Brief Report

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Human-Centered Design in the Energy Turnaround Project Enera – It Pays to Go Off the Beaten Track!

Abstract: In this article, we give insights into the development of an 'interface of energy', which is developed as part of the energy turnaround project 'enera'. This interface shall allow communication between the human and the future energy network which will be dominated by renewable energy sources and on-site power generation. We show how we applied Human-Centered Design methods to address the challenge of designing a user interface for an infrastructure that is still in development. Further, we show how this approach was successfully combined with public relations, such as feedback sessions on prototypes as part of an open Barcamp. We give insights into interviews, profiles, personas, public operations, user needs, prototyping and testing. As a special feature we conducted prototyping and prototype testing workshops in a residential house within the project region. These turned out to be very successful for many reasons, e. g., in that the natural environment served as a creative stimulator. Besides, the workshops had a lasting effect on the participants, who were members of the project as well as volunteers living in the project region.

Keywords: Human-centered design, design thinking, prototyping, speed testing, personas, energy turnaround, public relations

1 The Transition Towards Decentralized, Renewable Energy Sources Drives our Work

In 2050, 80 percent of Germany's current consumption shall be covered from renewable energy sources [7]. This transition towards decentralized, renewable energy sources is called 'energy turnaround'. To accom-plish this goal, we need new solutions in many domains. A new infrastructure for energy supply is needed. The energy turnaround project enera [3], which is funded by the German Federal Ministry for Economic Affairs and Energy, wants to demonstrate how the future energy system could work as a holistic system, i. e., from the generation of energy across energy data processing up to energy consumption. In enera, 33 interdisciplinary project partners work together to accomplish this goal within the project region, which consists of three administrative districts in Northwestern Germany. The ample project region close to the Northern Sea is characterized by small cities, pasturage, farmland and wind power plants.

The energy turnaround will change the human role from a passive buyer to an active participant. Our goal within enera is to enable this active participation. Therefore, we want to develop a user interface that allows communication between the human as prosumer and the future energy network. Being a prosumer who produces and consumes energy, the human becomes an active part who needs to communicate with the energy network to, e. g., manage production, consumption, trading and to be able to act energy efficiently. The challenges we face are that, the future infrastructure is currently in development, it is not yet clear which functionality is needed, who is going to use the interface in which contexts and how it should be designed physically and interactively. Further, the target group has few knowledge about the energy industry, energy supply system and technical interactions and is mostly not familiar with technologies that will be widely available in future, such as smart meters, sensors and actuators in smart home environments, data analysis and blockchain. Besides, hardly any comparable systems are available. In this paper, we present how we use Human-Centered Design [2] methods to develop a user interface for humans to communicate with the future energy network. And in this case 'communicate' is ambiguous: We successfully combined the challenge of developing a user interface with participation and public relations not only to inform people but to really involve and get to know them.

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Figure 1: One of the authors interviews a bicycle mechanic in his bicycle repair shop within the project region.

2 Steps in our Human-Centered Design Process

In the following, we give insights into the development of the 'interface of energy'. We present the Human-Centered Design process we followed. It started with interviews that we processed into profiles and personas. Further it included public operations, as well as the definition of user needs and finally prototyping and testing.

2.1 Interviews in the Project Region Help to Understand Target Group and Context of Use

The goal of the project's work package is to develop a user interface for the future energy system which will be dominated by renewable energy sources and on-site power generation. To gather information about the context of use and the target group, i. e., people living in the project region, we conducted 15 semi-structured interviews with persons living in the project region. Participants were volunteers that we recruited from contacts out of the broad project context. To gather information from a broad group of representatives, we selected participants from the three different districts of the project region that varied in, e. g., gender, age, occupation and number of people living in the same household. We also included energy consumers as well as prosumers, who both consume and produce en-

ergy. Participants worked in industry, public administration, trade or agriculture and were either self-employed or employed. They lived in households of one to five people, mostly in their own properties, and were aged between 22 and 66. Twelve participants were male and three were female. Interviews lasted for about 1–2 hours and took place in the natural environment of the participants, i. e., their workplaces or homes. For all interviews, alternating one of the authors interviewed and the other recorded by taking notes as well as by audio recording. We started the interviews with questions on the life situations of participants and characteristics of their homes regarding energy consumption and production. We further talked about personal mobility, participation in social media and the participants' experiences of digital products, particularly related to energy and home. Also, we asked about participants' positions on topics such as energy, energy turnaround, digitization and the supply of personal data.

For the analysis of the interviews, we followed the qualitative content analysis by Mayring [6]. This included the definition of categories and the assignment of interview data to these categories. Categories were, e. g., 'living', 'mobility', 'saving electricity' and 'funding of renewable energy'. We found that different types of people living in the project area can be clustered according to their life situations and needs. E. g., we found farmers live remotely and their daily life takes place on the farm. Typically, their farms are highly automated, and they are open-minded towards functional technology that supports their farm and

Figure 2: Part of our work was realized with interdisciplinary workshops with various members of the project. The picture shows how we created profiles for all interviewees with catchwords and sketches on big posters.

house work. For them, social cohesion is very important, particularly in the neighborhood. Further types of people we found were, e. g., self-employed master craftsmen, employed people living in small cities who are open-minded towards technology, people with a high need for security in daily life, and senior citizens.

2.2 Profiles and Personas Make the People in the Project Region Tangible

We have pseudonymized the findings from the interviews and have converted them into so-called profiles. Each profile represents a single interviewee. A profile summarizes an interview by key points, statements and sketches, which are placed on large-format, transportable posters. These illustrative representations of an individual made the interviewees more tangible and eased us and other project members to work with them. Reading or listening to the interviews is impractical and time-consuming.

Part of this process was a visual haptic and qualitative analysis of the results. What does that mean in con-

crete terms? We very quickly realized the importance of the individual natural person interviewed in the context of further work and for the extended circle of project participants. However, the results were rather difficult to access. Despite the manageable number of interview partners, one would have had to individually and serially access the files and documents in order to gain an overview of the results. For this reason, we decided to liberate the previous results from their digital graves and to prepare statements and key points together with sketches in large format. First, we did this for the first six out of fifteen interviewees. Then, we placed the corresponding profiles on the walls of a room and invited other project members to comment on these. The result was convincing: Project members who had not been involved so far with the interviews were able to comment on the profiles just minutes after entering the room and could imagine working with these results. Hence, in a first interdisciplinary workshop, for all 15 interviewees profiles were created on large-format, transportable and reproducible posters. Still today, these posters serve as an important working basis, summarizing the interview results in an evocative way.

Figure 3: One of the authors and a colleague are talking to a farmer in her cowshed during the bicycle tour in the project region. A friend accompanied the project members by bike on this day.

For the development of a user interface, we needed to derive personas [1] from the data collected. Personas are concrete, fictive representatives of a person or group of persons that are derived from real data. They help to empathize with the target group and thus to design a human-centered interaction. Based on the interviews and their analysis, we derived seven personas in total.

The persona Lars, e. g., lives and works in the region. He´s a so-called 'interested domestic consumer' and though he has got a background (employed, aged 33, in relationship, daughter), his needs and values make him tangible. He's the one, who is interested in technology but doesn't always want to be the first to use new gadgets. He uses social networking services more consuming than producing and has a strong 'analogue' social network in his hometown and, e. g., in his sport club.

2.3 Public Relations Support the Human-Centered Design

In parallel to the human-centered design approach described above, which was geared towards individuals and a small cohort, retrospectively public relations and networking activities in the region play a decisive role. In context of the question on how to get to know the people in the project region and to actively integrate them into the project, innovative formats designed for both – random encounters and participations – were tested and successfully carried out. The benchmark was to open up success opportunities with as little effort as possible on as many levels as possible.

In summer, immediately after completing the interview series and evaluating it, a bicycle tour by freight bicycles took place across the region. One of the authors and a colleague from the project went independently through the three districts of the project region. The goal was to spontaneously get in direct contact with as many people as possible in their respective living environment. The team talked with the people about the project enera, their personal needs and wishes, energy supply and other topics correlating the semi-structured interviews before. In this way, about 250 random encounters came about within a week – in public space, in people's workplaces, at home, at different times of the day and during leisure activities.

In addition to the interactions on the various social media channels, these concrete and unpredictable or predictable encounters played a decisive role in completing the image of the people in the region. For both, profiles and personas, matching people and characteristics were found.

In autumn 2017, the first 'Barcamp Dangast' was held. An event that was designed as a participatory format from the outset as a so-called 'non-conference'. It was publicly announced via newspaper and social media and open for anyone. The agenda is developed and defined by the participants themselves on the day of the event. More than 60 regional and national people discussed various aspects of their respective, concrete living environment in an open barcamp on two days. Thanks to the heterogeneous mix of age, regional origin, education, occupation and personal background, this open format provided important insights into the motivations, interactions and needs of the participants. This event has also supplemented the Human-Centered Design approach. For example, there were sessions about mobility as well as about renewable energy and discussions concerning living, learning and digitization. At the second Barcamp Dangast in 2018, prototypes and development approaches were discussed and evaluated to a significant extent with an even larger number of participants but similarly heterogeneous composition.

2.4 User Needs and Insight Statements are Phrased to Create Scenarios and to Stimulate the Design Process

Based on the developed personas, further, interdisciplinary workshops were carried out. Above all, in order to identify and describe first use cases and usage scenarios. So, what did we do? First, we screened each single interview to find out, which needs were announced. Because of the familiar character of the conversations, this was not the easiest to do. Rarely the individual needs were clearly labeled. Often, we had to identify the background and intentions behind the statements. For this, it was helpful to get to know the people's living situation and to have an overview about the whole development from first contact until this step. Putting all the results together, we were able to create a ranking from the most mentioned needs like mobility and social interaction to the average ones, like saving time and those at the end of the list like the desire for sustainability. By taking this 'hit-list' from all 15 interviewees and the references to the individuals, the profiles, you could see individual patterns. Interviewees matching the persona Lars, e. g., had distinct higher interest in sustainability then all the others in the cohort.

Figure 4: We created a full-scale put-up hinge with a drawing of the persona Lars to make the persona tangible. This put-up hinge helped us and project members during various workshops to empathize with the persona.

Recognizing, that uttered user needs, such as 'saving money' and the interviewees' opinions regarding, e. g., 'sustainability' is not really objective, was help- and needful. E. g., sustainability for Lars could mean to keep his 25-year-old washing machine. To decode this, it was necessary to generate so-called insight statements [5]. These were answers to the question on how to solve a problem for the individual (profile) or satisfy their needs. E. g., an insight statement of Lars matching the user need 'social interaction' was 'Exchange of experiences and knowledge in my personal environment is important to me.'. On this basis, we prepared use cases and usage scenarios within interdisciplinary workshops with members of the project. This work was exciting and challenging in many ways. On the one hand, it turned out that working in workshop format in varying composition served to introduce a wide variety of employees to the topic and the methodology. On the other hand, the existing information and previous findings and work results had to be presented in each case. The different approach to some completely new tasks for

Figure 5: A participant takes part in a prototype test session during one of the workshops for ideation, prototyping and testing which took place in a residential house in the project region.

the colleagues, then also led to surprising and very different new results.

2.5 Workshops for Ideation, Prototyping and Testing Take Place in a Residential House in the Project Region

After we developed personas, defined user needs and developed typical scenarios, we went into ideation, prototyping and testing. For this phase, we decided to continue to work with the persona Lars. We chose Lars as he was the persona that matched the highest number of interviewees, i. e., 5 out of 15 interviewees matched Lars. On the basis of the insights we gained so far and with regard to the overall project goal, we phrased the following design challenge: "How can Lars be enabled to influence his energy budget intentionally, at short notice and simply?". In addition, actual needs of the persona Lars were phrased as 'How might we?' questions to motivate the creative process [5]. These questions were deduced from the insight statements, e. g., 'How can we support exchange of experiences and knowledge in Lars' personal environment?'.

The goal of this phase was to generate many ideas for a user interface and to get early feedback in an iterative manner. By this, appropriate concepts could be developed further, and improper ideas could be discarded early. Therefore, we conducted two two-day workshops in a residential house within the project region. Luckily, one of the authors lives in the project region and provided his house. We decided to hold the workshops in a residential house because we wanted the working and testing environment to be as natural as possible regarding the target group, i. e., persona Lars. Also, we wanted participants that joined for testing sessions to have short ways and to feel highly comfortable. The location was easily reachable and invitingly as being located in their neighborhood.

During each workshop day, 8–9 members of the project ideated and built lo-fi prototypes within small groups. According to the Quick and Dirty [4] approach, participants used all kind of everyday materials to build lo-fi prototypes, possible shapes or interactions. A speed testing session took place on each workshop day, each after the prototyping. During a test session, 5–6 participants individually evaluated each prototype within 10 minutes in the presence of the team that built the prototype to be tested. Participants could freely comment on the pro-

totypes. Further, members of the prototyping team asked questions of particular interest, e. g., on the understanding of interface elements or the conceptual idea. At the end of a test session, participants completed a questionnaire which assessed how the presented solution matched the user needs of Lars, that we derived beforehand, by means of six 5-point Likert scales ranging from 'I totally disagree.' to 'I totally agree.'. A user need was, e. g., phrased as 'The solution is easy to manage.'. Test sessions took place in parallel in different rooms with participants moving from room to room to test all prototypes. On the second workshop day, project members could either prototype and test another aspect of the prototyped idea from the previous day, or choose and prototype a new idea, e. g., from the ideation from the first workshop day. The procedure of the second workshop day was then the same as for the first day.

To benefit from different perspectives, we included project members with technical, marketing, design and economic backgrounds and males as well as females. Further, volunteers recruited from personal contacts who live in the project region and match the persona Lars took part in speed testing sessions. As we knew the volunteers, we could easily choose those best matching the persona Lars, according to criteria such as life situation, openness, social interaction, interest in new technologies and sustainability. Volunteers were aged 20 to 55, with 8 males and 5 females.

The workshops resulted in about 100 interface ideas, 12 developed lo-fi prototypes, and feedback from four test sessions with a total of 13 participants. Interface ideas were, e. g., a moving robot watching over the house, an interactive mirror serving as energy control, automatic daily energy reports, a plug and play system for capturing meter readings, a portable illuminated cube visualizing energy data of the house, and an app managing monetary compensation for resourcing of computing power during times when electricity is oversupplied. We analyzed the tested prototypes according to the qualitative feedback from the test sessions and the results of the questionnaires, which assessed the match with the user needs that we phrased with regard to the design challenge. We found which prototyped ideas are worth to be followed up, which aspects worked well, and which aspects should be refined or could be combined. E. g., the concept of the interactive bath mirror performed very well. Particularly, participants appreciated to get information on the energy household while performing a manual, regular daily task such as brushing one's teeth. We also found, e. g., that energy consumption ipso facto must not be displayed in a negative way as there are situations in which energy consumption is unavoidable or accepted purposely.

Overall, the workshops were a very successful experience – for the participating project members as well as for the test participants. The compact setting, i. e., a day for familiarization, ideation, prototyping and testing allowed to generate numerous ideas and to get early feedback indicating whether an idea is worth to be followed up or not. The natural environment served as a creative stimulator for project members and the house setting allowed working very comfortably. Further, project members who were totally new to this approach were able to actively take part in the workshop just after a short time of familiarization. In the end, they were surprised how the workshop worked out, how much was done and how many findings were gathered in just a few hours. The realistic environment allowed to prototype and to test, e. g., a prototype of an interactive mirror, in an actual bathroom. This stimulated the prototyping process and allowed participants to easily empathize with the situation to be tested. Besides, test participants were grateful for that they could contribute to solve a realistic challenge in their living environment. Even weeks after the test sessions they talked about the project and their experiences and also offered their homes for future workshops.

3 Conclusions

We found the qualitative approach according to the Human-Centered Design process to be an appropriate choice for the development of an 'interface of energy', i. e., a user interface for an infrastructure that is still in development. Particularly helpful were deep conversations during interviews with individuals, a good understanding of the subject area 'energy turnaround' and upcoming technologies by the project members working with us, and well-prepared interdisciplinary workshops with a lot of visuals and examples to support the design process. However, the work was challenging and there were several learnings. E. g., the recruitment of interviewees as well as later on finding testers that match a persona was not easy and took time. We found additional value in the so-called profiles. Although personas are well-known and approved, also the natural person behind the profile and their individual personality was useful to work with. Working in several workshops and different compositions was challenging but also inspiring and changeful. By working like this, many different people from the project were involved and could get in touch with methods and representatives from the

region. It was possible to integrate prototype-testing into public events like the Barcamp and thus, reach more people. We found great value in conducting compact prototyping workshops in a residential house in the project region. Particularly, the execution in a residential house in the project region offered a number of advantages. Further, the workshops had a lasting effect on test participants. Even weeks after participants actually took part in a test session, they were talking about the project and offered their help.

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Bionotes

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