Interviews in the first half

Regarding the nine interviews, in the explore phase, both performance and outcome have experienced proceeding very good and successful; and are considered the other main second half in replacing the need for an in situ study. The interviews have given much input to this study, mainly for an understanding of the household practices in LIE and LMIE and the general context explored. The number of interviews was considered sufficient for an overall understanding of the household practices and their context. However, when the narrowing down had been made, it was discovered that some gaps in the more detailed mapping of the elements (materials, competences, and meanings) were located.

Three out of nine interviews were performed in Swedish as the interviewees were fluently speaking Swedish and were thus considered beneficial. For the remaining interviews, English was used, where the interviewer (the author of this master's thesis) and the interviewees had different accents. This entailed some language confusion as the interview proceeded; also due to bad internet connection for some of

the interviewees, as sometimes the sound quality made it difficult to perceive complete sentences; nevertheless, as audio recordings were made, these smaller problems resolved once transcription was made. Hence, this is not considered making too big of an impact on the reliability of the gathered information.

6.3.3 Analysis

Overall, using a practice-oriented approach is considered beneficial, especially now, in retrospect of the study. However, when performing the approach, it felt somewhat like a restraint as a first-time practitioner of practice-theory where the approach was not fully understood until the latter part of the exploration in the study. While still not a full understanding of the theory is deemed to have been achieved.

In the practice-oriented approach, materials do not have a central role; however, in this study, it has been seen that materials differentiate a lot between different income economies and slightly less between different parts of the world. Thus it can be concluded that the role of materials in the practice-oriented analysis should potentially have a bigger role than the usual. Still, meanings and competences also differ between income economies, but these have been discovered as more general and often more common than the third element, materials. However, it is also acknowledged that the research has not been fully completed and saturated as gaps in the analysis have been discovered, as earlier mentioned.

Furthermore, a recommendation is to explore historical careers in a practice-oriented approach [26]; however, due to time limitations and prioritization of other areas to cover, this was chosen not to be investigated. In retrospect, this also feels correct to opt-out as in this study, a broad area and a lot of different types of contexts are the main focus. Additionally, as in this thesis, the aim is to gather knowledge about how LIE and LMIE households work in the present time and how this can inspire and result in creating a design for all. Thus, understanding the historical career is still seen as something secondary, sometimes abundance regarding this study, and is seen as preferable as skipped due to the conditions in this study, both regarding time and scope size and intended outcome.

6.3.4 The research approach Research through Design

In the second half of the study, the research approach Research through Design was utilized, where the approach indeed did help increase or even enable the validity in the result. Without the help of the conceptual sketches and design proposals, what has been learned about would not have been or at least not as exhaustive as experienced in this study. It has been invaluable and impossible to do without the design proposals and the research approach as the so-called artifact was unknown for all and so was the experience of a power outage, especially for HIE. Thus, it did indeed help the potential users in perceiving and reflecting about how it would be experienced when seeing an example that one can visualize in one's everyday life. Thus, using Research through Design when investigating an unknown topic with

potential future users and what can be learned through this creation has truly been appropriate.

6.3.5 Creation of concepts

In the creation of the design proposals suited for all income economies, it is indeed regarded beneficial in using co-creation sessions when generating concepts. This, which is recommended by a plurality of researchers, where the importance of using co-creation when especially being a HIE designer/engineer designing for low income is illuminated [42, 44, 45, 46]. This has considered making a positive impact on the reliability of the study's generated concepts in that they could work for everyone. However, it could have been even more beneficial if performing more co-creation workshops or continuing the co-creation process when elaborating on the generated concepts with both people from LIE, LMIE, and HIE.

In the co-creation workshops, it was experienced as hard to explain the requirements, needs, and contexts for the participants. While still, mostly the focus in both co-creation sessions was to encourage the participants to think according to their own experiences. The participants were yet prepared beforehand with explanations of the LIE and LMIE context through texts, scenarios, and a reflective assignment to be done before the workshop. Especially regarding the HIE co-creation session, the context is a future scenario where they in a probable future are expected to experience more disruptions, interruptions, and a need to be more energy-resilient. Thus this is complicating the idea generation. While two of the participants in HIE afterward mentioned that they still felt they could familiarize themselves with designing for this context, whereas the third participant is very familiar with the future scenario through her research in the field. Therefore, this is not seen as affecting the reliability.

The workshop with designers resulted in more ideas, and it was clear that the idea generation and development were closer at hand to these participants than to the LIE/LMIE workshop participants, who still were engineers. However, the ideas from the co-creation workshops did not differ that much. Perhaps all participants were involved academically, and five still were last year's students, making the participants too similar. It would indeed have been interesting to perform co-creation workshops with people living in more rural settings from LIE, LMIE, and HIE, and with households not with all participants with higher education of at least five years of study. This would most likely have minimized that small but existing gap in the eight concepts where some, especially the households in rural settings, experienced a need for another type of solution, a somewhat bigger battery backup solution. Hence, the choice of participants impacted the reliability of the eight created concepts. Still, the concepts were generally considered to cover everything needed when experiencing a power outage as expressed by LIE, LMIE, and HIE respondents; and may therefore be considered not making too big of an impact.

6.3.6 Evaluation of concepts

The validity and reliability of the evaluation of concepts are generally seen as being good. This as over 80 responses in the survey together with 12 performed interviews is seen to be exhaustive and complementing each other in both methods and with respondents with experience of 28 different countries, as well as a distribution demographic aspects.

One factor that might have impacted the reliability in the evaluation of the concept could be that it was as many as eight concepts were being evaluated. In the interview evaluation of the concepts, all concepts were being regarded simultaneously. Some interviewees seemed to have difficulties relating and remembering that many concepts; sometimes the concepts were mixed up, and some interviewees forgot important details in some of the concepts. It was also understood that some interviewees might not have fully understood the concepts despite saying so at the beginning of the interview. While the eight concepts being evaluated through the survey seem to have been a better execution where focusing on one concept at the time instead was the case. However, this way may as well have affected the answers as the respondents did not get the full picture at the start but instead had to answer what they thought about a concept before knowing what came next. Additionally, all concepts were evaluated in the same order for all respondents. Still, the possibility of going back in order to change an answer on the earlier concept exists, while most likely a respondent did not do that due to the survey being long, maybe a fear of losing an answer and the interface of the Google Forms not making it clear that the result is saved despite going back.

A cause that could potentially have impacted the answers and the outcome, both positive and negative, and the validity and reliability of the study might have been the time of the year the study was executed. This is due to weather, geographical and societal factors making an impact. Weather, meaning power outages are more common and the needs are differentiating due to different types of weather depending time of the year. Geographical, as sunrise and sundown, may depend on the time of the year. While societal factors are making an impact due to Covid-19 being ongoing throughout the study for the last two years. Additionally, unusually and extremely high electricity prices at the time of the study being performed are likely to have affected the study's outcome. This was happening in Sweden, where most of the HIE responses came from, also other HIE's, which may have impacted the responses and the result. This might as well have resulted in more people being interested in the study as the survey thus became even more *in time* than it already is with our great need and many times dependency of electricity, lack of electricity networks in Sweden as well as the transition in the world towards renewable energy. While still the responses might have been affected in people being more open towards some of the solutions when having this experience than they normally would be. Thus, it would be preferable and a recommendation to investigate in a time without Covid-19, and with a more normal electricity price and different times of the year, which may entail different temperatures, situations, and habits; and potentially an even more reliable and accurate result.

Another factor that may be affecting the reliability of the result is the lack of respondents from LIE and LMIE households living in rural contexts. Thus, this needs to be considered when the concepts are concluded if they are to work in LIE or LMIE rural settings and how households perceive the concepts in these areas. While many of the respondents living in urban contexts also had an experience of rural settings, this could mean the responses still can be seen as reliable.

6.4 Future research

In this section, the recommendations for future research are explained and discussed.

If performing a similar project it stands as a recommendation, what has been truly important in this study, to first of all spend much time in understanding the context of LIE and LMIE thoroughly, while still more time could have been spent on this in understanding it further. Also, the use of co-creation when idea generating can not be emphasized enough when designing for such a differentiating context than being used to.

Additionally, using the research approach of Research through Design in such a study is seen as appropriate. That is, in a study with an unknown topic for the potential future users and an unknown future artifact with potential future users, and also seeing what can be learned through this creation. Through this research approach, what has been learned can thus be used further by others if someone is to investigate in the area of backup system and lighting.

In general, it can be concluded that more research is needed about the different factors affecting the area of backup system and lighting when designing for all. Investigate more about how the factors are linked within each other, to households, and the household practices. Thus, more can be learned within the area of backup system and lighting when designing for all income economies.

In a continuation of the study, the concepts are in need of being tested in an actual scenario to gather tacit knowledge from potential future users. During some of the evaluative interviews, it emerged that some interviewees thought they would do it in some way, while later, it appeared to be in another way. Thus, testing in real scenarios and with an actual prototype would be an obvious next step that should not be avoided. This depends on the different concepts; it may be hard to imagine being in the situation, especially for someone with less experience of power outages. This would entail a more thorough gathering about how households habits would have changed. Additionally, more evaluation about how long power outages or what time of day would it take for certain concepts to be useful and in general about how different lengths of power outages would affect. Additionally, more research about how the different aspects impact the different concepts. Further, the concepts need to be evaluated regarding more aspects: capacity of the batteries, efficiency of the crank charging, and more about the concept in regards to sustainability. More specifically, an investigation about economic factors, what do future users see themselves pay-

ing for the different concepts. It would also have been interesting to gather more information about how the concept would facilitate in the event of a power outage.

Another point in need of being researched more is the concepts in regard to being shared. What is it affecting why some users are positive at first towards the concepts and towards sharing in general but later not wanting to use the concepts? Also, it was acknowledged that potentially some households are willing to share depending on how it is shared. Thus, to conclude what more specifically is affecting this and which types of households stands as a recommendation. Is it space, time, room, sharing economically, whom the concept is shared with, what factors might be impacting the power outages, or how long the outages are? Hence, the option of sharing concepts needs to be investigated more to conclude if sharing is possible.

If the study continued, the concepts would be in need of being further elaborated, where a recommendation in order for the concepts being designed for all and in all income economies is to use tools, principles, and criteria enabling this [42, 47, 48] as brought up in section 4.1.2. It also stands as a recommendation to continue elaborating the concepts through further co-creation sessions with the different income economies. Also, and more specifically, if going forward with any of the concepts using batteries, the product must be designed for circularity in order for them to be recycled or reused and thus be sustainable [104]. Furthermore, in a development it is important to ensure the choice of materials and the longevity in the concepts as well as designing for circularity in general in order for all concepts to be sustainable, recyclable, or reused.

6.5 Conclusion

Through this exploratory study, everyday life in LIE and LMIE regarding energy resilience has been investigated together with an inquisition of the possibilities of a design proposal for all income economies within the area of lighting and backup system when experiencing power outages. From this exploration, it has been understood that LIE and LMIE households are energy resilient in many practices, especially since many practices are independent of electricity and most households are prepared for power outages. While the energy resiliency is generally more lacking in the practices communicating, entertaining, and educating, still depending on the households habits and the households having general meanings and competences, suggesting they may as well be energy resilient in these practices. Eight design proposals were developed within a more narrowed down area of power outages, lighting and backup system. From the evaluation of these, it was understood that there is a unity in households from all investigated income economies, LIE, LMIE, and HIE. All seem to prefer easily accessible and implemented solutions that function with a small effort. Affirmed through and resulting in two out of eight concepts being most appreciated and believed that if developed further in a co-creation process as well with the recommended tools and principles, these will truly facilitate and contribute towards energy resiliency before and in the event of a power outage. It has thus also been concluded that it is possible to design for all income economies within the

area of lighting and backup system when experiencing power outages. Still, with the exception of not *all* within the income economies, due to all not having access to electricity are not having the same need as those having access. Additionally, the study has shown a plurality of different factors that are essential when going forward in developing the concepts beyond a conceptual level within the area. Therefore, the study can also conclude that differences on an individual level impact significantly more and should be regarded instead of solely on an income economy level.

In order for all income economies to transition into sustainably developed countries, the path of being inclusive of energy resilient design may be one way in facilitating the future dilemma; while more research within this area is in need of being done to take this path. Who knows? Eventual future research may entail further developed versions of the two preferred concepts being available in many of all income economies' future households. The recommended future approach is believed to enable one step closer to reaching "medium" for all within the area of backup system and lighting.

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A

Interview Script in English

Interview script

Hi, my name is Nelly Sevelius, nice to meet you!

[short about me]

First of all, thank you for participating in an interview! It means a lot for my thesis.

First I will tell you a short introduction/recap to what my master's thesis is about. I am investigating everyday life in countries classified as low and lower-middle income economies. In particular, I am interested in how everyday chores are in these countries and how you handle, are prepared for and experience disruptions and power outages in electricity networks. A further part of my project will be to investigate with inspiration from low-income economies, how to create something that suits all income economies and helps in everyday life to become more resilient to disruptions / outages. Since they are expected due to conversion to renewable energy sources and also due to potential climate change.

When we talk about everyday life, I will talk about household practices and with that I for example mean:

- Bathing
- Toilet
- Cleaning
- Cooking
- Dishes
- Laundry
- Entertainment

Do you have any questions or are you curious about something before we start?

Before I start with my questions, I would like to ask if it's okay if I record the interview?
If yes, only the sound will be recorded.

1. Would you like to tell me briefly about yourself?
    a. Who are you?
    b. Where do you come from?

2. Do you have experience of
    a. Rural/countryside?
    b. Urban/city?
    c. Plurality of places?

3. What would you say is the biggest difference? (between countryside and city?
    a. Are there any differences related to electricity?
    b. Thoughts? Habits? Products used?

4. Do you have experience with power outages?
    a. How often would that be?
    b. Are they planned? Do/did you get any heads up?
    c. How is your experience/feeling about power outages?
    d. Is something extra changed?
    e. Is there something you prioritize especially in such cases?

5. Do you have experience with limits of electricity usage? No outage but limit of what is possible to use?
    a. What happens then?
    b. How is your experience with this? How does it feel?
    c. How do you handle the situation if you are in the middle of a daily routine?
    d. Do you know about it in advance when there may be a shortage?
    e. Is there something you prioritize especially in such cases?

6. If you had access to more electricity, do you think your daily chores would have changed?
    a. How?

   b. Something to the better or for worse?

7. If, on the contrary, you had access to less, how would it have changed your daily chores?

8. What is valuable when you have electricity?
9. What is valuable when you don't have electricity?

10. Does the weather in any way affect where you live / come from?
    a. What is the most altered?
    b. How do you prepare?
    c. Do you change your habits in any way?

11. Do you have a favourite household practice?
    a. Why?
    b. When you do this practice, is there a specific product you use for this then?

12. Would you say you have any product you could not live without? Like a favorite product (in LIE)?
    a. Why that product?

13. Would you say you have any habit in your everyday life that is particularly valuable for you?
    a. Why that habit?

14. Would you like some chores / products to be more / less electrically dependent?
    a. Why? / Why not?

15. What do you think is the most important knowledge when living in the context you know/speak about?
    a. Why this knowledge?
    b. How have you learnt this?

16. Do you or the society you tell about any routine, norm or "rule" that you think more people should take part in?

17. Is there anything you would have liked to take with you from your home country / where you live now? And vice versa.
    a. It may be practice, habit/routine, norm, product etc.

18. The five most important things in your home? Start a new home, 5 things start with.

19. Is there anything you wish was in your home that could facilitate in some way?

20. Do you have an experience or something else you would like to share?

21. Do you have any advice or tips for me?

22. Do you have any questions for me?

B

Preparatory PDF before Workshops

Co-creation workshop

Thank you very much that you want to participate in a co-creation workshop as a part of my master's thesis. To give you an idea of what it will be about, here, one week in advance, is some information about the master's thesis and the workshop to look through.

The workshop takes place online through Zoom the 17th of december 10:00 to 12:00. To connect to the workshop please use the link and password below.

Date: Friday 17th of December
Time: 10:00-12:00
Link: [redacted]
Password: [redacted]

Up until now, the goal of my master's thesis has been to investigate everyday life in low and lower-middle income economies in regards to energy resilience. Where low and lower-income according to The World Bank's division are the two more poor income economies out of the four in total. Energy resilience in this project is defined as the following: *To be able to respond, recover or resist various disturbances in regards to energy and in the context of everyday household practices.* In the master's thesis I have thus investigated the existence of different types, parts and interrelations of practices connected to energy resilience in low and lower-middle. In order to create this knowledge I have brought up facts about several countries in two continents and created an understanding of the household practices performed there.

Next half of the project, which this workshop is a part of, will investigate the possibilities to create a design proposal for all income economies within a smaller area, namely *backup system and lighting* which will be described in the following paragraphs.

Area - Backup system and lighting
To give you an idea of what backup system and lighting contains in this workshop follows first a shorter description on this and then a list of material/products of which this area has been found to contain within low and lower-middle income economies today; also which household practice that may be connected to the area.

Backup system and lighting was chosen in regards to being one of the most necessary to continue with according to the study. This, as here is where the low and lower-middle income economies have electricity dependency, the opposite to the most household practices where they are completely independent of electricity. The area is important as it meets necessary needs for someone who experience power outages and/or disruptions and also are or would like to be living energy resilient. Moreover, this is a problem for both low, lower-middle as well as high as the future most likely to entail these types of disruptions in a potential future. Thus, the area is highly relevant for all income economies. In order to keep the area somewhat smaller, backups reserved for the whole home have

been opted out together with non-electrical needs within the area of backup system. Within the area of lighting both electrical as well as non-electrical wil be considered.

Material/products that is included in backup system and lighting today within low and lower-middle income households are:

- Battery backup systems
- Power bank
- Solar charger
- Solar backup system

- Light bulb
- Candle
- Oil lamp (incl. oil)
- Kerosene lamp (incl. kerosene)
- Gas lamp (incl. gas)
- Flashlight
- Solar cell lighting

Reflective question before the workshop

In order for you to put yourself in the mood of our planned workshop, here follows a reflective question that I am happy if you will be able to have thought about before the workshop. From your reflection it would be very nice if you brought a short answer that we will discuss during the introduction of the workshop.

➢ Think about what you have done today.

Now imagine that the situation had looked different and you instead would experience a 4 hour long power outage in the evening after dark. This, as it is not an unusual scenario in a low- and lower-middle context and as it is believed that the future may also look like for a high-income country.

➢ How would this have affected your day and what would you have made different? *(especially in regards to backup system and lighting)*

The workshop

First during the workshop, I will give you a short recap/introduction of the topic and then together we will discuss a bit about the reflective question and the topic in general. Then the workshop will consist mainly of two idea generating methods through which we together will create concepts of the above described topic through and with the help of an online whiteboard tool called Miro. The link to Miro will be sent during the Zoom-meeting once the workshop has started.

Looking forward to next week!
Kind regards, Nelly

C

Evaluative Survey

SURVEY - Evaluation of 8 concepts

Hey!

My name is Nelly Sevelius and I am currently completing my master's thesis on the Industrial Design Engineering program at Chalmers in Gothenburg.

The master's thesis project is part of a larger research project at Chalmers, which together with the companies RISE and Boid, is investigating how we and products in the future can become more resistant to disruptions and interruptions in electricity supply, something that in the project is called energy resilience. More disruptions and disruptions are expected through our transition to a use of more renewable resources together with an increasing dependency on energy. Many countries, especially low-income economies and lower-middle-income economies, are already experiencing daily disruptions and power outages. As my part in the project, I have thus investigated how low-income economies already handle and are prepared for disruptions and interruptions in the electricity supply. Based on this collected knowledge, 8 concepts have been developed on ideas to facilitate disruptions and interruptions in our household electricity. It is therefore these concepts that will be evaluated through this survey with the help of your answers.

Thank you very much for wanting to take the time and help me evaluate the concepts developed in my master's thesis!

NOTE! All answers are completely anonymous, unless you choose to enter your email in the very last question of the form.

*Compulsory

ABOUT YOU

To get an idea of who are answering, here are a few short questions about you.

1. How old are you? *

- ◯ - 19
- ◯ 20 - 29
- ◯ 30 - 49
- ◯ 50 - 69
- ◯ 70 -

2. What is your gender?

- ◯ Female
- ◯ Male
- ◯ Other: _____

3. What country do you live in? *

_____

4. Have you lived in another country for a long period of time? If yes, where? *

_____

5. Accommodation type *

- ◯ Apartment
- ◯ House
- ◯ Other: _____

6. Location of accommodation *

- ◯ Countryside
- ◯ Village
- ◯ City
- ◯ Bigger City (more than 300 000 inhab)
- ◯ Other: _____

YOUR EXPERIENCES

Here, I am interested in getting some knowledge about your experiences linked to power outages and disruptions in electricity supply.

7. How much experience do you have with SHORT (max 1h) power outages? *

- ☐ Daily
- ☐ Monthly
- ☐ Yearly
- ☐ Once every two years or less
- ☐ None

Other: ☐ _____

8. How much experience do you have with LONG (more than 1h) power outages? *

- [ ] Daily
- [ ] Monthly
- [ ] Yearly
- [ ] Once every two years or less
- [ ] None
- [ ] Other: _____

9. What is the biggest annoyance when you have experienced power outages?

_____

_____

_____

10. Do you already have a way or a specific product that helps you in being prepared and / or deal with any interruptions or disturbances in the electricity supply?

_____

_____

_____

CONCEPT
EVALUATION

Now you will see the concepts that have been developed through this master's thesis project and answer 7 questions about each concept.

Concept 1

A community-website-service with information, tips and tricks connected to energy usage.
It serves as both a website and an app where a user may login to enable specific tips as well as the possibility to download information to mobile phone, computer or tablet to use when in offline mode.

Information, tips and tricks can be found about the following: How to save and store energy; How to be prepared when power outages occur; When, how and why most energy is consumed. One can also share tips world-wide with others; compete and compare one's consumption to others both local and global; as well as ask questions to others that might have more/other experience.

11. What is your first impression of the concept? *

12. Do you feel that the concept would simplify an everyday life with power outages? *

	1	2	3	4	5	6	7	
Disagree	◯	◯	◯	◯	◯	◯	◯	Agree

13. How likely is it that you would use this concept in an everyday life with power outages? *

	1	2	3	4	5	6	7	
Not likely	◯	◯	◯	◯	◯	◯	◯	Very likely

14. Would this concept change anything in your everyday life? If yes, describe what and how here.

15. Do you see any problem with this concept? *

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ Don't know

16. If you answered "yes" or "maybe" on the previous question, what did you had in mind?

17. Do you have any other comment about the concept? If yes, write it here.

REPEATING OF THE SAME STRUCTURE AND QUESTIONS REGARDING CONCEPTS 2-8.

INTEREST IN A FOLLOW-UP INTERVIEW?

67. Between 7th-11th of February I plan to conduct some supplementary online interviews (about 30-40 min long) to this form, is this something you would be interested in? *

- Yes
- No

68. If YES to the previous question, write your email address below.
NOTE that the survey you just answered will no longer remain anonymous.

D

Interview Script in English - Evaluation

Interview script - Evaluation

Hi, my name is Nelly Sevelius. Nice to meet you!

[short about me]

First of all, thank you for participating in an interview! It means a lot for my thesis.

I will tell you a short introduction/recap to what my master's thesis is about.

I have investigated everyday life in countries classified as low and lower-middle income economies and more specifically how we and products in the future may become more resistant to disturbances and interruptions in the electricity supply that are predicted to become more common in some countries. I have now come to a step where 8 concepts have been developed and which are now to be evaluated. And where this interview is a part of the evaluation of these concepts. Throughout the interview it's okay to just interrupt me and ask a question if something is unclear.

- Do you have any questions or are you curious about something before we start?

Before I start with my questions, I would like to ask if it's okay if I record the interview?
If yes, only the sound will be recorded.

*** = Fill in about each interviewee

SHORT SMALL TALK

So, you're from *** and have *** much experience of power outages...

EVALUATION OF CONCEPTS

Now I will start with showing you all 8 concepts and ask you a total of 13 questions.

[Share PDF with concepts]

- Before I ask the questions, do you feel that you know all the concepts? Or do you want me to explain something? (we can of course do this gradually also)

1. Your first impression with the concepts were ***.
    - Unsure towards concepts ***.
    - Positive towards concepts ***.

2. Would any of the concepts change anything in your everyday life? [Don't try to pull out an answer]

    *[Connect to previous answer ***]*

    - Elaborate on this question. Would you be in need of changing any habit/practical thing in order for any of the concepts to work?

3. How do you feel about sharing the concepts with others?

    1, 6, 7 and 8 are shared

    - How many would you be comfortable to share with?

    Applies mainly to 7 and 8

4. How do you feel about walking / the need to move in order to use the concepts?

    Applies mainly to 7 and 8

    - How far would you be willing to walk/transport?

SCENARIO BASED EVALUATION

I will now present 3 short scenarios where you will be asked 3 questions connected to each scenario. Imagine...

- It's morning, a weekday and it's a 3h long power outage. You will be eating breakfast and doing your morning routine as you do on a weekday.

    5. Would you say that any of the concepts satisfies your basic needs when experiencing a power outage? Which do you envision that you would use in that situation? *(considering what the concept aims to fulfill)*
    6. Is there anything that you would like to add to the concepts, in order for it to feel more useful? Do you miss anything?
    7. Is there anything that feels superfluous/unnecessary with the concepts?

- It's an early Saturday night and you were just about to do something but unfortunately a power outage occurs. You don't know for how long the power is gone.

    8. Would you say that any of the concepts satisfies your basic needs when experiencing a power outage? Which do you envision that you would use in that situation?
    9. Is there anything that you would like to add to the concepts, in order for it to feel more useful? Do you miss anything?
    10. Is there anything that feels superfluous/unnecessary with the concepts?

- It's night and you wake up because you're in need of going to the toilet and you realize a power outage has occurred. *Most probably only concerning lighting.*

    11. Would you say that any of the concepts satisfies your basic needs when experiencing a power outage? Which do you envision that you would use in that situation?
    12. Is there anything that you would like to add to the concepts, in order for it to feel more useful? Do you miss anything?
    13. Is there anything that feels superfluous/unnecessary with the concepts?

END

- Do you have something you would like to discuss or comment about the concepts?