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SCHOOL OF ENGINEERING

Department of Mechanical and Industrial Engineering

MSc. Design and Technology Futures

**DESIGNING FOR LONGEVITY IN
MICROMOBILITY SYSTEMS: REFRAMING URBAN
MOBILITY THROUGH ENERGY-AS-CURRENCY
APP DESIGN.**

**MIKROMOBIILSUSE PIKAEALISUSE DISAIN: LINNALIIKUMISE
ÜBERMÕTESTAMINE ENERGIA-KUI-VALUUTA RAKENDUSE KAUDU**

MASTER THESIS

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Tallinn 2026

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THESIS TASK

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(in Estonian) MIKROMOBILIILSUSUSTEEMIDE PIKAEALISUSE KAVANDAMINE: LINNALISE LIIKUVUSE UMBERRAAMISTAMINE ENERGIA-KUI-VALUUTA RAKENDUSE DISAINI KAUDU

Thesis main objectives:

1. To identify and analyse the behavioural and systemic drivers of premature e-scooter retirement in shared urban micromobility systems through lifecycle assessment literature review and systems-oriented mapping of the Tallinn micromobility ecosystem.
2. To design and develop EcoMobility — a speculative energy-accountability platform that uses kilowatt-hours as the primary unit of account in mobility decisions — as a design response to the commons governance failure driving short e-scooter lifespan.
3. To critically evaluate the institutional conditions required for deployment of an energy-accountability mechanism, and to propose a grounded organisational deployment model as a realistic pathway from speculative concept to implemented programme.

Thesis tasks and time schedule:

No	Task description	Deadline
1.	Literature review, systems-oriented GIGA-mapping of Tallinn micromobility ecosystem, and identification of gap nodes and behavioural drivers of premature e-scooter retirement	07/2025
2.	Speculative design development across two phases: city-scale EcoMobility concept and organisational deployment model, including UI design, stakeholder value map, financial model, and institutional limitation analysis	02/2026
3.	CDR critical reflection, thesis writing, and finalisation	04/2026

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PREFACE

This thesis begins by addressing the issue of shared e-scooters being used and discarded too quickly. As I researched deeper into the problem, I realised that this wasn't something that could be solved with better materials or a stronger frame; it was a complex set of behavioural and systemic factors that this work seeks to understand and explore.

The research was carried out within the MSc Design and Technology Futures programme at Tallinn University of Technology (TalTech) and the Estonian Academy of Arts (EKA). Tallinn provided an inspiring environment, given its status as the global headquarters of Bolt, one of the world's largest micromobility operators, and its role as a hub for a dynamic, complex shared mobility ecosystem. The system mapping developed in Chapter 5 is the result of several months of close observation and engagement with a range of mobility actors, including micromobility operators, city transport planners, e-vehicle maintenance service providers, and individual users.

The design work moved through two distinct phases. The first phase explored EcoMobility as a city-scale speculative platform, a system in which kilowatt-hours replaced money as the governing unit of mobility decisions. The second phase emerged from an honest reckoning with the institutional limitations of the first. Without compelling reasons for operators and city governments to participate, the city-scale vision was not a realistic design proposition. The reframing of the research led to the concept of EcoMobility as a corporate or campus sustainability programme.

I wish to express my deepest gratitude to my supervisors, Kätlin Kangur and Martin Pärn, for their wise remarks, sharp critiques, and for asking the right questions that helped me better understand my own materiality and the consequences of my designs. I also thank the fellow students from the Design and Technology Futures program for their participation in class discussions and for lively debates during studio sessions that forced me to define and refine positions I had taken for granted.

Keywords: micromobility, e-scooter lifespan, lifecycle assessment, energy accountability, speculative design, organisational deployment, design probe, master's thesis.

LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation	Definition
CDR	Constructive Design Research
CO ₂ eq	Carbon dioxide equivalent — standard unit for greenhouse gas emissions
CSRD	Corporate Sustainability Reporting Directive (EU, 2024)
EV	Electric Vehicle
g/pkm	Grams per passenger-kilometre — unit for transport emissions intensity
GIGA-map	Rich visual mapping tool central to Systems-Oriented Design (Sevaldson, 2011)
kWh	Kilowatt-hour — unit of electrical energy (3.6 MJ)
LCA	Lifecycle Assessment — a method for evaluating total environmental impact
MaaS	Mobility as a Service
NREL	National Renewable Energy Laboratory (USA)
SDT	Self-Determination Theory (Deci & Ryan, 2000)
SOD	Systems-Oriented Design (Sevaldson, 2011)
TalTech	Tallinn University of Technology
TPB	Theory of Planned Behaviour (Ajzen, 1991)
EKA	Estonian Academy of Arts

1 INTRODUCTION

Shared e-scooters have become a symbol of urban sustainability ambitions — and of their failures. Lifecycle assessment studies find that shared e-scooters produce between 66 and 202 g CO₂/pkm across their lifetime, higher than buses and often higher than car journeys, because a short operational lifespan means the emissions of manufacturing must be amortised over far fewer kilometres (Hollingsworth et al., 2019). The average shared e-scooter lasts between one and three years in service. Many do not last a year. It is this premature failure, not the act of riding, that drives the sector's environmental cost.

The cause is not primarily technical. Well-engineered vehicles are still being retired early due to rough handling, improper parking, and the lack of an accountability mechanism that links how users treat shared vehicles to the consequences they face. In the shared fleet context, damage is socialised: it falls on the operator, the fleet, and ultimately future users and the environment. This is a classic commons governance failure (Ostrom, 1990). Addressing it requires a design intervention, not a materials upgrade.

This thesis develops EcoMobility, a speculative platform that makes energy accountable in mobility decisions. The research question is: How can an energy-accountability design mechanism, put into practice as a speculative platform and reframed for organisational deployment, address the behavioural drivers of short e-scooter lifespan in shared urban micromobility? The study proceeds through systems-oriented mapping of the Tallinn micromobility ecosystem — documented in Chapter 5 and Appendix 1 — iterative speculative design development in two phases, and critical reflection on the design process and its outcomes.

Chapter 2 reviews LCA evidence and behavioural theory. Chapter 3 presents the theoretical framework: Systems-Oriented Design, Speculative Design, and Constructive Design Research. Chapter 4 describes the research methodology. Chapter 5 documents the design process across two phases. Chapter 6 presents the critical analysis. Chapter 7 concludes.

2 LITERATURE REVIEW AND BACKGROUND

This chapter reviews the scientific and design literature that frames the research problem. Section 2.1 examines the lifecycle assessment evidence on e-scooter lifespan and its environmental implications. Section 2.2 reviews the behavioural theories and empirical studies most relevant to the design of EcoMobility. Section 2.3 surveys existing platform precedents. The chapter ends by synthesising these three bodies of literature into the specific research problem this thesis addresses.

2.1 E-SCOOTER LIFESPAN: LCA EVIDENCE AND ITS IMPLICATIONS

Life-cycle assessment of shared e-scooters has become a growing area of study in transport environmental research. In the short time that shared e-scooters have been in operation, numerous studies have assessed their environmental impacts across their lifecycle – manufacture, use, and end of life. The most cited piece of research on the environmental impacts of shared e-scooters is the 2019 report by Hollingsworth, Copeland, and Johnson, which assessed the lifecycle impacts of three dockless shared e-scooter operators in three US cities. Similar studies have since taken place in cities across Europe and Asia. Their findings made for concerning reading, with a single e-scooter journey having an emission impact of 66–202 g CO₂/pkm – higher than many other transport modes, including the commonly lauded electric bicycle at 26 g CO₂/pkm and large buses at 41 g CO₂/pkm. The findings of the Hollingsworth, Copeland, and Johnson report and similar research since have been met with significant surprise, and indeed debate, in the urban mobility industry.

The environmental impact of shared e-scooters is largely concentrated in the early stages of the product lifecycle. In their paper, Hollingsworth et al. (2019) found that shared e-scooters accounted for around 50% of their lifetime emissions during manufacturing. A further 33% were attributed to the collection and redistribution of e-scooters for sharing. In-use electricity consumption comprised less than 5%, and end-of-life disposal accounted for 12%. Thus, the apparent zero tailpipe emission benefit during use is outweighed by the upstream and downstream emissions. Additionally, the in-line consumption of energy and materials over a short operational lifespan means that the return on investment in terms of miles travelled per vehicle is far less than for a traditionally owned vehicle, which would retain its value over a 5-year lifespan.

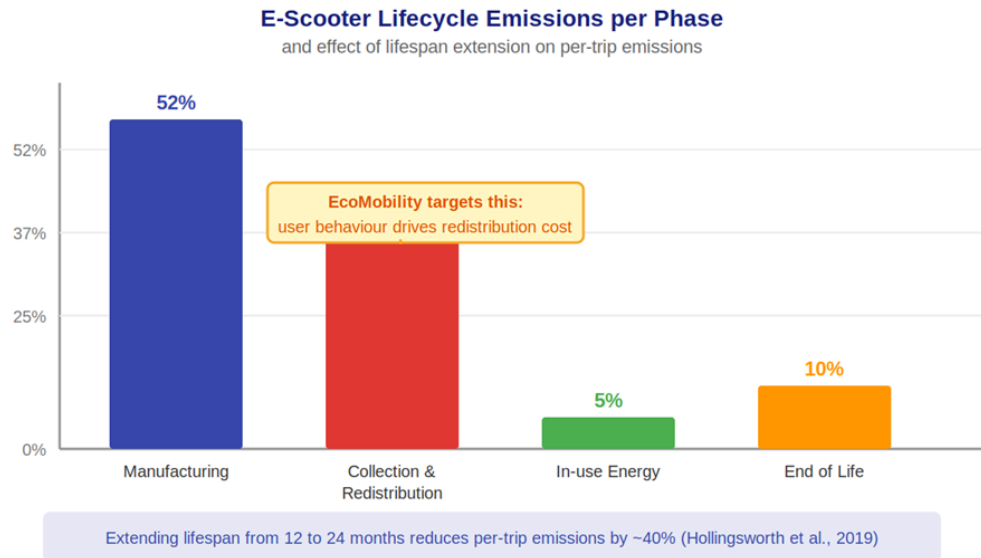


Figure 2.1. E-scooter lifecycle emissions by phase. Manufacturing (52%) and collection/redistribution (33%) dominate; in-use charging is only 5%. EcoMobility aims to redistribute costs through behavioural design—source: Hollingsworth et al. (2019).

E-scooters shared for transport could be as environmentally friendly as public transport, and potentially even more so, by extending their lifespan on the road by just a year or so to halve their lifecycle emissions per kilometre travelled. In fact, extending the lifespan of e-scooters on the road is the single highest-leverage point for impact in the micromobility sector, surpassing battery improvements, 100% renewable energy, and redistribution logistics. Despite the simple maths around reducing e-scooter waste, there is a lack of research in this area, and this thesis aims to fill the gap.

What goes wrong with e-scooters early on? E-scooters can fail early for a variety of reasons, including mechanical failures, electrical failures, failures in the waterproofing of electronic components, and design failures. In many cases of abandonment we have investigated, we have seen structural fatigue causing frame or fork failure due to owners kicking the scooter against kerbs when locked, or to rough streets and surfaces the scooter travels over. Battery failures have also been observed due to excessive charge-discharge cycles and low temperatures in Northern European climates. All these issues are still open engineering problems.

Despite considerable investment in engineering the lifespan of e-bikes, they are being retired from service early. Several factors drive fatigue development, most

significantly the user's behaviour. Vandalism and operator misuse are known to cause many e-bikes and scooters to be retired early from service, although the responsible operator is often kept confidential. However, the engineering problems are not the primary cause of early retirement. Several forms of user behaviour are documented in the literature as causes of accelerated e-scooter deterioration. Hollingsworth et al. (2019) identify rough handling, improper parking, and overloading as primary behavioural drivers of premature vehicle retirement. Portland Bureau of Transportation (2020) further reports instances of vehicles abandoned in unsuitable locations, damage following collisions, and use on rough terrain incompatible with vehicle design specifications. One behaviour of particular relevance — not always foregrounded in the LCA literature but directly pertinent to the behavioural framework of this thesis — is overspeeding: riding above the vehicle's rated speed generates mechanical stress on frames, forks, and brakes that accelerates structural fatigue, and if overspeeding results in a collision, the vehicle is typically written off immediately. EcoMobility does not prevent overspeeding directly — no app-based intervention can enforce safe riding in real time. However, the energy wallet and lifecycle impact screen establish the first feedback loop between individual user behaviour and vehicle outcomes in any shared mobility platform, creating the informational conditions under which users can begin to connect their choices to the shared consequences. The accountability gap that makes overspeeding, rough handling, and careless parking rational for individual users — no consequences, no feedback, no connection to outcomes — is what EcoMobility is specifically designed to close. Whether this feedback is sufficient to change high-risk driving behaviours such as overspeeding is an open empirical question acknowledged in the limitations in Section 6.4.

The anonymous, transient nature of shared mobility structurally produces this behavioural gap. When a user damages a private bicycle, they are responsible for the repair costs. When they damage a shared e-scooter, the cost is socialised across the operator, the fleet, and, ultimately, the environment and future users. This is a classic commons problem (Ostrom, 1990): in the absence of monitoring, accountability mechanisms, and graduated consequences, rational actors will treat shared resources less carefully than private ones. Ostrom's foundational research on the governance of common-pool resources demonstrates that this dynamic can be counteracted — but only through institutional design that creates legible, fair, and enforceable rules for resource use. EcoMobility is, in part, an attempt to put in place such rules at the level of the individual user experience.

2.2 BEHAVIOURAL DRIVERS: THEORY AND EMPIRICAL EVIDENCE

From an engineering perspective, the transition to sustainable transport is technically feasible. However, when one shifts to a behavioural perspective, all the knowledge needed to foster pro-environmental behaviour must be taken into account. Over the last three decades, a wealth of theoretical frameworks has been developed on this topic, which have reached a high level of sophistication and are supported by extensive empirical evidence. This chapter discusses relevant theoretical frameworks for EcoMobility, presents empirical findings, and elaborates on their limitations.

Ajzen's (1991) Theory of Planned Behaviour (TPB) proposes that behavioural intentions are the closest predictors of actual behaviour. These intentions in turn are predicted by three variables: attitude toward the behaviour (the individual's overall evaluation of performing it), subjective norm (perceived social pressure from significant others), and perceived behavioural control (the individual's belief in their capacity to perform the behaviour). From this perspective, careful handling of sustainable vehicles like those used in micromobility would be more likely to occur if people have a positive attitude toward careful handling, perceive that important others would also do so, and feel able to do so themselves. The Theory of Planned Behaviour has been empirically validated for a variety of environmental actions (Bamberg & Möser, 2007). However, there is a very large attitude-intention-behaviour gap (Verplanken & Wood, 2006) – intentions are a very poor predictor of behaviour for long-standing habits like commuting. Thus, EcoMobility design should look beyond forming intentions and consider also the habits that currently structure how people get around, and how changes in context can support sustainable transport behaviour.

Thaler and Sunstein's (2008) Nudge Theory offers a micro-level design inspiration for interfaces of EcoMobility initiatives. While Nudge Theory does not specify which options should be provided, it describes how the architecture of these options shapes the decisions of individuals and groups. The most relevant nudge mechanisms for EcoMobility are: salience (making energy cost visible at the decision point, when it can actually influence choice); defaults (presenting the lowest-energy option first); and social proof (displaying aggregate community behaviour). Although Nudge Theory has garnered significant attention, there are important critiques of its long-term effects. Jachimowicz et al. (2019) conducted a meta-analytic review of 71 studies on nudge interventions. They found that nudge interventions are highly context-bound and there is little carryover from one decision to another. The limitation of EcoMobility lies in its restriction to change on the go through only

app-based interaction, rather than generating sustainable change by inducing new habits and value shifts.

While Nudge Theory helps to introduce behaviour, the question then becomes: how to maintain it? Deci and Ryan's (2000) Self-Determination Theory (SDT) looks at motivation from the inside out. SDT identifies two types of motivation: Extrinsic and Intrinsic. External factors, such as the pressures and expectations of others and external rewards and incentives, drive extrinsic motivation. In contrast, intrinsic motivation comes from within an individual: it is driven by the meaningfulness of a behaviour, and the extent to which it aligns with their interests, identity and values. Research indicates that Intrinsic motivation is more sustainable, more adaptive and creative, and more reflective of important aspects of identity and values than Extrinsic motivation. Intrinsic motivation cannot be externally installed: it develops over time as individuals experience autonomy, competence and relatedness with respect to the behaviours that are important to them. For EcoMobility, this means that while behaviour change strategies such as gamification and rewards can introduce new behaviours, in the long run, identity and values associated with energy stewardship must drive participation.

Feedback on energy use has been shown to positively impact energy conservation. Abrahamse et al. (2005) reviewed 38 studies on feedback as a tool for household-level energy conservation. Interventions with feedback were found to increase household energy conservation by 5–12%. Feedback was most effective when it was personalised and provided frequently. One field experiment provided participants with feedback on shower energy use without offering any financial incentives. The study found a 22% reduction in shower energy use in hotel settings, but only a 6% reduction in dormitory settings. Studies on feedback as a means to increase energy conservation provide useful insights into this mechanism of behaviour change; however, they typically focus on energy consumption within a single household and for domestic purposes. Shared mobility offers opportunities for behaviour change and presents barriers to increasing the use of eco-friendly modes of transport. The use of feedback in EcoMobility scenarios has not yet been studied in depth; hence, the findings of existing studies on energy and feedback cannot be taken for granted. They need to be addressed in Chapter 6.

Theory	Core Claim	Empirical Support	Limitation Relevant to This Thesis
Theory of Planned Behaviour (Ajzen, 1991)	Behavioural intentions determine action; shaped by attitude, norms, and perceived control.	Meta-analysis of 185 studies: between intention and behaviour (Bamberg & Möser, 2007).	Better at predicting intentions than behaviour; limited for habitual actions (Verplanken & Wood, 2006).
Nudge Theory (Thaler & Sunstein, 2008)	Choice architecture shapes decisions predictably without restricting freedom.	Meta-analysis of 71 studies shows significant effects (Jachimowicz et al., 2019).	Effects are often short-lived, context-dependent, and may not produce durable habit change.
Self-Determination Theory (Deci & Ryan, 2000)	Intrinsic motivation is more durable than extrinsic; it is supported by autonomy, competence, and relatedness.	Extensive review across health, education, sport, and work contexts (Ryan & Deci, 2017).	Intrinsic motivation cannot be directly installed; it requires sustained experience and social context.
Energy Feedback Research (Abrahamse et al., 2005; Tiefenbeck et al., 2018)	Visible, personalised energy feedback produces measurable conservation behaviour.	5–22% reduction in consumption in multiple field studies.	Evidence is from domestic/hospitality contexts; transfer to shared mobility requires qualification.

Table 2.1. Summary of behavioural theories applied in EcoMobility design, their empirical support, and known limitations.

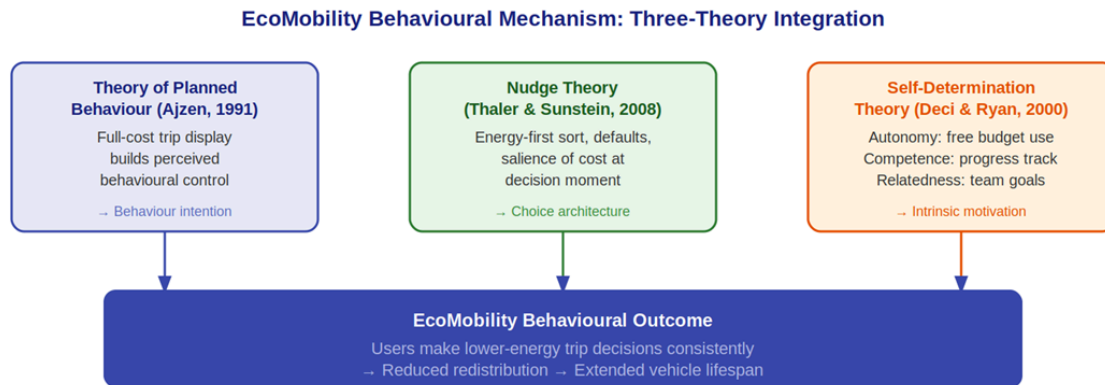


Figure 2.2. Integration of three behavioural theories in EcoMobility design. TPB provides the mechanism (intention via perceived control), Nudge Theory provides choice architecture, and SDT provides the durability condition through intrinsic motivation. Together, they address initiation, direction, and maintenance of sustainable behaviour.

2.3 PLATFORM PRECEDENTS

Although there are already many programmes and platforms addressing aspects of EcoMobility, they can serve as a starting point to build on the insights gained and address the remaining gaps that current initiatives do not cover.

To organise the search for relevant work, I began by identifying technical precedents for the entire NREL OpenPATH platform (National Renewable Energy Laboratory, 2022). OpenPATH is open-source software for monitoring and mapping trips across all modes and providing users and decision-makers with a near-real-time assessment of the energy and carbon impacts of those trips. It has been used in several US cities as part of larger e-bike transition programs. Like this research, it found that people value seeing an energy dimension when it is presented in an organised and personal way. However, there are significant limitations of OpenPATH for this research goal. First, OpenPATH is a monitoring and information platform, not a governance platform. Once users see their energy consumption, there are no consequences, incentives, or community elements that can follow.

Cellina et al.'s (2019) GoEco! project is the most methodologically rigorous precedent for app-based sustainable mobility behaviour change. In this study, the authors test

the potential of personalisation and gamification to encourage sustainable mobility behaviour among 600 individuals in a canton in Switzerland over 6 months. The results are promising: there is potential for behaviour change among engaged users (on average, sustainable modes increased by 2% per week). There is a strong novelty effect: after 4-6 weeks, engagement with the app drops off dramatically, and users return to their baseline behaviour. Importantly for the EcoMobility Lab, the study highlights the necessity of social embedding and value congruence for sustained behaviour change. A standalone app is not sufficient. This finding has been taken into account when setting up the organisational deployment model for EcoMobility. The organisational deployment model incorporates the institutional context of behaviour change (a company's sustainability programme), providing the social embedding that the app alone cannot achieve.

There is little research on the corporate mobility management programmes most relevant to the organisational dimension of EcoMobility's implementation concept. Yet several large employers in Europe regularly offer their employees the option to spend part of their monthly mobility budget on sustainable modes of transportation. Employers like Philips in the Netherlands offer employees the opportunity to spend their mobility budget on sustainable transport each day (e.g., car-sharing). Also, companies like Siemens in Germany offer employees a fixed monthly allowance that can be used for any mode of transport they choose. While individual-choice approaches to changing travel behaviour tend to achieve relatively low penetration rates and are limited in sustainability, initiatives that promote employer-led mobility management so far achieve much higher penetration rates and yield more sustainable outcomes (Vanoutrive et al., 2012). The accountability-in-context dimension is particularly relevant in this scenario where sustainable behaviour needs to be visible, valued and supported within a particular organisational culture. In such initiatives, social norm factors are fully at work in the TPB (Ajzen, 1991).

2.4 SYNTHESIS: THE BEHAVIOURAL GAP AS A COMMONS GOVERNANCE PROBLEM

Drawing on three fields of inquiry, this chapter presents evidence that while shared e-scooters have considerable potential to reduce environmental pollution from car travel, their lifespan is crucial. Next, studies on shared e-scooter behaviour identify a set of user behaviours causing the shared e-scooters to have a very short lifespan. These are rational for the user but destructive to the e-scooters as a shared, commonly used resource – the classic commons dilemma (Ostrom, 1990). Finally, lessons from platforms that have promoted mobility shifts through encouraging

bicycle and other shared e-mobility solutions suggest that digital interventions are effective to change mobility behaviour in a sustainable direction, provided they establish 'accountability connections' between individual behaviour and systemic outcomes, and are embedded into institutions or contexts that provide enough value to sustain usage over time. The chapter argues that the main challenge to extending the lifespan of shared e-scooters lies in commons governance rather than technological innovation.

EcoMobility was designed based on this diagnosis. This thesis describes the energy-accountability mechanism designed into the system as part of EcoMobility. The following thesis describes the theory and methods used to design and evaluate this accountability mechanism.

3 THEORETICAL FRAMEWORK

The theoretical framework integrates three design research perspectives: Systems-Oriented Design (SOD), Speculative Design, and Constructive Design Research (CDR) with the three behavioural theories reviewed in Chapter 2. This section explains why each framework was chosen, what specific tools or concepts it contributes, and how the combination of frameworks addresses the limitations of any single approach.

3.1 SYSTEMS-ORIENTED DESIGN (SOD) AND GIGA-MAPPING

The primary theoretical framework for the systems work in this thesis is Systems-Oriented Design (SOD), developed by Birger Sevaldson (2011, 2013). SOD is chosen over the more broadly defined field of 'systemic design' because it is a specific, tool-equipped methodology with a defined set of instruments — notably GIGA-mapping and the Rich Design Space — that are directly applicable to the kind of complex, multi-stakeholder mobility systems this thesis addresses.

SOD also argues that maps can be highly valuable for design research and design thinking. Sevaldson (2011) speaks of “productive mapping” in design and calls the practice of it GIGA-mapping. The GIGA-maps are rich, visual, and multi-layered tools for mapping stakeholders and relations, as well as processes, flows, and dynamics. Regular stakeholder maps, like service blueprints, are meant to simplify or distil a phenomenon to get at its core. The opposite is true with GIGA-maps; they are meant to contain as much information as needed to grasp a system and to reveal as many relations as required to develop systemic intuition. The strength of GIGA-maps lies in the level of detailed mental models of complex systems they can provide to designers. These models are detailed enough to pinpoint where to intervene in a system.

In the first stage of the research, SOD and GIGA-mapping were used to map the Tallinn micromobility ecosystem. The results of the analysis showed six main groups of actors who are involved in the micromobility ecosystem, and their connections (flows) were mapped in three dimensions: energy (from production to distribution, use, waste), data (trip data, fleet condition, payment, maintenance data), value (financial, social, and environmental value created or destroyed). The mapping was done iteratively, starting with a rough sketch of the actor network and gradually refining it with more detailed information, revealing the feedback loops and tensions within the system.

While researching and GIGA-mapping for the Sevaldson (2011) paper on Systems Thinking, the “gap node” of the system was identified – where is the critical flow that is missing? For the Tallinn micromobility system, it was found that the missing link was between user behaviour and the implications for the vehicle’s lifespan – specifically, that there was no feedback from the current system to the user on how they treat the vehicle. While good data exists on the condition of the vehicles (indeed, the operators have very good data on maintenance and failure), this is not currently accessible to the user. While good data also exists on user behaviour (te.g., trip data from bike-sharing and other mobility services, this data is not currently connected in any way to the vehicle's outcomes. This finding about the system informed the design of EcoMobility’s energy accountability mechanism, a systems-grounded intervention rather than a simple add-on feature.

A terminological note is necessary here regarding the language used to describe this mapping work throughout the thesis. The approach used was inspired by the Giga-map methodology (Sevaldson, 2011). Still, it would be more precise to say that Giga-mapping served as an inspirational framework and starting point, rather than claiming that the work constitutes a fully realised Giga-map in the strictest methodological sense. The maps produced were large-format, hand-drawn, iterative, and multi-layered — consistent with Giga-mapping practice — but the process was applied selectively and adapted to the specific needs of this research rather than followed as a complete protocol. Where the thesis refers to “the GIGA-map” or “GIGA-mapping,” readers should understand this as mapping inspired by and informed by the Giga-map tradition, used as a sensemaking tool during Phase 1 of the research.

3.2 SPECULATIVE DESIGN

Dunne and Raby’s book *Speculative Everything* (2013) explores the potential of Speculative Design, a method of anticipating change and its impacts through the design of alternative possible futures. Their experience suggested that the objective of design is not to solve the well-defined problem at hand, but rather to challenge some of the underlying assumptions which shape the very terms of the problem. Speculative Design thus operates in an entirely different direction to more conventional problem-solving approaches to design, and this is reflected in the type of artefact created and in the use of uncertainty as a positive resource rather than an inevitable design limitation.

My research looks at the space opened up by 'near-future' speculative design to consider how critical practices might develop future scenarios for urban mobility.

EcoMobility positions itself roughly halfway along this spectrum, between the critical, dystopian/absurdist projects of Dunne and Raby at the critical end, and futures thinking/strategic Futures practice scenario planning at the entrepreneurial, optimistic end. Rather than imagining and critiquing all the potential futures of mobilities, EcoMobility explores one specific, technically viable mobility scenario – sustainable travel incentivised by energy budgeting via a mobile app – and imagines its organisational form. My research question is: what critical thinking can offer in developing futures scenarios for urban mobilities? It demonstrates that a 'near-critical' practice can develop and suggest more practical and realisable futures for urban mobility than those currently offered by critical design practice.

Auger (2013) has referred to practices of this nature as 'domesticated speculation' – imagining scenarios that are just credible enough to be of interest, yet close enough to current commercial practices to allow meaningful critical commentary.

3.3 CONSTRUCTIVE DESIGN RESEARCH (CDR)

The book *Constructive Design Research* by Koskinen et al. (2011) introduced a new way of doing research that legitimises a certain kind of knowledge, namely knowledge produced through the construction of designed artefacts. This is different from earlier models of research that viewed design as a process that could be informed by research; instead, research is the process itself, and the artefact that emerges from it is used to generate new knowledge. The kind of knowledge that emerges from such a process would not have been possible to acquire by studying products and existing design solutions, nor by reading design literature.

In this thesis, the CDR process is represented in the 'showroom' mode as described by Koskinen et al. (2011). In the showroom mode, the designed artefact, here EcoMobility, is created and explored, normally through the designer's critical reflection on the design, though here largely generated by the written client brief and subsequent discussion rather than user testing. The showroom mode of CDR aims to develop an understanding of the design space that a particular design proposition offers. The showroom mode is honest about what it purports to do. It generates propositional and interpretive knowledge but not factual knowledge that generalises across contexts.

In contrast to advocacy, CDR requires the designer to consider what the designed

artefact achieves and fails to achieve, what assumptions the design makes and what it cannot see. In this thesis, the institutional limitation that drove the pivot from city-scale to organisational deployment is explicitly documented in Chapter 5 (Figure 5.1), and the energy-as-currency behaviour change mechanism is critiqued in Chapter 6.

3.4 WHY THIS COMBINATION?

The three frameworks are combined because, individually, they present limitations and gaps that are not addressed by singular use. Using SOD provides a systematic, rigorous way to address sustainability problems by framing them beyond mere paper sustainability aspirations. This is then followed by Speculative Design to facilitate generative and critical thinking and to develop design ideas that are truly innovative within the boundaries of current institutions and technologies. CDR makes it possible to maintain conceptual honesty, acknowledging that design is a generator of knowledge rather than treating it as an already validated solution.

The three behavioural frameworks in Chapter 2 – TPB, Nudge Theory, and SDT – serve as the micro-level design logic to inform the design of EcoMobility features that support behaviour change. The various combinations of mechanisms and conditions define boundaries for successful behaviour change and specify application possibilities. The design limitations of the behavioural frameworks in Chapter 2 (Table 2.1) have been taken into account to avoid flawed assumptions arising from overly optimistic use of design logic at the micro level.

4 RESEARCH METHODOLOGY

This chapter explains how the research was conducted, justifies the methodological choices made, and describes the three phases through which the study progressed.

4.1 RESEARCH PARADIGM AND KNOWLEDGE CLAIMS

The findings of this thesis need to be related to the peculiarities of design research, which are different from those of the natural sciences. How do we come to know things in design research? By trying to manage variables and testing hypotheses in controlled conditions? Or is it a matter of making interpretations and testing interpretations through the making of different versions of interactive installations, interpretations of the results of these tests, and reinterpretations? The insights and results of this thesis are based on interpretations and propositional knowledge. The knowledge is not verified through empirical methods. The rigour of design research lies in the honesty of its reflective practice, the groundedness of its decisions in prior knowledge, and the clarity of its claims about what the research can and cannot demonstrate.

This thesis is conducted within the Constructive Design Research (CDR) paradigm, according to Koskinen et al. (2011). Three arguments support the application of CDR in this work. Firstly, the research question asked in this work is a design question, not a social science question. The research question investigates the relationship between a design artefact and a systemic problem, which can only be studied through design. Secondly, the primary empirical material of this work is the design process: the series of decisions, tensions encountered and shifts in design models, followed by lessons learned through critical reflection on the design process. A third key feature also characterises CDR's methodology: it is epistemologically honest about what design research can do. Unlike most research methodologies, CDR does not pretend that design research can arrive at verified facts about what works through the vehicle of controlled experiments. The CDR process in this thesis produces three kinds of knowledge, each grounded in the design work itself rather than in theoretical deduction alone. First, propositional knowledge: the design of EcoMobility produced explicit, revisable claims about how energy-as-currency could function as a governance mechanism — claims sufficiently specific to be tested in future empirical work. Second, process knowledge: the pivot from city-scale to organisational deployment (documented in Sections 5.2–5.3) was not a logical inference from the

literature but a finding produced by the design process itself — by developing the city-scale concept far enough to encounter its institutional barrier concretely. Third, reflective knowledge: the critical analysis in Chapter 6 evaluates each design decision against the gap nodes identified in the GIGA-map, producing an honest account of what the design achieves and what it does not. These three kinds of knowledge are generated through making and reflection on making, not solely through theoretical argumentation.

The research paradigm also affects the researcher's role. In CDR, the researcher and designer are the same person, presenting both opportunity and risk. The advantage is that the designer has unique first-hand knowledge of the reasoning behind design decisions, which can be difficult for others to capture. The disadvantage is that the designer is too close to the work and cannot fully appreciate its limitations. This thesis attempts to mitigate this risk by systematically employing the GIGA-mapping methodology (SOD) to evaluate whether design decisions are sufficiently grounded in mapped system problems. Chapter 5 provides a detailed account of the design process and the resulting institutional limitation analysis that guided the pivot from city-scale to organisational deployment. It shows clearly where the pivot point in the research process was: where the researcher realised that the initial design concept was not going to be suitable, and therefore the research was taken in a completely different design direction.

4.2 RESEARCH PHASES

The research follows a three-phase structure of systems knowledge (what problems I am dealing with), design knowledge (how can I address these problems), and analytical knowledge (what I can learn from design about these problems and the limitations of design for addressing them). The three research phases are: Phase 1 SOD mapping, Phase 2 speculative design development and Phase 3 CDR reflection. This approach consists of three phases. In each phase, a distinct function is fulfilled; Phase 1 grounds Phase 2. Phase 2 gives something for Phase 3 to reflect on. The three phases are not three isolated steps; rather, they constitute a process for acquiring knowledge structured in a particular order.

Phase	Primary Method	Knowledge Produced
1: sod mapping	Giga-mapping of Tallinn micromobility ecosystem; LCA literature review; direct observation	Actor network, energy/data/value flows, identification of gap nodes; behavioural diagnosis of lifespan problem
2a: city-scale design	Speculative design development; scenario writing; iterative sketching	City-scale ecomobility concept; identification of institutional buy-in as a central limitation
2b: organisational pivot	Speculative design development; institutional analysis; CDR reflection	Organisational deployment model; resolution of institutional limitations; design of four core components
3: cdr reflection	Critical analysis of the design process and outcomes against the theoretical framework	Findings on energy accountability as a design mechanism: contributions and limitations

Table 4.1. Research phases, methods, and knowledge produced.

4.3 PHASE 1: SYSTEMS-ORIENTED DESIGN MAPPING

The GIGA-mapping process is described in detail in Chapter 5; the methodological point to make here is why GIGA-mapping was chosen over other systems analysis approaches. Several alternatives were considered: service blueprinting (too operationally focused — it maps service interactions but not systemic dynamics) and causal loop diagramming (too abstract — it captures feedback dynamics but loses the actor- and material-specificity that design work requires). GIGA-mapping was chosen because it is the only approach that simultaneously maps actors, flows, tensions, and gap nodes at a level of specificity that can directly inform design decisions. The map produced in Phase 1 was the primary design brief for Phase 2. Every feature of EcoMobility was developed in response to a specific gap node identified on the map, and any feature that could not be connected to a gap node was rejected.

4.4 PHASE 2: SPECULATIVE DESIGN DEVELOPMENT

The second phase of the research consisted of two sub-phases: Phase 2a and Phase 2b. Phase 2a developed the city-scale concept, the more ambitious and speculative version of EcoMobility. The research aimed to examine the institutional barriers to scaling up EcoMobility in a clearer, more concrete way. Therefore, it started by developing the more provocative city-scale concept rather than the less provocative yet politically viable organisational model, which could be easier to deploy. Phase 2b built on the research findings from Phase 2a and developed the organisational deployment model. This section is not further detailed; however, the design choices for the sub-phases and how they resolve the gap at the node are discussed in Chapter 5.

Phase 3 was from February to April 2026. The CDR reflection for Phase 3 of the program again returned to the full design process, this time with a new set of sharper critical reflection questions, such as: Does each design element actually address the gap node it was intended to address? Does the organisational deployment model address the institutional limitations of the city-scale concept under study, or does it sidestep them? What assumptions has the design made that have not been interrogated and tested? What would need to change for the design to have intended effects? These issues are discussed in further detail in Chapter 6. The same questions were explored during the reflection phase that shaped the discussion of limitations in Chapter 6.

4.5 PHASE 3: CDR REFLECTION

The reflection phase was from February to April 2026. I returned to the full design process and interrogated every aspect of what had been developed. Is every design feature genuinely addressing a gap node? Is the organisational deployment model genuinely addressing the institutional limitations of city-scale ideas, or is it avoiding uncomfortable decisions? What assumptions were made that were not tested? These questions are discussed in Chapter 6. As part of my reflective practice, I completed Chapter 6, specifically the section entitled 'Critical evaluation of the teaching/learning episode' and the section within that identifying the limitations of what can be claimed by the research.

4.6 JUSTIFICATION OF KEY METHODOLOGICAL CHOICES

In this reflection, I will elaborate on two of the methodological choices I made during the research process. The first concerns the fact that I did not develop a fully functional CDR prototype to test and refine. My practice and understanding of speculative design do not necessarily follow the typical trajectory or expectations established within the field. In particular, I do not see value in creating a fully functional prototype of a designed system unless the research questions pertain to aspects of usability, interaction quality, or user preferences – in other words, unless the research outcome would benefit from users actually using the designed system to some extent. The research question in this thesis, “How an energy-accountability design mechanism can be developed, specified, and evaluated as a response to the governance failure driving premature e-scooter retirement”, calls for exploration through a design process rather than prototype testing. The question is open-ended: it asks about the form, mechanism, and conditions of the design intervention, not simply whether such an intervention is possible.

The second justification concerns choosing SOD mapping as the primary evidence base for design decisions, rather than empirical user research. This choice is made because the problem is structural rather than experiential: the absence of a feedback loop between user behaviour and vehicle outcomes is a system property, not a user preference. User interviews or ethnographic studies would have confirmed that users find shared scooters convenient and do not think about vehicle lifespan — findings already established in the literature. The GIGA-map was chosen because it reveals where in the system design can be intervened upon and why those interventions would have leverage. Critically, every design decision in EcoMobility is documented with an explicit reference to the gap node from the GIGA-map that motivated it. Table 5.2 lists each component alongside the specific gap node it addresses and the behavioural mechanism it employs. The double diamond process map (Figure 5.1) shows how the design moved from gap node identification through concept development to the institutional limitation finding that drove the pivot to the organisational deployment model. Section 5.3 explicitly documents this pivot as a CDR finding: the city-scale concept was developed not to be discarded, but to produce the institutional analysis the organisational model required. The design process is therefore evidence-based, as shown in the GIGA-map (Figure 5.2), the double diamond (Figure 5.1), and the gap node table (Table 5.2), rather than merely described.

The thesis’s contribution is addressed in Chapter 7 with three-level claims.

5 DESIGN PROCESS

This chapter describes the EcoMobility design process in the sequence in which it occurred. The chapter also confronts the design process's limitations, failures and blind spots. These are the CDR findings from the design process, documented in Figure 5.1. The design process is presented following the Design Council's (2005) double diamond design model. The first diamond represents the first round of the design process, consisting of the discover and define phase. The problem was first defined in the engineering domain and later reframed as a behavioural and governance challenge of the urban commons. The second diamond describes the second round of the design process, consisting of the develop and deliver phase, during which the city-scale concept was developed, the design's limitations were identified, and an organisational deployment model for the design was developed.

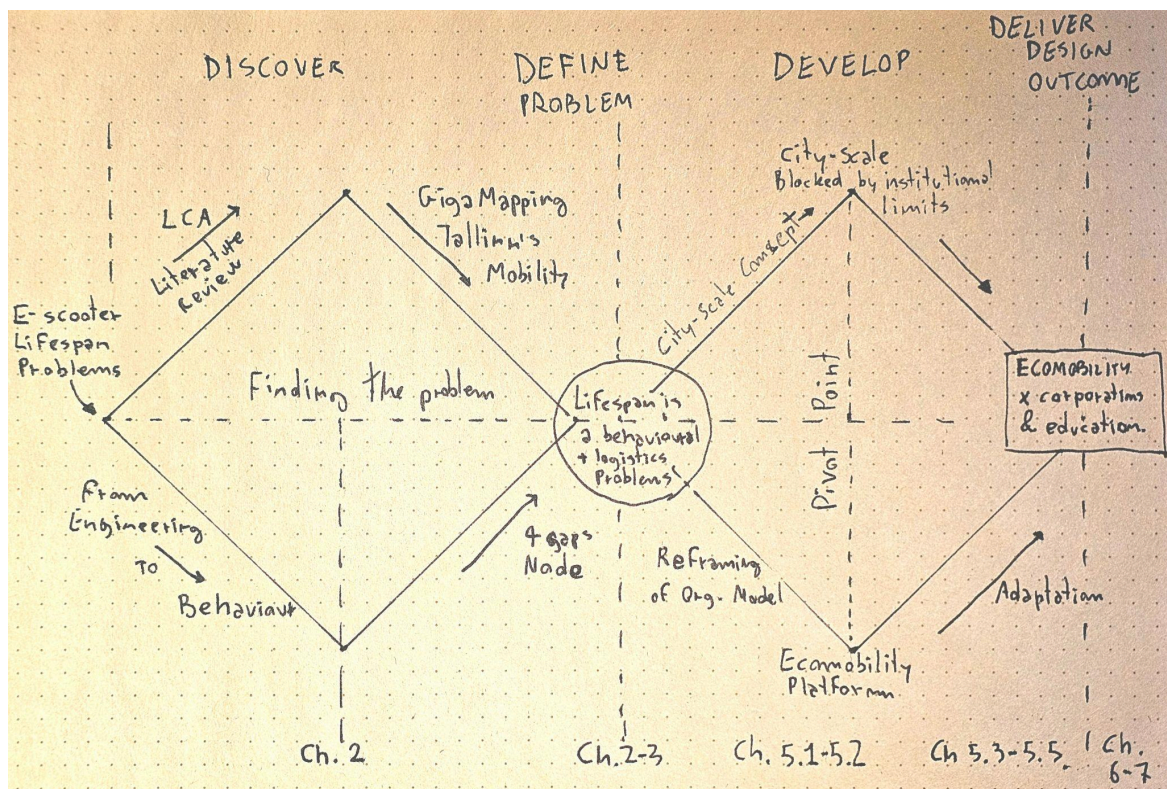


Figure 5.1. Double diamond process map of the EcoMobility design research. Diamond 1 (left) shows the discover–define cycle through which the problem was reframed from an engineering question to a behavioural and commons governance problem. Diamond 2 (right) shows the develop–deliver cycle through which the city-scale concept was developed, its institutional limitations identified, and the organisational deployment model produced as the design outcome.

5.1 THE GIGA-MAP OF TALLINN MICROMOBILITY

The chapter starts with a description of the system map created during the SOD mapping phase (detailed in Chapter 4) of Tallinn's micromobility ecosystem. The network consists of six groups of actors linked to one another through energy, data, and value flows. By representing the actors in a single network, all relationships and tensions within it can be explored. These relations emerge from the already existing rules of the game that shape how different actors interact within the ecosystem.

The map shows where there is an asymmetry in accountability within the system, with operators/users/transit authorities/energy providers having different levels of knowledge about vehicle and fleet data, sustainability, energy, and emissions. City transport authorities have a strong interest in sustainability but no say in how operators manage their fleets. Energy infrastructure providers generate renewable electricity that powers the e-scooters, making them low-carbon to use. But users of the shared e-scooters should know how their behaviour will affect the lifespan of the vehicles. These imbalances are not intractable and result from current commercial and regulatory circumstances. The system map highlights four potential areas for design intervention: vehicle design, operator incentives, regulatory requirements, and user behaviour.

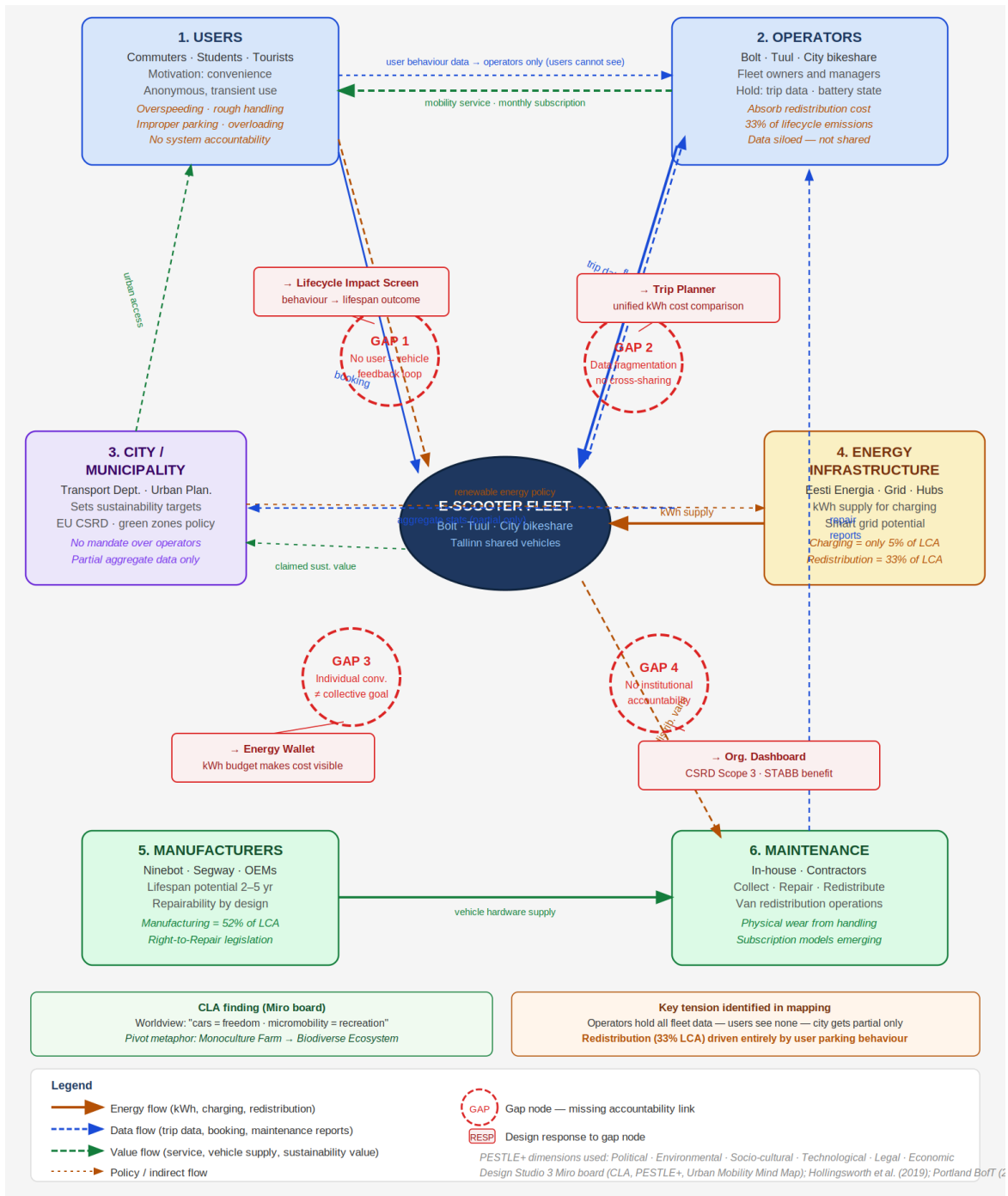


Figure 5.2. Schematic summary of the GIGA-mapping findings — Tallinn micromobility ecosystem (researcher's own, 2024–2026). See Appendix 1 for photographic documentation of the physical mapping process.

Note: The diagram presented here is not a reproduction of the GIGA-mapping work itself but a schematic summary of its principal findings. The mapping process was conducted iteratively throughout the research using large-format paper and physical sticky notes, with successive rounds of addition, revision, and removal across multiple working sessions. This process — messy, non-linear, and cumulative by nature —

cannot be meaningfully reproduced at the page scale. What is shown instead is a structured distillation of the most significant outcomes of that process: the six actor groups, four flow types, and four gap nodes that proved most consequential for the design decisions that followed. Readers wishing to understand the mapping process itself are directed to the photographic documentation in Appendix 1, which shows the working maps at various stages of development.

In the first design phase, we explored the point of intervention in user behaviour in light of the energy-as-currency concept. In the LCA literature, the behavioural gap is identified as the biggest single cause of early vehicle retirement. A design approach could address this by targeting user behaviour, without attacking vehicle engineering, operator business models or regulatory frameworks. We translated these findings into a design approach that focuses on user behaviour and developed the energy wallet concept: an experience of personal control over a fair and visible budget of kWh, along with gentle incentives that motivate low energy use.

The city-scale concept for intelligent energy use was iteratively developed over about six weeks with lots of sketching, brainstorming different scenarios and building a system map. While iteratively refining ideas to address gaps in the system map, I identified a set of features that could be relevant to the challenge. Some of the features I conceived include the ability to top up energy via an energy wallet, a unified trip planner that lets users compare trip details across all Tallinn operators, lifecycle feedback, and community challenges. I was particularly excited about the unified trip planner, which solves a data fragmentation problem, because users currently have to switch between apps to view information from different Tallinn operators. For example, a trip planner sorted by energy cost will naturally disadvantage less energy-efficient options because switching modes (e.g., opening a new application) requires more energy than travelling directly.

5.2 PHASE 1: CITY-SCALE ECOMOBILITY CONCEPT

Applying the energy-as-currency framework to the city-scale concept required four main features. The Energy Wallet feature provided users with a weekly allowance of kWh from the city's notional energy funds. The Unified Trip Planner feature generated trip plans using the APIs of all relevant operators (Bolt, Tuul, city bikes, and public transport) and sorted them by energy cost. The Lifecycle Impact feedback feature connects trip post-trip summaries to the vehicle's current state. The City Dashboard

feature provides the city's transport authority with city-wide statistics on energy consumption and overall sustainability.

Another design question for the energy budget model was how to set and communicate the total energy for the week to users, and how to determine that amount. Three options for energy allocation were considered: equal per capita, needs-adjusted, or market-rate. For this city-scale prototype, I opted for an equal-per-capita model of 70 kWh/week per user, with the intention of offering supplemental models for users with higher-than-average mobility needs. I chose an equal per capita model for its simplicity and alignment with the civic commons vision of energy as a shared resource, distributed according to clear, publicly communicated criteria.

The scenario that tested the city-scale concept followed a Tallinn resident, Anna, over a typical Tuesday in 2040, navigating work commute, lunch trip, and evening return using EcoMobility. The scenario revealed several design strengths: the energy cost differential between options was motivating and surprising (users had not realised the scale of the difference between cycling and ride-hailing); the community comparison feature created genuine social engagement; and the post-trip lifecycle feedback produced reflective responses about the relationship between individual choices and collective vehicle condition.

The scenario also revealed the concept's central weakness: it assumed a level of institutional alignment — data sharing between operators, regulatory mandate for interoperability, city governance of the energy budget — that has no current pathway to realisation. The critical review conducted in November 2025 concluded that the city-scale concept was a valuable design vision but not a viable design proposition at the current stage of institutional development.

5.3 THE INSTITUTIONAL LIMITATION: A CRITICAL FINDING

During the critical review of the city-scale design in November 2025, one key question went unanswered: Why would Bolt, Tuul, or Tallinn City Government want to be part of the governance of the EcoMobility Hub? From the perspective of mobility operators, they would be forced to share proprietary data and would be expected to accept lower margins under new pricing rules and tariffs. They would have to have faith that they would gain value from the new governance framework, while also having meaningful influence in its decision-making processes. From the city's perspective, this would require creating new regulations and legal frameworks to mandate data sharing between companies, as well as developing and enforcing new

interoperability standards for vehicles that currently lack them. Both employers and workers have little incentive to change their current arrangement.

This is not a design error, but rather a systems finding about what a city-scale concept reveals: the necessary institutional requirements for its implementation and the systemic barrier that any city-scale energy accountability intervention would encounter. It is a fundamental methodological commitment of this thesis to uncover such limitations.

5.4 PHASE 2: THE ORGANISATIONAL DEPLOYMENT MODEL

When thinking about organisational deployment, I looked at where within the Tallinn micromobility solution organisations are already committed to driving change. Three types of organisations were identified for whom a sustainable mobility programme for their members/employees would be of significant value. Large employers with sustainability reporting obligations (under the EU Corporate Sustainability Reporting Directive, which came into force for large companies in 2024); universities and higher education institutions with sustainability commitments and student populations that are already heavy micromobility users; and public sector bodies (hospitals, government departments) that are subject to green procurement requirements. All of these organisations have existing institutional structures within which a well-designed EcoMobility programme could be implemented, rather than creating new institutions from scratch.

The organisational deployment model differs from the city-scale model in five key ways. Firstly, the energy budget is set by the organisation (i.e., the employer or university) rather than the city, and may be based on factors such as commute distance or job type. Secondly, participants are well known to each other (i.e., all employees or students of the organisation), which mitigates the anonymity problem that affects accountability in the city-scale model. Thirdly, all existing reward systems are taken into account when designing the positive incentives offered. For example, for every unit of energy (kWh) saved, users can earn the chance to spend the 'saved' credit in real terms on sustainable alternatives (funded by the organisation's sustainability budget) such as a free cycle repair, public transport pass or donation to plant a tree on their behalf. It is possible to undertake both city-scale and organisational-scale energy reductions, with one organisation taking responsibility for all energy use by the buildings they occupy within a city. Finally, organisational-scale deployment can occur at a much larger scale, such as at the national or multinational level. Fourth, the data governance structure is simpler: the organisation, not the city,

is the data controller, and those being tracked have given their consent to monitoring as part of a voluntary approach. This is simpler than requiring a city-level governance structure to manage privacy for individual users, and is suitable given that the approach is primarily intended for organisational-level monitoring and analysis.

Fifth, and most importantly, the institutional buy-in problem is substantially addressed. Organisations are participating in the approach voluntarily and are gaining benefits in sustainability reporting, employee engagement, and even a potential reduction in fleet management costs.

5.5 THE FINANCIAL MODEL: ENERGY BUDGET AS EMPLOYER BENEFIT

A critical design question for the organisational deployment model is how the energy budget reaches users without creating the perception that it is deducted from their salary, which would be both legally complex and motivationally counterproductive. The design proposes that the energy budget should be structured as an additional employer benefit, separate from salary, analogous to existing employer wellness benefit schemes. In the Estonian context, the most relevant precedent is the Estonian employer health and sports benefit, a tax exemption under the Income Tax Act that allows employers to provide employees with up to €400 per year tax-free for sports, gym, and health activities. Under the EcoMobility organisational model, a company would provide each enrolled employee with a monthly kWh energy budget — the research uses an indicative figure of 200 kWh per month — as an additional company benefit, administered in the same way as an employer wellness allowance. This is not taken from the employee's salary. It is an additional resource provided by the company to support sustainable commuting. Once the budget is depleted, the user may top up at their own cost, but the baseline allocation is company-funded at no personal expense to the employee. This framing is not peripheral: the behavioural science literature (Thaler & Sunstein, 2008; Deci & Ryan, 2000) is clear that people respond very differently to a resource framed as a gift than to one framed as a monitored deduction. A benefit-framed budget activates gain orientation and autonomous motivation; a salary-deduction model activates loss aversion and compliance behaviour. The design deliberately uses benefit framing, and this choice should be explicitly stated in any deployment proposal.

The health and sports benefits, as well as the employer wellness benefit model, also connect to the Scope 3 compliance function of the Organisational Dashboard. The EU Corporate Sustainability Reporting Directive (CSRD), which came into force for large companies in 2024, requires organisations to disclose Scope 3 Category 7 emissions

— those arising from employee commuting. The EcoMobility app generates individual trip-level data that, when aggregated across enrolled employees, produces a granular and verifiable Scope 3 commuting dataset. This transforms EcoMobility from a wellness programme into compliance infrastructure: the company’s investment in the energy budget benefits directly from the data-collection mechanism in its regulatory reporting. This alignment of employee benefits, behavioural incentives, and regulatory compliance is the strongest institutional argument for organisational adoption, and should be made explicit in the deployment proposal rather than left implicit in the Dashboard description.

The following screen shows the employer-facing Organisational Dashboard, accessible only to sustainability managers within the enrolled organisation. Individual employee data is never visible here; the employer sees only aggregated and anonymised fleet-level metrics.

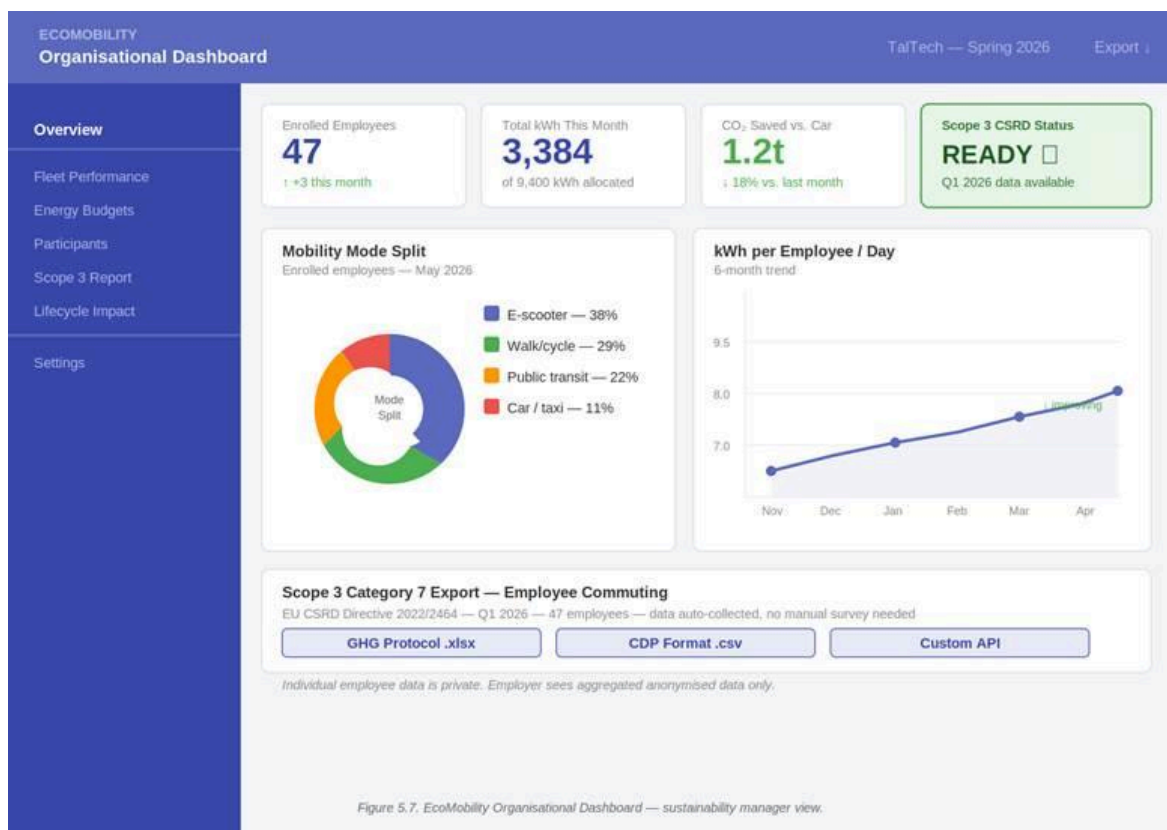


Figure 5.3. EcoMobility Organisational Dashboard — sustainability manager view (mockup made with Visily). The dashboard displays enrolled employees, total kWh allocated, CO₂ saved per car, Scope 3 CSRD status, and mobility mode split, alongside a trend of kWh per employee per day.

The Organisational Dashboard is the B2B component of the EcoMobility Management Toolbox. The Organisational Dashboard provides sustainability managers with a tool

to monitor total kilometres travelled by modes beyond cars, outreach and engagement for programmes, the location of key sustainability reports relevant to the programme, allocated budgets, and rewards schemes for participants. The Organisational Dashboard transforms EcoMobility from an engagement tool for consumers into a full-fledged sustainability management system that supports organisations' sustainability reports and complements their management goals and existing KPIs.

Dimension	City-Scale Model	Organisational Model
Participant group	All Tallinn micromobility users (anonymous)	Employees/students of a specific organisation (named, consenting)
Budget allocation	City government (equal per capita)	Organisation (potentially role/commute calibrated)
Data controller	City transport authority	Organisation (employer/university)
Operator buy-in required	Yes — mandated data sharing across all operators	No — optional integration; users connect existing accounts
Regulatory change required	Yes — interoperability mandate	No — voluntary CSR programme
Incentive architecture	City sustainability credits	Organisational reward system (vouchers, benefits)
Scale of impact	City-wide (large but shallow)	Organisation-wide (smaller but deeper)
Pathway to deployment	Requires a 5–10 year policy process	Deployable within existing CSR frameworks

Table 5.1. Comparison of city-scale and organisational deployment models across key institutional dimensions.

5.6 ECOMOBILITY ORGANISATIONAL COMPONENTS

The organisational deployment model for EcoMobility comprises four components. These components are developed based on a systems-level analysis of the Tallinn micromobility map and the organisational change behaviour models described in Chapter 2.

This visual presentation of the remaining energy budget in the form of an Energy Wallet encourages users to cut their energy use before running out of wallet budget, thereby reducing energy consumption through a mild loss-aversion incentive. The wallet is a personal weekly allowance of kWh set by the organisation, represented by a circular gauge on the app dashboard. Users can see how much they have remaining in the wallet for the week, as well as, on a daily basis, how they have used energy that day, including the number of trips taken and the mode of travel. Remaining energy (how much you have in the wallet) rather than consumed energy (how much you have taken out of the wallet) is a positive framing to the wallet display, opposed to a negative framing, which would inadvertently create anxiety and guilt in the user, especially when they were likely to be motivated enough by initial installation. The framing effect (Kahneman & Tversky, 1979) states that most people are more risk-averse when potential losses are involved than when potential gains are involved. However, in this instance, a mild form of loss aversion has been incorporated by showing the remaining energy budget.

The Trip Planner incorporates shared mobility options: Bolt e-scooters and e-bikes, Tuul scooters, city bikeshare and public transport. The options are sorted by energy cost, so the most eco-friendly solution will be the default. This utilises the principle of status quo bias, a mechanism described by Thaler & Sunstein (2008). Users will also be shown the impact of the chosen solution on their remaining weekly budget for free rides. This makes users aware of the cumulative effects of their decisions.

The Lifecycle Impact screen provides users with feedback on the potential vehicle condition impacts of the trip taken and connects that back to the overall lifespan of the fleet. For example: "Your careful riding today has contributed to a high maintenance score for the vehicle. Vehicles with high maintenance scores on average last 40% longer." This is the most direct design intervention addressing the lifespan-accountability gap identified in the GIGA-map.

Lifecycle Impact, Air Quality, and Community

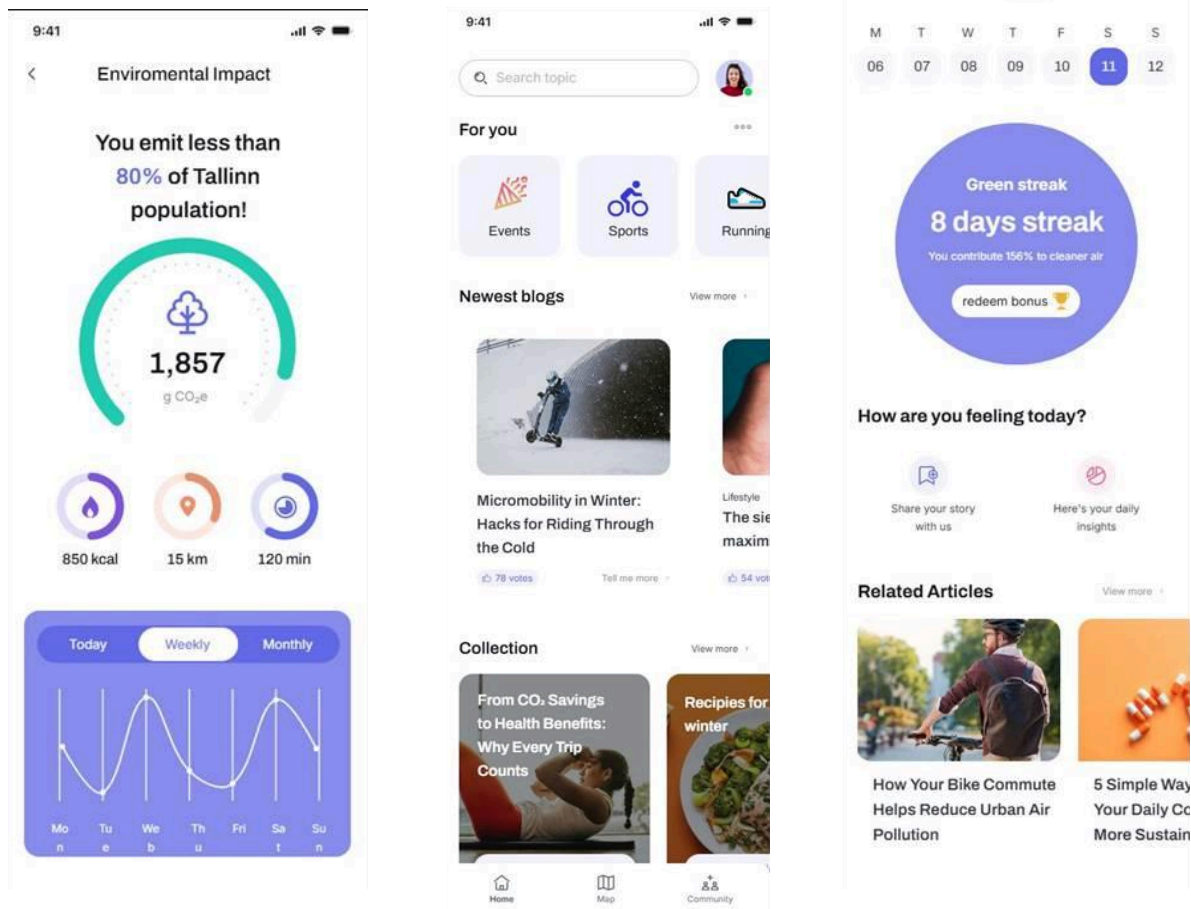


Figure 5.4. Environmental Impact screen (left): personal CO₂e emissions compared against the Tallinn population average, with calorie, distance, and time summary and weekly trend chart. Community screen (centre): social embedding through blogs, events, and collections — the mechanism that addresses the GoEco! finding that standalone apps lose engagement without social context (Cellina et al., 2019). Air Quality screen (right): 8-day green streak showing personal contribution to cleaner air, with bonus redemption feature—mockups made with Visily.

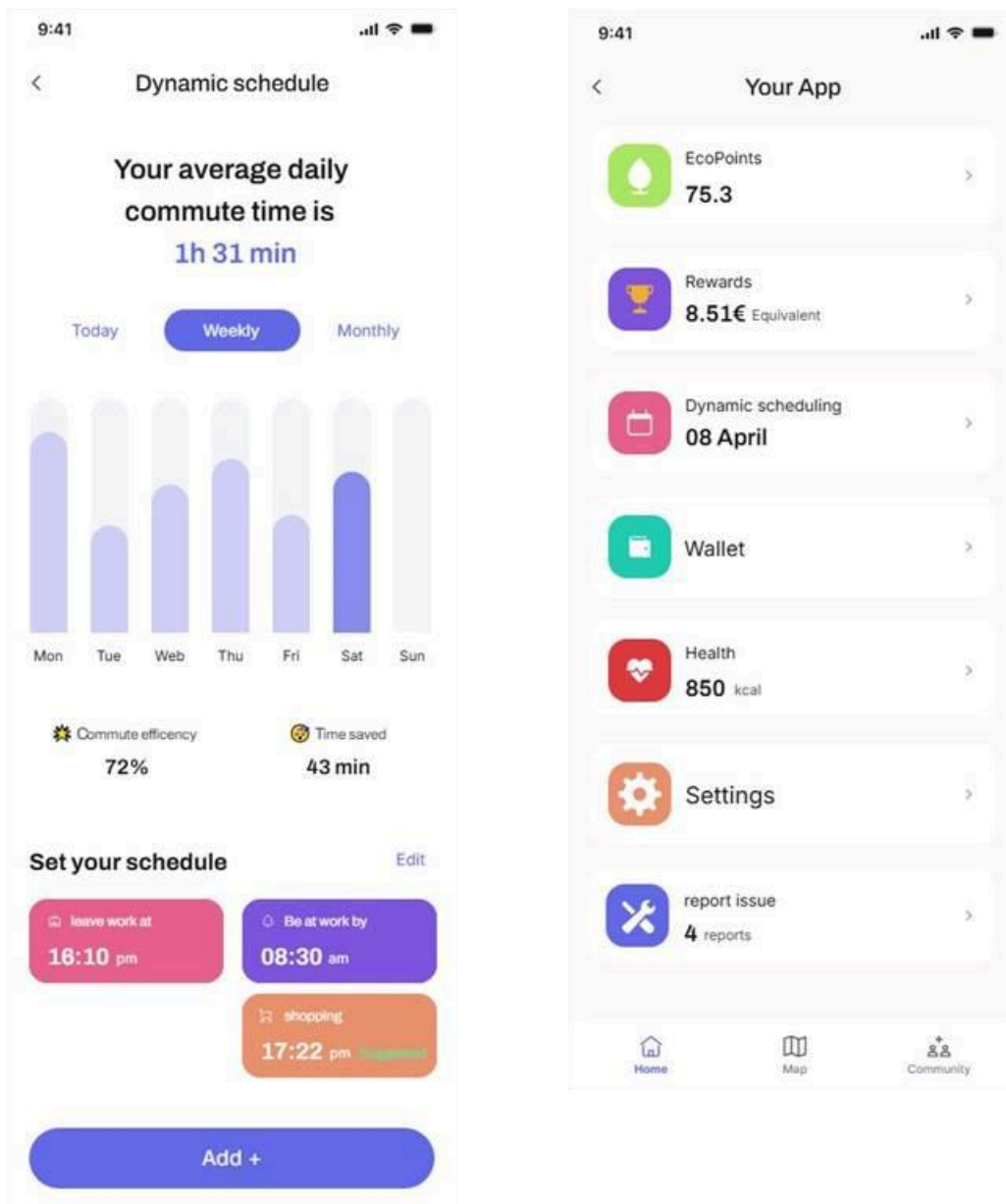


Figure 5.5. Dynamic Schedule screen (left): personal commute pattern data showing 1h 31min average daily commute, 72% efficiency rating, and 43 minutes saved, with AI-suggested optimal departure and arrival times. All-Health Dashboard (right): consolidated overview connecting EcoPoints (75.3), monetary rewards (8.51€ equivalent), dynamic scheduling, energy wallet, and health statistics (850 kcal) in a single interface. Mockups made with Visily.

5.7 STAKEHOLDER VALUE MAP

The EcoMobility design creates distinct value for each of the four primary stakeholders. Making this value explicit is important because it grounds the institutional argument for adoption in specific, concrete benefits rather than general sustainability aspirations. The following paragraphs outline the value the system provides to each stakeholder and the design mechanism that delivers it.

Employee (enrolled volunteer): receives a monthly mobility budget as a company benefit; gains real-time cost transparency for trip decisions; can reduce personal top-up spending through smarter choices; participates in team challenges that connect individual action to collective outcome. Enabled by: Energy Wallet, Trip Planner, Lifecycle Impact screen.

Organisation/employer: receives aggregated Scope 3 Category 7 emissions data for CSRD compliance reporting; demonstrates employee sustainability investment; no manual data collection required, and enabled by: Organisational Dashboard, automated reporting export.

Fleet operator: benefits from reduced redistribution trips through behaviour-driven parking optimisation; longer vehicle lifespan from reduced handling; potential for anonymised fleet behaviour data partnership. Enabled by: Trip Planner redistribution overhead calculation; Lifecycle Impact screen.

City/municipality: reduced redistribution vehicle activity in public space; improved spatial distribution of parked vehicles; potential access to aggregated mobility data for transit planning, and enabled by an optional city-level data-sharing agreement with participating organisations.

5.8 USER JOURNEY: ANNA

To make the design concrete and evaluable beyond component descriptions, the following user journey follows Anna, a 34-year-old employee at a medium-sized Tallinn technology company that has enrolled in EcoMobility. Her company provides 200 kWh per month as an employer benefit, credited to her Energy Wallet. This is additional to her salary, not deducted from it, structured exactly like an employer health and sports benefit under the Estonian Income Tax Act.

Monday morning: Anna opens EcoMobility at 8:20. The home screen shows her wallet at 187 kWh with 13 days left in the month. The Trip Planner shows three e-scooter options. Scooter A12 displays 4.2 kWh (1.8 propulsion + 2.4 redistribution overhead:

the destination zone has moderate afternoon demand). Scooter B04 shows 3.1 kWh (1.8 + 1.3: the office parking hub generates high natural demand, so redistribution is unlikely. Scooter C07 shows 5.8 kWh (1.8 + 4.0: a side street that historically requires operator collection every Monday morning). Anna selects B04. The Trip Planner also shows a tram-plus-walk option at 0.9 kWh with 4 extra minutes. She taps it to see the route, decides on the scooter today, and confirms.

Evening: returning home, Anna notices that parking near a tram stop rather than outside her building would earn a small redistribution credit. She parks at the stop, three minutes' walk from her door. The Lifecycle Impact screen confirms: "Your scooter was collected naturally by another user within 2 hours. No redistribution trip needed. Your careful parking has extended this vehicle's expected lifespan by approximately 0.3 days." Small feedback, but cumulative. Over the month, Anna made 18 similar decisions. Her smart-parking behaviour avoided 6 redistribution events. Her final wallet balance: 148 kWh — 52 kWh under her allocation. She carries nothing forward (budgets reset monthly) but has benefited from the difference by not needing to top up.

Company impact: at the end of Q1, Anna's sustainability manager opens the Organisational Dashboard. The 47 enrolled employees collectively made 812 trips, avoided an estimated 196 redistribution events, and generated Scope 3 Category 7 data ready for CSRD export — without any manual survey or estimation. The data feeds directly into the annual sustainability report.

Table 5.2. EcoMobility organisational components, design rationale, and behavioural mechanism.

Component	Description	Design Rationale (from system map)	Behavioural Mechanism
Energy Wallet	Personal weekly kWh budget allocated by organisation; circular gauge display; positive (remaining) framing.	Closes the accountability gap node by making individual energy consumption visible and personally consequential.	Loss aversion nudge (Kahneman & Tversky, 1979); perceived behavioural control (Ajzen, 1991).

Trip Planner	Multimodal route comparison sorted by energy cost; wallet impact preview.	Responds to data fragmentation gap: unifies operator options for fair comparison.	Default nudge — lowest-energy first (Thaler & Sunstein, 2008); attitude formation.
Lifecycle Impact Screen	Post-trip feedback connecting handling behaviour to vehicle maintenance score and projected lifespan.	Closes the lifespan-accountability loop: the first mechanism connecting user behaviour to vehicle condition outcome.	Temporal feedback (Abrahamse et al., 2005); competence building (Deci & Ryan, 2000).
Organisational Dashboard	Management interface for sustainability managers: aggregate energy data, participation rates, and CSR reporting export.	Provides institutional value proposition: integrates with CSRD reporting obligations.	Institutional social norms (Ajzen, 1991 — subjective norm); programme sustainability.

5.9 ECOMOBILITY APP — USER INTERFACE SCREENS

The following screens present the complete EcoMobility user interface as designed in Visily. They are presented here as design probes rather than deployment-ready prototypes, consistent with the CDR methodology (Koskinen et al., 2011). Each screen addresses one or more of the gap nodes identified in the GIGA-map.

Launch and Home Dashboard

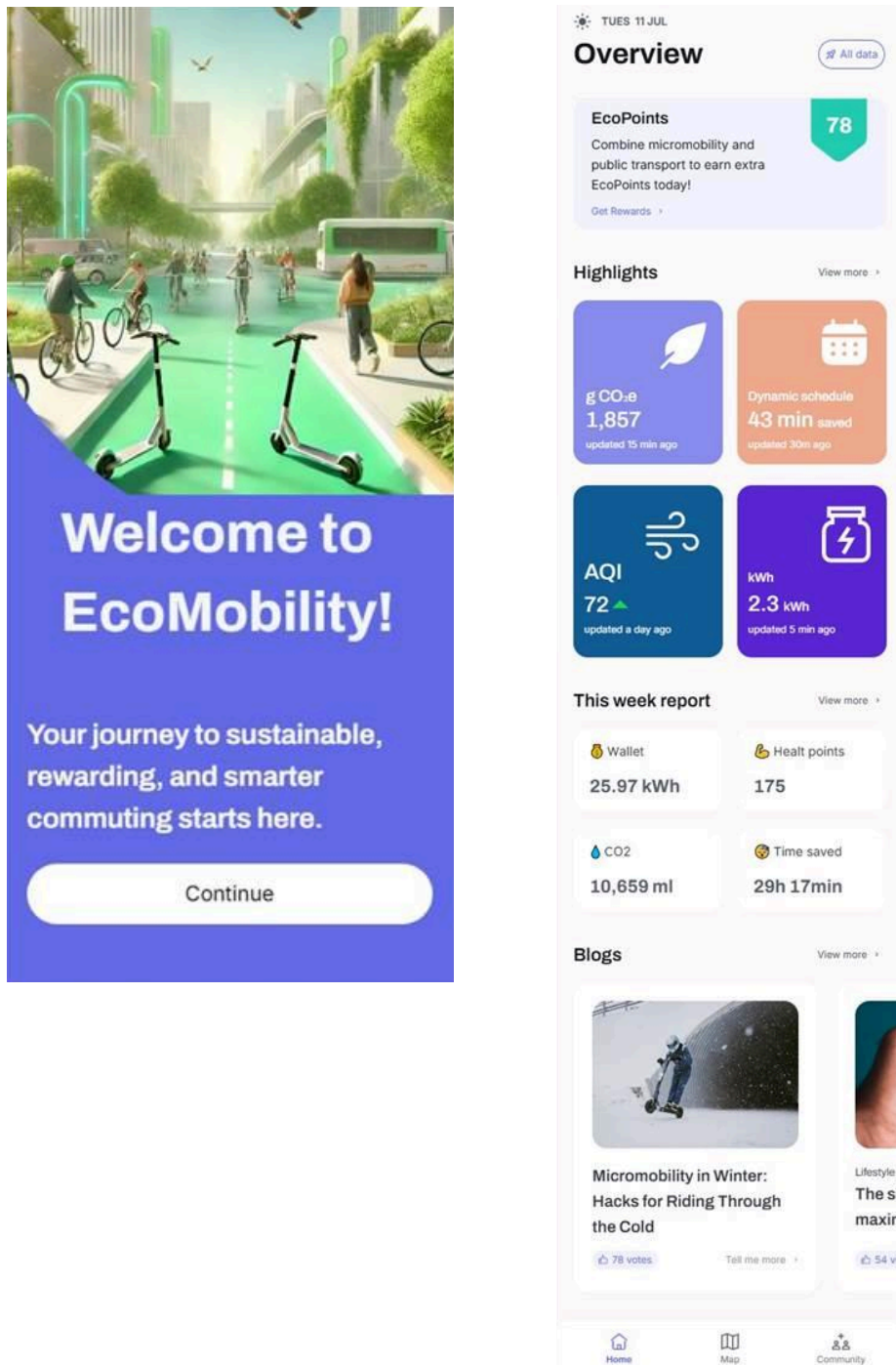


Figure 5.6. Launch screen (left): EcoMobility welcome screen made with Visily. Home Dashboard (right): overview screen displaying EcoPoints (78), CO₂ saved (1,857g), Air Quality Index (72), kWh consumed (2.3 kWh), dynamic schedule savings (43 min), wallet balance (25.97 kWh), and weekly CO₂ total (10,659 ml). The four highlight metrics correspond directly to the four gap nodes identified in the system map: energy accountability, environmental impact, operational efficiency, and mobility scheduling. Mockup made with Visily.

5.10 HOW THE APP MECHANISM WORKS: THE FULL-COST DISPLAY

The most significant design intervention in EcoMobility is the full-cost trip display. This needs explanation beyond the component descriptions in Table 5.2, because it is the mechanism through which the accountability gap identified in the GIGA-map is closed at the moment of the user's decision.

When a user opens the Trip Planner to select a vehicle or route, the app displays a cost figure in kWh for each option. This figure combines two components. The first is propulsion cost: the energy consumed by the vehicle's motor to complete the trip, calculated from the vehicle's battery specifications, trip distance, and terrain data. This component is approximately equal across vehicles of the same type on the same route. The second component is redistribution overhead: an estimated probability-weighted cost reflecting the likelihood that the vehicle will need to be manually collected and moved by an operator van after the user parks it. This is calculated from historical demand patterns at the user's destination and at the time of day. Suppose the destination is a high-demand location — a transit stop, office district, or popular area — redistribution probability is low and overhead is minimal. If the destination is a low-demand residential street, the redistribution probability is high, and the overhead figure is correspondingly larger.

The sum of these two components is the kWh figure shown to the user. This transparency is intentional: the design goal is not to obscure complexity behind a single number, but to make the system's cost logic legible enough that users can develop a genuine understanding and act accordingly. This addresses the TPB requirement for perceived behavioural control (Ajzen, 1991): users who understand how their parking choice affects the cost figure have genuine agency over it, not just notional choice.

The redistribution overhead component is also what produces the differentiation that drives behaviour. Without it, all scooters of the same type on the same route would show identical costs, and the trip planner would provide no incentive to choose a parking destination that reduces fleet operational load. With it, the cost differential between a well-placed and a poorly-placed parking choice is typically 1–4 kWh — small enough not to feel punitive, but large enough to be perceptible and to accumulate meaningfully across a month of use. The energy wallet framing makes this accumulation visible: a user who consistently chooses lower-overhead options will have more budget remaining than one who does not, creating a tangible personal benefit from pro-system behaviour without requiring any external penalty.

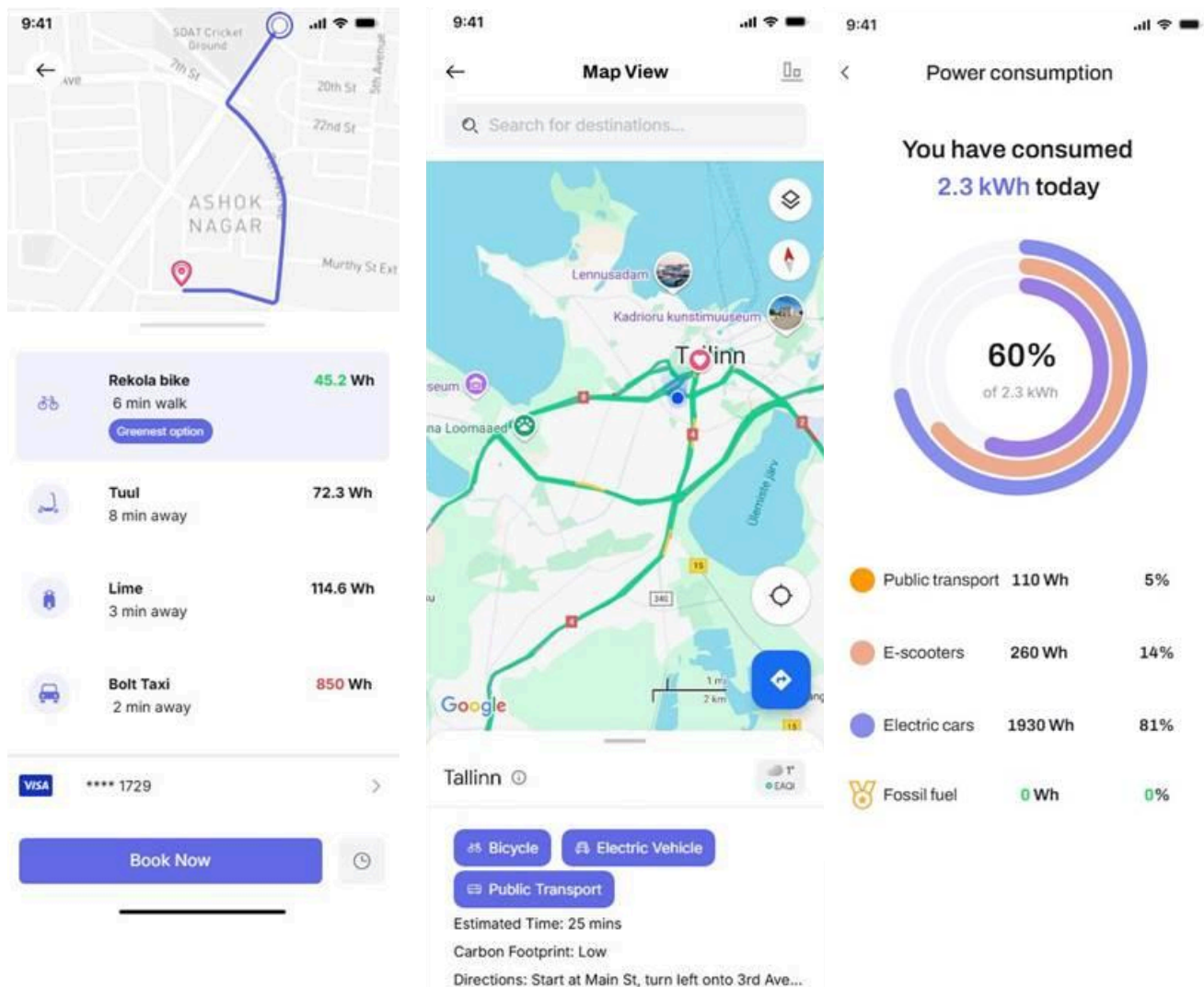


Figure 5.7. Trip Planner screen (left): multimodal options sorted by energy cost, with Rekola bike highlighted as the greenest option at 45.2 Wh, followed by Tuul (72.3 Wh), Lime (114.6 Wh), and Bolt Taxi (850 Wh) — illustrating the energy cost differential the full-cost display mechanism produces at the moment of user decision. Map View (centre): Tallinn route display with bicycle, electric vehicle, and public transport mode filters, showing estimated time of 25 minutes and a low carbon footprint rating. Energy Wallet screen (right): personal power consumption breakdown showing 2.3 kWh consumed today across public transport (110 Wh, 5%), e-scooters (260 Wh, 14%), and electric cars (1,930 Wh, 81%)—mockups made with Visily.

5.11 DESIGN TENSIONS AND LIMITATIONS

Three tensions in the design require explicit acknowledgement, consistent with the CDR requirement for reflexivity.

The main issue here is finding a balance between accountability and privacy. A system like EcoMobility, which tracks people's movement in real time, can pose problems in a work setting. This is because it gives the employer a lot of information about how their employees commute, which could be used for more than just sustainability management. To address this, the system aims to use as little data as possible, tracking only overall energy use rather than each trip. It also requires explicit permission to track this information and keeps sustainability data separate from human resources systems. However, this problem can't be completely solved by design alone. Any system that makes people accountable by making their actions visible also carries the risk of being used to spy on them. This trade-off needs to be acknowledged honestly, rather than trying to find a way around it. For example, think of it this way. If a company wants to encourage its employees to use more sustainable transportation, it might use a system like EcoMobility to track their progress. But this could also be used to monitor where employees are going and when, which could be an invasion of their privacy. So, the company has to weigh the benefits of using this system against the potential risks to its employees' privacy. It's not just about finding a balance, but also about being transparent about what information is being collected and how it's being used. This way, employees can make informed decisions about whether or not to participate in the system. Ultimately, it's a complex issue that requires careful consideration and honest communication.

The main challenge is finding a balance between how simple and how ambitious our plan is. If I make it smaller, like just for a company, it's easier to manage, but it won't make a large difference. A company can change how its employees get around, but it can't change how a whole city with 450,000 people manages its transportation energy. So, we plan to use the company model as a test and a learning tool, gathering evidence to help make a case for larger changes in the city. This way, it's not meant to be the final solution, but a step towards something bigger.

The third tension is between energy-as-currency as a design metaphor and as an actual governance mechanism. In the current concept, kWh is a unit of accountability rather than a literal currency: users manage a notional budget, but they do not actually purchase energy or trade energy credits in a market. The distinction matters because it affects what the mechanism can claim: it can produce behavioural accountability effects (making energy consumption visible and consequential), but it

cannot produce the market efficiency effects or the civic commons effects that a genuine energy currency might enable. Future iterations of the concept might explore whether a more literal currency mechanism — with actual energy trading between users — is technically and institutionally feasible. Still, the current design does not make this claim.

6 FINDINGS AND CRITICAL ANALYSIS

The critical analysis of EcoMobility proceeds from three questions derived from the theoretical framework: Does the design mechanism address the identified problem (the behavioural gap in e-scooter lifespan)? Does the organisational deployment model resolve the institutional limitations of the city-scale concept? And what does the design process reveal about the broader challenge of designing for systemic sustainability in micromobility?

6.1 DOES THE DESIGN MECHANISM ADDRESS THE IDENTIFIED PROBLEM?

On the first question, the design analysis provides cautiously affirmative evidence. The energy wallet mechanism directly targets the accountability gap identified in the system map: by making individual energy consumption visible, personal, and cumulative, it creates the information conditions for behavioural self-regulation. The lifecycle impact feedback loop addresses the missing connection between user behaviour and vehicle condition. The trip planner's energy-first presentation creates decision architecture that systematically favours lower-energy choices. Each of these features addresses a specific, empirically identified gap in the current system rather than a generic sustainability aspiration.

However, the design analysis also surfaces important limitations. The most fundamental is the gap between accountability and motivation. EcoMobility creates the information conditions for sustainable behaviour but does not, in itself, ensure that users will respond to that information with durable behaviour change. The energy feedback literature (Abrahamse et al., 2005; Tiefenbeck et al., 2018) provides good evidence that energy information changes behaviour when it is salient, immediate, and personally relevant — conditions that EcoMobility's design attempts to meet. But the GoEco! Evidence (Cellina et al., 2019) also shows that novelty effects dominate in the first weeks of engagement, with behaviour reverting toward baseline as engagement declines. The organisational deployment model partially addresses this through institutional embedding — a company-wide programme creates ongoing social norms that sustain engagement beyond the novelty period. Still, it does not eliminate the fundamental challenge of habit formation.

The user perspective requires more explicit treatment than it receives in the current design documentation. The behavioural theories cited — TPB, Nudge Theory, SDT — each predict what will change behaviour, but they do not automatically translate into user experience. What does it actually feel like to use EcoMobility? What would a user

notice first? What would frustrate them? What would make them continue? The Anna user journey in Section 5.8 above is one attempt to make this concrete. A more rigorous treatment would require reflective walkthrough sessions or design probe activities with representative users. Without this, the thesis's claims about behavioural mechanisms remain grounded in theory but ungrounded in user reality. This is acknowledged as the primary limitation of the current phase of research, and is addressed in the future work recommendations of Chapter 7.

6.2 DOES THE ORGANISATIONAL MODEL RESOLVE THE INSTITUTIONAL LIMITATIONS?

The second question requires a more nuanced assessment. The shift to using organisations to get things done is a real and thoughtful move. It's based on a genuine problem with the system - getting institutions on board - and the organisational approach actually fixes some of the biggest hurdles that come with working at a city scale. For one, managing data becomes easier; people are more likely to participate because they have a say, incentives are aligned, and the program can be put in place without changing any regulations. These are all significant benefits.

The new way of organising things also brings some new problems that weren't there before. The biggest issue is that it limits impact: a company's sustainability program reaches only the people who work for that company, not everyone who uses transportation in the city. The goal of making large changes to how the whole city of Tallinn manages its shared transportation energy can't be achieved just by changing one organisation. A better way to think about EcoMobility in this form is as a test-and-learn tool: a way to gather evidence of what can be achieved in a controlled setting, which can then be used to make a case for changing city-level policies. This is a more humble goal than the original vision, but it's more realistic. The city-scale concept had a much broader reach, but this new approach is more focused on learning and demonstrating what works. It's a way to figure out how to make transportation more sustainable, and then use that knowledge to push for bigger changes in the city. By starting small and testing ideas in a controlled setting, EcoMobility can build a strong case for why city-scale changes are needed and how they can be achieved. This approach may not be as flashy as the original vision, but it's a more practical and effective way to create real change.

6.3 WHAT DOES THE DESIGN PROCESS REVEAL ABOUT SYSTEMIC SUSTAINABILITY DESIGN?

Looking at how the design process sheds light on systemic sustainability, some interesting points emerge. Firstly, the GIGA-mapping exercise showed that the most effective points for design intervention in complex systems are not always the most critical ones. The biggest changes needed to make a difference in city-scale energy governance are often institutional and regulatory, but these are hard for designers to influence on their own. The EcoMobility project, which focuses on changing people's behaviour, is a more manageable task for designers. Still, it's also less powerful in terms of making large systemic changes - a finding that's both useful and humbling for the design field, which sometimes overestimates its ability to drive systemic change. Secondly, the shift from focusing on the city as a whole to focusing on individual organisations highlights a key principle of systems-oriented design: being honest about the institutional and political constraints that exist is not a cop-out, but rather a necessary condition for making real systemic change. A design that ignores these constraints is not more ambitious or systemic; it's just less realistic.

The design process teaches us a lot about what's needed to make something work. In this case, the idea of designing an entire city was not a failed experiment, but rather a way to determine what would be required to make it a reality. This kind of knowledge is really valuable, as it shows us what's missing and what needs to be changed. It's not just about finding solutions that work, but about understanding what's needed to make those solutions happen. By shifting the focus to how design can be used within organisations, I am not giving up on my goals; rather, I am being more realistic about what can actually make a difference right now. This approach can help create real change by understanding the systems and institutions that need to be in place for the designs to succeed.

6.4 LIMITATIONS OF THE RESEARCH

There are some large limitations to this research that I need to be upfront about. First, the prototype couldn't be tested with real users, so I don't know for sure whether they'll work as intended. The design is based on lessons from similar studies, such as those on energy feedback and company mobility programs. Second, when I mapped the micromobility ecosystem in Tallinn, I had to rely on publicly available information and what I could observe directly, rather than accessing private data held by the companies involved. This means the map might not be complete, which could affect the accuracy of my analysis of the system's gaps. Third, I developed a plan for

putting ideas into practice at an organisational level, but it wasn't tested with any real partners. Lastly, there's a strong question about fairness that I haven't fully answered: how do I decide how much energy each user should get, and what criteria do I use to make that decision? These are important limitations to keep in mind when thinking about this research and how it might be used. By being honest about what I don't know and what I still need to figure out, I can ensure my ideas are developed and used responsibly and effectively.

These limitations don't mean the research is flawed, but they do show what it can and can't do. The thesis offers design ideas and insights into the process, rather than proving facts through experiments. This aligns with the CDR methodology used and the speculative design approach of EcoMobility, but it's essential to be clear about this rather than ignore it. The research aims to contribute to the field by offering new design perspectives and understanding of the process, even if it doesn't provide empirical proof. By being transparent about its limitations, the thesis can help others understand its value and potential applications.

7 CONCLUSION AND FUTURE WORK

This thesis began with a concrete problem — shared e-scooters break too quickly — and arrived, through a process of literature review, systems mapping, and iterative design, at a specific and grounded design proposition: EcoMobility as an organisational energy accountability platform. The journey between these two points is the intellectual content of the research, and the findings it produced are more interesting and more honest than the original concept that seeded the work.

The main idea of this research was to examine the short-term LCA of e-scooters and their environmental impacts. Treating energy as a currency can help solve this issue. This idea is based on three main pillars: first, studies have shown that making e-scooters last longer is the best way to reduce their negative impact on the environment; second, research has identified a gap in accountability as a major reason why e-scooters don't last long enough; and third, behavioral theories have shown that when people are held accountable for the energy they use, it can lead to lasting changes in how they behave. By treating energy as a currency, we can design systems that encourage people to take care of e-scooters and keep them in good condition, which would be good for the environment. This approach aims to address the problem of e-scooters not being used sustainably by raising awareness of the energy they consume and their environmental impact.

The main idea is to create a plan to make shared micromobility more accountable for energy use. This plan, called a deployment model, outlines a specific proposal for introducing energy accountability mechanisms at scale without changing city regulations. This model isn't a complete design yet, but rather a detailed direction that's backed up by analysis of systems, behavioural theory, and a critical look at its own limitations. It's a practical way to make shared micromobility more energy-efficient, grounded in real-world considerations. The goal is to make a positive impact without requiring large changes to existing regulations.

There are a few areas that need further investigation—testing the organisational deployment model in a real-world setting, such as a university, to see whether it works with this target. This would involve working with a partner to set up a living lab and trying out the ideas in practice. We also need to consider how to ensure our energy budget allocation is fair. Who gets to decide how much energy each person or group gets, and what are the rules for making those decisions? This is an important question that needs a thorough investigation. Another thing we need to consider is how to use the information we get from our organisational deployments to make a

case for changing policies at a city-wide level. It's not always easy to take a small project and scale it up to a larger, systemic reform, so we need to carefully design a pathway from a demonstration project to a larger, systemic reform. By looking into these areas, we can make our organisational deployment model more effective and fair, and help create a more sustainable energy system for everyone.

The future work directions above benefit from a more specific proposed pathway, grounded in the institutional analysis of Chapter 5. The following three-phase implementation plan translates the organisational deployment model from a speculative concept into a testable proposition.

Phase 1 (0–6 months) — Feasibility and Partnership: identify one willing partner organisation in Tallinn (candidate types listed in Appendix 2). Assess appetite for voluntary enrollment, map the technical integration requirements with at least one fleet operator (Bolt or Tuul), and design the data governance architecture. Establish the energy budget as a health and sports benefit under the Estonian Income Tax Act exemption, in coordination with the organisation's HR and legal teams. This is the most critical institutional step, as it determines whether the energy budget can be offered as a tax-exempt benefit or must be treated differently. Pilot with 20–30 volunteer employees.

Phase 2 (6–18 months) — Living-Lab Deployment: deploy with the pilot cohort. Collect trip-level data through the app, track Energy Wallet usage patterns, and run monthly reflective sessions with participants to assess motivational dynamics (using SDT scale measures of autonomy, competence, and relatedness, Ryan & Deci, 2017). Compare redistribution event rates between enrolled and non-enrolled employees using fleet operator data. Generate the first Scope 3 Category 7 report for the partner organisation and validate it against their existing reporting methodology.

Phase 3 (18+ months) — Evidence and Scaling: use living-lab findings to make the case for city-level policy development. The specific regulatory ask is modest: recognition of mobility energy budgets as a qualifying health and sports benefit under the Estonian Income Tax Act by the Estonian Tax and Customs Board. If achieved, this would make EcoMobility deployable by any Estonian employer within existing legal frameworks, without requiring any operator mandate or city-level governance change. This is a credible and achievable policy goal, precisely because it builds on an existing, widely-used benefit structure rather than creating new institutional architecture. The path from organisational demonstration to policy change is the same path that corporate health programmes, e-bike purchase subsidies, and green procurement schemes have followed in European countries over the past decade.

SUMMARY

Designing for Longevity in Micromobility Systems: Reframing Urban Mobility Through Energy-as-Currency App Design

The research examines the problem of premature e-scooter failure in shared urban micromobility systems, arguing that the dominant cause is behavioural rather than engineering: the absence of any accountability mechanism linking how users treat shared vehicles to the consequences they experience. Through a review of lifecycle assessment literature, systems-oriented mapping of the Tallinn micromobility ecosystem, and iterative speculative design development, the thesis proposes EcoMobility — an energy-accountability platform that replaces monetary cost with kilowatt-hours (kWh) as the primary unit of account in mobility decisions — as a design response to this gap.

The design process proceeded in two phases. The first phase developed EcoMobility as a city-scale governance system, integrating all Tallinn shared mobility operators into a unified energy budget interface. A critical analysis of this concept revealed a fundamental institutional limitation: without compelling incentives for operators and the city government to participate, the city-scale vision requires regulatory changes that do not currently exist. This finding — produced by the design process itself, through honest engagement with institutional constraints — led to a principled pivot in the second phase: EcoMobility reframed as an organisational deployment tool for corporations, universities, and other large institutions.

The organisational deployment model resolves the institutional buy-in problem by embedding the programme within existing corporate sustainability structures. It introduces four integrated components: an Energy Wallet (personal weekly kWh budget), a Trip Planner (multimodal route comparison sorted by energy cost), a Lifecycle Impact screen (post-trip feedback connecting user behaviour to vehicle lifespan), and an Organisational Dashboard (management interface for sustainability reporting). Each component is grounded in specific findings from the systems map and specific mechanisms from behavioural theory (Ajzen, 1991; Thaler & Sunstein, 2008; Deci & Ryan, 2000).

The thesis makes three contributions. Theoretically, it frames the e-scooter lifespan problem as a commons-governance failure of commons governance and proposes energy-as-currency as a design mechanism to address it. Methodologically, it

demonstrates a three-phase SOD/speculative design/CDR methodology for complex sustainability design problems, distinguished by its explicit engagement with institutional constraints. In practice, it proposes a specific, institutionally grounded organisational deployment model that provides a realistic pathway from a speculative concept to an implemented programme. The thesis concludes that EcoMobility's most important contribution may not be the platform itself but the process by which it was developed: a process that treated design as a mode of honest systemic inquiry rather than as a vehicle for a predetermined conclusion.

Keywords: micromobility, e-scooter lifespan, lifecycle assessment, energy accountability, systems-oriented design, speculative design, constructive design research, organisational deployment, behaviour change, master's thesis

Mikromobiilsuse pikaajalise disain: linnaliikumise ümbermõtestamine energia-kui-valuuta rakenduse kaudu

Käesolev magistritöö uurib jagatud linnalähedase mikromobiilsuse süsteemides esinevat e-tõukerattaste enneaegse rikke probleemi, väites, et selle probleemi peamine põhjus on käitumuslik, mitte tehniline: puudub vastutusmehhanism, mis seoks kasutajate käitumise jagatud sõidukitega nende kogetavate tagajärgedega. Elutsükli hindamise kirjanduse ülevaate, Tallinna mikromobiilsuse ökosüsteemi süsteempõhise kaardistamise ning iteratiivse spekulatiivse disainiarenduse kaudu pakub töö välja EcoMobility — energiaarvestuse platvormi, mis asendab rahalise kulu kilovatt-tundidega (kWh) liikumisotsuste peamise arvestusühikuna.

Disainiprotsess kulges kahes faasis. Esimene faas arendas EcoMobilit linnatasandi juhtimissüsteemina, integreerides kõik Tallinna jagatud liikuvusoperaatorid ühtsesse energiaeelarvega liidesesse. Selle kontseptsiooni kriitiline analüüs paljastas fundamentaalse institutsionaalse piirangu: ilma operaatorite ja linnaomavalitsuse osaluseks veenvate stiimuliteta eeldab linnatasandi visioon regulatiivset muutust, mida praegu ei eksisteeri. See leid — mille tootis disainiprotsess ise läbi institutsiooniliste piirangutega ausa tegelemise — viis teises faasis põhjendatud pöördeni: EcoMobility kujundati ümber organisatsioonilise rakenduse tööriistaks korporatsioonidele, ülikoolidele ja teistele suurorganisatsioonidele.

Töö annab kolm panust. Teoreetiliselt sõnastab see e-tõukeratta eluea probleemi ühisressursside haldamise ebaõnnestumisena ning pakub energia-kui-valuuta disainimehhanismina selle lahendamiseks. Metoodiliselt demonstreerib see kolmefaasilist SOD/spekulatiivse disaini/CDR metoodikat keerukate jätkusuutlikkuse disainiprobleemide jaoks. Praktiliselt pakub see konkreetset, institutsioonaaalselt põhjendatud organisatsioonilise rakenduse mudelit.

Märksõnad: mikromobiilsus, e-tõukeratta eluiga, elutsükli hindamine, energiaarvestus, süsteemipõhine disain, spekulatiivne disain, konstruktiivne disainiuurimus, organisatsiooniline rakendus, käitumismuutus, magistritöö

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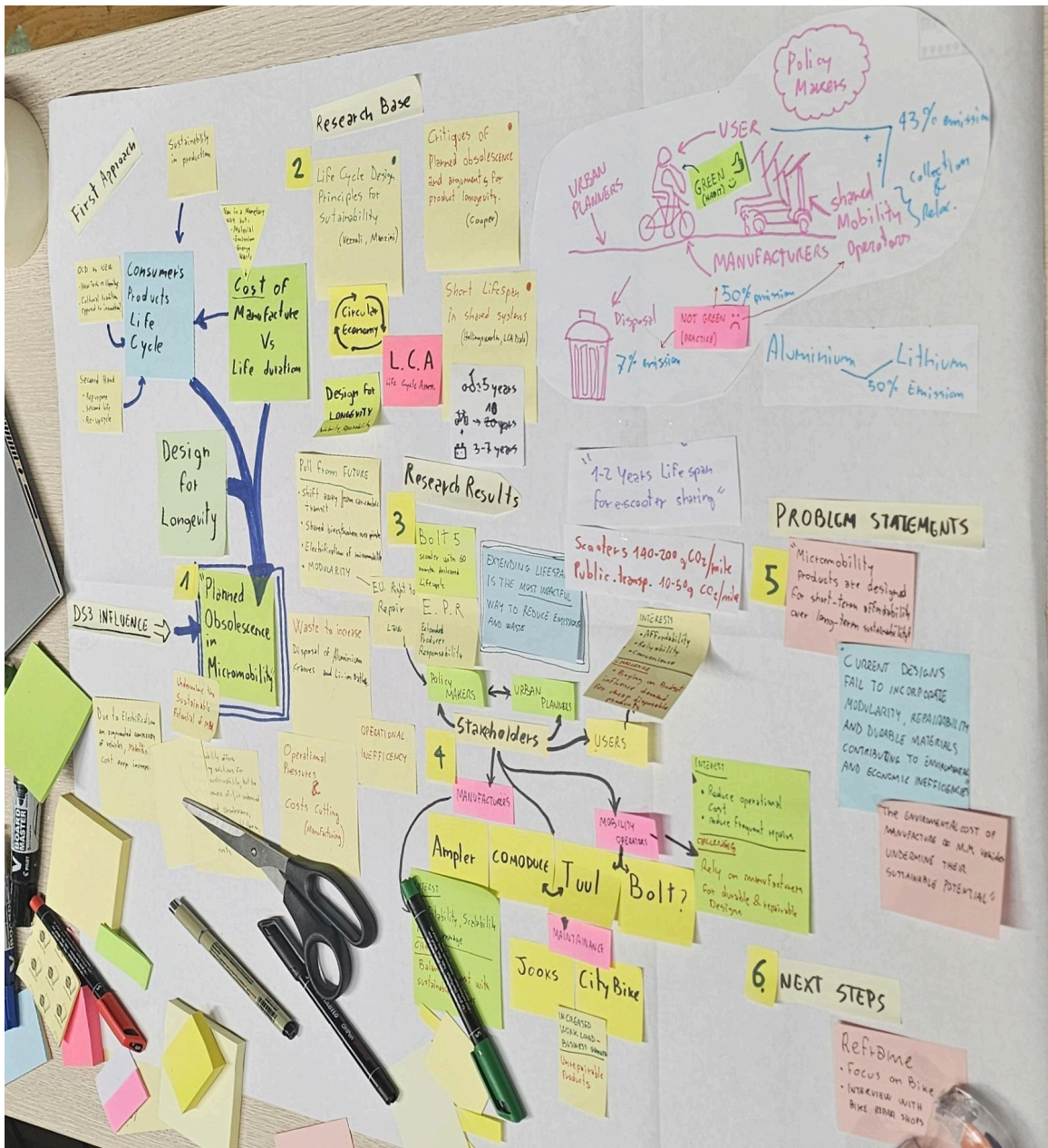
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APPENDICES

Appendix 1. GIGA-Map Actor Groups and Flow Types — photographic documentation of the physical mapping process



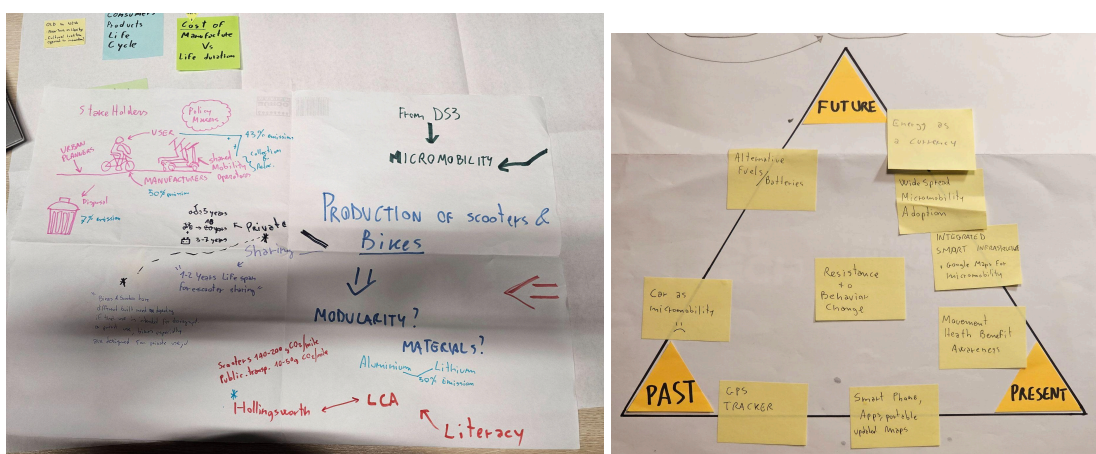


Table A.1. Actor groups in the Tallinn micromobility GIGA-map.

Actor Group	Sub-actors	Primary Role in System
Users	Commuters, tourists, students, recreational riders	Generate trips; determine vehicle handling quality; primary source of behaviour data
Shared mobility operators	Bolt, Tuul, city bikeshare (Tallinn)	Own and manage vehicle fleets; set pricing; collect trip data; responsible for maintenance

City transport authority	Tallinn Transport Department, Urban Planning Office	Regulate operators; manage public transit; set sustainability targets; hold city mobility data
Energy infrastructure	Eesti Energia, the grid operator, and charging hub operators	Provide electricity for vehicle charging; manage charging infrastructure
Vehicle manufacturers & supply chains	Ninebot, Segway, custom OEMs, battery suppliers	Design and manufacture vehicles; determine reparability and lifespan potential
Maintenance & logistics providers	In-house operator teams, third-party contractors	Collect, repair, and redistribute vehicles; manage end-of-life

Table A.2. Gap nodes identified in the Tallinn micromobility GIGA-map.

Gap Node	Description	Design Response in EcoMobility
User-vehicle condition loop	No feedback connecting individual user behaviour to vehicle condition or lifespan outcomes.	Lifecycle Impact screen: post-trip feedback on handling behaviour and maintenance score.
Energy data fragmentation	Operator energy consumption data is not accessible across platforms or to users.	Trip Planner: unified energy-cost comparison across operators.
Sustainability goal misalignment	Individual user convenience goals and collective sustainability goals are not connected.	Energy Wallet: a personal budget that makes collective resource use individually visible.
Institutional accountability gap	No mechanism for users or the city to hold operators accountable for lifecycle performance.	Organisational Dashboard: aggregate reporting that enables institutional sustainability management.

Appendix 2. EcoMobility Organisational Deployment – Candidate Organisations

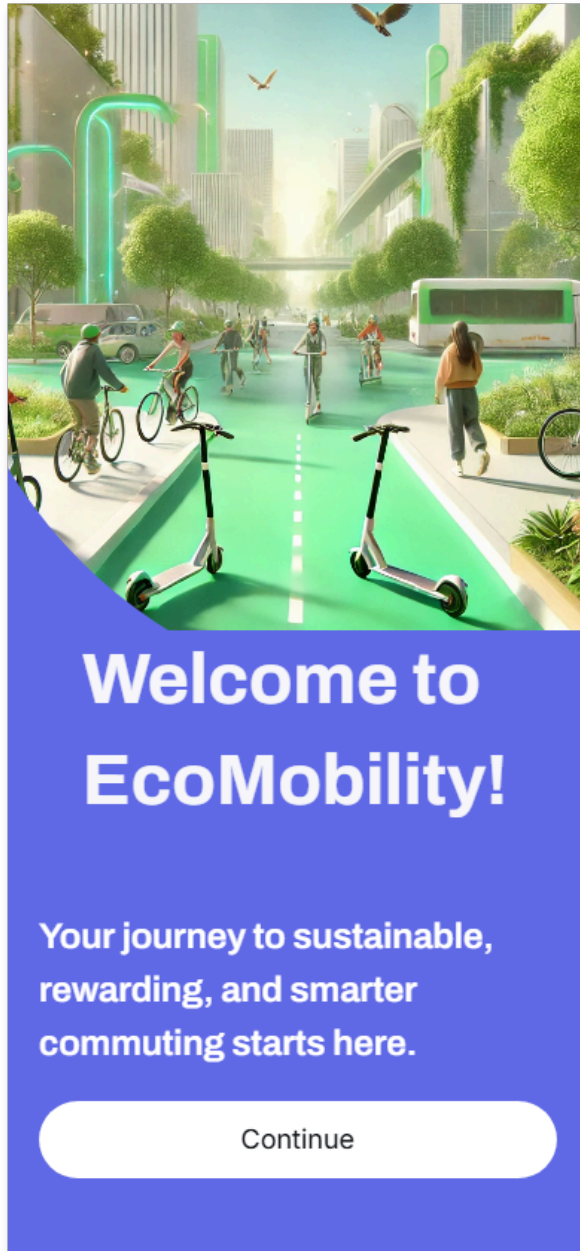
The following table presents three candidate organisation types for EcoMobility deployment, with analysis of their institutional incentives, existing sustainability infrastructure, and relevant regulatory context.

Organisation Type	Sustainability Incentive	Existing Infrastructure	Regulatory Context	Estimated
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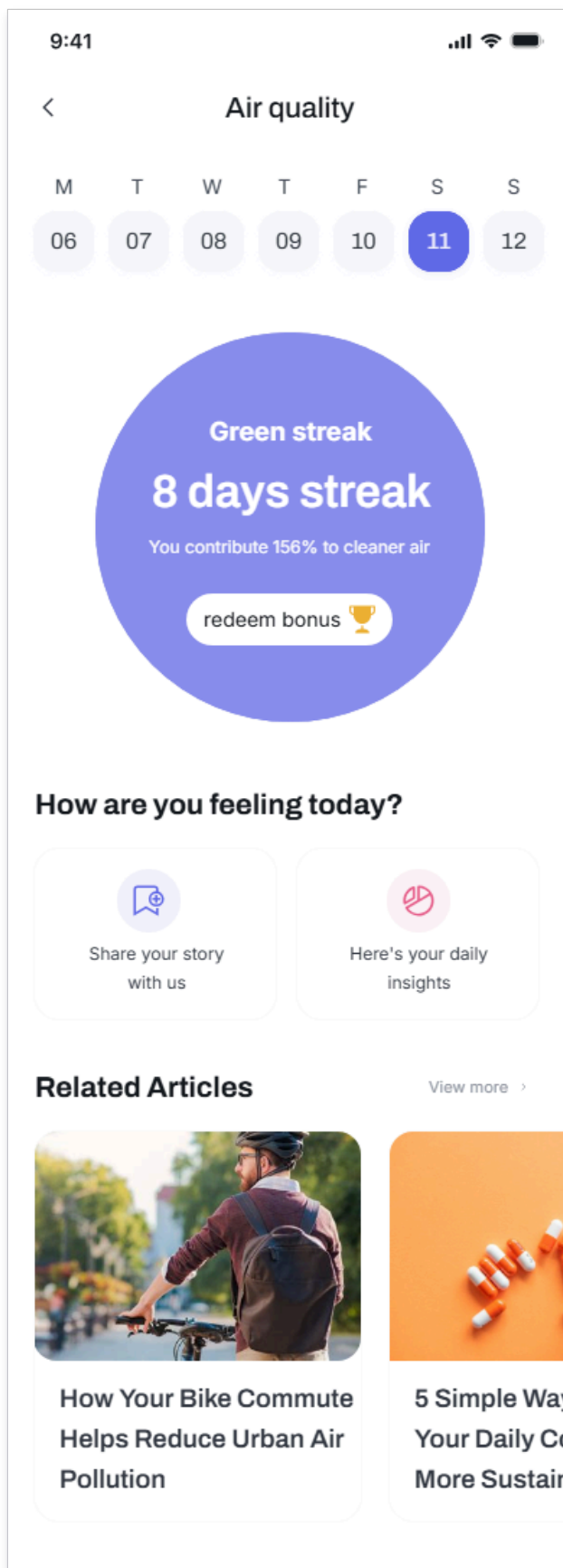
				User Base
Large employer (500+ employees)	CSRD reporting obligations; employee engagement; ESG scores	Sustainability Dept.; HR mobility benefits; often existing commute subsidies	EU CSRD (2024) mandates sustainability reporting for large companies	500–5,000 users per deployment
University/higher education	Institutional sustainability commitments; student engagement; research partnership potential	Student services, sustainability office, campus card infrastructure	No specific mandate, but strong reputational incentives	1,000–20,000 users
Public sector body (hospital, govt dept.)	Green procurement requirements; public sustainability commitments	Fleet management, procurement team, and often existing travel policies	EU Green Public Procurement criteria; national green transport targets	200–2,000 users

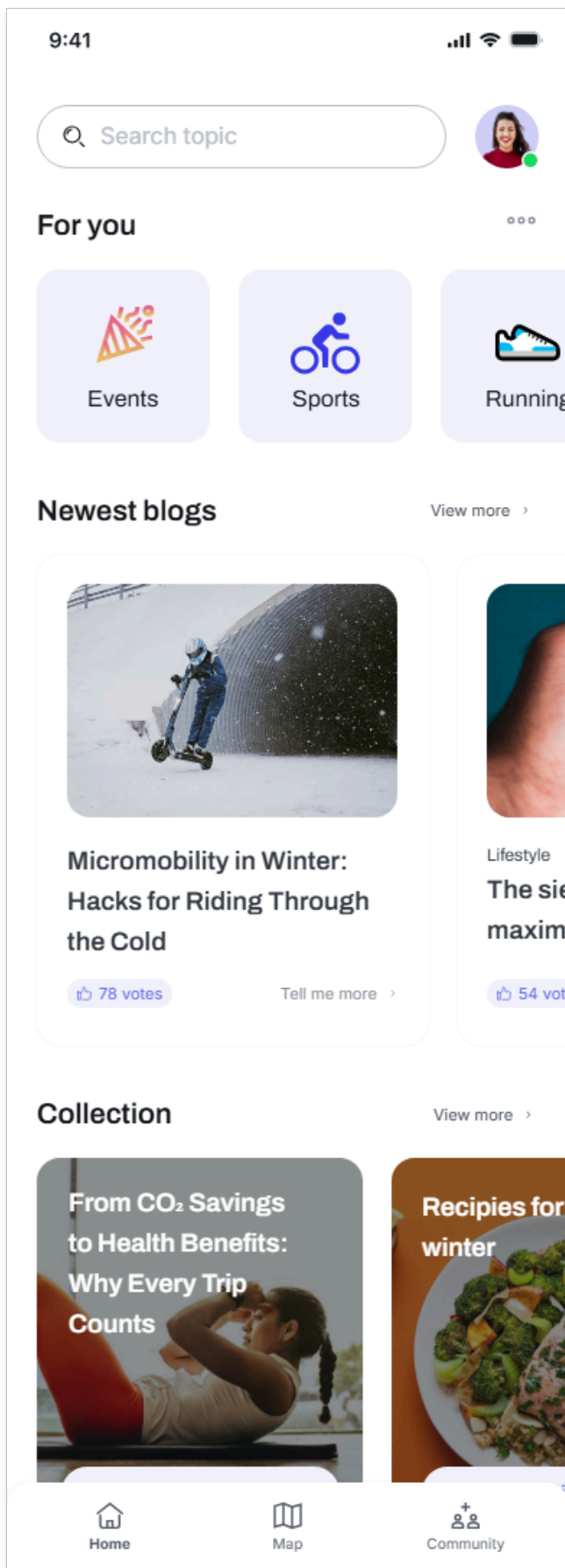
GRAPHICAL MATERIAL

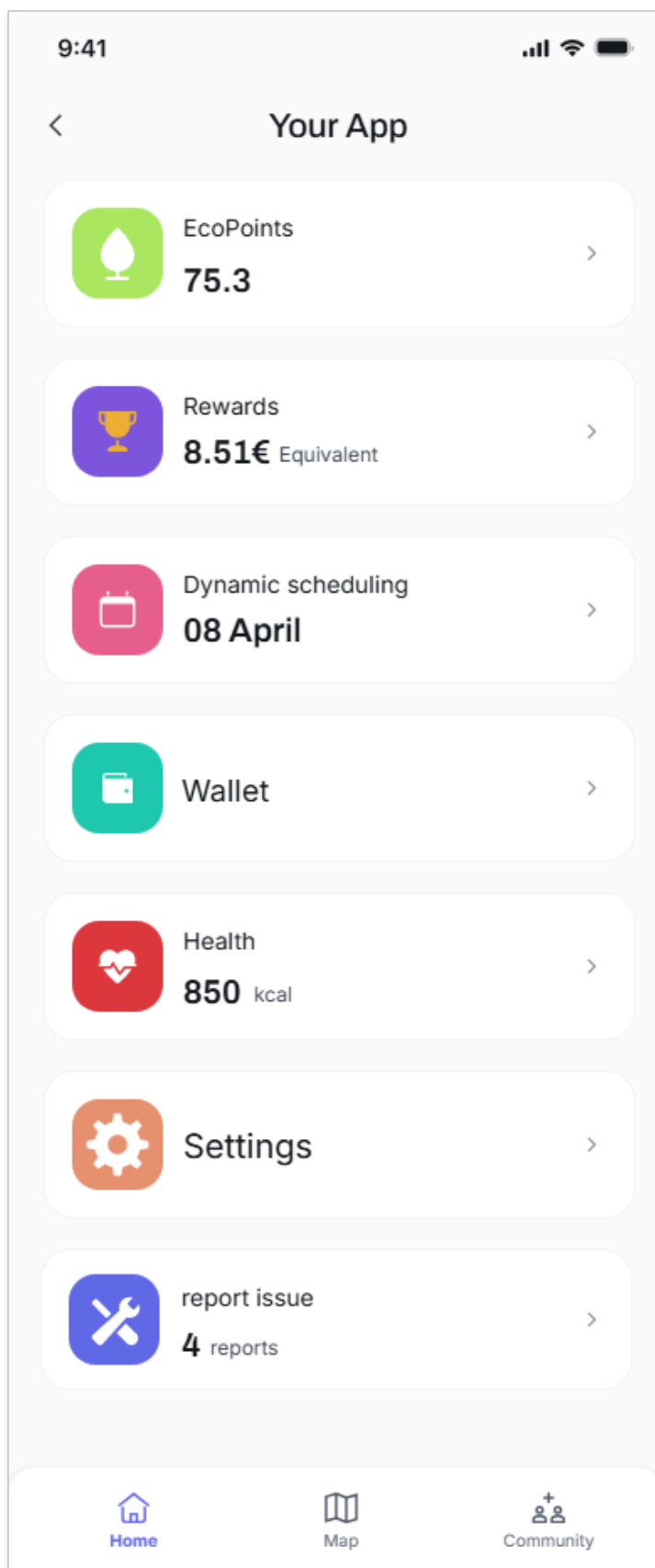
Mock-up screenshots of the EcoMobility made with Visily.

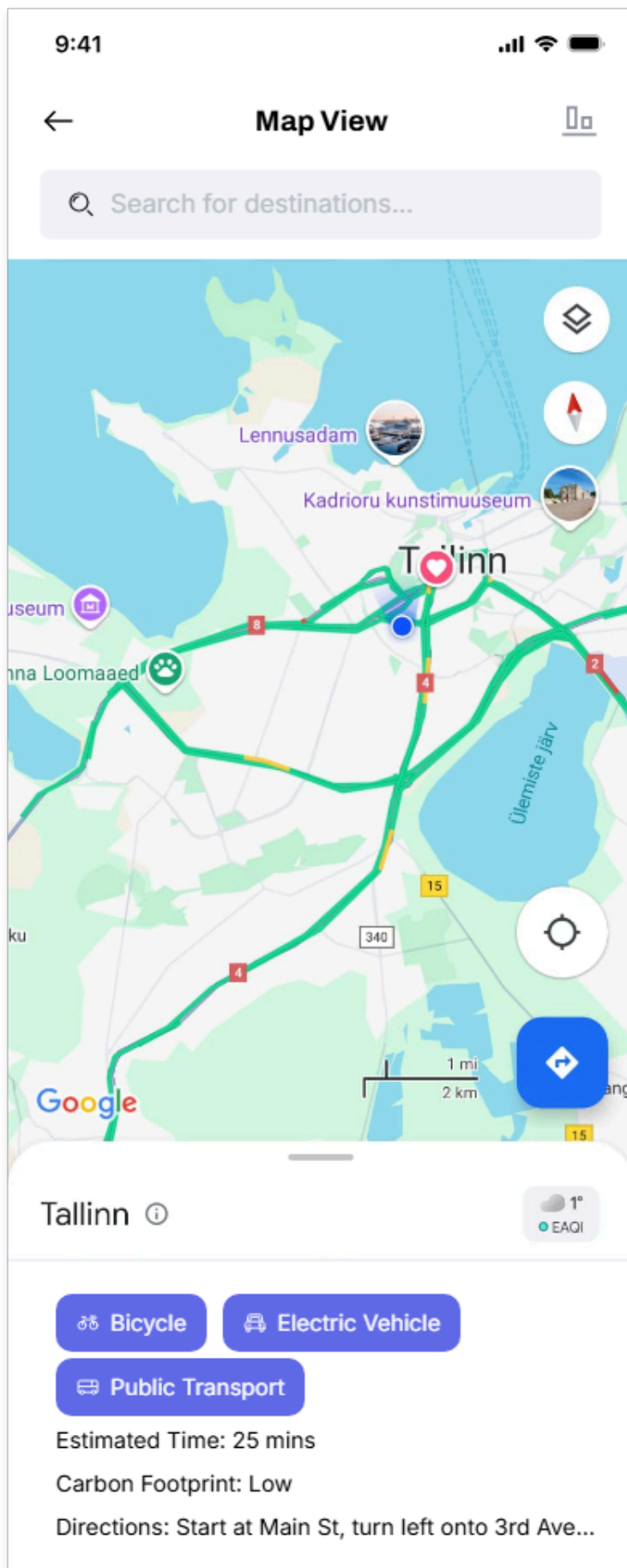


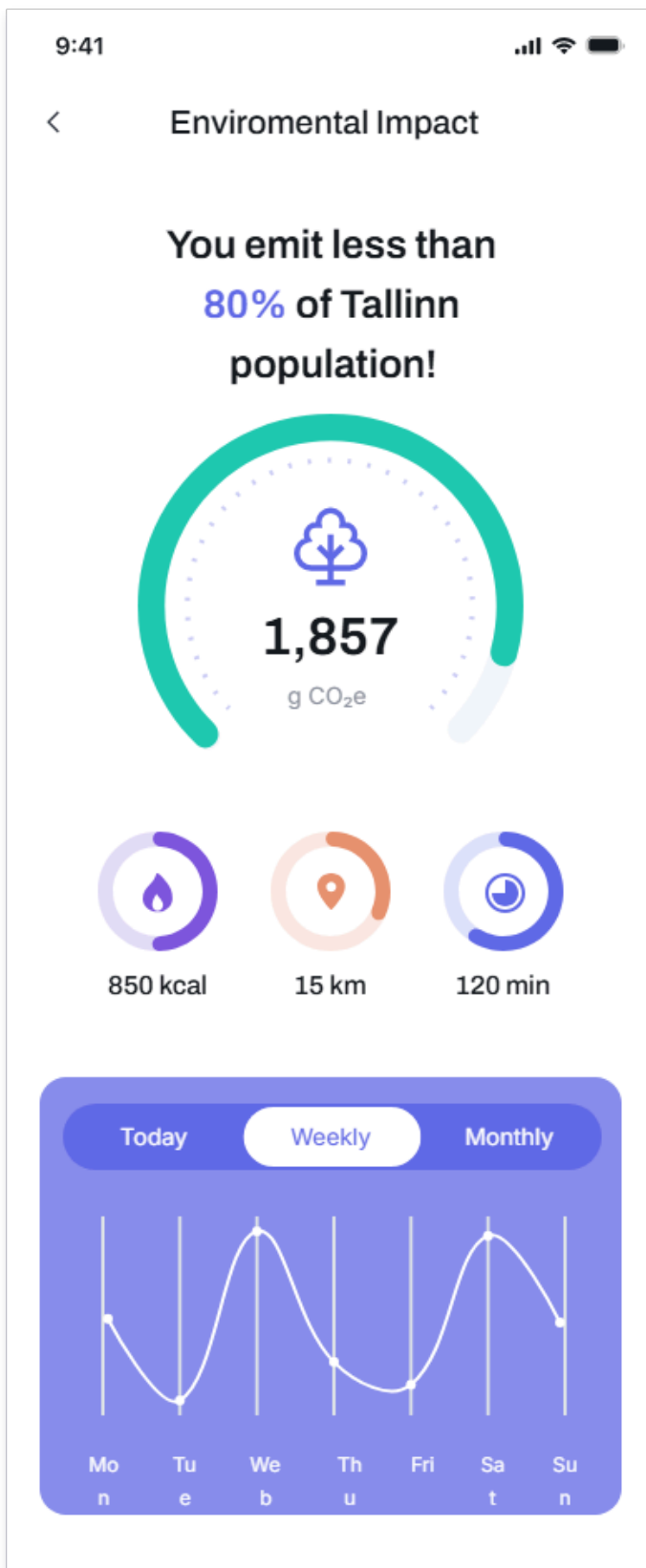
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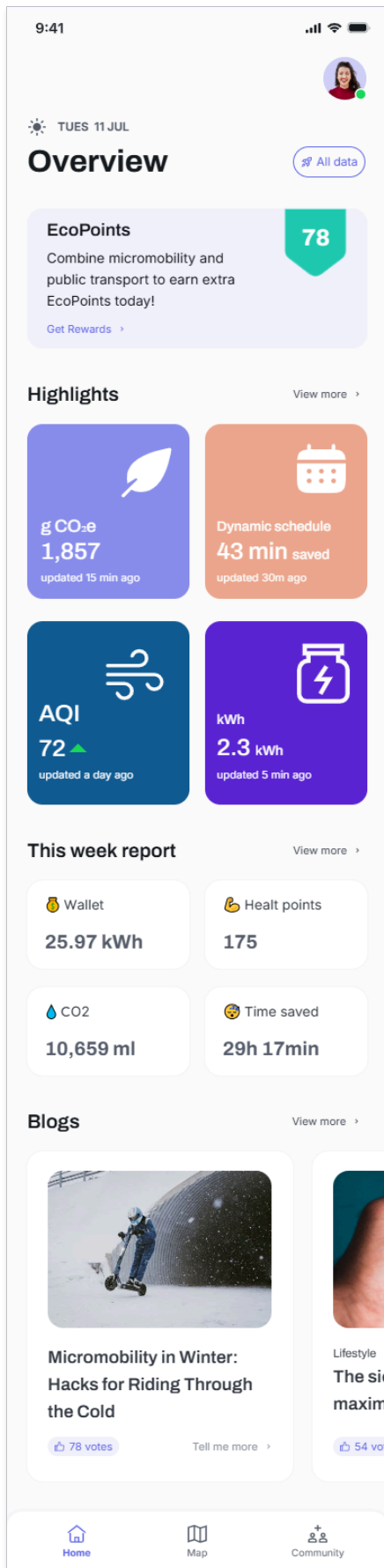


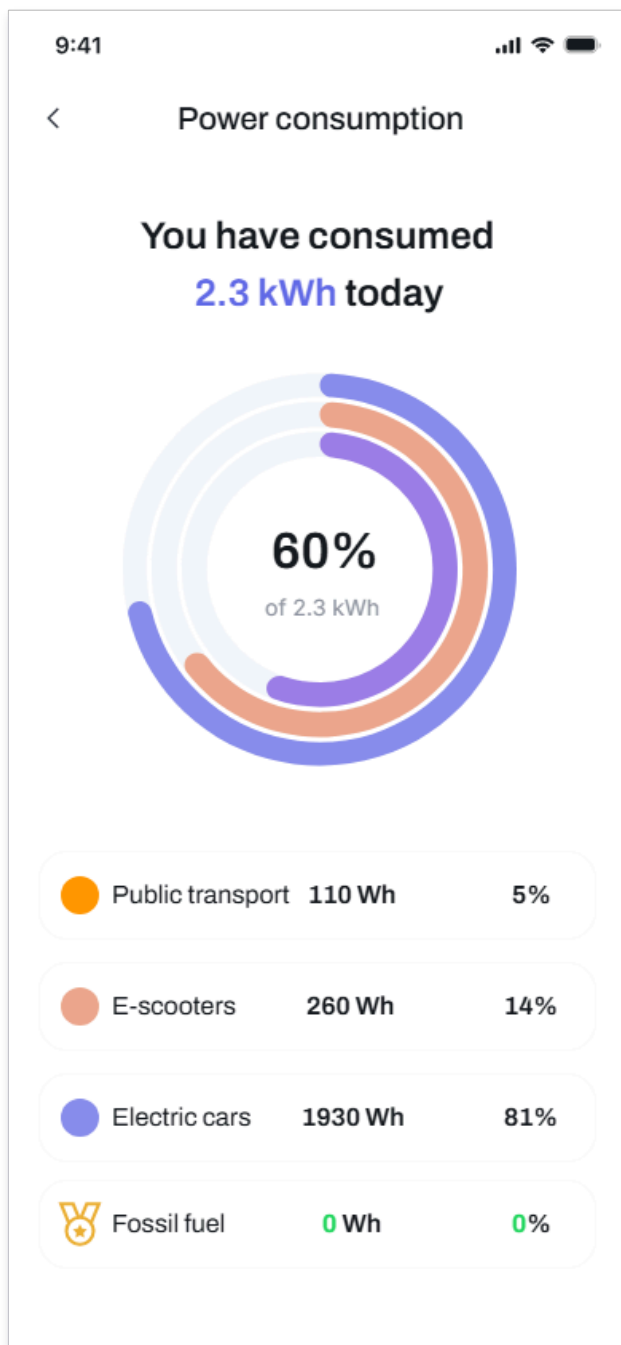




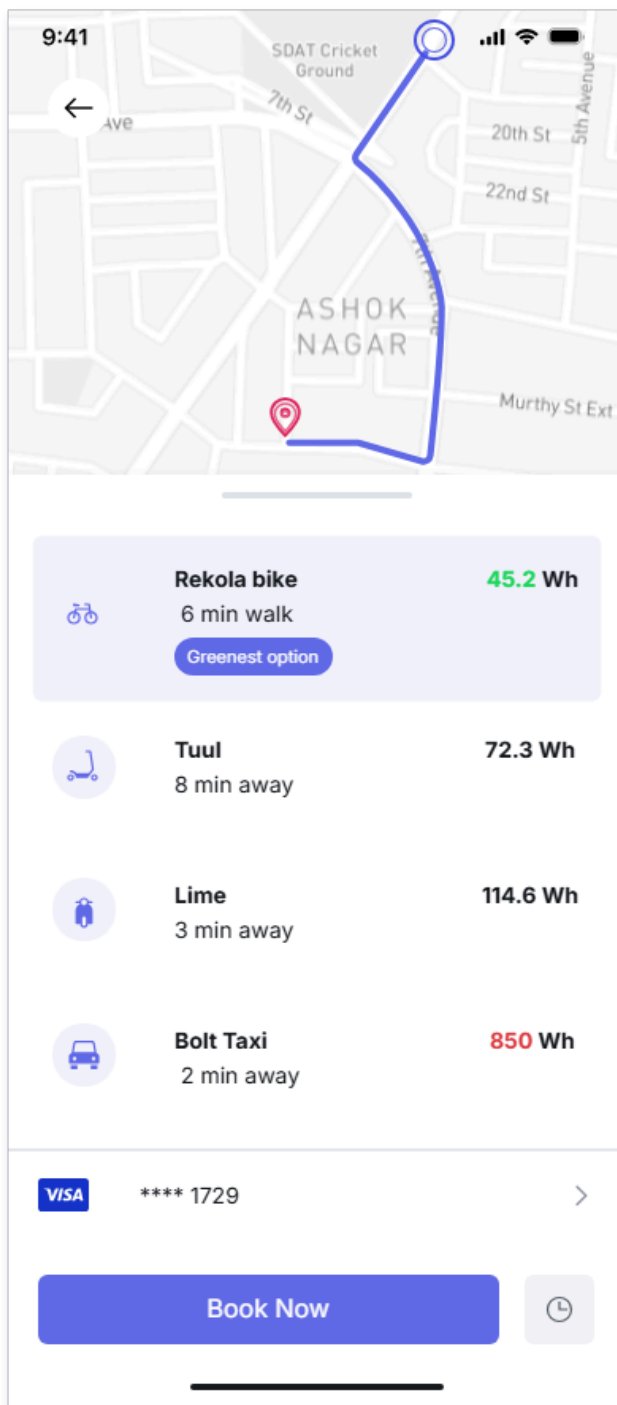








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