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SONNET - Social Innovation in Energy Transitions

Co-creating a rich understanding of the diversity, processes, contributions, success and future potentials of social innovation in the energy sector

D4.7 (D18): Report on the SIE City Lab in Basel

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SOCIAL INNOVATION IN ENERGY TRANSITIONS

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2	Dutch Research Institute for Transitions	DRIFT	NL	
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13	City of Basel (Associated Partner)	BASE	CH	

Executive Summary

The Basel city lab differed slightly from the other SONNET city labs, as it involved a collaboration between the state-owned local energy utility and the SONNET academic partner ZHAW. While the involvement of the city administration supported the initial set-up and scoping of projects with the academic partner, they were subsequently less directly involved. Nonetheless, the city lab, involving the local energy utility as the "city partner" successfully developed and tested a social innovation in energy (SIE).

The SIE in focus was a smartphone app designed to encourage reducing an individual's CO_2-footprint. The app was in an early stage of scale up and the city lab developed a real-world experiment with ca. 500 participants to measure the impact of the app and focused on one specific feature (value-based motivational messaging). During the city lab, the app was fully released, and still exists while continuing to look for a viable business model. Key results of the Basel city lab are as follows:

- Results of the outcomes evaluation indicate that the app can be an effective support for people wanting to reduce their CO_2-footprint.
    - App use increased knowledge about the CO_2-emissions associated with various everyday behaviours in the domain of mobility and eating, led to an increase in perceived responsibility for climate change and increased the personal obligation (personal norm) for taking action against climate change.
    - The app had a direct impact on CO_2-relevant food choices.
    - Motivational messages delivered in the app, which were formulated with a specific value perspective (i.e., environmental / biospheric or human-centred / altruistic motivations) did not cause a significant impact on behaviour change, thus future development of the app should focus on other features.
    - A smartphone app is an SIE which changes how people "think", "act" and "organize" in order to lower their CO_2-footprint.
- Enabling factors for the city lab:
    - The citizens of Basel have demanded action for a sustainable energy future which drives the local government and energy utility to innovate and support projects like the SONNET city lab.
    - Despite the special partnership conditions of the Basel city lab under SONNET, with the city of Basel only being an associated partner without funding, all partners were willing to engage and the small team managed resources and capacity to see the project to completion.
- Barriers for SIE:
    - The economic viability of the app remained in the foreground and thus a viable business model is necessary to maintain the SIE into the future.

The Basel city lab achieved its goals of collaboratively working together to test an SIE in the real world. The city lab supported the development of the app, as well as the capacity for transformative change through collaboration, by identifying measurable impact through a scientifically rigorous process and reflecting on the relevance of science and practice working together.

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1 INTRODUCTION

The SONNET City Lab in Basel was a collaboration between the Zurich University of Applied Sciences (ZHAW) and the city of Basel and the local state-owned energy and water utility Industrielle Werke Basel (IWB, or further referred to as the local energy utility or the city partner). There was an existing research partnership between ZHAW and IWB, as well as personal relationships, which facilitated the city lab partnership, as Basel is only an associated partner in SONNET.

The city lab focused on the further development and testing of the smartphone App "enerjoy": an app created by IWB that addresses users who are interested in environmental protection and are willing to *think*, *act and organize* differently to make their lifestyle more sustainable. The app serves as a support to reduce consumption-related CO_2 emissions in a targeted manner. In a simple and playful way, users are enabled to track their own behaviour. Central to this is the recording of food and mobility choices, but energy consumption associated with heating, washing, or showering as well as other consumer behaviours are also considered in the footprint calculations. Users can simply enter their own behaviour and consumption choices, such as how far they travelled to school or work and using which mode of transportation, and thus learn about their CO_2 footprint. The footprint is immediately compared with the maximum footprint per person allowed according to a 1.5-degree Celsius target for global warming. The app also provides suggestions for behaviour change to reduce one's footprint. Tracked changes or improvements become immediately visible. In addition, the app features information on sustainability topics in the form of links to articles and blog entries. These serve to improve people's knowledge on such topics, and act as a support for reducing one's own emissions. To make behaviour tracking more attractive, users can take part in weekly challenges on their own or together with other users.

Figure 1 provides an overview of the most important features of the app together with some screenshots. The screenshots show the version of the app at the time of the city lab outcomes evaluation (described in more detail in section 4).

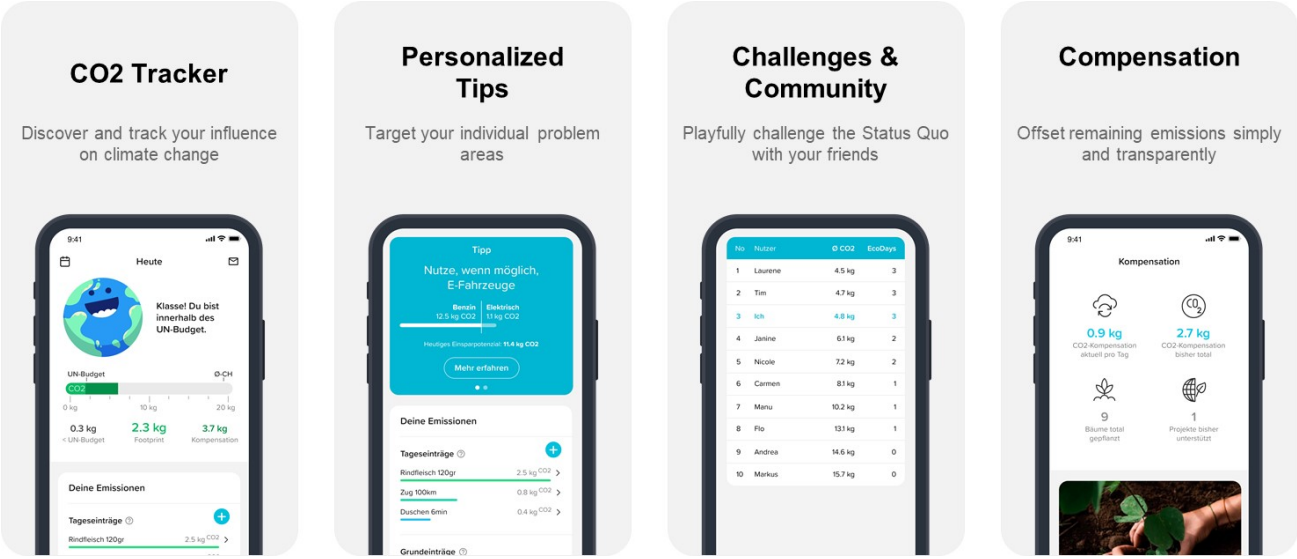


Figure 1: Most important app features and illustrative screenshots

At the start of the SONNET city labs, the app was already developed to a beta version, however, not fully launched. During the Basel city lab, the aim was to further develop and rigorously test the effectiveness of the app in a joint co-creation process involving the app developer team at IWB, current and potential app users, and researchers from the Zurich University of Applied Sciences (ZHAW). Below we provide some background information on how the app was developed before the SONNET city lab process started. Note that we include this information in this academic report, because there is no city partner report for the Basel city lab, as the city of Basel is only an associated partner, and therefore does not receive any funding from SONNET.

1.1 Information about City Lab-like Activities before SONNET: Development of the enerjoy App

The enerjoy app was developed as a start-up within the local energy utility of Basel. The local energy utility initiated the project and a small team of developers was hired and granted relative freedom in terms of work processes and organization. One of the few requirements was that the team had to present their progress every three months in front of a committee of utility-internal "sponsors" that had to grant the regular funding necessary for the continuation of the project. Extraordinary expenses also had to be brought in front of this committee. The plan was that the app development would receive initial internal funding from the utility, but that the development team would come up with a business model that is at least self-financing and ideally even yields profits for the utility once the development phase is over. The search for a viable business model continued after the city lab ended, and it still remains to be seen how the app can generate profit and what the impact is on the local energy utility. The current app, now available in the Apple app store and Google Play store for Android, comes with a subscription model costing 60 Swiss Francs per year. In turn, the current version is free from advertisements. The app developers emphasise that from their perspective the payment model ensures that the app is financially sustainable also in the long run and does not depend on constant monetary support or advertisements. Moreover, they believe that attracting users that are willing to pay for the app leads to a more engaged community of app users.

From a technical perspective, the app is relatively simple. Its basic functionality is to connect user inputs with data on the carbon footprint of the tracked behaviours and to display the results to users. The most relevant technical questions involve making sure that the app displays well and offers its full functionality on different operating systems (Apple and Android) and different smartphone types. Moreover, questions of usability and behavioural effectiveness, in the sense of trying to make sure that the app has a significant impact on user behaviour, are most important.

The utility invested in the development of the app for various reasons. First, it sees itself as an efficient service provider for renewable energies, with the goal of providing a climate-friendly energy supply to its customers. Developing an app that helps users to reduce their CO_2-footprint complements this overarching aim. Second, developing such an app allows the utility to foster its image as an innovative green energy provider who is willing to support its customers to reach their pro-environmental goals. This seems particularly important in light of a potential

liberalisation of the electricity market for household customers in Switzerland in the near future (currently the utility is the monopoly provider to household customers in its region). Finally, the utility is an independent but state-owned public enterprise in a canton with powerful Green and Social-Democratic political parties and an electorate that puts a strong emphasis on energy and environmental topics. For instance, already in 1979, the voters of the canton of Basel-Stadt accepted a popular initiative that prohibited the use of nuclear power and required the active promotion of renewable energies. Ever since, IWB as the local energy utility has therefore not included any nuclear power in its electricity mix (this is significant as nuclear power makes up 40% of the domestic electricity production in Switzerland). As the urgency of addressing climate change has become an important topic in political and societal discussions, taking active steps to help people reduce their carbon footprint is therefore also in line with political goals in the city of Basel.

1.2 Understanding of SIE for SONNET

The SONNET city lab in Basel focused on the potential of a digital tool in the form of a smartphone app to foster individual and collective action through social innovation for advancing sustainability transitions. Even though initiated by an actor from the energy sector, the local energy utility of the city of Basel, the app, and as such the Basel city lab, is not restricted to energy topics only, but covers environmental sustainability in a broader sense by also including other climate-relevant domains such as food consumption and mobility choices. More traditional energy topics, such as heating and lighting are covered by the app too, but were not evaluated in the city lab.

To accommodate this broad range of application, we adopted a definition of SIE that understands social innovation as "new practices and behaviours that enable society to meet its needs more sustainably" (European Environment Agency, 2016, p. 22). This definition "reflects a conviction that engaging society in new practices and behaviours can shape core beliefs and values — and that this is ultimately essential for sustainability transitions" (ibid, p. 22).

Initial discussions between city administration representatives from the department of environment and energy, representatives from the local energy utility responsible for strategy and innovation, and ZHAW researchers highlighted a variety of innovation activities relevant to energy and sustainability in Basel including the development of smart city strategies for the city and region, energy efficient renovations for affordable rent, to electromobility planning. Due to the stage and timing of the enerjoy project, the accessibility of the team, and the relative freedom in development, the enerjoy app project was deemed to be the most fitting project which could be used for the city lab. Thus the “city partner” in the project practically were the team behind the enerjoy app at the local energy utility.

The decision to focus on the further development and testing of the enerjoy app for the SONNET city lab seemed promising, as it allowed to further develop and strengthen an already existing initiative. Moreover, the co-creation between practitioners and researchers seemed particularly fruitful for this type of city lab project. From a SONNET researcher perspective, the case of a **sustainability-oriented smartphone app as a form of SIE seemed interesting as digital innovations can potentially facilitate social innovations** by providing a structure or platform to

develop *new practices and behaviours that enable society to meet its needs more sustainably*, in line with the understanding of SIE described above. Moreover, from an impact perspective, digital tools are promising because they are in principle easy to scale up, if proven effective.

2 Overview of the Evaluation Process

This section briefly defines the approach to evaluate the process (subsection 2.1 Ongoing evaluation) and the results of testing the app (subsection 2.2 Outcomes evaluation) in the Basel city lab. This is an attempt to separate these two evaluations for clarity, thus discussing the overall process of the city lab with its unique goals separately from the specific results of testing the app in the field experiment conducted for the outcomes evaluation and described in section 4. However, the outcomes of the field experiment are embedded in the city lab process and thus there are interdependencies between the evaluation approach and the results, and some repetition in sections 3 and 4 will occur in order for each section to be complete in itself.

2.1 Ongoing Evaluation

The Basel city lab is understood as both a testbed for a social innovation, specifically a CO_2-savings app, as well as a transdisciplinary format for collaboration, hence the intention of "lab" within the name. The ongoing evaluation looks specifically at the latter, that is the collaborative format, which arose during the city lab and is structured to assess the relevance of the actions taken and the inclusiveness of the process.

The relevance of the Basel city lab process is reflected in the activities undertaken to achieve the following **goals** which were intuitively developed in the initial phase of collaboration between the city and academic partners: i) **capture additional benefits** through collaboration; ii) develop an **approach to evaluate impacts** of the city lab; iii) **support long-term viability** of the social innovation. Thus, the ongoing evaluation is a reflection on how pathways were developed and how effective these pathways were to achieve these goals. Specifically, questions will be answered related to what actions were taken, who was involved in decision-making, how were differences managed, and what was the outcome on the goals.

Related to the inclusiveness of the process, the city and academic partners of the Basel city lab had not previously worked with each other, and thus the collaboration style was co-created over the first few months of working together through an intuitive and experimental approach. This process will be described in further detail to highlight the challenges and successes.

2.2 Outcomes Evaluation

Based on our definition of SIE — according to which the goal of SIE is to foster "new practices and behaviours that enable society to meet its needs more sustainably" and that assumes that such "new practices and behaviours can shape core beliefs and values" — the purpose of our outcomes evaluation was to investigate the influence of the enerjoy app on the sustainability-related practices and behaviours of its users, as well as users' knowledge, norms, and beliefs. From a more applied perspective, the goal is to test what the application can (and cannot) contribute to combating climate change by helping people to change their practices and behaviours towards more sustainability.

For the outcomes evaluation, we therefore developed indicators attempting to measure the impact of the active use of the app on i) **users' knowledge** about the carbon footprint of different

consumption choices and behaviours, ii) **users' beliefs** about **and norms** towards climate change and environmental problems, and iii) **users' actual behaviours** and consumption decisions. We describe the exact operationalization of these indicators in more detail in section 4.

3 Ongoing Evaluation

This section first outlines the Basel city lab process and activities and reflects on the implication towards the city lab goals as an evaluation of the process (subsection 3.1). The second subsection (3.2) outlines the testing of the enerjoy app and evaluates the impact as a social innovation for reducing CO_2-intensive behaviours.

Note that this is an attempt to separate the process and the outcomes of the city lab, however there are interdependencies between the two as the outcomes are embedded in the process.

3.1 Ongoing Evaluation of the Process

3.1.1 Basel City Lab Process

The Basel city lab had a specific timeframe and goal to field test and evaluate the impact of the enerjoy app during the collaboration within the SONNET project (see Figure 2 for timeline of activities). In order to do this, the city partner (the local energy utility) and academic partner (ZHAW) had to commit to working closely together to satisfy the aims of both parties, which differed between producing academically relevant results and commercial development interests. Despite these different perspectives, **the intention of both partners was to mutually support each other**, within reasonable goodwill of time and effort, to co-develop the field test.

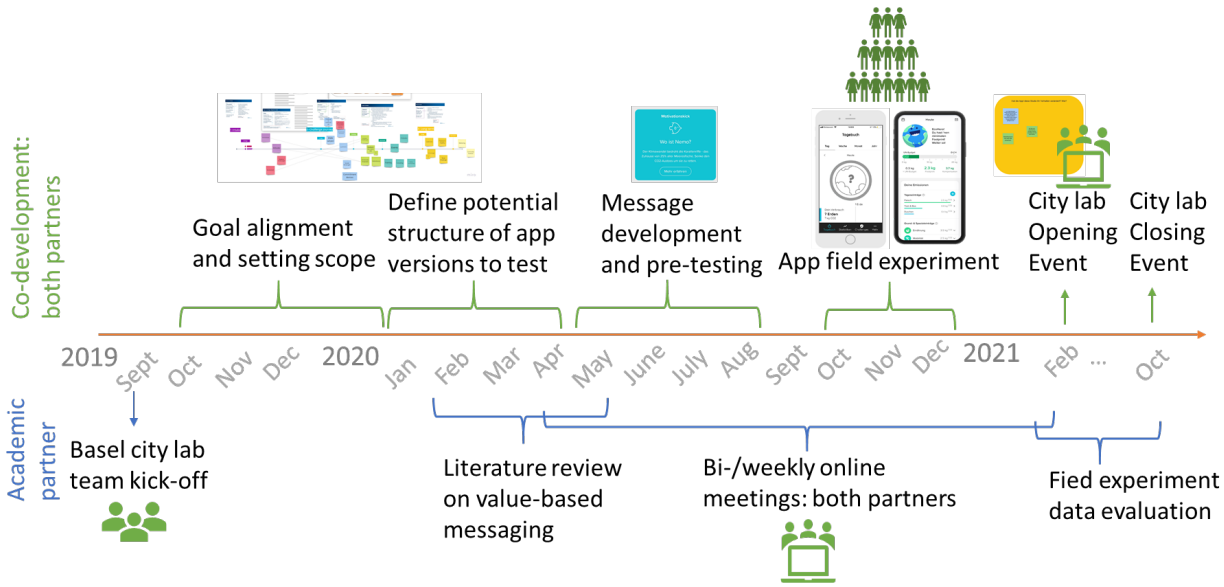


Figure 2: Basel City lab activities by academic partner and co-development with city partner

The academic partners led the process from the SONNET side, as the city partners were not full partners in the SONNET project, and thus Figure 2 shows the activities of both partners, as well as activities uniquely undertaken by the academic partner.

In September 2019, the Basel city lab kicked off with the core team of researchers from ZHAW and the app development team from the local energy utility. The following months until the end

of 2020 involved a series of meetings to define the respective expertise of the partners, potential benefits for the app and the goal and scope of a field experiment together. This process was worked on unilaterally and in meetings using the online whiteboard tool Miro, as shown exemplarily in Figure 3. The team followed approaches to define personas (Pruitt and Grudin 2003), which helped define the type of user the app would target. This fed into developing a customer journey (Polaine, Løvlie, and Reason 2013), which defined the way the app will be used and impact behaviour. Finally, the study design for the outcomes evaluation was developed with the user surveys before, during and after the experiment (Sovacool, Axsen, and Sorrell 2018), and the design of a coaching feature (Kulyk et al. 2014) to support an individual's personalised change.

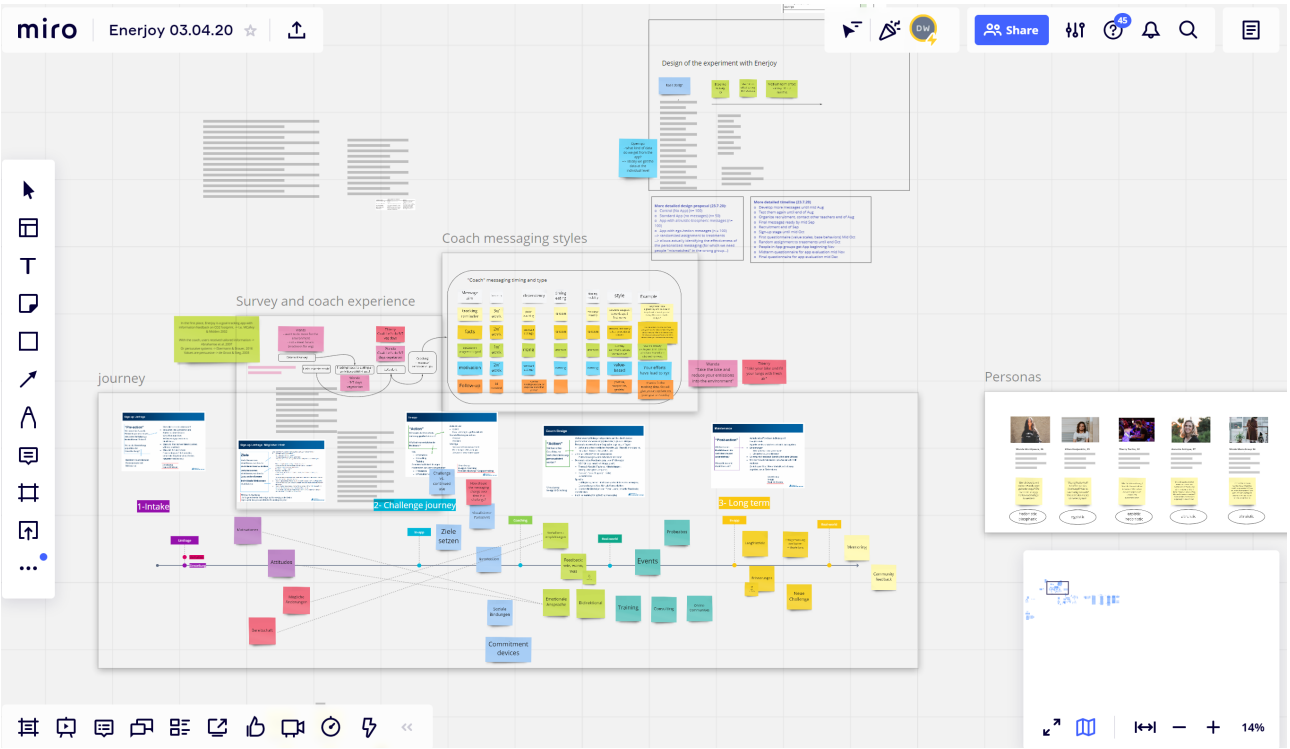


Figure 3: Exemplary screenshot of the online whiteboard tool used for goal alignment and setting the city lab scope

At the beginning of 2020, the city lab team decided on a structure of the app, as well as one specific function, to test. The discussions around a potential coaching function in the app evolved into providing motivational messages based on underlying value statements (i.e., environmental/ biospheric or human-centred / altruistic see Figure 4 for two examples), which could motivate behaviour change for people with similar values, and thus could be implemented in an app version and compared to another version without these messages.

The academic partners conducted an extensive literature review to better understand the impact of values on behaviour and how the messages could be structured (see, e.g., Stern et al., 1999 or de Groot and Steg 2008). Between May and August 2020, the value-based messages (example in Figure 4) were written by the whole team and tested with an online panel. During this phase of collaboration, the academic and city partners met online every second week and then increased to weekly meetings as the field experiment approached.

Notes: The figure shows two examples of motivational messages that were included in one version of the App to be tested in the field experiment (see section 4). The image to the left provides an example of an environmental / biospheric value-based message. The German text says: "Motivation kick – Where is Nemo? – Climate change threatens coral reefs - home to 25% of all marine fish. Reduce CO2 emissions to save them." The image to the right provides an example of a human-centred / altruistic value-based message. The German text says: "Serial killer summer? – An increasing number of heat days causes the mortality rate to rise markedly. Let's do something for grandma and grandpa." A click on "Mehr erfahren" ("learn more") at the bottom would open a link to a website containing additional information on the respective topic.

Figure 4: Examples of motivational messages tested in the field experiment

Between October and December 2020, the field experiment was run to test the impact of the motivational messages versus a basic version of the app without messages on mobility and food choices that are CO_2-relevant. The behaviour change seen in the app test groups was compared to a control group without the app (see section 4 for a more detailed description). This required considerable coordination between the academic and city partners to prepare the app, onboard the 500+ participants, and manage the communications.

When the field experiment was complete the academic partner used the survey data collected before, during and after the field experiment to evaluate the impact. The preliminary results of the field experiment were presented to approximately 90 participants, mostly field experiment participants, at the "City Lab Opening Event" in February 2021. This 1.5 hour online workshop explained the study (see exemplary screenshot displayed in Figure 5), showed the preliminary results on the behavioural impact of the app, and also included breakout sessions for gathering specific feedback on pre-defined questions (exemplary breakout session online white board shown in Figure 6).

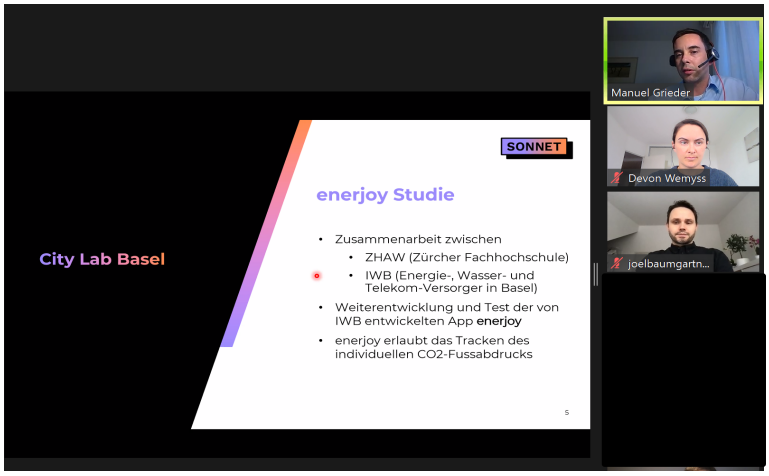


Figure 5: Screenshot of presentation at City Lab online opening event

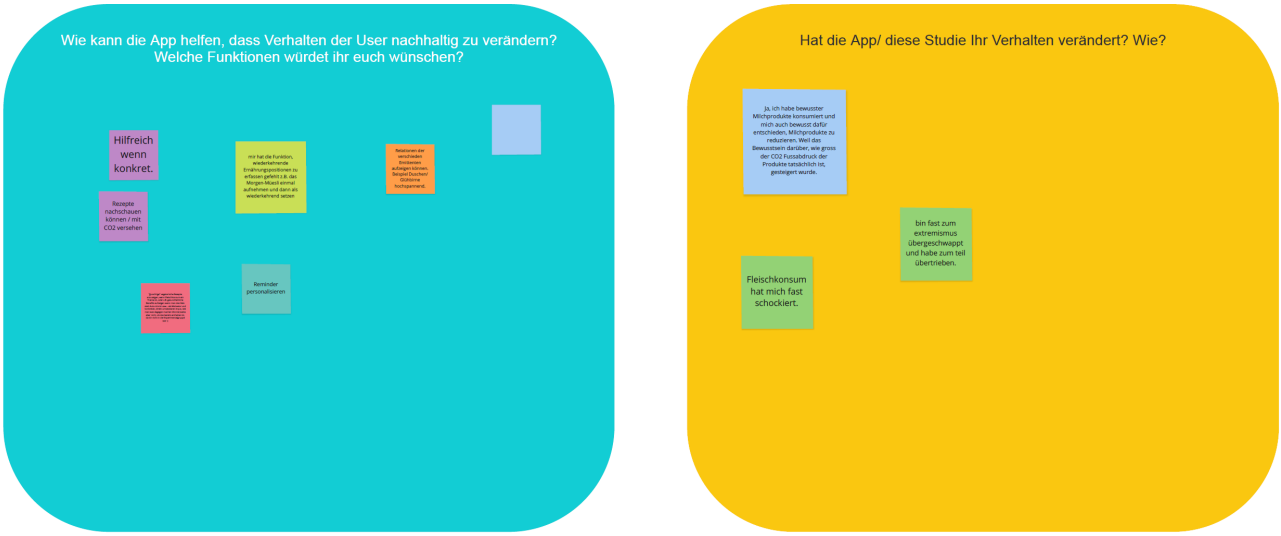


Figure 6: Example of the questions discussed during the City Lab Opening Event workshop

At the time of writing this report, the “City Lab Closing Event” has not yet taken place, but is planned to be an online networking event in October 2021 to discuss the final results of the collaboration in SONNET and the future direction of the enerjoy app.

3.1.2 Co-development

The co-development in the Basel city lab included a small team of two academic researchers and one city partner who led the app development team at the local energy utility. Additional support, if needed, was brought in by the city partner, for example related to technical possibilities or marketing material, and in this way the co-development was particularly efficient and straightforward.

The **co-development was a significant commitment to collaboration for the city partners**, as it involved work outside of their daily business to fulfil the requirements for academic rigour of the field experiment. This included, for example, defining two specific versions of the app to test using an A/B testing approach, preparing the app specifically for the experiment and making it uniquely available only to participants, managing the users, providing data feedback to the academic team, and transferring all data after the experiment. On the other hand, the academic partners adapted the field experiment design in order to effectively work with the city partners and fulfil practical boundaries, taking into account the technical limitations and possibilities of the app, the time required for development, and the data that would be available from the app.

While there was an implicitly balanced relationship between the city and academic partners, with both partners taking on tasks presumably fairly, the app development lay completely in the control of the city partner. This resulted in some information asymmetries between the city and academic partners as the technical or capacity limitations were best understood by the city partner. On a few occasions, unilateral decisions were made by the city partner in order to move forward with a pragmatic solution and were communicated to the academic partner in the subsequent meeting. This was to no detriment of the project but highlights that decision-making was not always done in consensus between the partners.

3.1.3 Communication

Early on in the process of working together, a communication channel on Slack (a business communication platform used by the city partner) was started specifically for the city lab team and thus included the academic partners, and a common work environment in Miro (an online whiteboard) helped develop the scope and structure of the app together. As well, about mid-way through the development, as the start of the field experiment was approaching, fixed bi-weekly, and then weekly, meetings were set up to address issues related to the field experiment.

As the city partner was not in the same city as the academic partner, an initial meeting was held in person, but regular meetings were held online thereafter, using a video conferencing tool such as Zoom or Google Meet. Thus, the impact of the COVID-19 restrictions on travel and meeting were minimal for collaboration.

3.1.4 Goal Attainment

The Basel city lab had the following three goals: i) capture additional benefits through collaboration; ii) develop an approach to evaluate impacts of the city lab; iii) support the long-term viability of the social innovation.

The process of developing the field experiment allowed for a single feature of the app to be more thoroughly tested and to reflect on the impact of various features of the app. While this testing procedure was a longer route, as compared to what would have normally been done by the city partner on their own, it resulted in a more robust evaluation and the data for informed discussion on further development possibilities. This required a **new conceptual approach to the design** for the city partner, away from intuitive experience-based decisions, to rather follow scientific best practices for testing and impact evaluation. Reaching a common understanding of what is needed to make the field experiment scientifically sound involved a **learning process and checking in on assumptions to find an approach that satisfied all**. This is a common tension and revolves around assumptions about what is practically feasible and what is scientifically necessary to prove impact (see, e.g., List, 2014 for related discussions). Overall, both the city and academic partners were able to fulfil their aims, and in the process of co-creation gained additional benefit from working with each other.

Important to both partners was the chance to rigorously test and evaluate the impact of the app, and thus the field experiment design was co-developed. This entailed deciding which features could be isolated for testing within the app and ultimately choosing to focus on value-based messaging within the app, attempting to increase app users' motivation to reduce their personal carbon footprint, by speaking to their human-centred / altruistic and environmental / biospheric values (see Stern et al., 1999). The messages were developed by the entire city lab team, with the city partner in the lead, and were pre-tested using an online panel in advance of implementation. This led to the two static versions of the app tested in the field experiment: one with the newly developed value-based messages and one without.

The academic partner was in charge of recruiting participants for the field experiment. While the city of Basel is central to the development context of the app, the social innovation, being digital, is applicable in a broader setting and the app is available to all of German-speaking Switzerland due to the language and accessibility in the app stores. Therefore, the team extended recruiting for the field experiment to Eastern Switzerland, in order to reach more participants. The field experiment did recruit enough participants for a control group, as well as the two app user groups, and **sufficient comparison was possible to reliably evaluate the impact of the app on behaviour change** (see section 4 for more details and the results of this outcome evaluation).

The inputs from the academic partners on the impact of the app on reducing the users' CO_2 footprint have fed into the further development of the app by the city partners. Further evaluation studies, as well as a continued collaboration between the city and academic partners are possible in the future. Working with the city partner meant implementing a social innovation which would have not been possible to do otherwise. However, considering that the app exists within a commercial environment, and is not a fully public tool funded by the city, the SIE is **more fragile** and may not survive without city engagement and investment. The app team is actively working on finding a self-financing business model, which takes up considerable focus, and is dependent on balancing operating costs (i.e., further development) with the interest of people to pay for the app service which is impacted by the broader awareness of climate change issues.

3.2 Ongoing Evaluation of Experiments

The field experiment to test the impact of the enerjoy app involved two steps: first, to develop and test the value-based messaging with an online panel; second, to test a basic version of the app compared to a version with the value-based messages against a control group in a real-world experiment. These two **procedures were chosen to rigorously test the app in a scientifically sound way, while also considering a pragmatic and time-effective approach for the city partners**.

After it was decided to test the specific app feature of providing value-based messages, approximately 50 messages were developed by the city lab team of which 16 were selected to test their effectiveness with an online participant panel. In this way, the impact on motivation could be examined to determine if there is a correlation between the values of the respondent and the value inherent in the message. The results of this pre-test indicated that appealing to environmental / biospheric and human-centred / altruistic values was more promising than appealing to hedonic and egoistic values. This led to the decision to focus on motivational messages appealing to environmental / biospheric and human-centred / altruistic values for the field experiment. This approach was agreed upon between the city and academic partners as it involved an additional step that the city partners would not normally have taken, but also provided a good argument for choosing specific messages to implement in the app. This created a balance between rigour and pragmatism.

The field experiment and evaluation procedure for A/B testing is described in detail in section 4 and was developed in a way that the academic partner could recruit and manage participants and the city partner provided the technical infrastructure of the two app versions. This clear division of tasks helped to manage the efforts for the team, particularly the city partner. However, there are always surprises when working "outside the laboratory" and there was a lot of work to remind participants to download the app (e.g., up to three reminders for the two-step download process), correct email addresses (e.g., participants signed up with multiple email addresses that needed to be cross-linked), answer questions about the app (e.g., when someone ate completely vegan and did not know what they should track), and trouble shoot technical issues. Thus, it became clear that running a field experiment with an app has additional complexities beyond supplying a functioning app.

The "City Lab Opening Event" occurred after the field experiment and was held with participants of the field experiment in order to gather their experiences and feedback on the app in a more open format. In this way, the city lab was able to integrate citizen user opinions into the collaborative (transdisciplinary) process.

Ultimately the app was evaluated for its impact on changing users' behaviour, and thus **the social innovation does not change energy, per se, but rather people**. This supports a more secure, affordable, and sustainable energy future.

3.3 Methods evaluation

The Basel city lab was primarily focused on developing, testing, and evaluating the impact of different versions of a smartphone app designed to motivate people to reduce their personal CO_2-footprint, and thus the evaluation of the process has been primarily focused on the ability to evaluate the app impact.

The city and academic partners spent several meetings to co-develop the app evaluation approach in a way which satisfied both the necessary scientific rigour and practical feasibility in terms of technical and resource restrictions. We decided to conduct a field experiment involving a control group (without the app), and two groups using two different versions (with and without value-based motivational messages) of the app. This research design allows to draw clear conclusions on the causal effects of the app per se (control vs. app groups) and the effects of the new feature of the app (without vs. with value-based messages). From a scientific perspective, field experiments are ideally suited for identifying causal effects in relevant field contexts (see, e.g., Harrison and List, 2004; Sovacool, Axsen, and Sorell, 2018). From a practitioner perspective, the approach is valuable because the feedback and data obtained from the participants are also ideally suited to provide relevant new insights for the future app design and development.

To reach this evaluation approach, the co-development evolved intuitively with suggested structures (e.g., weekly meetings, ongoing discussions on Slack) and design inputs from both partners. For what this process may have lacked in structure initially, it made up for in flexibility to shift based on new inputs and technical limitations, and ultimately produced a sense of trust and cooperation to achieve tasks by the set deadlines.

Thus, the method developed to evaluate the social innovation was effective and after successful implementation it provided a very clear result on the impact of the app on users' behaviour and generated valuable insights for the further development of the app.

4 Outcomes Evaluation

To conduct the outcomes evaluation and to obtain reliable data on the **causal impact of the app on users' knowledge about their personal CO_2-footprint, beliefs and norms concerning climate change and their personal CO_2-emissions, as well as on their environmentally-relevant practices and behaviours**, we conducted a field experiment, or randomized controlled trial (RCT), with around 500 volunteer participants over the course of two months from mid-October to mid-December 2020. We recruited most of the participants via message boards and email lists of different universities and other institutions of higher education in German-speaking Switzerland. The participants were randomly assigned to three experimental groups. The first group ("*Basic App*") used a base version of the enerjoy app during a pre-defined study period (of around six weeks in total). An extended version of the app ("*App+*") including the value-based motivational messages developed in the co-creation process described in subsections 3.1.1, 3.1.2, and 3.2 was provided to the second group of participants for use during the same period. In addition, we included a control group without app use ("*No App*").

To evaluate the impact of the app, it was crucial to include a control group that did not use the app. For measuring the impact of the app, i.e., comparing the different outcomes of app users with those of non-users, we could therefore not rely solely on the data gathered via the app. Instead, data collection occurred in three surveys between mid-October and mid-December 2020 (see Figure 7), in which participants from all three experimental groups responded to the same questions to measure relevant outcomes (see subsection 4.1 for a detailed description of the most important measures). The first survey was conducted at the beginning of the study (starting on October 19), to elicit baseline data on participants' values, knowledge, beliefs and norms, and about CO2-relevant practices and behaviours. We used the data from this first questionnaire to conduct a stratified random assignment to the three experimental conditions to ensure that there were no significant differences between the three groups on important dimensions. Participants in the app groups were then asked to download and use the app (starting on November 9). The second survey was conducted two weeks after the app downloads around the middle of the study period (starting on November 23). The responses to the second survey therefore provide a first indication of the app's impacts. The third and final survey (starting on December 13) was conducted five weeks after the app downloads at the end of the study. The data from the third survey thus allow us to estimate the impacts of the app on a slightly longer time horizon.

Figure 7 provides an illustration and overview of the design and the timeline of the field experiment conducted for the outcomes evaluation. In subsection 4.1, we describe the most important measures included in the three surveys in more detail. Subsection 4.2 describes the participant sample. Subsection 4.3 provides an overview of the most important empirical results. Subsection 4.4 summarizes the lessons learnt from our outcomes evaluation and discusses potential future developments.

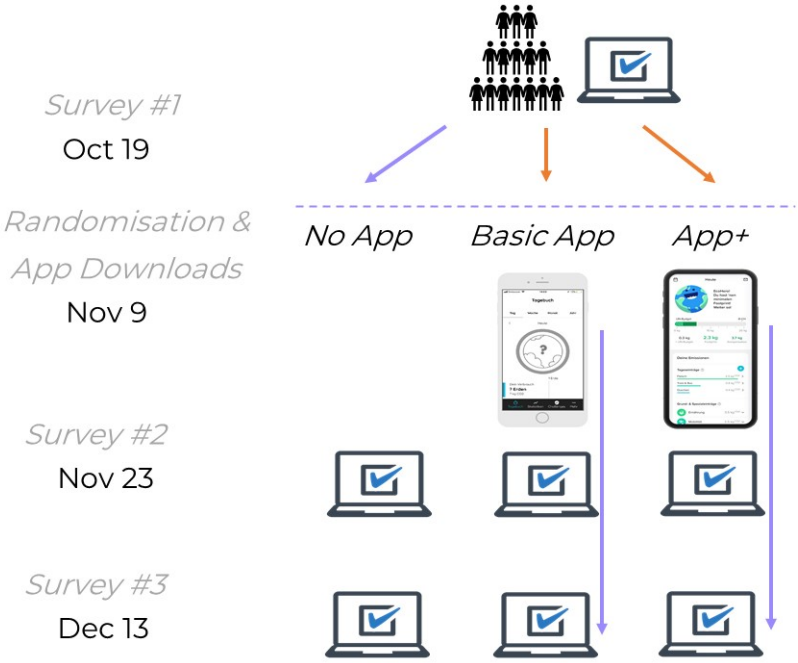


Figure 7: Overview of the design and the timeline of the field experiment conducted for the outcomes evaluation

4.1 Measures

The questionnaires administered in the three surveys aimed to measure indicators for i) participants' knowledge about the carbon-intensity of relevant behaviours or practices, ii) participants' actual behaviours and practices (during the week prior to the respective survey), and iii) participants' beliefs and norms about climate change and their personal carbon footprint as well as their motivation to reduce their carbon footprint. All these measures were included in all three surveys to ensure that we were able to measure the impact of the app use over time. The comparison between the app groups (*Basic App* and *App+*) and the control group (*No App*) on these measures in Survey 2 and Survey 3 **allows to identify the short- and (somewhat) longer-run impacts of the app**. In the following, we describe how we measured the most relevant concepts on which we focus in this report. The surveys contained additional measures on individual differences and values, open questions, and items designed to obtain more detailed feedback for the further app development from the participants in the app groups. To keep within the scope of this report, we do not describe these measures in detail and do not report these results here, but they will be part of future scientific publications.

4.1.1 Knowledge

To measure participants' knowledge about the CO_2-intensity of various behaviours and practices, respondents had to arrange various activities in descending order of their CO_2-intensity. In each survey, a total of 8 activities had to be ordered from the highest to the lowest CO_2-intensity. The participants therefore had to decide whether, for example, the consumption of a beef steak (200g) causes more CO2 emissions than a car trip from a given city to another or the consumption of a tablespoon of butter. To avoid learning effects stemming purely from the measurement itself, we changed the activities to be ranked in each survey. For the analyses, we created a deviation

score by summing up the absolute value of the difference between a participant's rank given to an item and the true rank of that item for all items to be ranked. The score thus measures how well a participant's ranking corresponded to the true ranking. We multiplied this score by minus one, such that lower (more negative) values correspond to a larger deviation from the true ranking and the maximum value (zero) corresponds to a participant's ranking perfectly in line with the true ranking.

4.1.2 Eating

To capture participants' food choices, we asked participants how many times they had consumed items from a particular food category in the last week. We focused on the food categories that have a relevant CO_2-footprint and that are also mostly covered in the app. Specifically, we asked, for example, how many meals included meat, dairy products, or vegetarian products. To facilitate responses, the questions were asked separately for breakfast, lunch, dinner, and "snacks" (small and irregular meals throughout the day). To keep things simple, and because we were mainly interested in differences across time and between (randomly assigned) participant groups, we did not attempt to measure actual quantities participants consumed per meal, but only whether a certain food category was consumed or not. For the analyses, we further aggregated the responses to create measures of the cumulative weekly consumption for main relevant food categories such as red meat, fish and poultry, dairy products, and vegetarian products.

4.1.3 Mobility

To capture mobility choices, we asked participants how many trips they made during the last seven days with a certain means of transport, i.e., by car, by bike, by public transport, etc. Again to keep things simple, similar to the approach we followed for the food category, we did not ask participants about the distances covered with each means of transport, but only how many trips they took (roughly) in the last week.

4.1.4 Beliefs, Norms, and Motivation

In addition to the above-described (self-reported) measures of participants' CO_2-relevant behaviours, we also measured participants' beliefs and personal norms with respect to climate change and environmentally sustainable consumption. Specifically, building on the *Value-Belief-Norm theory* (Stern et al., 1999), we used adapted versions of scales developed by Steg et al. (2005) to measure participants' *Awareness of Consequences* of climate change (6 items, e.g., "global warming is a problem for society"), *Ascription of Responsibility* for climate change (4 items, e.g., "I feel jointly responsible for the creation of environmental problems"), and *Personal Norm* for reducing CO2-emissions (6 items, e.g., "I feel personally obliged to reduce my CO_2-emissions"). In addition, we also measured participants' *Willingness to Sacrifice* their personal benefit or gain to advance environmental protection (3 items, e.g., "How willing would you be to pay much higher prices in order to protect the environment?"; see Newman & Fernandes, 2016) and participants' *General Motivation* to reduce greenhouse gas emissions (1 item, "How motivated are you to reduce greenhouse gas emissions?"). All items in this question category were measured on 7-point Likert scales. For the multi-item scales, we use mean scores in the analyses (all scales had at least acceptable scale reliability with Cronbach's alpha >.60).

4.2 Sample

631 participants filled in the first survey in full and were therefore randomly assigned to an experimental condition. 473 participants (75%) answered all three questionnaires completely. In the following, we base our analyses on the responses of these 473 participants, of which 132 were in the control group ("*No App*"), 173 were given access to the basic version of the app ("*Basic App*"), and 168 received the extended version of the app ("*App+*").[1] Table 1 below provides an overview of the participant characteristics by experimental condition, as well as for the entire sample (right-most column). Importantly, there are no statistically significant differences between the experimental conditions in the final sample for any of the variables included in Table 1 ($p > .10$ for all comparisons). Despite some attrition during the study period, the random assignment therefore led to comparable groups also in the final sample.

	No App	*Basic App*	*App+*	Total
Age in years	25.3 (5.1)	25.1 (4.9)	25.6 (5.9)	25.3 (5.3)
Female	64.4%	72.3%	66.0%	67.9%
Student	94.7%	96.5%	94.6%	95.4%
Full- or part-time employed	67.4%	60.7%	64.3%	63.9%
Vegetarian or vegan	31.8%	33.0%	30.4%	31.7%
Owns public transportation pass	95.5%	93.1%	96.4%	94.9%
Biospheric values	5.8 (0.9)	5.8 (0.9)	5.9 (0.9)	5.8 (0.9)
Altruistic values	5.8 (0.8)	5.8 (0.8)	5.9 (0.9)	5.8 (0.8)
Hedonic values	6.0 (0.9)	5.9 (0.9)	5.8 (0.9)	5.9 (0.9)
Egoistic values	2.8 (1.0)	2.8 (1.1)	2.9 (1.1)	2.8 (1.1)
# Participants	132	173	168	473

Notes: For non-binary variables, the table shows means and standard deviations (in parentheses). Biospheric, altruistic, hedonic, and egoistic values were measured in the first survey (before experimental conditions were randomly assigned to participants) on 1-7 Likert scales using the measures developed by Bouman et al. (2018). Scale reliabilities according to Cronbach's alpha were .85, .77, .79, and .71 respectively.

Table 1: Participant characteristics by experimental condition

The participant sample mainly consisted of students and is therefore rather young on average. Nevertheless, almost two thirds of participants were at least part-time employed. Given that people self-selected into participating in a study on the personal CO_2-footprint, it is not surprising that we find relatively strong biospheric and altruistic values in our sample. This makes this group

[1] We deliberately under-sampled the *No App* control condition to have more participants in the app conditions. The goal was to generate more relevant feedback for the further app development.

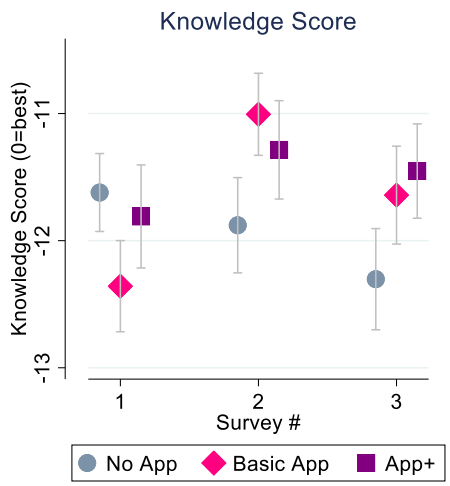
of participants a relevant sample considering the target audience of the app, which addresses environmentally-minded citizens who are motivated to decrease their personal CO_2-footprint. Of course, this sample structure also comes with limitations, especially in terms of the age structure and their potential for change given their prior intrinsic interest.

4.3 Results

In the following, we highlight the most relevant results of our outcomes evaluation. Given the scope of this report, this is necessarily a selection of results. We plan to publish a more complete overview of the outcome evaluation results in the form of a journal article. To make the analyses easily accessible, in this report we mainly rely on graphical illustrations of the results, while referring to statistical analyses in the form of regression or other analyses in the text.

4.3.1 Knowledge

Figure 8 depicts the average knowledge scores participants achieved in the three experimental conditions across the three surveys. Note that the knowledge score was created such that higher values (closer to zero) indicate smaller deviations from the true score, i.e., better knowledge. Note also that the items used in the ranking task were not identical in the three surveys, such that for the interpretation we need to focus on the differences between the experimental groups and not on the time trends per se. The figure illustrates that in the baseline survey 1, which occurred before participants were randomly assigned to experimental conditions, participants in the app groups performed very similarly, or slightly worse, in the knowledge ranking task compared to the participants in the *No App* control group. After having used the app, the picture changes: participants in both app groups now perform better on average than participants in the *No App* group. This indicates that **the app helped participants to improve their knowledge about the relative CO_2-footprints of different behaviours**.



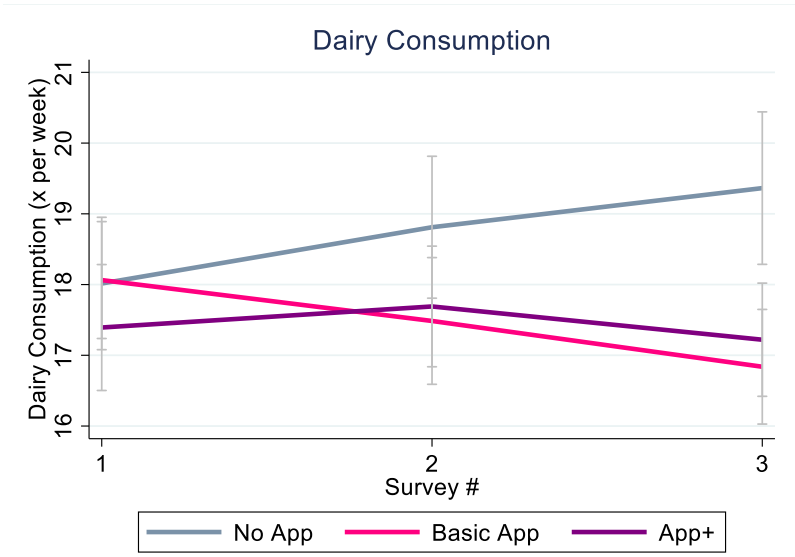
Notes: The figure displays the average knowledge score in the experimental conditions across the three surveys. Higher values indicate better knowledge. Error bars (in light grey) depict standard errors of the mean.

Figure 8: Knowledge Score in the experimental conditions across surveys

The difference between the two app conditions, *Basic App* and *App+*, is small and not statistically significant. When collapsing the two app groups, we find, however, a statistically significant effect of the app on the knowledge score in both survey 2 (p = .03) and survey 3 (p = .03) as compared to the *No App* control group in a random effects panel regression controlling for baseline performance on the knowledge score (i.e., a "difference-in-difference" comparison).

4.3.2 Eating

For the analysis of the app's effects on participants' food choices, we focus on the two categories of food with the largest CO_2-footprint: dairy and red meat. Figure 9 depicts the development of reported dairy consumption by our participants in the three experimental conditions. In the *No App* control group, we observe an increase in dairy consumption from survey 1 to survey 2 and 3, which might be driven by the weather getting colder from October (when survey 1 took place) to November (survey 2) and December (survey 3). Many dairy dishes in Switzerland are particularly popular in winter (e.g., cheese fondue). Interestingly, in the two app groups, we do not see such an increase, but rather a modest decrease. Again, there seems to be no difference between the *Basic App* and the *App+* conditions. A difference-in-difference panel regression collapsing the two app groups indicates that the effect of the app on dairy consumption was not statistically significant in survey 2 (p = .26), whereas it was significant in survey 3 (p = .04) compared to the *No App* control group. **There is thus some evidence that the app helped participants to reduce their dairy consumption**.

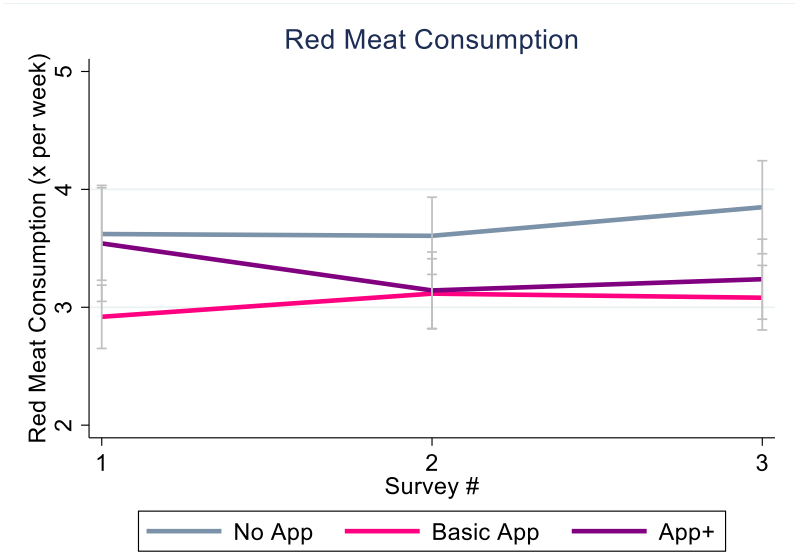


Notes: The figure displays the average reported number of participants' meals that included dairy products (milk, cheese, yoghurt, butter, and other dairy products) in the week prior to taking the survey. Error bars (in light grey) depict standard errors of the mean.

Figure 9: Development of Dairy Consumption in the experimental conditions across surveys

Figure 10 depicts the development of the reported consumption of red meats by our participants across the three surveys in the study. The differences between the experimental conditions are

small initially (as it is to be expected because of random assignment to conditions), and **there is no clear difference between the conditions in the development over time for the consumption of red meats**. The results from a difference-in-difference panel regression show that there is no significant effect of the app neither in survey 2 (p = .62) nor survey 3 (p = .38) when collapsing the observations from the two app groups and comparing to the *No App* control group.[2]



Notes: The figure displays the average reported number of participants' meals that included red meat (beef, pork, and other) in the week prior to taking the survey. Error bars (in light grey) depict standard errors of the mean.

Figure 10: Development of Red Meat Consumption in the experimental conditions across surveys

Also for the consumption of other food categories not specifically reported here (fish, poultry, eggs, vegetarian alternatives), we do not find statistically significant effects of the app.

4.3.3 Mobility

We **did not find any significant effects of the app on participants' mobility behaviours**. This may indicate that it is more difficult to affect people's mobility choices with an app than, for instance, their food choices, potentially because mobility choices are determined more heavily by structural factors such as the availability and quality of public transport or commuting distances

[2] Having a closer look at Figure 9, we can see that there is a small decrease in red meat consumption in the *App+* condition in surveys 2 and 3 compared to survey 1. The effect is not statistically significant, however, when comparing this development in the *App+* condition to the development in the *No App* control condition in a difference-in-difference panel regression (p = .19 for survey 2 and p = .22 for survey 3).

and are also highly habitual (see, e.g., Thøgersen, 2006, but also Hunnecke et al., 2007 for a different perspective).

However, another important reason that may have contributed to this lack of an effect is that during our evaluation period COVID-19 restrictions were tightened in Switzerland (e.g., universities switching back to online teaching and businesses to remote working), leading to a general decrease in mobility from survey 1 to survey 2 and 3. People having to stay at home more often likely made it more difficult for the app to show an effect on mobility behaviours.

4.3.4 Beliefs, Norms, and Motivation

According to the Value-Belief-Norm theory, beliefs about the consequences of climate change, the perceptions of responsibility for climate change, and a personal norm for pro-environmental behaviour should be relevant antecedents of feasible forms of pro-environmental behaviour change (see, e.g., Stern et al., 1999 or Steg and Vlek, 2009). Analysing the app's effects on these concepts thus allows us to investigate the app's impact more broadly and beyond the effects on the behaviours we attempted to measure directly in our outcome evaluation. Below we describe the results of difference-in-difference panel regressions, conceptually identical to the ones described above when analysing the statistical significance of the app's effect on measured behaviours. As we did again not find any differences between the *Basic* App and the *App+* conditions, we collapsed the two app conditions for these analyses.

The app had no effect on participants' awareness of the consequences of climate change (p = .52 in survey 2 and p = .84 in survey 3). However, unsurprisingly given our participant sample, the awareness of consequences of climate change was already very high in our sample from the beginning (above 6 on average on a 1-7 scale). This may have made it difficult for the app to lead to an additional increase.

We do find that the **app had a significant impact on the measured ascription of responsibility for climate change** in survey 3 (p = .01), but not in survey 2 (p = .66). Being in one of the app groups led to a stronger perception of (partial) responsibility for climate change through one's own actions. Similarly, the app also had a **marginally significant positive effect on participants' personal pro-environmental norm to reduce their CO_2-footprint** in both survey 2 (p = .07) and survey 3 (p = .05). There is thus some evidence that the use of the app strengthens people's perception that they themselves are also partly responsible for the problem of climate change and that it fosters the development of a personal norm for taking action to reduce CO_2-emissions.

However, we do not find significant effects of the app on the reported willingness to sacrifice personal gain (and, for instance, pay higher prices or taxes) to protect the environment (p = .41 in survey 2 and p = .57 in survey 3). There is also no effect on the reported general motivation to reduce CO_2-emissions (p = .34 in survey 2 and p = .68 in survey 3), which was, however, also already quite high to start with in our sample (5.5 on a 7-point scale).

4.4 Lessons and Conclusions

The results from our outcomes evaluation indicate that **the app can be an effective support for people aiming to reduce their personal CO_2-footprint**. In particular, we found that the use of the app led to an increase in knowledge about the CO_2-emissions of relevant everyday behaviours and practices in the domain of mobility and eating. We also observed an impact on people's food choices in that the app seems to have reduced app users' dairy consumption during the study period. Moreover, the app also had an impact on the perceived responsibility for climate change and fostered the development of a personal norm to take action to reduce the personal CO_2-footprint.

There were several variables or entire domains on which the app did not produce any effects. Apart from dairy consumption, we did not find significant effects on other relevant food categories such as red meat. Moreover, we did not find any effect on people's mobility behaviour, which may be due, however, to the tightening of COVID-19 restrictions during the study period. Perhaps unsurprisingly given our self-selected and relatively young participant sample consisting mainly of university students, we also did not find effects on participants' awareness of consequences of climate change or on the general willingness and motivation to reduce CO_2 emissions.

It is also very clear from our results, that the value-based motivational messaging that we tested in the extended version of the app (in the *App+* group) did not produce the desired positive effect compared to the basic version of the app (*Basic App*). While this is somewhat disappointing, it was also a valuable result indicating that the **further development of the app should focus on other features**.

Overall, we consider the results from our outcomes evaluation to be encouraging for the further development and potential of the enerjoy app, and for the use of smartphone apps to foster pro-environmental norms, behaviours, and practices in general. One of the **advantages of such apps is that, at least in theory, they can be tested and adapted relatively easily and can be scaled up and deployed by many potential users**. Thus, the approach we followed is, in principle, easily repeatable in other cities or contexts. However, there are important practical challenges that must be addressed to ensure a successful development and that are also crucial for scaling up. We reflect on the most important ones, based on our experience within the SONNET Basel city lab, in the following section 5.

5 Analytical Reflection as a Summary

This section reflects on several key aspects of the Basel city lab which are relevant for future SIE development processes where collaboration occurs between academic and practice partners.

5.1 City Lab Process

The Basel city lab partners, while having previously worked in similar transdisciplinary settings, had not worked together before the SONNET project, and thus there was a process of getting to know each other and establishing a working culture (e.g., decision-making processes, timing of activities, responsibility delegation, communication). Overall, it was a very smooth, efficient, and enjoyable process to develop the project together, however there was a **learning curve in converging on a field experiment design which satisfied both the practical limitations and personal aims of each partner**. In the end, we feel that this was successfully achieved.

As the Basel city lab had limited resources, one success factor was that the project team remained small and the scope was clearly defined early on in the process. Despite trying to plan the extent of the work in advance, there were still unforeseen tasks and design challenges which the city partner pragmatically completed, and thus we are very grateful for their commitment to the common vision.

5.2 City Lab Outcomes

From our perspective, one of the strengths of the Basel city lab was a very stringent outcome evaluation conducted in the form of a randomized field experiment. The results from this evaluation demonstrate that **a smartphone app such as enerjoy can have positive effects on users and help them achieve desired pro-environmental behaviour change**.

Given the potential ease of scaling up smartphone apps by trying to extend the number of users, such solutions seem promising. However, they provide no silver bullet for behaviour change. In particular, the apps tend to reach only a relatively narrow target audience that is already interested in the topic, such as the participants in our field experiment. Even though this question was not part of our outcome evaluation, and we do therefore not have empirical data to answer it, it is likely that apps are much less effective at converting the beliefs, norms, and behaviours of more sceptical target groups, for instance doubting the relevance of climate change or feeling a general unwillingness to change their consumption behaviours to reduce CO_2-emissions. This limits the potential scope of applicability. We plan to investigate the limitations for scaling up smartphone apps in more detail in a paper we prepare for a special issue on social innovations together with other SONNET researchers.

5.3 Cross-cutting Issues

The social innovation developed and tested in the city lab was completely dependent on economic support from the state-owned utility which "housed" the innovation project. At the time of the city lab, the app was not financially self-sustainable, and a business model based on revenues generated from a user fee to access a premium version of the app was being tested. There are a myriad of smartphone apps for CO_2-savings available (Beck, Chitalia, and Rai 2019) though not as specifically targeted for Swiss citizens as enerjoy, and thus there is considerable competition and free alternatives. People's willingness to pay for data-driven services is a persistent challenge (Niemand, Mai, and Kraus 2019), likely also within the environmental sector, and **this puts these types of social innovation at risk of failing before they can reach their fully scaled potential**.

5.4 Enabling / Impeding Conditions

For the Basel city lab to occur, a considerable goodwill was required by all partners (particularly the city and the app-developer team within the local energy utility), as well as eagerness to learn from one another. It was particularly advantageous that the enerjoy project was already existing, albeit in an early stage, and that the academic partners could easily work with the city partners to provide an added value in testing the app.

Though indirect, the local interest in environmental issues has gradually impacted the city politics and the strategic direction of the energy utility. These can be seen not only in the innovation projects of the utility, but also in their infrastructure investments such as CO_2-neutral heating, electric vehicle charging stations, or landscape re-naturalisation. While it appears almost counter-intuitive that an energy utility would support a CO_2-savings app, the relevance of the state-driven mandates, as well as the local political atmosphere, ask for future-oriented innovation which also diversifies business models away from solely energy sales. However, the Swiss energy system has not yet been fully liberalized and thus the local energy utilities do not need to compete for customers on an open market, and thus not every utility puts in effort to diversify.

The project was always dependent on continued funding by the utility as the overarching driver of enerjoy, and thus there was an uncertainty throughout the city lab whether it could be cancelled within the next quarter. As this was fully in the hands of the local energy utility, the academic partners were unable to influence the decision-making here, and thus an **imbalance of power was inherently present**. While this imbalance was never really exploited, it may have led to some of the unilateral decision-making on the part of the city partner, particularly related to more commercially relevant design features as opposed to keeping a focus on scientific rigour and objective testing of different features. Ultimately, both partners were satisfied with the results and the aims of both were achieved.

As the social innovation was a digital tool in the form of a smartphone app, the COVID-19 restrictions did not significantly impede the implementation, however the results were not as significant as hoped for, considering that mobility was restricted.

5.5 City Lab as an Entry Point for SIE

As the Basel city lab did not work directly with the city, but with a state-owned (and therefore politically influenced) entity, we can reflect on the role of the local energy utility to support SIE. As noted, the project was dependent on a mutual interest to experiment, which we see as essential for this type of exploratory collaboration. It appears **necessary that these types of innovation teams exist** in order for the right people to come together and work through any barriers, such as bureaucracy or financial limitations.

As business models are not always clear when a social innovation is developing, support from the city, or a related entity, can be crucial. Thus, cities may evolve into effective gatekeepers for SIE in particular, considering the potential societal relevance of the impact (e.g., mitigating climate change, supporting engagement in local renewable energy, etc.). Additionally, working with a city offers a different channel to access citizens, which may be essential when developing collective-action-oriented SIE. In particular, partnering with a city administration can potentially offer opportunities going beyond collective action, such as facilitating impactful structural change to address climate change.

The SIE investigated in all of the SONNET city labs point to innovation that is happening outside of "typical" business sector innovation and thus likely requires alternative forms of initial financing, as well as support with access to resources, services, decision-makers, infrastructure or market actors in the case of the well-established energy sector. A SIE coming out of a local energy utility, as in the case of the Basel city lab, may appear counter intuitive, however there are underlying political and public service interests which can actually be an entry point to develop something that is well-placed to have a viable future.

6 REFERENCES

Beck, A. L., Chitalia, S., & Rai, V. (2019). Not so gameful: A critical review of gamification in mobile energy applications. *Energy Research & Social Science, 51*, 32-39.

Bouman, T., Steg, L., & Kiers, H. A. (2018). Measuring values in environmental research: a test of an environmental portrait value questionnaire. *Frontiers in Psychology, 9*, 564.

De Groot, J. I., & Steg, L. (2008). Value orientations to explain beliefs related to environmental significant behavior: How to measure egoistic, altruistic, and biospheric value orientations. *Environment and Behavior, 40*(3), 330-354.

European Environment Agency (2016). *Sustainability transitions: Now for the long term*. Luxembourg: Publications Office of the European Union. https://www.eea.europa.eu/publications/sustainability-transitions-now-for-the (accessed Aug 31, 2021)

Harrison, G. W., & List, J. A. (2004). Field experiments. *Journal of Economic Literature, 42*(4), 1009-1055.

Hunecke, M., Haustein, S., Grischkat, S., & Böhler, S. (2007). Psychological, sociodemographic, and infrastructural factors as determinants of ecological impact caused by mobility behavior. *Journal of Environmental Psychology, 27*(4), 277-292.

Kulyk, O., op den Akker, R., Klaassen, R., & van Gemert-Pijnen, L. (2014). Personalized virtual coaching for lifestyle support: Principles for design and evaluation. International journal on advances in life sciences, 6(3-4), 300-309.

List, J. A. (2011). Why economists should conduct field experiments and 14 tips for pulling one off. *Journal of Economic Perspectives, 25*(3), 3-16.

Newman, T. P., & Fernandes, R. (2016). A re-assessment of factors associated with environmental concern and behavior using the 2010 General Social Survey. *Environmental Education Research, 22*(2), 153-175.

Niemand, T., Mai, R., & Kraus, S. (2019). The zero-price effect in freemium business models: The moderating effects of free mentality and price–quality inference. *Psychology & Marketing, 36*(8), 773-790.

Polaine, A., Løvlie, L., & Reason, B. (2013). *Service design: From insight to inspiration*. Rosenfeld media.

Pruitt, J., & Grudin, J. (2003, June). Personas: practice and theory. In *Proceedings of the 2003 conference on Designing for user experiences* (pp. 1-15).

Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design. *Energy Research & Social Science, 45*, 12-42.

Steg, L., Dreijerink , L., & Abrahamse , W. (2005). Factors influencing the acceptability of energy policies: A test of VBN theory. *Journal of Environmental Psychology, 25*(4), 415 - 425.

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology, 29*(3), 309-317.

Stern, P. C., Dietz, T., Abel, T., Guagnano , G. A., & Kalof , L. (1999). A value belief norm theory of support for social movements: The case of environmentalism. *Human Ecology Review*, 81 - 97.

Thøgersen, J. (2006). Understanding repetitive travel mode choices in a stable context: A panel study approach. *Transportation Research Part A: Policy and Practice, 40*(8), 621-638.

Appendix 1: EC summary requirements

Changes with respect to the DoA

There were no major deviations from the work plan, except that the delivery due date of this report was moved from end of July to end of October 2021 and the city lab events were both shifted into 2021 with the hope that we would be able to hold these events in person. Unfortunately, holding the events in person turned out not to be possible and, in the end, both the opening and the closing event had to be held in an online format because of COVID-19 restrictions. The "opening" city lab event took place in February 2021 as a kick-off to the learning phase of the city lab and included many participants of the field study described in this report. The "closing" event, wrapping up on the analysis and learning process was held in October 2021, with a focus on future potential, dissemination and sustainability of the social innovation based on the learnings of the analysis of the experiment.

Dissemination and uptake

This deliverable will be made publicly available on the SONNET website (https://sonnet-energy.eu) as well as via Zenodo.

Short Summary of results

The Basel city lab focussed on a new smartphone app designed to encourage reducing an individual's CO_2-footprint. The app was in an early stage of scale up and the city lab aimed to further develop the app and managed to test its impact in a field experiment with ca. 500 participants. The results indicate that the app can be an effective support for people wanting to reduce their CO_2-footprint. Specifically, app use increased knowledge about the CO_2-emissions associated with various everyday behaviours, led to an increase in perceived responsibility for climate change and increased the personal norm for taking action against climate change. It also had a significant impact on CO_2-relevant food choices. Motivational messages delivered in the app, which were developed as part of the city lab, did not cause a significant impact on behaviour change, thus future development of the app will focus on other features. Taken together our results show that a smartphone app can be an SIE which changes how people "think", "act" and "organize" in order to lower their CO_2-footprint.

Evidence of accomplishment

This document.