Improving Energy Literacy: A UX Study on Guiding Homeowners Towards Effective Energy-saving

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Abstract

The aim of this study was to examine the user experience of Husguiden, an informational webpage by the Swedish Energy Agency (Energimyndigheten), identify areas of improvement, and build a prototype derived from them to later be expanded on. Through user testing, usability issues were identified, such as there being a surplus of overly abstract information as well as navigation issues. There were also requests for more personalized content, diagrams and other visuals. Several UX processes were executed, including affinity diagrams and method 635, ultimately leading to the creation of a low-fidelity (lo-fi) prototype, based on parts of the original Husguiden. The prototype was then usability tested and the main takeaways were that the prototype was perceived as useful; the initial filters that personalized the content were good but were sometimes used incorrectly; visually representing the return on investment with a timeline was helpful; the icons were appreciated but some were a bit confusing. The prototype had clear usability issues itself, some related to design and others to the lo-fi format. Additional concepts and design ideas not included in the prototype were also presented, as the objective was to build and test a prototype as a foundation that future iterations of Husguiden can build upon, in the interest of educating the public and increasing energy-saving behavior.

Keywords: User experience (UX), Low fidelity (lo-fi) prototype, Energy-saving, Energy literacy

1 Introduction

The goal of this study is to improve Husguiden, an informational webpage created by The Swedish Energy Agency (Energimyndigheten) in 2022, that seeks to help homeowners lower their energy consumption (Swedish Energy Agency, 2023b).

A Novus survey conducted on behalf of the Swedish Energy Agency found that 90% of Swedish homeowners consider it important to reduce energy usage (Swedish Energy Agency, 2022). However, uncertainty about the long-term profitability of energy-saving measures hinders their willingness to act, especially in the long-term. The most common action taken by participants was replacing old lightbulbs with energy-efficient LEDs. About 67% of respondents had taken at least one energy-saving action in the past six months. Awareness of government-provided information sources, such as climate advisors and energy declarations, was relatively low. The survey underscores the need for educational tools like Husguiden to provide valuable information on energy-saving measures (Swedish Energy Agency, 2022).

Husguiden offers realistic energy-saving suggestions and procedures adapted to various household types and conditions. The tool has five core processes, two supplementary steps, and a sidebar with external links for more information. The most flawed aspects are redesigned in a low fidelity (lo-fi) paper prototype to serve as an example for future versions of the website and as an object of study for user experience improvements.

The study consists of user research, carrying out user tests on the current website and using methods established in the field of user experience and interaction design to create the prototype. Finally, the prototype is usability tested to find out how that beneficial information can be better communicated to homeowners throughout Sweden.

The research questions for this project are as follows:

RQ1: What opinions do users have about Husguiden?

RQ2: How do we redesign Husguiden to further improve people's energy-saving behavior?

RQ3: What parts of our new design worked well and what should be avoided when designing future iterations of the website?

2 Theory

This section contains a brief summary of the relevant concepts, definitions, and existing theories.

Energy Literacy is the understanding of energy and its environmental impact, including knowledge, attitudes, and behaviors related to energy consumption and conservation (Martins et al., 2020). Alongside energy literacy, decision-making is also affected by a concept called *Bounded Rationality*. This theory states that humans make decisions based on a restricted set of options and information involving limited attention, time, and information processing abilities, within their cognitive constraints, which may not always result in ideal outcomes (Dharshing & Hille, 2017). *Temporal reframing* is a strategy that can be used to present rewards or benefits in different timeframes, such as emphasizing long-term savings over short-term outcomes (Dharshing & Hille, 2017). Central to the design process is attention and how it is allocated among perceived stimuli, something called *Selective Attention*. According to Treisman's attenuation model, stimuli not focused on is toned down, not lost (Purves et al., 2012). Pre-determining what information is relevant can help eliminate unnecessary stimuli, aiding our selection process. Related to selective attention, *Hick-Hyman's law* is a rule of UX-design stating that the amount of time a user takes to decide is positively correlated with the number of options presented (Arvola, 2020). In designing an interface, the bottom-line is to minimize the number of options presented, or at least sort or divide them.

3 Method

3.1 User research

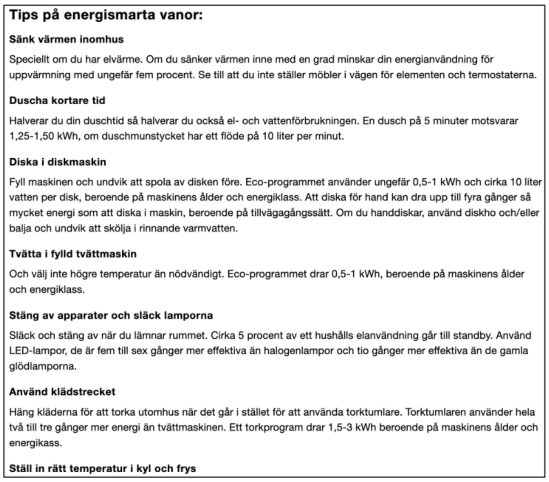
User research was conducted with the intention of identifying flaws in Husguiden and identifying participants' knowledge gaps on energy-saving. A convenience sampling was used to recruit six participants, including four villa owners, one townhouse owner, and one student renting an apartment. A questionnaire was then sent out to the participants prior to the interactive session to investigate their relation to the cognitive, affective and behavior dimensions of energy literacy. The interactive session consisted of recording the participant's screen activity through Zoom while implementing a think-aloud protocol, sharing their thoughts while browsing the page. Initially, they had freedom to explore the page as they wished, and after 15 minutes they were assigned a task to find the most cost-effective, energy-saving change based on their own conditions and preferences. Finally, a semi-structured interview with mostly open-ended questions was conducted to gather feedback from the participants on the usability and potential areas of improvement on Husguiden. This phase of the project followed the ethical guidelines as described by Arvola (2020), for example with an informed consent form.

Next, the data from the user research was analyzed through content analysis, affinity diagrams, and user scenarios. The aim of the content analysis was to understand how users interacted with different modules and steps of Husguiden by analyzing the screen recordings and transcriptions. In accordance with Arvola (2020), affinity diagrams and user scenarios were created to summarize the findings and identify areas of focus, difficulties, and improvement.

3.2 Design Development

The design development phase included methods and steps in accordance with Arvola (2020). Initially, a set of goals (effect, product, UX, and process goals) were formulated with the intention of defining clear and measurable goals for the project. It is crucial to establish a well-defined framework for prototype design, including details about the concept, target users, features, usage context, requirements, and significance. Hence, design aspects were established to address these fundamental aspects. Thereafter, method 635 was employed, which involves collaborative brainstorming on design concepts. Next, the project members engaged in an interface sketching session to define the visual presentation of the design concepts, following an iterative process outlined in Arvola (2020). The selected design ideas from the sketching session and subsequent discussions were translated into user cases, which helped define the functional requirements of the design implementation. Once the outline for the design was complete, the project members began creating a lo-fi prototype in PowerPoint. To make it a testable paper prototype, the slides were printed in full color, cut into sections, and pasted onto cardboard, simulating different screens of the website. Following the recommendation by Arvola (2020), the paper prototype was intentionally designed as a rough draft, allowing participants to provide feedback without hesitation

while still ensuring that the information and features were accurately scaled for a realistic experience. An example of the transformation from the original Husguiden (Figure 1) to the prototype (Figure 2) is shown below:



Tips på energismarta vanor:

Sänk värmen inomhus

Speciellt om du har elvärme. Om du sänker värmen inne med en grad minskar din energianvändning för uppvärmning med ungefär fem procent. Se till att du inte ställer möbler i vägen för elementen och termostaterna.

Duscha kortare tid

Halverar du din duschtid så halverar du också el- och vattenförbrukningen. En dusch på 5 minuter motsvarar 1,25-1,50 kWh, om duschmunstycket har ett flöde på 10 liter per minut.

Diska i diskmaskin

Fyll maskinen och undvik att spola av disken före. Eco-programmet använder ungefär 0,5-1 kWh och cirka 10 liter vatten per disk, beroende på maskinens ålder och energiklass. Att diska för hand kan dra upp till fyra gånger så mycket energi som att diska i maskin, beroende på tillvägagångssätt. Om du handdiskar, använd diskho och/eller balja och undvik att skölja i rinnande varmvatten.

Tvätta i fylld tvättmaskin

Och välj inte högre temperatur än nödvändigt. Eco-programmet drar 0,5-1 kWh, beroende på maskinens ålder och energiklass.

Stäng av apparater och släck lamporna

Släck och stäng av när du lämnar rummet. Cirka 5 procent av ett hushålls elanvändning går till standby. Använd LED-lampor, de är fem till sex gånger mer effektiva än halogenlampor och tio gånger mer effektiva än de gamla glödlamporna.

Använd klädstrecket

Häng kläderna för att torka utomhus när det går i stället för att använda torktumlare. Torktumlaren använder hela två till tre gånger mer energi än tvättmaskinen. Ett torkprogram drar 1,5-3 kWh beroende på maskinens ålder och energikass.

Ställ in rätt temperatur i kyl och frys

Figure 1: *A sample page from Husguiden (Swedish Energy Agency, 2023a)*

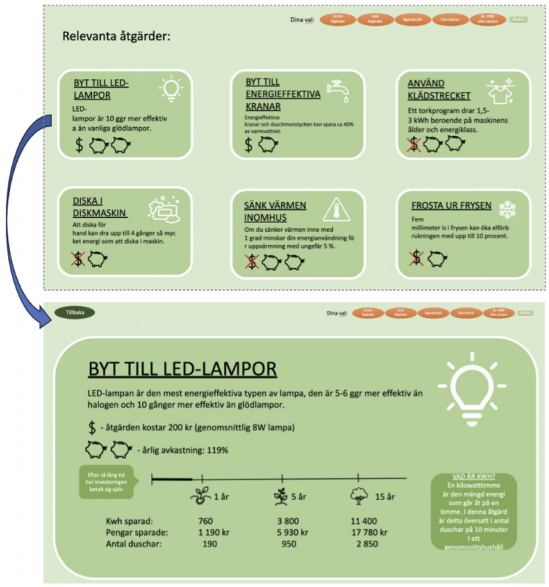


Figure 2: *Corresponding frames from the prototype. The arrow shows the relation between the frames*

3.3 Usability testing

Usability testing was conducted for the purpose of evaluating the prototype and receiving feedback. A convenience sampling was used to recruit eight participants for the trials, consisting of five homeowners and three tenants. The main requirement for participation was the ability to meet in person for the tests. According to Nielsen (2000), testing with as few as five participants can uncover around 85% of design errors, while testing with fifteen participants can help identify almost all errors. Therefore, our sample of eight participants was considered sufficient for the purpose of this study.

Each participant was given two task scenarios to complete, one at a time, and a think-aloud protocol was implemented. The paper prototype was presented one frame at a time to ensure reliable results and mimic the presentation of a computer-based prototype (Arvola, 2020). After the trial, the participants were interviewed to gather insight into what aspects they liked, disliked, areas where improvement was needed, and their overall impressions. Specific questions about different frames and metrics were also included. The usability tests followed ethical guidelines as described by Arvola (2020), including informed consent and participant rights. The test data included a few quantitative measurements. For example, success rate, which was the rate of completing the task as divided into subgoals (Albert & Tullis, 2022). The amount and types of errors were also aggregated and combined with estimated impact (See Table 1) to determine their severity (Nielsen, 1993, cited in Albert and Tullis (2022)).

Table 1: *Error 1-7 with corresponding level of impact on user experience and usability of prototype.*

Error	Impact	Description of error
1	Low	*Clicks on unclickable components*
2	Low	*Does not apply filter given in the scenario*
3	Low	*Task 2: Clicks on an action that is expensive*
3.5	Moderate	*Task 2: Clicks on more than one expensive action*
4	Moderate	*Chooses wrong filter alternative*
5	Moderate	*Task 1: does not choose more advanced filter*
6	Moderate	*Applies filters they do not get from the scenario on the advanced filter-page*
7	High	*Gets wrong order of action proposals*

Finally, the expectancy was measured for each task and participant. This consisted of collecting expected difficulty before each task and experienced difficulty after it (Albert & Dixon, 2003).

The qualitative test data included the observations and the user feedback from the post-test interviews. These were analyzed using a process inspired by Rettig's approach (1994, cited in Arvola (2020)).

4 Results

4.1 User research

Participants found the website to have a clear and relevant purpose, specifically related to energy issues. However, they had mixed opinions about

its effectiveness. Some participants felt that the content was too elementary and suggested adding more detailed information, particularly on energy conservation upgrades and cost savings. Participants also requested clearer and more motivating information. Some praised its visual appeal and user-friendliness, while others felt it could be improved. Suggestions for improvement included adding more visuals and interactive elements, as well as tailoring content to individual conditions. Navigation issues were reported, due to participants losing track of their progress and encountering unexpected redirections. The sidebar structure was preferred less when compared to the step-by-step guide with pictures, although some participants still used it out of habit.

The content analysis helped us delimit the key areas of Husguiden to focus on for the prototype regarding design, features, and content. The creation of affinity diagrams generated five main themes for improving Husguiden: navigation difficulties, enhancing visual aids, improve interactivity through personalization, individual motivation, and explanation.

4.2 Design development

Through the execution of all UX methods, it was determined that the primary functions of the prototype should consist of a filtering feature based on house conditions and commitment level, and a way of ranking the energy saving habits and investments based on monetary cost. Furthermore, it was identified as vital to present tangible actions that are concise and measurable in different currencies or that can be understood in comparison with other actions. The final lo-fi paper prototype contains four different types of frames: (1) a start page with a filtering function, (2) a drop-down page with advanced filters, (3) a page with actions divided into ”relevant” and ”other” categories based on user choices, and (4) a page with a detailed description of an action, using visual aid icons, along with an ”explanation box” defining kilowatt hour.

4.3 Usability testing

4.3.1 Quantitative measures

The average success rate across all tests for task 1 was 74% (2.25/3), while the average success rate for task 2 was 43.7% (0.875/2). 4/8 participants (50%) achieved all subgoals for task 1 and 2/8 (25%) achieved all subgoals for task 2. The average expectation of difficulty for task 1 was 3.25 (out of 7) and the average experienced difficulty was 3.25 (See Table 2). For task 2, the average expectation was 4.125, and the average experience 3.75 (See Table 3).

Table 2: *Success rate and expectancy for task 1*

Partic.	Success	Expectation	Experience
201	3/3	3	4
202	2/3	3	2
203	3/3	4	2
204	3/3	5	5
205	1/3	1	4
206	1/3	3	2
207	2/3	5	5
208	3/3	2	2
Avg	**2.25**	**3.25**	**3.25**

Table 3: *Success rate and expectancy for task 2*

Partic.	Success	Expectation	Experience
201	1/2	5	5
202	1/2	4	3
203	2/ 2	3	2
204	2/2	4	3
205	0/2	4	2
206	0/2	6	6
207	1/2	5	6
208	0/2	2	3
Avg	**0.875**	**4.125**	**3.75**

Regarding errors, the average number of errors committed across all trials was 3 and in three trials, no errors occurred at all. The most severe error as shown in Table 4 below was when participants applied filters that were not specified in the scenario (error 6), which had a moderate impact and high frequency. Other errors to consider were getting the wrong order of measures (error 7) and choosing the wrong filter alternative (error 4).

Table 4: *Severity rating of errors. Numbers represent the error type*

Impact				
High	7			
Moderate	5	4	6	
Low	3, 3.5	1, 2		
	Low	Moderate	High	Frequency

4.3.2 Qualitative observations and user feedback

Usability testing results showed a positive overall perception of the prototype, but also highlighted areas for improvement. One issue was the clarity of options in the first frame, particularly regarding the meaning of ”Yes, I want more customized suggestions,” and ”No, take me to the proposed actions.” Participants suggested rephrasing these options to clarify the potential for entering additional information or relying on the choices already made. Another concern was the use of the term ”äganderätt” (ownership) in the first frame. Participants recommended using terms like ”villa,” ”apartment,” and ”terrace house” to better differentiate between residence types, and therefore get even more specified information. While the focus was on distinguishing between ownership and renting, incorporating both suggestions, such as ”apartment - condominium” and ”apartment - ownership,” could improve user experience by presenting more relevant energy-saving actions. Balancing the number of options without overwhelming the user remains a challenge.

For the second frame, half of the participants experienced issues with the advanced filtering options that appeared if they chose to add more information. The issues included the uncertainty of how to act if one does not have the information needed to fill in the filters and a few requested an option to choose “I don’t know” or “Skip.” Both the third and fourth frame received positive feedback in terms of relevant information and visual design. The usage of the timeline and icons was appreciated, although some found one of the icons confusing.

5 Discussion

The study was limited due to methodological choices and practical restrictions. The samples for the tests were small, which could have an influence on the validity of the results. Paper prototypes were utilized for low-tech usability testing, but it was not deemed crucial to compare them to the current product. The limited pilot testing and the difficulties in defining successes and errors may have impacted the results.

Regarding the quantitative results, the average success rate across all trials was below 100%, which suggests some design flaws. Both tasks fell short of the product objective, with success rates lower than 78%. Task complexity rather than design flaws may have contributed to task 1’s greater success rate (74%) compared to task 2’s success rate (43.7%). Both tasks had similar levels of predicted and actual difficulty, although the latter did not match the success rate, indicating participant misconceptions. Crucially, within subjects, the discrepancy between expected difficulty and experienced difficulty was negligible. Several errors occurred in the trials, however some of them may have been brought on by a lack of comprehension of the tasks. They did point to specific problems though, such as users selecting the incorrect sequence of action suggestions, applying the incorrect filters, and choosing the incorrect filter alternatives.

From the qualitative analysis it was gathered that the first filtering options in the prototype were well-liked by the participants, but further adjustments are required to make the choices’ phrasing and meanings clearer, especially when it comes to ownership. Misunderstanding of the instructions most likely resulted in error 7 (wrong order of action proposals). For sophisticated filters, participants asked for the addition of a ”Skip” or ”I don’t know” button, indicating a need for more comprehensible navigation alternatives. The presentation of action proposals, which were meant to offer specific advice, received a favorable response from the attendees. Separating ”relevant actions” from ”other actions”, and adding icons allowed for rapid decision-making. Participants in the usability testing saw that displaying their previously selected filters at the top of the page aided in navigation and progress maintenance.

6 Conclusion

The goal of this project was to build a prototype using data collected from user research that increased the efficacy of communication of Husguiden. From user testing it was gathered that the current website is typically useful and helpful, but too rudimentary for some, and too abstract for others. It was also called for more visuals, diagrams, and easier navigation. Based on this user feedback, a low-fidelity prototype was created with the key interactive and individualized features. For simpler navigation, editable filtering options were provided, and a timeline with icons were added to make investments more concrete, facilitating understanding. The design concentrated on leaving out unnecessary material and making crucial information obvious and

easy to interact with. The usability testing indicated that the filter function was useful but still needs improvement, along with the conversion functionality. The prototype was successful in converting abstract ideas into specific examples. However, future iterations require better integration of advanced filtering choices, one possibility in the form of a dropdown menu with the default filters.

To summarize, the concrete goal of creating and usability testing a prototype was achieved. The key insight gained is that information must be both relevant and concrete enough to instigate interest and hopefully action in the individual. The implementation was limited by time and financial resources, but the route selected for the prototype generated useful UX-data. Hopefully, this project can help lay the foundation for the future design of Husguiden. The impact of the future efforts on energy literacy and energy-saving behavior in Sweden will determine how well the long-term goals are met.

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