WattsUp

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ABSTRACT

WattsUp is a phone-charging system powered by cycling, designed to make energy generation part of everyday life. As energy prices rise and sustainability becomes more urgent, this project offers a small but meaningful step towards personal energy independence. WattsUp repurposes e-bike hub motors as generators to turn pedaling into electricity for on-the-go phone charging. A companion app tracks your phone battery and energy generation, suggests routes to help you fully charge, and gives live feedback to keep you motivated.

More importantly, WattsUp offers a potential shift in how individuals perceive and interact with energy consumption. By linking physical activity to energy use, it makes something abstract feel more real. It is not trying to solve the world's energy problems, but it does aim to raise awareness and build better habits. Be active, be independent, and get your Watts Up!

PROLOGUE

As a fourth-year Industrial Design student, I have been working on my Final Bachelor Project under the supervision of Regina Bernhaupt. This project was done in the second semester of the academic year 2024-2025 within the Games & Play squad. The decision to choose this squad can be explained well with my experiences with playfulness and gamification embedded in my previous projects, my internship with LEGO Education, and my vision as a designer.

INTRODUCTION

The world is facing serious energy challenges [5]. Questions about where electricity comes from, how it is generated, and who has access to it are becoming more and more urgent. Currently, the majority of global energy production still relies on methods that emit greenhouse gases, and energy generation is responsible for 87% of all greenhouse gas emissions worldwide [1]. While the consumption of energy from renewable sources is rising in countries like the Netherlands, energy prices continue to rise, and hundreds of millions of people still lack reliable access to electricity [1][2][4][6].

The path from energy generation to consumption is complex and fragile. It depends on centralized infrastructure and many external factors. This vulnerability became painfully clear recently, during a large-scale power outage in southern Europe, where Spain and Portugal experienced nearly 24 hours without power [3].

Moments like these highlight the limitations and problems of today's energy systems and emphasize the need for change.

While solving these global issues is far from simple, I believe small, local contributions can still make a meaningful difference. This project is not presented as a complete solution, but more as a step toward increasing awareness and encouraging behavioral change. As a designer, I feel a responsibility to contribute to a more sustainable future by designing for energy-conscious living.

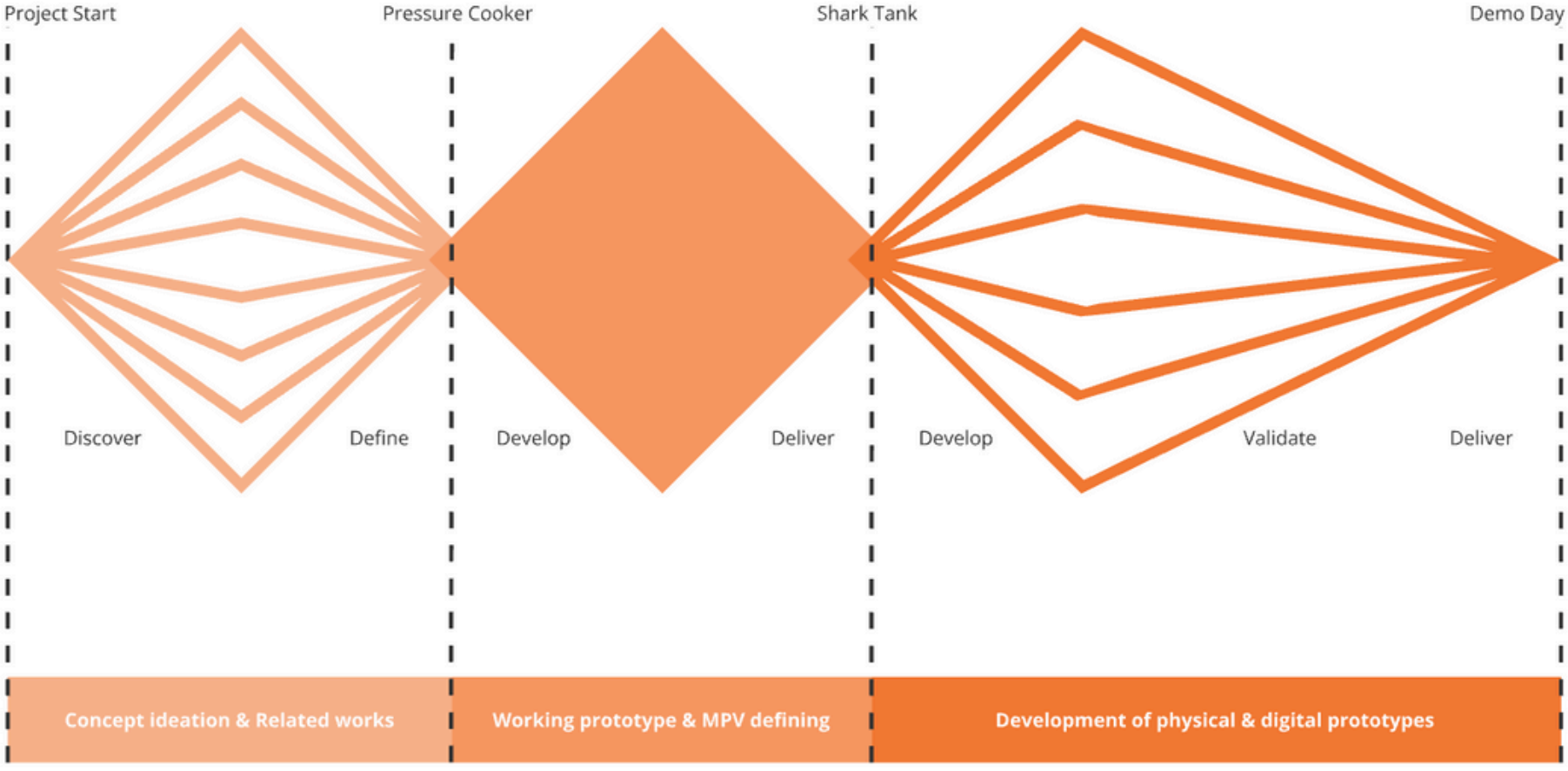
With this project, I aim to promote energy independence on an individual level. The goal is to give people a hands-on, physical experience with generating their own energy, by making a familiar daily physical activity like cycling into a way to power their own electronic devices. This system aims to help users reflect on the energy they consume and encourages a more active, self-sufficient, and sustainable lifestyle.

DESIGN PROCESS

At the start of the project, the decision was made to use a double diamond design process for my Final Bachelor Project. This was due to the fact that this design process was most familiar to me, with multiple of my previous projects during my bachelor's studies having followed the same design process.

This process encourages me as a designer to first explore a wide range of possibilities and then narrow down to the right solution two separate times. Firstly, it allows me to explore a chosen problem context, the users' needs, and existing related works. Secondly, it provides the space to do divergent problem-solving ideations and converge into a fitting solution.

However, during the project, there was a transition from a double diamond design process to a triple diamond design process due to the fact that one extra diamond was needed for the realization of the prototypes towards Demo Day. This triple-diamond design process aligned better with my goals, the design phases, and the deadlines provided by the squad.



FIRST DIAMOND

Before going to the first ideation phase, some related works were benchmarked. The first noticeable existing product category is modern bicycle dynamos for powering lighting during cycling. Two good examples that take old bicycle lighting dynamos to a modern era are Reelight and Magnic Microlight [10][11]. Instead of having a rotor turn the generator mechanism by friction with the bicycle tire, these modern bicycle dynamos use frictionless magnetic induction that provides just enough for an LED to light up.

The second category of related work can be summarized as energy-generating gym equipment. Examples of products and systems that exist are Energy Recumbent Bike, The Green Micro Gym, and Eco-Powr Indoor Cycle [7][8] [9]. These products or systems combine physical activity and energy generation with stationary outdoor gym equipment, a full indoor energy-generating gym system, and separate gym equipment that allows energy generation.

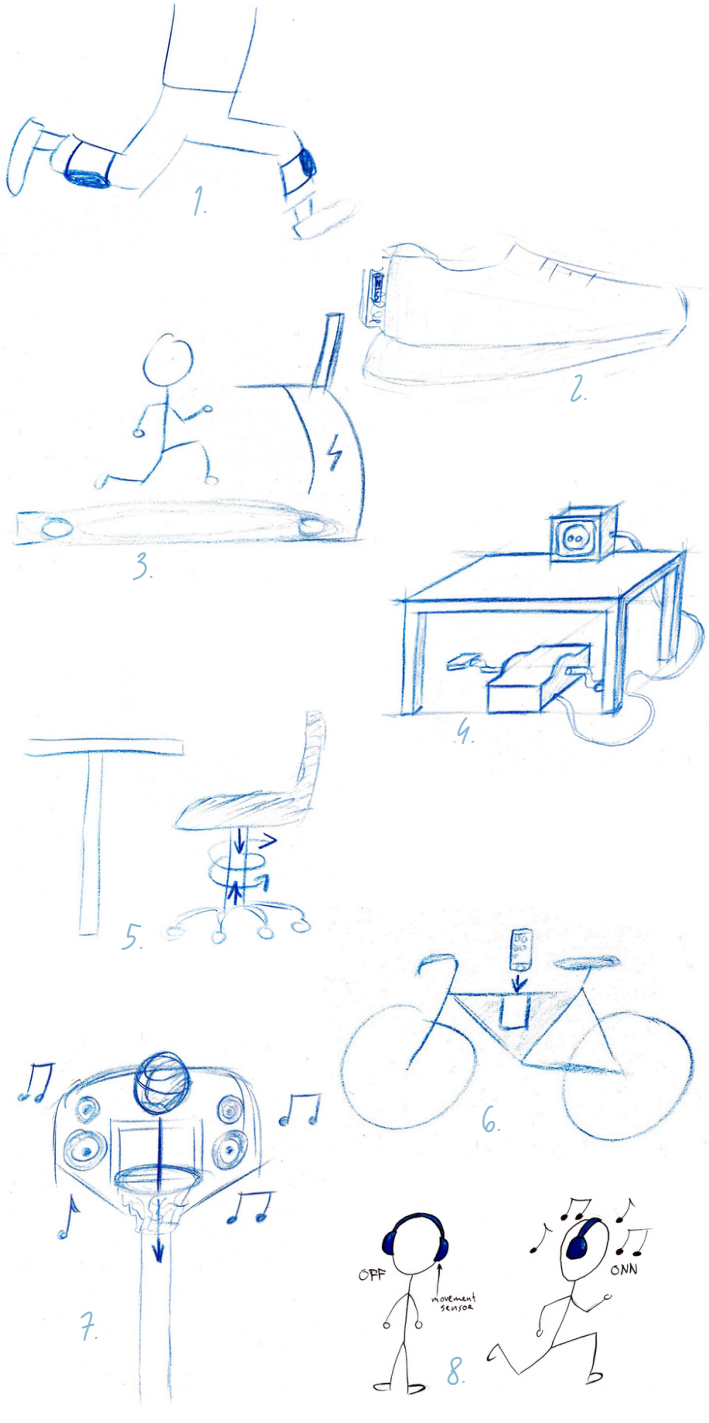
The third category is a very unique one. A project called Soccket provides a football that functions as an energy-harnessing ball where the kinetic energy from interacting with the ball gets converted and stored as electrical energy [12].

Lastly, when looking at existing phone applications that focus on motivation, there is a variety of apps that try to do this. Some apps that are worth mentioning are Duolingo, Habitica, and Strava [13][14][15].

These apps focus on using engaging and interactive experiences to spark intrinsic and extrinsic motivation when it comes to learning a language or encouraging physical activity.

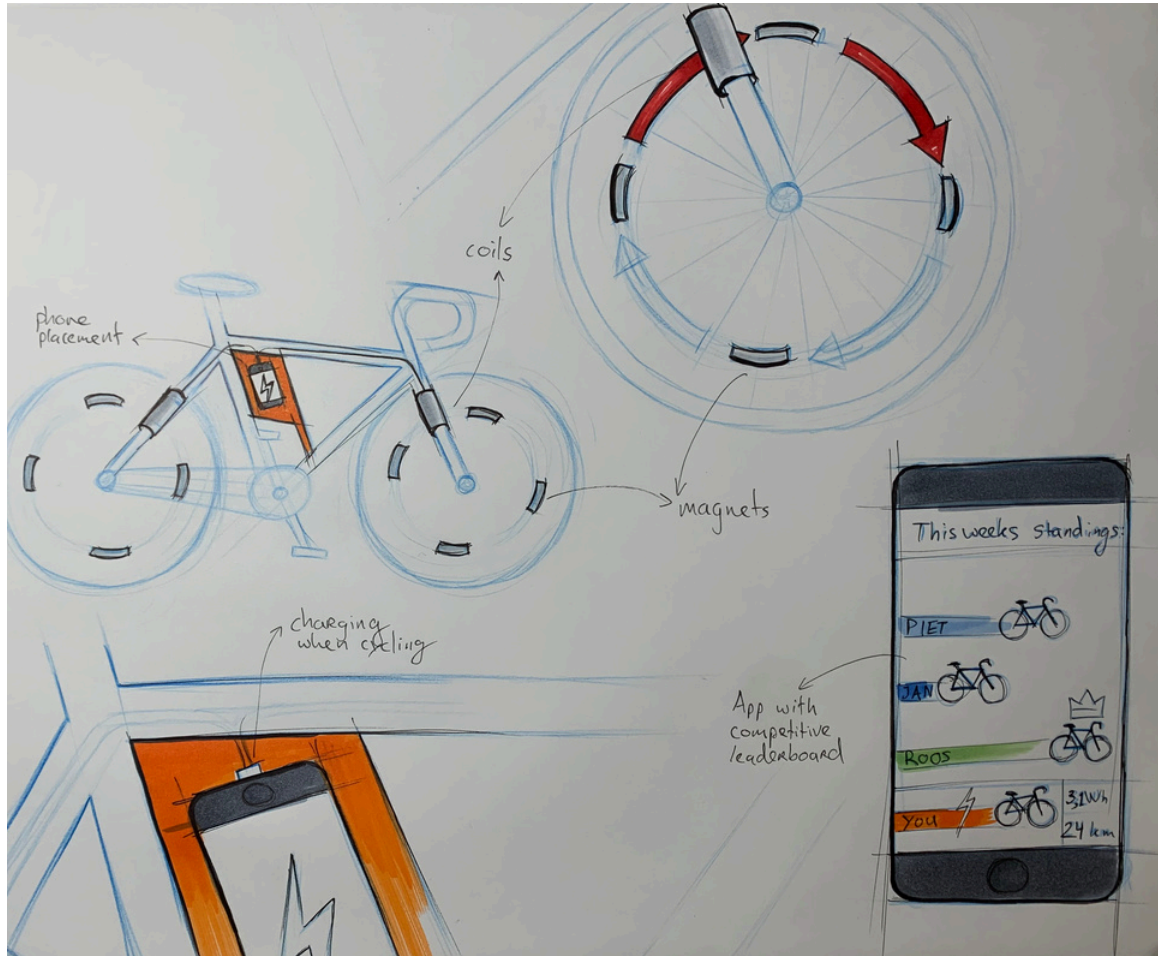
After having done problem exploration and benchmarking on existing related work, the project continued with ideating and sketching ideas about what daily physical activity could potentially be harvested for energy generation.

1. Shin guards that generate energy on the football pitch when running through the up and down movement of the legs.
2. Shoes with magnetic inductive coils that generate electrical energy as a reward for walking or running.
3. A treadmill with a TV screen that only turns on when running, which is linked to the energy source for the electricity needed to turn the TV on.
4. An office desk pedaling system, where pedaling generates the electrical energy for the office desk socket.
5. An energy-generating chair lets a sitting person generate electrical energy while moving on the chair.
6. A bike with an attachable phone holder lets dynamos charge the phone while cycling.
7. An interactive basketball court that uses the generated energy to improve the playful experience with sounds or lighting.
8. Headphones with an energy generation mechanism inside that allows for music listening while running.



FIRST DIAMOND

After the brainstorming session and feedback from my coach, it was clear that an important factor would be that it was needed to use an activity where it is actually feasible to generate enough energy for a yet undefined output. After talking with Bas Goossen about the feasibility of using a daily physical activity for energy generation, it became clear that it was more important for this project to go in a direction where an artefact could be build that would actually generate some energy rather than coming up with the most original concept of energy generation. This led to the decision to go for cycling/pedaling as a kinetic energy source. With the first squad deadline around the corner, being the “Pressure Cooker”, the concept was to use magnetic induction, similar to modern bike light dynamos, where kinetic energy is converted into electrical energy and transferred to a bike-mounted phone charging hub. A companion app will function as a digital twin and track weekly energy generation and introduce a competitive element, allowing users to compare stats with friends. To further enhance motivation, the app would potentially include unlockable rewards and customizations based on the energy generated.ing a language or encouraging physical activity.



SECOND DIAMOND

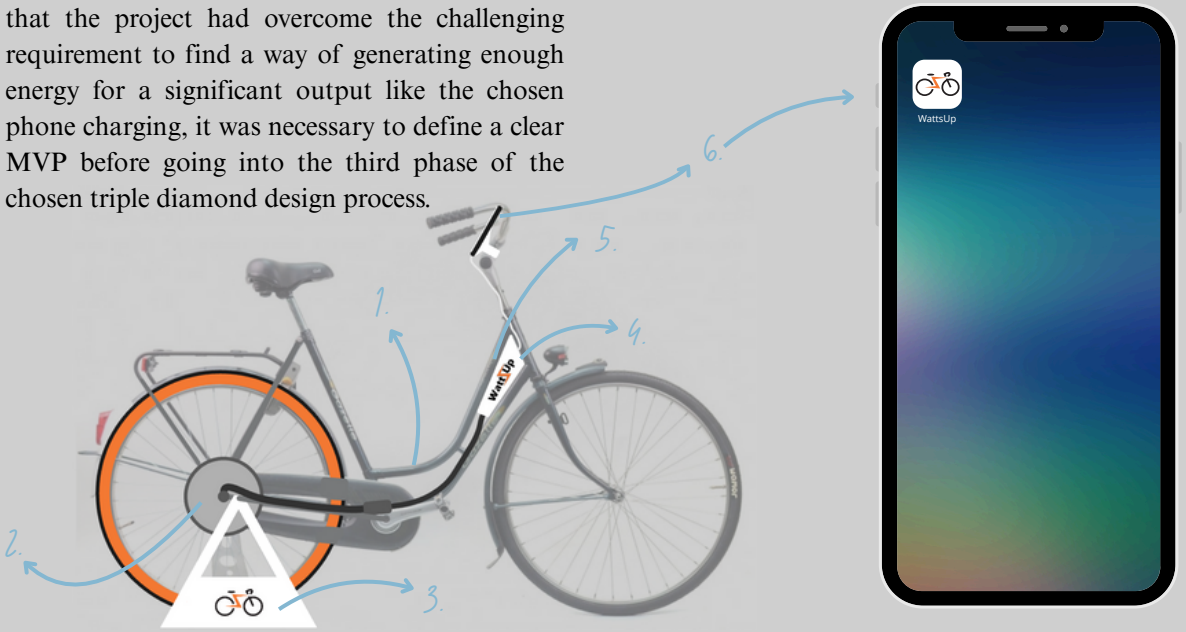
The main feedback from the pressure cooker was that although the concept sounds nice, it should not be underestimated that the difficulty of actually generating enough energy while cycling to charge a phone and with that, not ruin the cycling experience on its own. Regular bike light dynamos generate nowhere near enough electricity for phone charging. This led me to visit some experts in the d.search lab, with Geert van den Boomen among others, to discuss potential ways of building a generator or repurposing electrical motors. Having researched all kinds of possibilities and ideas of building a generator from scratch or reusing existing electrical motors to convert them into generators, incorporating with pedaling motion as input kinetic energy. Without too much success, it was necessary to visit some more direct stakeholders, namely bike shops and bike repairers. Visiting numerous bike shops and bike repairers in Eindhoven gave very helpful feedback and insights. These shops have a bunch of old e-bike wheel hub motors lying around, which work fine, but have bent spokes or minor visual damage. Normally, surpluses of these types of wheels are collected every so often by the scrap metal dealer for a low price [16]. Therefore, I got gifted one to use for the project. And this even became part of the business strategy. Namely, by outbidding the scrap metal dealers for repurposing the e-bike wheel hub motors instead of buying new, expensive hub motors, the product stays relatively cheap and is sustainable through recycling.

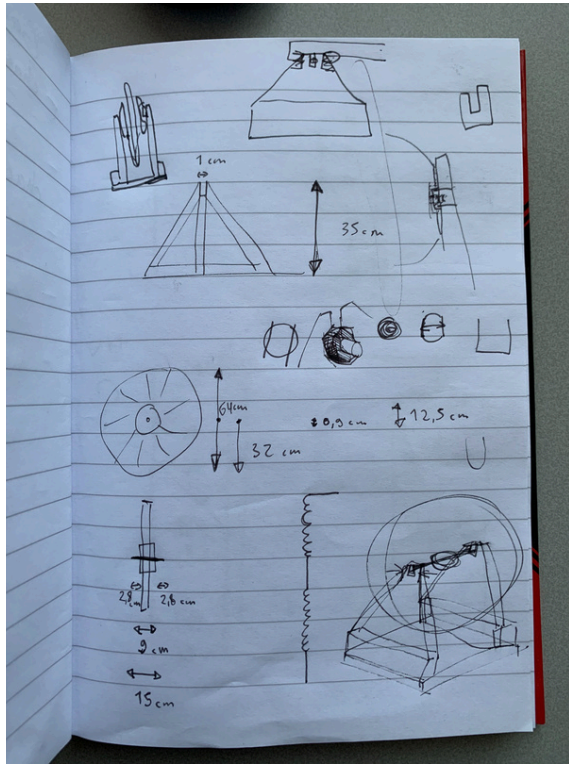
After a lot of testing in the d.search lab and building a test construction in the Vertigo workshop with MDF, it was found to have the potential to generate enough energy. The e-bike wheel hub motor consists of a BLDC motor with a three-phase output cable, only showing alternating current during tests. Therefore, an electronic circuit was thought out and built to convert the alternating current into direct current with a constant output of 5 volts. This constant voltage output is safe and enough to make phone charge up its battery.

The collective Shark Tank pitch session with the Games & Play squad provided good feedback on the direction that the project was going. Now that the project had overcome the challenging requirement to find a way of generating enough energy for a significant output like the chosen phone charging, it was necessary to define a clear MVP before going into the third phase of the chosen triple diamond design process.

For this, a Demo Day vision sketch was created. This contained all the parts needed for technical testing, user experience testing, user feedback through a questionnaire, and the working prototype for the Demo Day exhibition stand. The main parts consisted of:

1. A step-through bicycle frame
2. A repurposed e-bike rear wheel with hub motor
3. A bicycle stand for stationary testing
4. The electronics hub
5. A modular electronics hub holder fitting on the bicycle frame
6. The companion app functioning as the digital twin

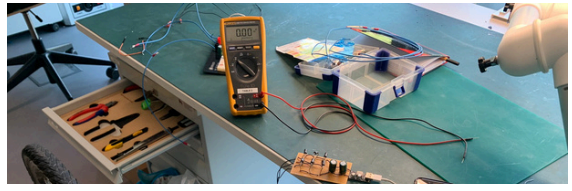


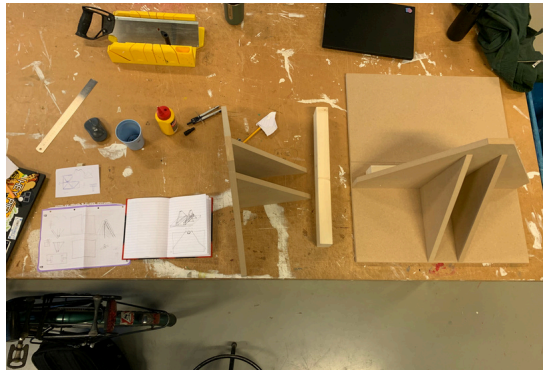


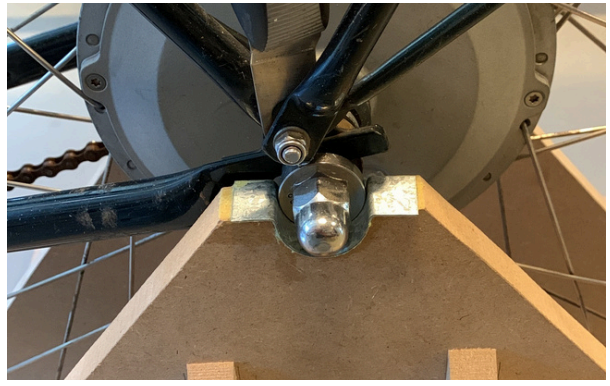
THIRD DIAMOND

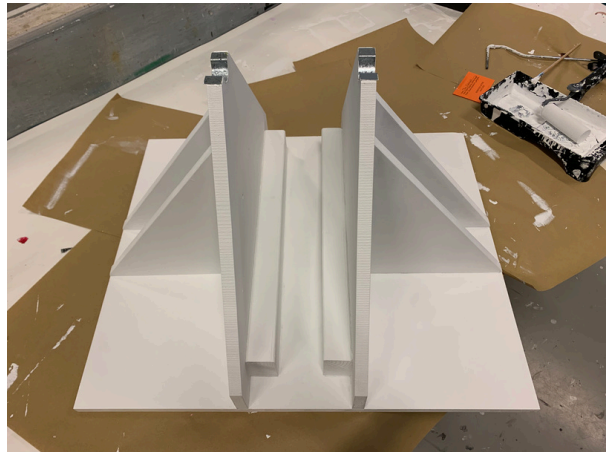
1. It was decided to use a step-through bicycle frame for the prototype setup due to its accessibility for both men and women. It is easier to hop on and off compared to other bicycle frames. Furthermore, it is ideal for people with limited mobility, injuries, or reduced flexibility. Therefore, it becomes easier for a range of users to interact with and experience the prototype.

2. Since the idea was to have testing done at a fixed location during Demo Day, it was needed to change the e-bike wheel hub motor from the previous prototype. Even though multiple other ideas were considered, it was still the most convenient way to, instead of a front wheel, use a rear wheel to have the pedaling motion directly be connected to the spinning of the wheel, which in turn ensures that the energy is generated. After some extra testing with the rear wheel e-bike hub motor, it turned out the specifications were slightly different, but the target of a constant 5-volt output was still working. The rims were painted with the orange color used in the rest of the graphic design and visuals of the project to make the e-bike wheel stand out a little bit more from the rest of the bicycle frame and the prototypes.









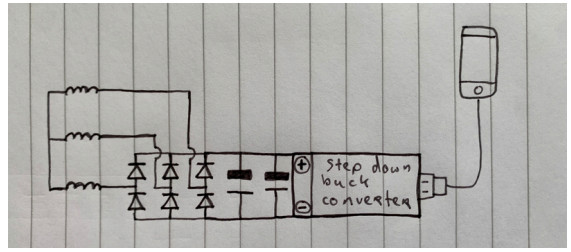
THIRD DIAMOND

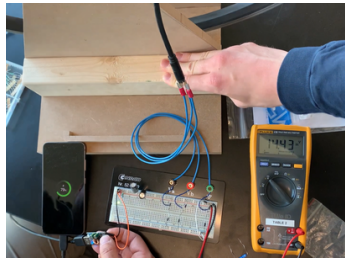
3. To ensure the test setup remained stationary during cycling, the rear wheel had to be lifted off the ground. Therefore, I used the Vertigo workshop to build a robust structure that enabled this and could withstand repeated user testing. After some low-fidelity technical sketches, the construction was built with MDF and a wooden beam with triangular shapes for stability. However, while sawing, I noticed that the MDF was relatively soft from the side, which could cause problems if a lot of weight were pressed on a small point. Therefore, two metal plates were cut and bent with a diameter of 30 mm for the bicycle to fit into with a little bit of friction. Adding these metal plates to the notches of the rear-wheel lift structure reinforced the pressure points and made mounting and dismounting the bike more convenient. After the construction was finished, it was made sure to be tested by people of all kinds of heights and weights. After the construction could be declared safe, I decided to paint it white to make it appear as part of the whole during Demo Day, since this color was part of the color scheme used in the project.

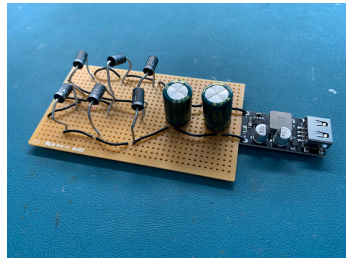
THIRD DIAMOND

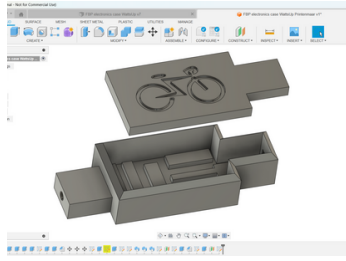
4. To convert the alternating current from the spinning BLDC motor (Brushless DC motor) in the e-bike wheel hub into a constant direct current, some work was needed. The BLDC motor has three-phase power, which has a three-wire alternating current power circuit, with each phase being 120 degrees apart from each other. To convert the AC from the three phases into DC, a three-phase full-wave bridge rectifier was needed. Together with help from Geert van den Boomen, multiple circuit iterations were drawn. After having the first breadboard setup iteration checked and tested with Bas Goossen, clear feedback was that the normal diodes had to be replaced with Schottky diodes for more efficiency. This has to do with their low forward voltage drop, and since the circuit uses 6 diodes, this made a significant impact. Where the early stage circuitry was built with a breadboard and jumper wires, the more finalised version was soldered on a prototyping board. The finalised circuit consists of 6 Schottky diodes (40V 3A - 1N5822) in the three-phase full-wave bridge rectifier, 2 electrolytic capacitors (2200uF 25V) in parallel, and 1 step-down buck converter with USB output (USB QC3.0 QC2.0 DC-DC). This ensures a constant and safe voltage output of 5 volts, which is enough to make a phone charge up its battery.

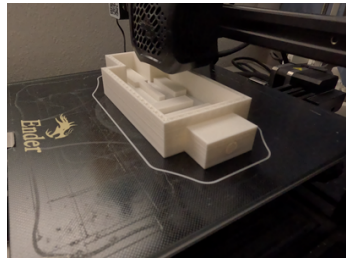
To safely and easily use the electronics board, it was decided to build a casing around it. This was designed with 3d modeling and fabricated with my 3D printer. It was designed to be easily accessible, enabling quick modifications if needed and offering transparency to Demo Day visitors.

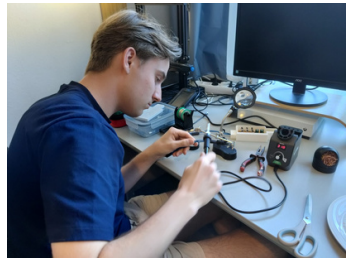


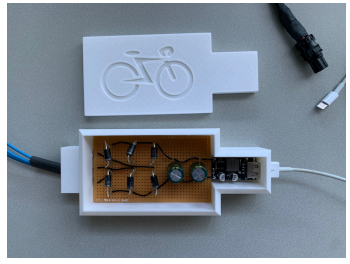


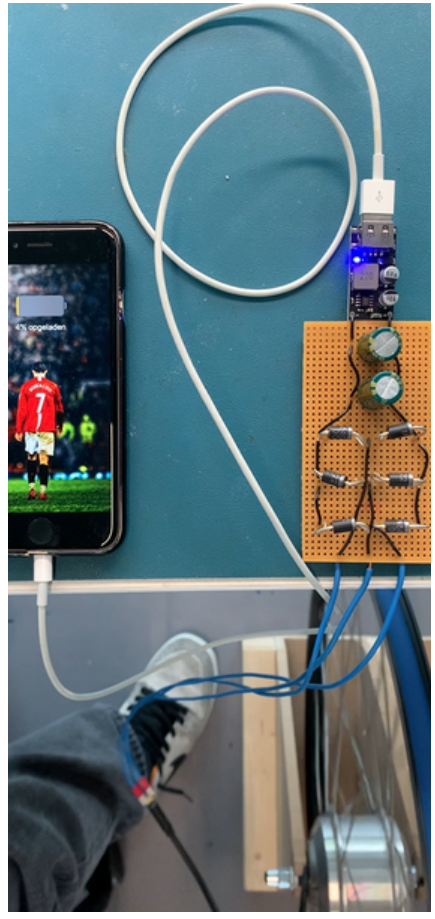










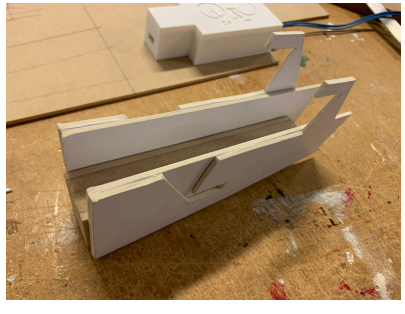
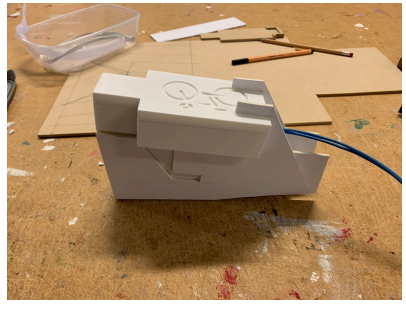


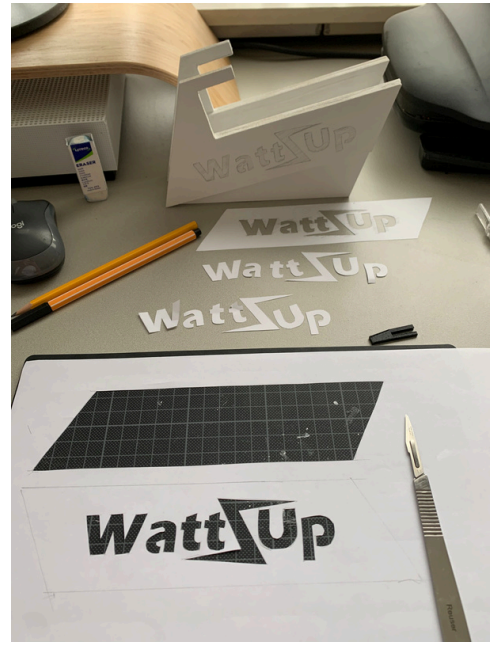
THIRD DIAMOND

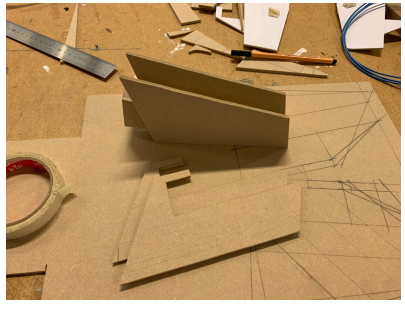
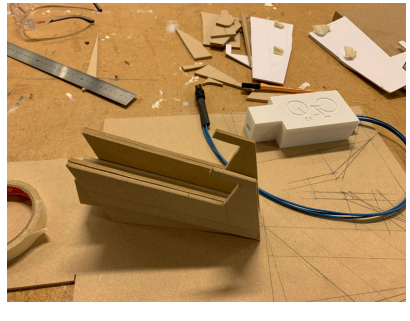
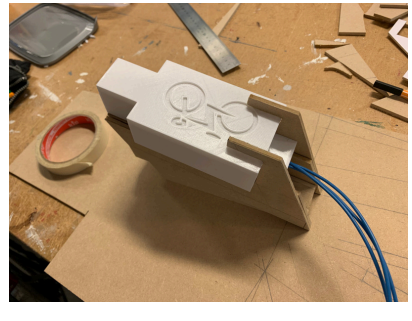
5. Inspired by existing bicycle accessories like bottle holders, I wanted to have the hub holder be more of a statement piece aesthetically, yet functional in the way that it can be easily attached and detached from the bicycle frame without the need for screws, straps or tools. To easily explore shapes and interactions, I took the bicycle frame to the Vertigo workshop and started with cardboard modeling. This led me to the finalised shapes and measurements that were later made from MDF board.

The shape is designed with sharp angles and parallel lines to express the bold, energetic character that I aimed to convey visually. More importantly, the shape functions as a holder for the electronics hub, keeping the lid closed and the electronics securely in place while still allowing easy removal. The design is a custom holder that fits seamlessly into the bicycle frame by putting it in from the widest part of the frame and then sliding it down to a slowly increasing narrow part of the frame, functioning as a friction-fit mount.

I designed a custom holder that fits seamlessly into the bike frame without the need for screws, straps, or tools — using an integrated frame mount into the shape mechanism to keep the electronics hub securely in place while still allowing easy removal.



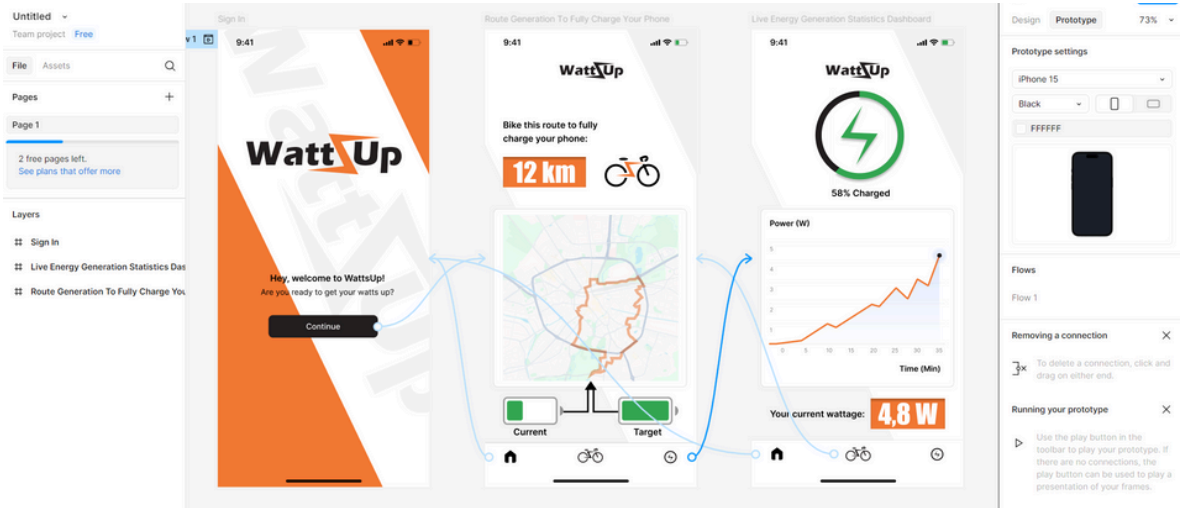
THIRD DIAMOND

6. At the start of the project, I had the vision to develop an extensive game in a phone application. However, as the project progressed, I received more feedback that this vision had to be scaled down. Nevertheless, it needed to be found out what functions and features the application would need to stay true to its purpose, namely to be a digital twin to keep users engaged and motivated. An ideation session was done to come up with several different app features. This resulted in 6 different concepts that needed to be user tested before narrowing down on the most fitting ones. Therefore, a questionnaire was made to gain feedback on all kinds of aspects of the project. One part dived deeper into the possible features of the companion app. The 6 different concepts that were shown are:

1. A competitive environment to compete with your friends
2. Live stats about your energy generation
3. Unlocking virtual rewards
4. Setting and hitting personal milestones
5. Seeing your contribution to sustainability
6. A suggested route to fully charge your phone

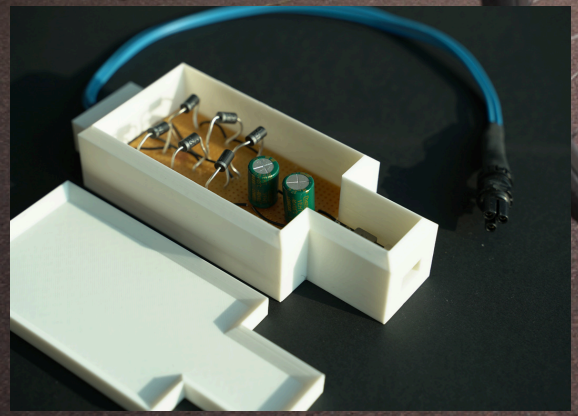
The questionnaire resulted in 26 responses with a lot of positive feedback [Appendix C]. When it comes to narrowing down on the most fitting app features, a data analysis was done with the questionnaire answers. This resulted in “2. Live stats about your energy generation” being the favorite one, and 5. and 6. coming in second place as favorites.

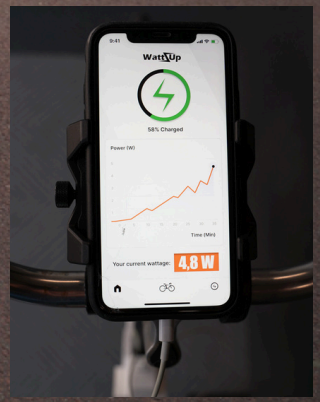
Further data analysis was done by splitting the age categories into two instead of 4, namely a younger audience aged 18-24 and a 25+ age group. This resulted in an interesting outcome where 2. was significantly voted as favorite by the younger age category, and 6. was voted as favorite by the older age category. This led to the design decision to incorporate both 2. and 6. into the app as features. This was done with the idea to capture a larger target audience and because these features complement each other well. Project time played a significant role in the choice to build the app with Figma, and therefore, make this part of the prototype Wizard of Oz.



RESULTS

The final prototype setup results in a phone-charging system powered by cycling, designed to make energy generation part of everyday life. WattsUp repurposes e-bike hub motors as generators to turn pedaling into electricity for on-the-go phone charging. The companion app tracks your phone battery and energy generation, suggests routes to help you fully charge, and gives live feedback to keep you motivated.





DISCUSSION

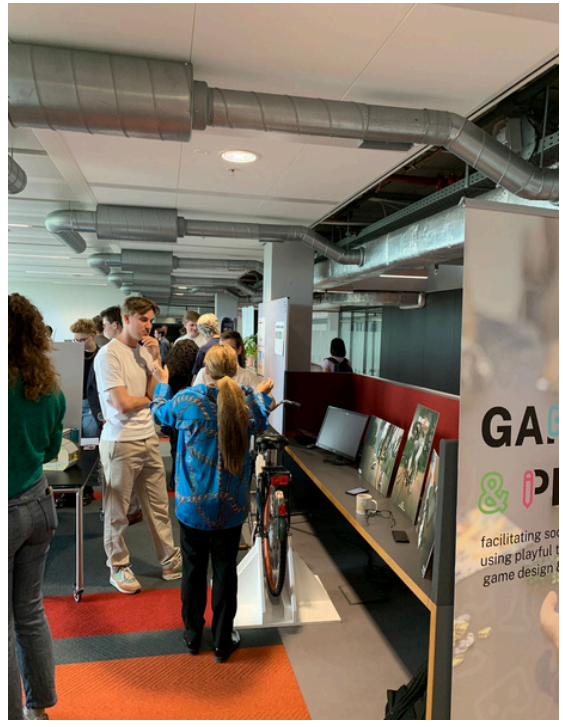
While WattsUp was a success during Demo Day, since it showcased a working demonstration, received positive feedback, and showed potential as an engaging and motivating experience around making energy generation part of everyday life, several limitations, possible changes, and future works should be addressed.

This project had two faces, on one hand, I wanted to come as close as possible to creating a fully functioning product that could be integrated into users' lives and therefore have an immediate impact. The product is a phone-charging system powered by cycling, designed to make energy generation part of everyday life. On the other hand, since it is a semester project done by one person, downsizing this vision is necessary due to this being a guaranteed limitation. It therefore becomes more important to focus on offering awareness rather than only a product. To offer users a potential shift in how they perceive and interact with energy consumption is already a good step in the right direction.

Looking back on the project, room for improvement can be found in a variety of areas. Even though I tried to reach out to the right experts for help during design obstacles and important aspects, I did not ask for enough help regarding project and vision guidance. This resulted in, for example, sloppiness with the way of using a double diamond design process.

A consequence of this was that I focused too much on persevering in getting things working, but not realizing that this took up so much time and space that other important aspects of the project received much less attention than they deserved. There is a significant time during the project when it felt more like an engineering project rather than a design project, which could have been prevented if the planning around the chosen design process had been more strictly enforced.

Potential future works would entail making the app actually work instead of the Wizard of Oz prototype made in Figma, and creating a fully functional physical prototype with a complete business plan, including marketing strategies. Since cycling is done outdoors, the prototype would need to be weather resistant, which is quite a challenge when working with electronics.



CONCLUSION

WattsUp offers a potential shift in how individuals perceive and interact with energy consumption. Linking daily physical activity to energy use makes something abstract feel more real. It is not trying to solve the world's energy problems, but it does aim to come one step closer towards personal energy independence by offering a product that lets energy generation become part of everyday life and, as a result, raise awareness and build healthy and sustainable habits.

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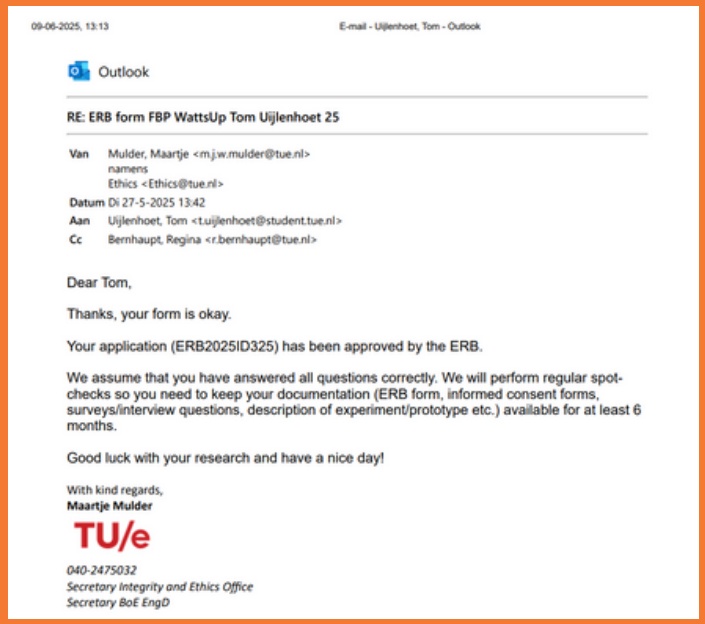
APPENDICES

Appendix A: ERB approval email



09-06-2025, 13:13 E-mail - Uijlenhoet, Tom - Outlook

Outlook

RE: ERB form FBP WattsUp Tom Uijlenhoet 25

Van Mulder, Maartje <m.j.w.mulder@tue.nl>
namens
Ethics <Ethics@tue.nl>
Datum Di 27-5-2025 13:42
Aan Uijlenhoet, Tom <t.uijlenhoet@student.tue.nl>
Cc Bernhaupt, Regina <r.bernhaupt@tue.nl>

Dear Tom,

Thanks, your form is okay.

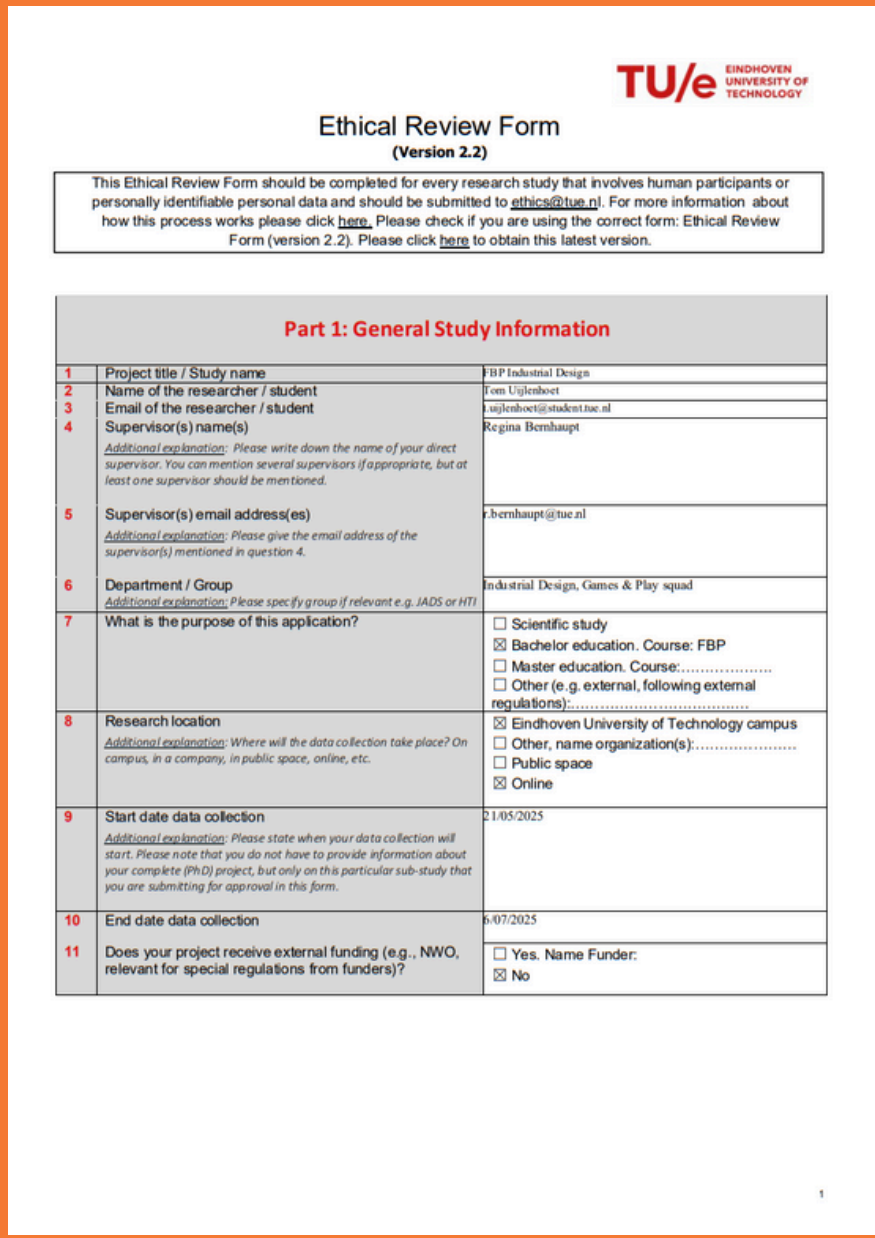
Your application (ERB2025ID325) has been approved by the ERB.

We assume that you have answered all questions correctly. We will perform regular spot-checks so you need to keep your documentation (ERB form, informed consent forms, surveys/interview questions, description of experiment/prototype etc.) available for at least 6 months.

Good luck with your research and have a nice day!

With kind regards,
Maartje Mulder
TU/e
040-2475032
Secretary Integrity and Ethics Office
Secretary BoE EngD

Appendix B: ERB form with questionnaire and informed consent included



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Ethical Review Form
(Version 2.2)

This Ethical Review Form should be completed for every research study that involves human participants or personally identifiable personal data and should be submitted to ethics@tue.nl. For more information about how this process works please click here. Please check if you are using the correct form: Ethical Review Form (version 2.2). Please click here to obtain this latest version.

Part 1: General Study Information

1	Project title / Study name	FBP Industrial Design
2	Name of the researcher / student	Tom Uijlenhoet
3	Email of the researcher / student	t.uijlenhoet@student.tue.nl
4	Supervisor(s) name(s) *Additional explanation: Please write down the name of your direct supervisor. You can mention several supervisors if appropriate, but at least one supervisor should be mentioned.*	Regina Bernhaupt
5	Supervisor(s) email address(es) *Additional explanation: Please give the email address of the supervisor(s) mentioned in question 4.*	r.bernhaupt@tue.nl
6	Department / Group *Additional explanation: Please specify group if relevant e.g. JADS or HTI*	Industrial Design, Games & Play squad
7	What is the purpose of this application?	☐ Scientific study ☒ Bachelor education. Course: FBP ☐ Master education. Course:..... ☐ Other (e.g. external, following external regulations):.....
8	Research location *Additional explanation: Where will the data collection take place? On campus, in a company, in public space, online, etc.*	☒ Eindhoven University of Technology campus ☐ Other, name organization(s):..... ☐ Public space ☒ Online
9	Start date data collection *Additional explanation: Please state when your data collection will start. Please note that you do not have to provide information about your complete (PhD) project, but only on this particular sub-study that you are submitting for approval in this form.*	21/05/2025
10	End date data collection	6/07/2025
11	Does your project receive external funding (e.g., NWO, relevant for special regulations from funders)?	☐ Yes. Name Funder: ☒ No

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	• *(commercial) partners, companies, government bodies, municipalities, consultancy firms, hospitals or care institutions that provide data (e.g., contact details of participants, data for further analysis).* *Indicate which role each party plays: who defines the means and purposes in the study, who will supply the data (external parties?), who will process/handle the data, who will be able to access the data during and after research (only researchers at TU/e or also others)?*	External parties • Other universities/institutions: • Others: ……
13	Have any special agreements already been made with an external party, such as a Non-Disclosure Agreement (NDA) or a data sharing agreement?	☐ Yes, namely: ☒ No
14	Has your proposal already been approved by an external Ethical Review Board or Medical Ethical Review Board? *Additional explanation: For example, when you are collaborating with another university and the project has been approved by their Ethical Review Board, or when you received a WMO-waiver from a Medical Ethical Review Board.*	☐ Yes ☒ No
15	If yes: Please provide the name, date of approval and contact details of the ERB. Please also include the registered number for your project approval. Additionally, please send in the Ethical Review Form upon which ethical approval was granted together with this form.	not applicable
16	If you process personal data that are likely to result in high privacy risks for participants, you need to perform a Data Protection Impact Assessment (DPIA). Have you done this for this or a very similar project? ***Please read the information below: a DPIA is not the same as a regular privacy impact assessment. More detailed questions on privacy will follow in the section below.*** *Additional explanation: A Data Protection Impact Assessment (DPIA) is a formal document that must be drafted under the guidelines of the General Data Protection Regulation (GDPR). Think of research with vulnerable people, high-risk medical research,* *The Dutch DPA (Autoriteit Persoonsgegevens) and our website provides more information about a DPIA.*	☒ Not applicable (no high privacy risks) ☐ Yes (the form is attached to the application) ☐ No

Part 2: Medical study

1	Does the study have a medical scientific research question or claim? *Additional explanation: Medical/scientific research is research which is carried out with the aim of finding answers to a question in the field of illness and health (etiology, pathogenesis, signs/symptoms, diagnosis, prevention, outcome or treatment of illness), by systematically collecting and analyzing data. The research is carried out with the intention of contributing to medical knowledge which can also be applied to populations outside of the direct research population. If your research contains questions about health and health related parameters (such as well-being, vitality, feelings of anxiety or stress) but your research question is not primarily medical, then you can answer 'no' to this question.*	☐ Yes* ☒ No *If yes or in doubt, please contact Susan Hommerson via s.m.hommerson@tue.nl

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12	Which internal and external parties are involved in the study? Think about sharing data or information between TU/e and other universities, commercial companies, hospitals, etc. *Additional explanation: Describe all internal and external parties that are involved in the study or project, including:* • *researchers or research groups at the TU/e who participate in the study;* • *(Researchers at) other universities/institutions that provide data/services, help analyzing the data, etc.;*	Internal parties • Researcher(s): Tom Uijenhoet • Supervisor: Regina Bernhaupt

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Part 3: Use of (medical) devices in the study

1	Does your research include a device? *Additional explanation: A device is a complete piece of physical hardware that is used to compute or support computer functions within a larger system. Devices can be divided into input-, output-, storage-, internet of things-, or mobile device.*	☐ Yes, not self-made ☒ Yes, self-made ☐ No
2	Please describe your device or link to an online description of the device	I repurposed a bike wheel hub motor as a generator, converting cycling energy into electricity for on-the-go phone charging. https://youtu.be/eVDXM93EpAk The cycling generates 5 volts, which is just enough to charge a phone and all electronics are safely concealed and tested. The bike wheel hub motor is a Koga/Sparta Ion Technology wheel. And the electronics I have made have been checked by Geert van den Boomen (/d.search lab) and Bas Goossen.
3a	Will you use a device that is 'CE' certified for **unintended use** (meaning you will use existing CE certified devices for other things than they were originally intended for) or use a device that is not 'CE' certified? *Additional explanation: You can find more information about CE certification here*	☒ Yes ☐ No
3b	If no: Please explain to what extent the device was assembled according to relevant standards and provide a risk assessment *Additional explanation: You can find more information about a risk assessment here*	Not applicable
3c	If yes: Do you use a device or software that has a medical purpose such as diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease or injury?	☐ Yes, my device or software currently has a medical purpose ☐ Yes, my device or software could have a medical purpose in the near future ☒ No ☐ I'm not sure

Part 4: Information about the study

1	What are your main research questions? *Additional explanation: You need to provide at least one clear research question.*	How can I design for more energy independence by harvesting energy from daily physical activity and making it motivating with gamification?
2a	Please check the box that indicates the relevant study population *Additional explanation: Please select which persons are eligible for your study.*	☒ Students ☐ General healthy population ☐ General population with specific feature, e.g., pregnancy, specifically ..... ☐ Patients, specifically ..... ☐ Other, specifically .....
2b	Age category of participants	☐ Younger than 12 years of age ☐ Older than 11 and younger than 16 years of age ☒ 16 years or older

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3	Description of the research method (select all that applies)	☐ (Semi-structured) interviews ☒ Surveys

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7	Describe the way participants will be recruited *Additional explanation: How will you recruit participants for your study? For example, by using flyers, personal network, panels, etc.*	☒ Survey link posted online, e.g., social media platforms ☐ On campus flyers ☒ Personal network ☐ Via a company, namely ..... ☐ Via a hospital, namely ..... ☐ Via an organization ..... ☐ By a Consortium Partner, namely ..... ☐ Other, namely .....
8	Provide a brief statement of the risks you expect for the participants or others involved in the study and explain. Also take into consideration any personal data you may gather and associated privacy issues. *Additional explanation: Risks for the participants can be anything from risk of data breach to risk of safety or well-being (think about stress, extreme emotions, visual or auditory discomfort). Describe these possible risks and describe the way these risks are mitigated.*	For the survey I do not expect any risks, since it will be filled in anonymously and the closest question to asking for regular personal data would be asking for their "age category" from 18-24 or 24-30 and so on. And I used a step-through bicycle frame for the prototype, which makes it easier for possible users during demo day.

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	Additional explanation: Please specify your research method. Note that you need to provide information about the research method in an additional file that you attach to the ERB form. E.g., for interviews you provide the interview questions, for surveys you provide the survey questions, etc.	☐ Group workshops/roundtable discussions ☐ Diary studies ☐ Behavioral observations ☐ Building sensor data ☐ Wearable device (e.g. Fitbit watch, on-skin sensors) ☒ User testing ☐ Pilot study ☐ GPS tracking/location data ☐ Living Lab ☐ Other, namely .....
4	Description of the measurements and/or stimuli/treatments *Additional explanation: Think about your outcome measures and the variables you will be collecting and describe them in a way such that another person understands what the participant will experience. For example: Participants will perform task A and see pictures from database B, and we measure validated Scale 1.*	Participants will fill in a short one-time survey with questions about the project to gain more insights into participants' view on their cycling behavior, energy usage, possible motivational factors for behavior change and feedback on. And I will use their input and answers anonymously for my design considerations and justifications.
5	Describe and justify the number of participants you need for this study. Also justify the number of observations you need, taking into account the risks and benefits. *Additional explanation: Think about if you need 3 or 30 participants for example, and why? Do they need to provide their input once, or several times, and why? If relevant, specify the duration of the study per participant and the compensation that is needed for the study.*	For the survey I would like to get between 20 and 50 participants. At least 20 because it gives me enough inside and to cover some possible outliers, and 50 would be enough, since more than 50 would be too much to process all the qualitative answers and do justice to the effort of the participants.
6	Explain why your research is societally important. What benefits and harm to society may result from the study? *Additional explanation: What benefit will the results of your study have to society in general?*	This project addresses the growing need for awareness around the vulnerability and limitations of today's energy systems. By offering a tangible and interactive way for people to generate their own energy, it encourages users to reflect on how much power is actually needed to support everyday activities, such as charging a phone. The project/study provides a small but meaningful step toward personal energy independence. By making energy generation part of a familiar activity, like cycling, the product helps bridge the gap between abstract sustainability concepts and everyday behaviour. If successful, it could promote more conscious energy use, increased motivation to adopt sustainable habits, and a shift in how individuals relate to energy consumption. Potential societal benefits include greater environmental awareness, healthier lifestyles through cycling, and reduced reliance on centralized power sources. However, there is also a risk that the system may appeal only to a niche group of users or oversimplify the complexities of energy sustainability. It is important that the product is framed not as a total solution, but as a stepping stone toward broader behavioural change.

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Part 5: Self-assessment checklist

	Note: answers in the blue boxes indicate that your research is eligible for fast-track approval	Yes	No
1a	Does the study involve human material? (e.g., surgery waste material derived from non-commercial organizations such as hospitals)		X
1b	Will blood or other (bio)samples be obtained from participants? (e.g., hair, sweat, urine or other bodily fluids or secretions, also external imaging of the body)		X
2	Will the participants give their consent – on a voluntary basis – either digitally or on paper? Or have they given consent in the past for the purpose of education or for re-use in line with the current research question?	X	
3	Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator? Additional explanation: Think about doing research on your own students or on your own employees. When there is a dependency or power imbalance between you and the research participants, you need to answer 'yes' to this question.		X
4	Does the study involve participants who are particularly vulnerable or unable to give informed consent? (e.g., children (<16 years of age), people with learning difficulties, patients, people receiving counselling, people living in care or nursing homes, people recruited through self-help groups)		X
5	Will participating in the research be burdensome? (e.g., requiring participants to wear a device 24/7 for several weeks, to fill in questionnaires for hours, to travel long distances to a research location, to be interviewed multiple times)?		X
6	May the research procedure cause harm or discomfort to the participant in any way? (e.g., causing pain or more than mild discomfort, stress, anxiety or by administering drinks, foods, drugs, or showing explicit visual material)		X
7	Will financial inducement (other than reasonable expenses and compensation for time) be offered to participants? Additional explanation: For an explanation of what is considered a reasonable compensation, see the topic participant fees from the HTI group		X
8a	Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people)		X
8b	If yes: Will you be observing people without their knowledge in public space? (e.g. on the street, at a bus-stop)		X
9	Will the study involve actively deceiving the participants? (e.g., will participants be deliberately falsely informed, will information be withheld from them, or will they be misled in such a way that they are likely to object or show unease when debriefed about the study)		X
10	Will participants be asked to discuss or report sexual experiences, religion, alcohol or drug use, suicidal thoughts, or other topics that are highly personal or intimate? Additional explanation: Think about your research population. For some participants, particular topics can be considered sensitive or intimate, whereas the same topics will not be perceived as such by other participants.		X
11	Elaborate on all boxes answered outside of the blue boxes in part 5. Describe how you safeguard any potential risk for the research participant.	Not applicable	

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Part 6: Self-assessment on privacy

The following questions (1-11) concern privacy issues, as laid down in the General Data Protection Regulation (GDPR). The Data Stewards and – if necessary – privacy team of TU/e will assess these questions. In some cases, more information is required to assess the privacy risks. If this is the case, you will be notified that the Data Stewards team will contact you.

The GDPR defines 'personal data' as any information relating to an identified or identifiable natural person ('data subject'). Personal data also includes data that indirectly reveals something about a natural person. Personal data can lead to the physical, physiological, genetic, mental, economic, cultural or social identity of a natural person. There are two main categories of personal data: regular personal data and special category personal data.

If you are not sure whether some of these questions below should be answered with a Yes or No, please contact a Data Steward first through rdmsupport@tue.nl.

	Note: answers in the blue boxes indicate that your research is eligible for fast-track approval	Yes	No
1	Will the study involve discussion/collection/processing of **regular** personal data, or will you collect and (temporarily) store video or voice recordings for the purpose of conducting interviews? *Additional explanation: For example, name, address, phone number, email address, IP address, gender, age, video or interview recordings? If you are not sure whether your data contains personal data, please contact the Data Stewards Team (rdmsupport@tue.nl).*		X
1A	If yes: Please describe which regular personal data you will collect in this study?	Not applicable. The survey will include a question regarding the participants "age category". So 18-24 24-30 etc. Not a specific age number.	
2	Will the study involve discussion/collection/processing of **special category** personal data or other **sensitive data**? *Additional explanation: Examples of special category personal data are race, religion, health information, political views, genetic or biometric data for the unique identification of a person, sexual preference, etc. Health information concerns personal data of the physical or mental health of persons, including the provision of health care. Examples of other sensitive data is information such as communication data, financial records or credit scores, camera surveillance data, location/GPS data, internet-of-things data, employee monitoring, observing or influencing behaviour, criminal records, data of vulnerable persons (children, people with disabilities, refugees), BSN number etc. Please be aware that the use of special category personal data in research requires extra security measurements in order to safeguard the privacy of data subjects and to comply with the GDPR. Processing of this special category data is prohibited, except for specific purposes and under certain circumstances. If you need to process special category data, please consult the data stewards at rdmsupport@tue.nl.*		X
2A	If yes: Please describe which special-category personal data and/or sensitive data you will collect in this study?	Not applicable	

If you answered yes to either question 1 or 2, please answer the questions below. If you answered no to both questions, you can skip this part and continue onto part 7. Also, if an answer to any of the following questions is 'yes', please contact a Data Steward at rdmsupport@tue.nl

		Yes	No
3	Will your project involve the processing of personal data on a **large scale**? *Additional explanation: In general, any processing that involves more than 10.000 data subjects should be considered "large scale". However, if the data of approximately 1000 persons (or more) are involved, the data processing may still be considered large scale. In that case, besides the number of persons involved in the study, one should also assess (i) the amount of data collected from these persons taking into account the type/risk level of the personal data, (ii) the duration of the data processing, (iii) the geographic scope or extent of the processing. For example, if you would collect and process data across several European countries with 10+ socio-economic data items of 1200 individual persons for several years in a row, that is likely "large-scale processing". Other examples of a large-scale processing activity are:* • *Monitoring driving behavior of road users on Dutch highways* • *Collecting data of Covid patients* • *A hospital that processes patient data as part of its usual operations*		X

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	• *A transport company that processes travel information of people who travel by public transport in a certain city. For example, by tracking them through travel maps.*		
4	Does this processing activity involve the use of new or innovative technologies? *Examples of a new technology: combining fingerprints and facial recognition for physical access control, the use of bodycams in public spaces, the use of new technical methods in conducting research such as AI. This question also refers to new technologies that have not been deployed by TU/e so far.*		X
5	Does your study involve systematic (c.q. automated) monitoring of persons? *Additional explanation: Consider data processing activities that have the purpose of observing, monitoring or controlling individuals, for example in circumstances where the individuals are not aware by whom their personal data is collected and how it is used. Examples of such activities are using camera systems to monitor driving behavior on highways, monitoring email inactivity or employee phone use, certain applications of machine learning and artificial intelligence.*		X
6	Does the study involve collaborations (with third parties) in which data are shared or exchanged in order to link or combine data? *Additional explanation: This may often apply in a collaboration between the university and a commercial party, contract research, etc. It is important to assess this for all data in the entire project, not just your own data. An important consideration in this situation is whether the person whose data is involved could have expected that data from these different databases or sources of information were to be combined. For example, it is less likely for data subjects to expect that databases from different parties will be combined and the results are used for different purposes than one could reasonably expect; this may apply for example in a collaboration between the university and a commercial party.*		X
7	Will the study include data processing activities that prevent data subjects from exercising their rights or using a service or contract? *Additional explanation: Examples include processing operations carried out in public places that people cannot avoid (train station, airport, shopping mall, public university premises, etc.) or processing operations whose purpose is to allow or not allow data subjects to use a service or enter into a contract (examples: by refusing to pay a benefit, not being able to apply for a loan, etc.).*		X
8	Will the study process personal data to score, rank or profile persons? *Additional explanation: Examples: monitoring (highway) roads to give road users a "score" based on their detected driving behavior, a bank assessing its customers based on their creditworthiness, or an organization building behavioral and marketing profiles based on use of their website or navigating their website.*		X
9	Does your data processing include activities that involves composing "**blacklists**" – and, in particular, in relation to sensitive or special category data, such as communication data, financial records or credit scores, genetic data, biometric data, health data, camera surveillance data, location/GPS data, internet-of-things data, employee monitoring, observing or influencing behaviour, etc. *Additional explanation: This situation will not be a common occurrence in research, but you may indirectly be involved in this. In general, this typically concerns processing operations involving personal data relating to criminal convictions and offences, data relating to unlawful acts, data concerning unlawful or annoying behaviour or data concerning bad payment behaviour by companies or individuals are processed and shared with third parties (blacklists or warning lists, as used, for example, by insurers, hospitality companies shopping companies, telecom providers as well as blacklists relating to unlawful behavior of employees, for example in the healthcare sector or by employment agencies, etc.).*		X
10	Will personal data be transferred or shared outside the EU/EEA? EU data protection rules apply to the European Economic Area (EEA), which includes all EU countries and non-EU countries Iceland, Liechtenstein and Norway. *Additional explanation: The GDPR has drafted additional requirements for transfers data outside of the EU/EEA. Typically, additional safeguards must be implemented to protect the personal data of residents in the European Union. For example, if you collaborate with an American, Indian or Chinese university or other third party outside the EU/EEA, you must first check whether this is allowed and under which conditions this is allowed. Another typical example is storage of data on American providers of cloud (storage) services. Please contact the data stewards first to discuss this.*		X
11	Will any raw or anonymized personal data or any other sensitive data or research results from the project possibly be transferred to a high-risk country*? ***High risk countries**: China, Russia, Iran, Turkey, and North Korea.* *If personal data or other potentially sensitive data is exchanged with one of these countries, or if part of the data processing takes place in one of these countries: **an advice from the Data Protection Officer, the kennisveiligheidsteam (Knowledge Security team), and the CISO (Chief Information Security Officer) is ALWAYS required.***		X

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Part 7a: Processing of research data

1	Is consent your legal basis for processing the personal data in your study? *Additional explanation: What is a legal basis? One of main principles in the GDPR is to ensure that personal data is processed lawfully, fairly, and transparently. To comply with this principle, the processing of personal data also requires that you have a valid legal basis for the personal data processing activity. In research projects, the legal basis is often but not always consent. However, it is possible that it is not clear or not possible to establish whether to use consent as a legal basis. Some examples where consent may not be applicable as legal basis are covert research, data collection in public spaces, secondary data analysis of existing data, data that are transferred to you by a third party, consent is not possible or would require disproportionate effort, etc. In that case, please indicate which legal basis you think that applies or (preferably) contact a data steward first.*	☒ Yes and it will be obtained via the survey An informed consent template* is attached to this application. ☐ No, I will use another legal basis to process the data. Namely, …….. * You can download a suitable template **here**.
2	Where will the data come from?	☐ Data obtained from another party (secondary data use) ☒ New data collected only by my research team ☐ New data collected together with collaborators
3	Which of the following tools will you use to process personal data?	**Surveys** ☐ Qualtrics ☐ Limesurvey ☒ MS Forms ☐ Other, namely …….. **Interview/workshop recordings** ☐ Voice/video recorder ☐ Phone in a flight mode ☐ MS Teams ☐ Other, namely …….. **Transcription** ☐ Manual transcription ☐ Microsoft Office software (e.g. Word, Teams) ☐ Other, namely …….. **Statistical analysis** ☐ SPSS ☐ R ☐ Other, namely …….. **Other tools**, specifically……..
4	Where will the data and in particular the personal data be stored during and after completion of the study? If you have already uploaded your Data Management Plan, you can refer to your Data Management Plan.	☒ Onedrive ☐ Research Drive ☐ Network Drive

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	Additional explanation: University supported-storage facilities are SURF Research Drive, Ceph, departmental drives (this includes BE Project Drive), and the TU/e instance of Microsoft OneDrive. For most personal data, the use of SURF Research Drive or departmental drives (including BE Project Drive) is required.	☐ Research Manager ☐ Other, namely ……

Part 7b: Safety and security measures

1	Will you pseudonymize/anonymize the data? *Additional explanation:* *Anonymization: remove all direct identifiers (name, address, telephone number etc.) but also indirect identifiers (age, place of birth, occupation, salary) that, linked with other information, can lead to a person's identification. Anonymization to the point that a data subject is no longer identifiable means that the anonymized data is not considered to be personal data anymore.* *Pseudonymization: replacing the unique identifier of a data subject with an artificial pseudonym. This means that identification is still possible with the identification key. The identification key needs to be stored securely and separately from the pseudonymized data. If the data subject can be identified by combining data with additional information, the data is also called pseudonymous.*	☐ Yes ☒ No If yes, describe how:
2	Is access to (personal) data restricted? (Select all that apply)	☐ No ☐ Yes, via access control ☐ Yes, via password protection ☒ Yes, access only given to TU/e research team ☐ Yes, access only given to research team, including non-TU/e collaborators ☐ Other, specify……..
3	Who will have access to the data during and after completion of the project? (Select all that apply)	☒ Main researcher ☒ TU/e supervisor(s) ☐ External supervisors ☐ TU/e research team ☐ Other, specify……..
4	Will you store data for future research?	☒ No ☐ Yes, in a public data repository ☐ Yes, in a public data repository under restricted access ☐ Yes, in a TU/e-recommended storage (SURF Research Drive, Network Drive)
5	Will you share data outside the TU/e?	☒ No ☐ Yes, in a fully anonymized form ☐ Yes, raw or pseudonymized data* *If you selected this box, make sure that a suitable data agreement is put in place. You can contact the Data Stewards for support in preparing such an agreement
6	How long will data be stored after the end of the project?	5 years

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Part 8: Closures and Signatures

1	Enclosures (tick if applicable and attach to this form):	☒ Informed consent form ☐ Informed consent form for other agencies when the research is conducted at a location (such as a school) ☐ Text used for ads (to find participants) ☐ Text used for debriefings ☐ Approval other research ethics committee ☒ The survey the participants need to complete, or a description of other measurements ☐ Data Protection Impact Assessment checked by the privacy officer ☐ Data Management Plan checked by a data steward
2	Signature(s)	Signature(s) of applicant(s) Tom Cuijlenhoet Date: 21/05/2025 Signature research supervisor R. Bevilacqua Date: 26/05/2025

FBP Questionnaire *WattsUp*

* Vereist

Informed Concent

1

Introduction You have been invited to take part in research project *WattsUp*, because you represent an important part of our intended user group. Participation in this research project is voluntary: the decision to take part is up to you. Before you decide to participate we would like to ask you to read the following information, so that you know what the research project is about, what we expect from you and how we deal with processing your personal data. Based on this information you can indicate via the consent declaration whether you consent to take part in this research project and the processing of your personal data. You may of course always contact the researcher via t.uijlenhoet@student.tue.nl if you have any questions, or you can discuss this information with people you know.

Purpose of the research This research project will be managed by Tom Uijlenhoet. The purpose of this research project is to gain more insights into participants' view on their cycling behaviour, energy usage, possible motivational factors for behaviour change and feedback on design considerations.

What will taking part in the research project involve? You will be taking part in a research project in which we will gather information by means of this form. This study will be completely anonymous, and the data obtained from the study will not be traceable to you. For your participation in this research project you will not be compensated.

Potential risks and inconveniences Your participation in this research project does not involve any physical, legal or economic risks. You do not have to answer questions which you do not wish to answer. Your participation is voluntary. This means that you may end your participation at any moment you choose by letting the researcher know this. You do not have to explain why you decided to end your participation in the research project. Ending your participation will have no disadvantageous consequences for you. If you decide to end your participation during the research, the data which you already provided up to the moment of withdrawal of your consent will be used in the research. Do you wish to end the research, or do you have any questions and/or complaints? Then please contact the researcher via t.uijlenhoet@student.tue.nl.

Confidentiality of data The raw and processed research data will be retained for a period of 5 years. Ultimately after expiration of this time period the data will be either deleted or anonymized so that it can no longer be connected to an individual person. The research data will, if necessary (e.g. for a check on scientific integrity) and only in anonymous form be made available to persons outside the research group. Your anonimyzed data can be made available for future research, for example by sharing those data with fellow researchers or making anonymized/pseudonymized data available via a data archive or repository. This research project was assessed and approved on [*date*] by the ethical review committee of Eindhoven University of Technology.

2

By signing this consent form I acknowledge the following:

1. I am sufficiently informed about the research project through a separate information sheet. I have read the information sheet and have had the opportunity to ask questions. These questions have been answered satisfactorily.

2. I take part in this research project voluntarily. There is no explicit or implicit pressure for me to take part in this research project. It is clear to me that I can end participation in this research project at any moment, without giving any reason. I do not have to answer a question if I do not wish to do so.

*

- ○ Yes
- ○ No

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General information

3

What is your age? *

- ○ Under 18
- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45+

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Ethical Review Form

26-05-2025, 12:05 FBP Questionnaire WattsUp

Cycling behavior

4

Approximately how far do you cycle each week? *

- ○ Less than 10 km
- ○ 11-25 km
- ○ 26-50 km
- ○ 51-100 km
- ○ 110-150 km
- ○ More than 150 km

5

Do or did you ever use any devices or accessories on your bike? (e.g., phone holders, a bottle holder, lights, odometers, etc.)? *

- ☐ Bottle holder
- ☐ Phone holder
- ☐ Lights
- ☐ Odometer
- ☐ Dynamo
- ☐ Bicycle bag
- ☐ Other
- ☐ None

Phone behavior

6

What was your average daily screen time on your phone last week? *

- Less than 1 hour
- 1-2 hours
- 2-3 hours
- 3-4 hours
- 4-5 hours
- 5-6 hours
- 6-7 hours
- 7-8 hours
- 8-9 hours
- 9-10 hours
- More than 10 hours

7

How often do you run out of phone battery during the week? *

- Daily
- A few times a week
- Once a week
- Less than once a week

8

How do you usually charge your phone? *

- With the socket at home
- With public charging stations (like in the train, at work or other facilities)
- With a powerbank
- Other (please specify in next question):

9

Have you ever had your phone run out of battery while you were out? *

- Never
- Rarely
- Sometimes
- Often
- Very often

WattsUp

WattsUp is about converting cycling energy into electricity for on-the-go phone charging. Current tests show that cycling for 10 minutes increases phone battery life by 10% without excessive pedaling force. By making energy generation part of a familiar activity, like cycling, the product aims to help bridge the gap between abstract sustainability concepts and everyday behavior. A companion app will function as a digital twin to track weekly energy generation and increase motivation.

10

What is your first impression of the concept? *

11

Would you be more likely to cycle if your pedaling could generate energy for your phone to charge? *

12

Would you feel more energy independent if you were able to charge your phone with your own cycling energy? *

Companion App

13

Which possible app features would keep you motivated/engaged besides seeing your battery percentage go up? (see the visual above for possible representation) *

- [ ] 1. A competitive environment to compete with your friends
- [ ] 2. Live stats about your energy generation
- [ ] 3. Unlocking virtual rewards
- [ ] 4. Setting and hitting personal milestones
- [ ] 5. Seeing your contribution to sustainability
- [ ] 6. A suggested route to fully charge your phone

14

Which one of the above would be your favorite and why? *

15

(Optional) Any other features or ideas you'd like to see in a cycling-based energy app/game?

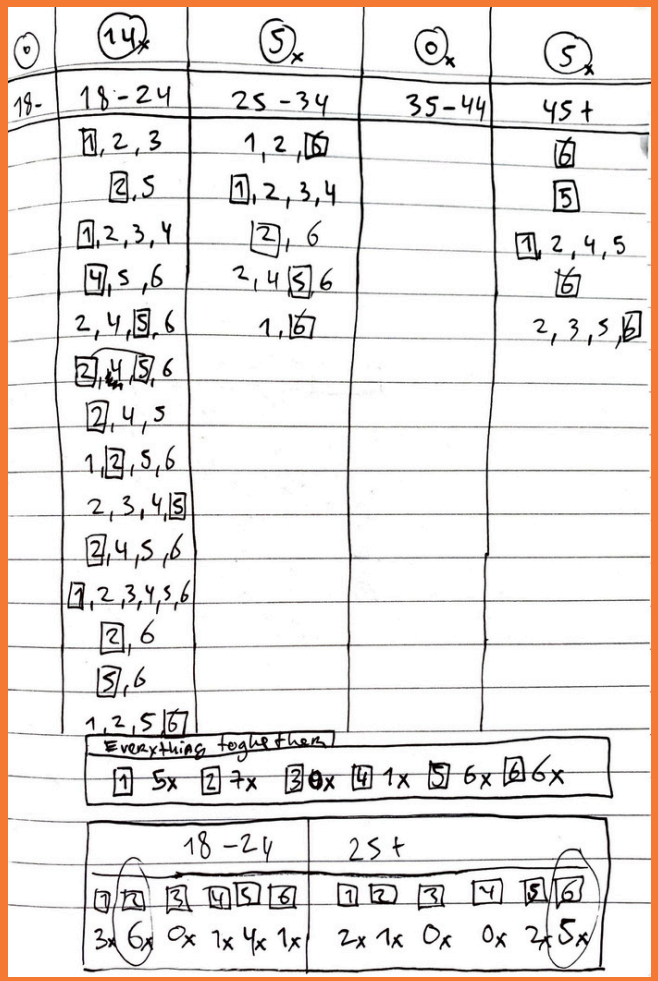
16

(Optional) Do you have any general feedback or question?

Appendix C: Questionnaire responses

FBP Questionnaire WattsUp.xlsx

Appendix D: Data analytics on application features



Appendix E: Graphic design