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MASTER

Searching for alternative sociotechnical imaginaries for transformative research towards sustainability
a participatory visioning process, at the Eindhoven University of Technology

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Searching for alternative sociotechnical imaginaries for transformative research towards sustainability: a participatory visioning process, at the Eindhoven University of Technology

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Abstract

The concept of sociotechnical imaginaries has gained significant attention as a means of understanding how society envisions and creates technological systems and their role in shaping social change. This study builds on this concept and explores the phenomenon of the emergence of sociotechnical imaginaries and their role in transformative change as part of a broader effort to facilitate the institutionalisation of sustainability at the Eindhoven University of Technology (TU/e) in the Netherlands. By employing mixed methods, including interviews, empathy maps, workshops, and surveys, the study analyses the formation process of these imaginaries before institutional stability. The focus is on transitioning from privately held to collectively held visions by examining private sociotechnical visions, alternative imaginaries identified through participatory workshops and shifts in future expectations resulting from these sessions. The study found that researchers are interested in pursuing transformative research while balancing academic pursuits with a focus on societal impact, bringing up transdisciplinary collaboration, social engagement, responsibility, local collaboration, the necessity for experimentation and better funding opportunities as focal points of envisioned futures. The study also identified three sociotechnical imaginaries at the collective level: the university as a platform for collaboration, experimentation, and knowledge sharing; the university as a leader in finding transformative solutions for sustainability; and the university fully committed to promoting sustainability. Participatory workshops were shown to influence individuals' beliefs and attitudes towards sustainability, highlighting shared commitment and motivation as essential drivers of change. The results provide a comprehensive understanding of the challenges, priorities, and values researchers encounter when pursuing transformative research for sustainability at the university, highlighting the areas that need attention to effect positive change. These insights can inform decision-making, strategy development, and action planning towards achieving their vision for the future. The alternative imaginaries identified can challenge and broaden the dominant sociotechnical imaginary that currently shapes TU/e's approach to sustainability, inspire and motivate actors, and create a sense of shared ownership and engagement among them.

Key-words: *participatory visioning; sociotechnical imaginaries; sustainability; transformative change; transformative research*

Acknowledgements

I am happy to present my master's thesis, "**Searching for alternative sociotechnical imaginaries for transformative research towards sustainability: a participatory visioning process, at the Eindhoven University of Technology**." This work represents the culmination of my thesis project within the #sustainableTU/e visioning process, marking the end of my Master's in Innovation Science at the University of Technology Eindhoven.

As a student, I had the pleasure of meeting many wonderful people who supported me in various ways, and I am deeply grateful for their contributions. I would like to extend a special thanks to a few individuals who played particularly important roles.

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Lastly, I want to express my heartfelt thanks to my friends, family, and especially my husband, Nicky van de Ven, for their unwavering support throughout this journey. They were there to celebrate successes but also to help me through the most challenging moments.

In closing, I wish the reader much joy in reading the result of our collective efforts.

Sincerely,

Kerylaine Cristina Assis Magalhães

Executive Summary

Introduction: Contemporary global challenges such as climate change, social inequality, biodiversity loss, and unsustainable growth cannot be resolved by merely amplifying current practices, necessitating transformational changes across different sectors of society. Achieving sustainability demands producing adaptable, reflexive, collaborative, and transformative knowledge by academia while prioritising positive impact. Sociotechnical imaginaries, which comprise collective visions of desirable futures and their attendant social and technological arrangements, can enable or facilitate transformational change, and comprehending alternative forms of such imaginaries is crucial for diversifying and shaping the future towards sustainability. This study explores the emergence of sociotechnical imaginaries and their contribution to transformative change as part of broader efforts to institutionalise sustainability at the Eindhoven University of Technology (TU/e) in the Netherlands. Specifically, by exploring the question of *"how can visioning processes be used in TU/e to stimulate the creation of alternative imaginaries regarding transformative research to facilitate the institutionalisation of sustainability at the university?"* this study analyses how these collective imaginaries are formed from private visions towards shared and collective visions about desirable futures. It discusses their implications for fostering new expectations and practices while creating space for discussion on sustainability at TU/e.

Methodology: For this thesis, a case study was performed. By employing a mixed-methods approach, this research uses a combination of semi-structured interviews, empathy maps, participatory workshops, and surveys to gather and analyse data. The analysis is divided into three parts: private sociotechnical visions held by the researchers, alternative sociotechnical imaginaries from visioning workshops, and the impact of the process on participants' future expectations.

Results: *Private sociotechnical visions* – The data analysis identified various perspectives, which, when converged, led to a few essential elements that embody the overall researchers' private visions for transformative sustainability research at TU/e, which include aspects of institutional research environments, research designs, mindsets, and skills. The table below summarises the six fundamental elements identified in this study.

Core Elements	Expectations/Opportunities	Challenges/Barriers
Positive Societal Impact	Desire to impact society positively; more solution-driven research	Emphasis on publishing over social impact; lack of support; the academic system may hinder the social impact
Social Engagement and Environmental Responsibility	More socially-engaged research; directing university resources towards energy transition and addressing global issues; improving the interaction between technical and social sciences	Conducting research related to fossil fuels; limited interaction between science and society; university primarily focused on economic growth

Scientific Cooperation and Transdisciplinarity	Collaboration between disciplines and beyond; trust-building learning spaces for effective collaboration	Concerns about criticism from other disciplines; difficulty in bringing disciplines together; lack of incentives for interdisciplinary work
Experimentation	Exploring and discovering new ideas without commercial constraints; making research visible and accessible to inspire others; fully engaging the campus in experimentation	Opening up to criticism; ensuring resources and infrastructure for experimentation; encouraging risk-taking
Local Collaboration	Co-production of knowledge with society at a local level	Difficulty in balancing business and community interests; the complexity of local issues
Institutional, Financial, and Administrative Support	Institutional support for academic researchers; increased investment in sustainability research; enhancement of mechanisms for creativity, reflexivity, collaboration, and skill development; long-term approach in research for sustainability	The burden of non-research tasks; difficulty obtaining funding for sustainability research; pressure for short-term results

Alternative sociotechnical imaginaries - This study has identified three alternative sociotechnical imaginaries, reflecting different perspectives on the university's role in promoting sustainability through transformative research. The workshops used a participatory format to encourage collective negotiations and coalition building, combining private visions into a shared vision representing all perspectives. The table below summarises the key points in the three alternative sociotechnical imaginaries identified in this research.

A platform for Collaboration, Experimentation, and Knowledge Sharing
- The university has transformed into a platform for collaboration, knowledge sharing, and experimentation. The campus serves as a fully functioning living lab facility where research is conducted, experimented on, and exhibited in public.   - The university operates as an open innovation campus, with institutes like Innovation Space, where students and researchers work together on systems and setups, blending teaching and research.   - The university collaborates closely with other universities, institutes, and the local community and prioritizes scientific cooperation rather than competition.   - The university prioritizes the use of locally available materials from obsolete products, with engineering capabilities focused on working with local materials and repurposing them.\   - The departments have clear goals for sustainability that rely heavily on collaboration, with students working on projects that directly benefit the campus and the local community.   - The university policy and system bring sustainability as a central subject in all departments, with human-centred design incorporated into all research projects.
Transformative Solutions for Impact

- The university is a leader in finding innovative solutions to sustainability challenges and creating a positive transformative impact on society. - The focus is on filling gaps in existing knowledge and developing adaptive solutions that can change in response to future needs. - The university is a hub for sustainability and climate action research, attracting outside stakeholders seeking transformative solutions. - TU/e is well-connected to entrepreneurship, and sustainability is now a core component of this. - The university offers a business mentoring and advisory service that leverages its expertise and experience to address sustainability issues and maximize external engagement and impact.
Sustainability at Heart
- The university is committed to promoting sustainability and making it an integral part of all its efforts. - Sustainability is woven into all aspects of campus life, making it the new normal at the university. - All technical departments are committed to finding solutions through sustainable processes and methods, and no resources are allocated towards research and development of unsustainable technologies. - Sustainability is considered one of the four pillars at the university, alongside education, science, and tech transfer. - The university creates a department specifically dedicated to sustainability, with sustainability playing a crucial role in research. - The funding and organization of sustainability science at TU/e are designed to allow researchers to focus on conducting research rather than being bogged down by administrative tasks.

Expectations – The results show that the workshops positively impacted participants' beliefs and attitudes towards sustainability at TU/e. However, their perception of TU/e's engagement with sustainability remained neutral. The workshops increased individuals' interest in sustainability and decreased concerns about TU/e's efforts, indicating a potential for long-term impact. These results highlight the importance of shared commitment and motivation as drivers for change based on collectively shaped expectations through participatory workshops.

Discussion: The participatory approach employed in this study allowed for a collaborative and inclusive process that incorporated diverse perspectives into the final visions. The results provide a deeper understanding of researchers' visions and the challenges they face in pursuing transformative research for sustainability, identifying areas that require attention and investment to bring about positive change. The alternative imaginaries identified can catalyse a shift in expectations and institutionalized responses towards sustainability, inspiring and guiding more inclusive and innovative approaches that better reflect the needs and aspirations of the wider community. The strengths and priorities of each imaginary can inform TU/e's future efforts towards sustainability, such as increasing partnerships with the local community, supporting businesses in integrating sustainability into their operations and incorporating sustainability more comprehensively throughout its institutional practices and decision-making processes. The alternative imaginaries can challenge and broaden the dominant sociotechnical imaginary, providing inspiration and motivation and creating a sense of shared ownership and engagement among the TU/e community. The findings can be used by TU/e and other universities or research institutions to inform their strategies and actions to support sustainability transitions and to ensure that their research is aligned with the visions of their researchers. By incorporating participatory approaches into sustainability planning, institutions can create more inclusive and innovative processes that better reflect the needs and aspirations of diverse actors. This can help to build momentum for transformative change and support the development of more sustainable and equitable futures.

Conclusion: This study investigated the emergence of sociotechnical imaginaries and their potential to support transformative change. The study highlights the importance of alternative imaginaries and participatory visioning processes in catalysing transformative change towards sustainability and challenging existing dominant structures. These imaginaries can guide more inclusive and innovative approaches, reflecting the wider community's needs and aspirations. The research suggests that considering various future imaginaries is crucial when promoting desirable and sustainable futures. Participatory visioning processes allow communities to engage in the collective imagination and develop shared visions grounded in diversity and collaboration, leading to a greater understanding and appreciation of diverse perspectives and experiences. By actively involving participants in co-creating shared visions, these processes promote a sense of ownership and responsibility for the future, encouraging more significant commitment and engagement towards achieving the envisioned outcomes.

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1. Introduction

Humanity faces significant global challenges like unsustainable growth, poverty, biodiversity loss, climate change, and social inequality. Due to their systemic complexity and uncertainty, these issues cannot be resolved by simply amplifying what is already being done (O'Brien, 2013; Sharpe et al., 2016). Instead, an effective response to these interlinked socio-environmental problems will require transformational societal changes at many geographical and social scales (O'Brien, 2012), including the environmental, economic, social, political, and technological aspects and their underpinning values, paradigms, and power (Kläy et al., 2015; van der Hel, 2018). However, a crucial question for humanity arises: how to achieve rapid and transformative societal change with an intentional and impactful contribution to sustainability?

Addressing this and other related concerns requires changing how academia produces knowledge (Hölscher et al., 2021). Although scientific progress has undoubtedly resulted in several benefits, it has also introduced new challenges that require innovative forms of thinking to address them. These approaches should encourage adaptability, reflexivity, collaboration, and transformative efforts prioritising positive impact. They should also promote dialogue between diverse groups of individuals and foster future-oriented awareness and a sense of empowerment and hope (Fazey et al., 2018; Kläy et al., 2015; Sharpe et al., 2016). Moreover, these approaches must account for normative factors, politics, inequalities, and power structures and should translate research into practice while engaging directly with society to co-create future visions and develop more realistic alternatives that are just, desirable, and sustainable (van der Hel, 2018; Wittmayer et al., 2021).

One of the critical challenges of research for transformation is identifying factors that can facilitate or enable transformational change. Recent research has suggested that "sociotechnical imaginaries" may play a crucial role in facilitating transition processes (Milkoreit, 2017). Imaginaries refer to collective visions of desirable futures, which can help set a particular direction for change and define transitional trajectories (Longhurst & Chilvers, 2019; Milkoreit, 2017). Rudek's (2022) recent study demonstrates that different private visions can transform into sociotechnical imaginaries under certain circumstances, such as collective negotiations and coalition building. When institutionally stable, these sociotechnical imaginaries can create expectations and shape the future through policies, strategies, technology, capital location, and everyday practices. Therefore, understanding the role of imaginaries in transformational change and identifying the circumstances under which they are created and institutionally stable can be crucial for designing effective transition strategies.

Although scholars have increasingly recognized the diversity of sociotechnical imaginaries across various contexts and scales and highlighted their complementarities and contestations (Longhurst & Chilvers, 2019; Milkoreit, 2017), research has primarily focused on the stabilized dominant form of imaginaries, overlooking the importance of alternative forms. However, recent studies have demonstrated that alternative sociotechnical imaginaries are essential for comprehensively understanding potential futures, challenging prevailing forms and altering

power relations (Hirt et al., 2022; Rabiej-Sienicka et al., 2022). Acknowledging the necessity and urgency of transformative change toward sustainability and the need to envision paths to achieve it, this research argues that investigating sociotechnical imaginaries, especially the alternative forms, and their emergence can be crucial in comprehending, diversifying, and shaping the future towards sustainability.

This study focuses on utilising future-oriented participatory practices as a means for individuals to share personal visions and collaboratively co-create inspiring and desirable visions. The goal is to investigate how such practices can be used at the Eindhoven University of Technology in the Netherlands to foster the emergence of alternative sociotechnical imaginaries related to transformative research in support of the institutionalisation of sustainability at the university. Therefore, the study aims to shed light on the phenomenon of the emergence of alternative sociotechnical imaginaries and their impact on transformative change by addressing the following research questions:

How can visioning processes be used in TU/e to stimulate the creation of alternative imaginaries regarding transformative research to facilitate the institutionalisation of sustainability at the university?

1. What visions do individual researchers commonly hold concerning transformative research? How do they differ from the dominant imaginary that informs universities' current practises?

2. What do collectively negotiated visions, captured in participatory workshops, reveal about alternative imaginaries for transformative research?

3. How can these alternative imaginaries inform a shift in expectations concerning the TU/e's future institutionalised responses regarding sustainability?

The central argument is that sociotechnical imaginaries arise when private visions are shared, negotiated, and transformed into coherent collective beliefs about desirable futures (Milkoreit, 2017). These sociotechnical imaginaries, in turn, create new expectations for change that inspire people and mobilize resources for specific tasks and projects. This process plays a critical role in assembling institutionalized responses designed to achieve the desired transformational outcomes (Rudek, 2022). Therefore, understanding the emergence of sociotechnical imaginaries and their implications for social change can inform strategies that promote desirable and sustainable futures.

A graph representing the research's general thesis and, therefore, the scope of analysis can be seen as follows:
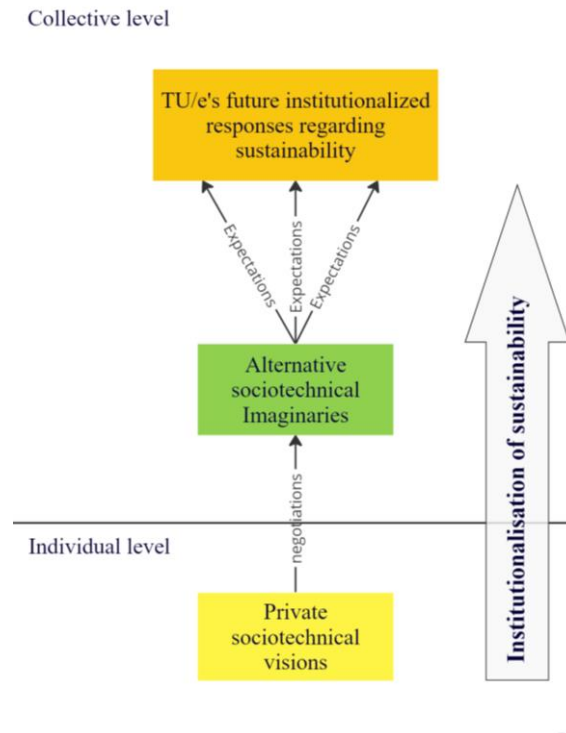
Graph 1.1. Research's scope of analysis

The present study employs a mixed-methods approach for data collection and analysis, which has been selected to facilitate comprehensive and nuanced data analysis, thereby leading to a more insightful and meaningful conclusion. Sub-questions 01 and 02 are qualitatively analysed using data collected from semi-structured interviews, empathy maps, and outputs from participatory visioning workshops. The NVivo software systematizes the coding process and organization of the codes, facilitating a thorough analysis of the data and aiding in answering the research questions. In contrast, sub-question 03 is addressed through a survey administered to workshop participants. Descriptive statistics (means) are used to analyse the survey data, and the statements are Likert-scaled and summarized as weighted means. Finally, the means are interpreted using an interval with a corresponding description.

This study contributes to the expanding body of research on sociotechnical imaginaries, focusing on empirical and local levels. The study establishes an unexplored connection between imaginaries and participatory visioning processes, advancing the comprehension of how sociotechnical imaginaries materialize and operate. Moreover, the study emphasizes the importance of acknowledging diverse future imaginaries, including those that are not yet stable but hold potential value from a policy perspective. This approach generates new knowledge and insights within a community of stakeholders, enabling researchers to gain deeper insight into their empirical context and laying a foundation for action. Additionally, the study aims to promote the institutionalization of sustainability at TU/e by comprehending its process, creating a platform for discussion, and moving from individual ideas of desirable futures towards shared and collective imaginaries, fostering new expectations and practices.

Embedding these expectations at the institutional level through conventional decision-making can lead to more significant changes.

This thesis comprises five chapters, structured as follows: Chapter 2 introduces the theoretical background, providing a theoretical perspective in which the research is embedded. Chapter 3 describes the methodology applied for data collection and analysis, along with the contextual setting in which the research was conducted. Chapter 4 presents and discusses the study's results. Finally, Chapter 5 concludes the overall research report.

2. Theoretical Background

2.1.   Sustainability and transformative change

The concept of sustainability has roots in both natural sciences and social theory and refers to meeting the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987). It is a complex and multifaceted concept encompassing multiple areas, including social, economic, and environmental aspects, as the central pillars (Hajian & Jangchi Kashani, 2021; Purvis et al., 2019). In the social sphere, sustainability includes issues such as social equity, human rights, and social justice. It is concerned with ensuring that all members of society have access to the resources and opportunities they need to thrive, regardless of their socioeconomic status, race, gender, or other factors. Social sustainability also entails promoting cultural diversity and preserving traditional knowledge and practices. In the economic sphere, sustainability is concerned with promoting long-term economic growth and development that does not harm the environment or compromise the needs of future generations. It entails creating sustainable business models and practices prioritising environmental and social responsibility while maintaining profitability. Economic sustainability also promotes equitable access to resources and opportunities, reducing poverty and inequality. In the environmental sphere, sustainability is concerned with preserving natural resources and ecosystems, reducing pollution and waste, and mitigating the impacts of climate change. Environmental sustainability includes promoting conservation and sustainable use of resources, reducing greenhouse gas emissions, and protecting biodiversity and ecosystems. It also involves promoting sustainable agriculture and forestry practices, reducing waste and pollution, and promoting renewable energy sources.

In recent years, the concept of sustainability has undergone a shift from emphasizing marginal or incremental improvements to advocating for more fundamental, systemic, or radical change towards transformative outcomes (Feola, 2015). Previously, sustainability was understood as balancing economic, social, and environmental concerns to ensure the long-term survival of human societies. This perspective considered sustainability a collection of issues that needed to be resolved by understanding and explaining environmental problems and identifying incremental approaches to address the impacts of pressing global challenges, such as climate change, biodiversity loss, and resource depletion   (O'Brien 2011, p. 110). However, this approach has been criticized for its narrow focus and failure to address the systemic and complex nature of sustainability challenges. It was argued that concentrating solely on incremental improvements and technological solutions would be inadequate for achieving sustainability, as it did not consider the systemic drivers of unsustainability or the interconnectedness of environmental, social, and economic systems.

The evolution of sustainability as a concept has resulted in a more comprehensive understanding that necessitates systemic and transformative change (Köhler et al., 2019;

O'Brien, 2012). Such change involves fundamental and systemic shifts in how society interacts with the environment and necessitates a holistic and integrated approach that considers the interconnectedness of social, economic, and environmental systems, with a collective effort from multiple stakeholders and sectors, including governments, businesses, civil society organizations, and individuals. Furthermore, transformative change requires challenging and transforming the dominant societal norms, values, and structures perpetuating unsustainable behaviours and practices. Examples of such change include transitioning to renewable energy sources, promoting circular economy models, redesigning more sustainable and equitable cities, and addressing social and economic inequalities through radical shifts to new socio-technical systems.

The call for transformative change for sustainability is gaining momentum as more people recognize the urgency and importance of addressing the origin causes of unsustainability from a systemic perspective, pressing to shift to a more sustainable path. However, many societies still struggle to transition to a more sustainable future. One reason is that the needed changes are challenging to achieve as individuals, organizations, businesses, or governments are often locked into their existing systems and do not know how to make the necessary changes.

Despite increasing recognition that transformative change is required for sustainability, there is still no consensus on what it entails and how to achieve it. Scholars such as Díaz et al. (2019) and Hoekstra & Wiedmann (2014) take a critical perspective on current economic practices and advocate for fundamental structural adjustments to production and consumption to address unsustainable outcomes. Conversely, Burch et al. (2014); Hermans et al. (2016); Sharpe et al. (2016) propose that transformational change should arise from grassroots-level networks of civic movements and initiatives that can effect significant and just transformations, despite operating in a potentially chaotic manner. McAlpine et al. (2015) and O'Brien (2012) argue that transformational change should be driven by a realignment of societal values, where individuals and collective capacities act deliberately and ethically to transform systems and structures as an integral part of an interconnected society and biosphere. Some authors highlight that existing knowledge that could facilitate transformational change is not being effectively utilized, and its ability to address complex global issues is limited (O'Brien, 2011, 2012).

It is also unclear what the role of research is in informing and enabling transformative change. Although the scientific community has excelled in comprehending the nature and implications of sustainability issues and offering technocentric solutions, it is yet to determine how transformative change can be practically achieved. Recent perspectives on transformative research advocate for a shift in academia's knowledge production approach, emphasizing the need to critically examine the application of science and technology in addressing societal needs and achieving sustainability and inclusivity objectives (Hölscher et al., 2021; Schot & Steinmueller, 2018). However, implementing this approach is challenging, given its contradiction with the prevailing scientific discourse and academic practices, which necessitates a fundamental change in how academic institutions organise education, research, and relate to society (Miller et al., 2011). The next session explores transformative research as a transformative approach to addressing complex sustainability challenges.

2.2.   Transformative research

There is an increasing recognition within the academic discourse that sustainable development cannot be achieved through traditional linear and incremental approaches. The urgency of global challenges demands transformative research that embraces complexity, interconnectedness, and innovative problem-solving. Transformative research stands apart from conventional research in its interdisciplinary approach, breaking traditional disciplinary boundaries. It employs multiple disciplines across varying scales to construct a comprehensive and integrated understanding of complex issues and devise effective solutions. Transformative research is characterized by its openness to new scientific discoveries and technological innovations rather than being confined by established methods of inquiry. The ultimate objective of this approach is to create a more equitable and sustainable future.

In their study, Wittmayer et al. (2021) highlight the distinctive approach transformative researchers took in their study. These researchers engage in conversations with individuals and communities to reframe societal issues, resulting in a co-constructed understanding of problems. The process of collaborative problem identification involves diverse stakeholders and multiple forms of knowledge and experience. Transformative researchers use a broad approach to identify the problem, seeking out different perspectives and types of knowledge to arrive at a more differentiated and reflective understanding of the issue rather than starting with a clearly defined problem and research question. Furthermore, transformational researchers foster experimentation, social design, and co-creation in practical projects and situations, facilitating structural and process-oriented functions. This approach leads to the development of new understandings and knowledge within a community of actors, providing researchers with a deeper awareness of their empirical setting and a foundation for action. Transformative research contributes to dismantling outdated systems and building new ones and highlights how the generation of empirical knowledge affects all individuals involved.

In their recent work, Hölscher et al. (2021) define transformation research as "a distinct research lens that converges different disciplines and research approaches to question the status quo and contribute to sustainability transitions fundamentally." According to the authors, adopting such a transformation research lens recognises the enduring nature of present societal issues, allowing the adoption of a counter-hegemonic position centred on radical societal change. From a perspective in which transformative research represents a crucially emerging discourse and practice in the current academic system that contests institutional structures, underlying values, and supporting routines, Wittmayer et al. (2021) argue that:

> "transformative research is committed to understanding and analysing persistent problems and to generate alternative ways of doing, thinking and organising social life that addresses these problems (...) it is based on a systems understanding and oriented towards reconstructing new systems; it acknowledges a plurality of understandings and the collaborative nature of societal action and reflection; and finally, it is best conceived as having an iterative process-based nature and focuses on reflexivity" (p. 6).

The concept of transformative research is part of a larger movement in scientific knowledge production towards a more socially robust system that is interdisciplinary and co-produced with societal actors (van der Hel, 2018). It includes many different approaches and perspectives, such as post-normal science (Ravetz, 1993), mode-2 science (Baber et al., 1995), and transdisciplinary research (Klein, 2014), which aims to improve the policy relevance of science by better connecting and applying scientific research to complex social issues and can be seen as seeds of change in the academic system. However, as argued by Hölscher et al. (2021), transformative research is distinct from these other approaches as it emphasizes contributing to sustainability transitions by recognizing the systemic nature of social issues and encouraging alternative ways of thinking, doing, and organizing society. While other approaches focus on understanding problems, transformative research emphasizes how to influence sustainable change. In order to be helpful in society and policy, knowledge must be socially robust, meaning it must be valid inside and outside academia (Miller et al., 2011). More recently, with an emphasis on the accessibility and democratisation of science, the notions of action research (Fazey et al., 2018; Stokols, 2006), responsible research and innovation (Owen et al., 2012), solutions-oriented research (Miller et al., 2014), and knowledge co-production (Clark et al., 2016) have also become influential in changes in knowledge production.

2.3. Futuring

In the context of a transformational change approach, it is pertinent to undertake a comprehensive analysis of interconnected elements such as past, present, and future situations. Future studies have gained momentum over the last few decades, attracting attention from sociologists, scientists, researchers, and futurists from diverse disciplines. These experts have developed quantitative and qualitative techniques to predict the future with a reasonable degree of accuracy (Bibri, 2018, 2020; Börjeson et al., 2006; Duinker & Greig, 2007; Piirainen et al., 2012; J. B. Robinson, 1990; Rubin & Kaivo-Oja, 1999; Vähäkari et al., 2020; Wiek & Iwaniec, 2014). The intuition for this lies in the awareness and recognition of the variety of possible futures and the fact that the future cannot be set or known with absolute certainty. Usually, this depends on people's choices and the course of action they choose in the present. Therefore, future studies do not aim to predict the future but provide decision-makers with a framework for making informed decisions in the face of uncertainty (Duinker & Greig, 2007). The primary objective of future studies is to understand potential opportunities and alternatives, enabling decision-makers to evaluate and clarify their future normative scenarios, develop visions, and formulate action plans (Bibri, 2020).

Various methodologies and approaches with different goals are used in future studies. According to observations found in the literature on the mainstream future (Börjeson et al., 2006; Marien, 2002; Rubin & Kaivo-Oja, 1999; Sharpe et al., 2016; Wiek & Iwaniec, 2014), the future can be categorised based on four ways of futures-thinking:

- *What might happen?* A predictive approach for investigating *probable futures*. It focuses on trend analysis and historical data and employs methodologies such as forecasting, trend analysis and foresight (Eames & Egmose, 2011; Nasruddin et al., 2012). Despite the challenges of describing or comprehending such changes, in these approaches, the future is typically seen as an extension of the past and is foreseeable within a set of known variations (Bibri, 2020; Sharpe et al., 2016).

- *What can happen?* Approaches that explore the representations of *possible futures* by employing scenario analyses and horizon scanning methodologies (Börjeson et al., 2006; de Brabandere & Iny, 2010; Eames & Egmose, 2011; Swart et al., 2004; van Vliet & Kok, 2015). These approaches explore uncertainties in an unknown future, usually by developing a small set of plausible and structurally different futures (Sharpe et al., 2016).

- *What is preferred to happen?* Approaches to explore the *preferable futures*, including methodologies such as visioning, narrative foresight and future imaginaries (Aitken et al., 2019; Cidell, 2017; Helling, 1998; Johansson et al., 2022; Kallis et al., 2009; Milojević & Inayatullah, 2015; Pereira et al., 2018; Riedy & Waddock, 2022; Sheppard et al., 2011; Sools et al., 2015). The primary idea is to maximise the possibility of the ideal future by describing how desirable situations might look to encourage specific courses of action.

- *How do we get there?* Approaches to identify and establish *paths*, strategic steps, or actions needed to achieve specified successful future outcomes. They include methodologies such as back casting, road maps, and action plans (Bibri, 2020; de Bruin et al., 2017; J. Robinson, 2003; Sharpe et al., 2016; Vergragt & Quist, 2011). These approaches are not limited to assessing how desirable futures can be generated and achieved; they also examine the extent to which undesirable futures can be avoided (J. Robinson, 2003).

All approaches presented here aim to create and enhance future awareness by offering alternative visions and potential courses of action based on those images. These approaches develop, present, manage, monitor, and evaluate information about the future, helping establish particular pathways, plans, and decisions about how to act to achieve the desired outcome. Working with future approaches facilitates thinking about the future by fostering creativity and expanding the temporal frame under consideration. As such, future studies entail much more than forecasting or predicting the future in terms of creating low-uncertainty predictions about specific future circumstances (Duinker & Greig, 2007). Instead, by illustrating and exploring various alternatives, these studies use various methods to develop a well-founded set of options for the future to pluralise it.

In the context of transformative change, future studies offer significant benefits by providing a conceptual framework for discussing the future and contributing to policy formulation, transition management, and the emergence of new possibilities. These studies facilitate decision-making under uncertainty, especially for long-term decisions. Researchers, scientists,

sociologists, and other futurists use various methodologies for future studies to manage uncertainty rather than eliminate it. As a result, these techniques support coping with this uncertainty by elucidating the most desirable alternatives, what is already known, what can be known, and how actions taken today may play out in each plausible future.

As previously explained, this study explores the visioning process approach adopted by TU/e to co-create a desirable, inspiring vision for the university's engagement with sustainability that can leverage the momentum of current efforts with a sharper sense of purpose. Therefore, the study does not aim to discuss probable and possible futures, although exploring the possibilities of preferable futures is crucial to broadening the study of the future to diverse perspectives. Instead, the study focuses on analysing visions of desirable futures to capture people's values, preferences, mindsets, and imaginations about an ideal future.

2.4.   Sociotechnical imaginaries

Collective and institutionalized visions about the future can serve as strong drivers of action in the present since these visions are embedded in decisions affecting the complex relationships between society, technology and power and their implications (Delina, 2018). These "visions" or, as framed in this study, "sociotechnical imaginaries", connect knowledge and technology with the production of power and social order to reach "desirable futures". The concept of sociotechnical imaginaries derives partly from the growing recognition that the capacity to see the future is a crucial aspect of social and political life. Imagination is no longer seen as a fantasy or an illusion but as a valuable cultural resource enabling new social arrangements by projecting and pursuing positive goals (Jasanoff & Kim, 2009). Nevertheless, it also fills a gap in the science and technology studies (STS) literature on theorising the relationship between science and technology and political power (Jasanoff & Kim, 2009).

Deeply rooted in the history of sociology and philosophy, the concept of "imaginaries" was developed by Jasanoff and Kim as a "term of art referring to collective beliefs about how society functions" (Jasanoff & Kim, 2015, p. 6).In their subsequent work, the authors emphasise the significance of imaginative labour, shared cultural resources, technoscientific activities and material infrastructures. Given the complex and comprehensive nature of the future, and the role of technology in shaping society, the authors refined the concept of sociotechnical imaginaries:

> Our definition pulls together the normativity of the imagination with the materiality of networks: sociotechnical imaginaries thus are "collectively held and performed visions of desirable futures" (or of resistance against the undesirable), and they are also "animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology." Unlike mere ideas and fashions, sociotechnical imaginaries are collective, durable, and capable of being performed; yet they

are also temporally situated and culturally particular. Moreover, as captured by the adjective "sociotechnical," these imaginaries are at once products of and instruments of the co-production of science, technology, and society in modernity (Jasanoff & Kim, 2015, p. 19).

Although the concept is well established in the literature, it is worth mentioning that imaginaries are different from policy agendas. Imaginaries are less transparent, less focused on a single issue, less goal-oriented, less politically accountable, and more instrumental. Instead, they are embedded in the metaphors, discourses, and cultural meanings that underpin actors' policy choices (Jasanoff & Kim, 2009). Neither are they narratives, which frequently extrapolate from the past and serve explanatory or justificatory objectives, "imaginaries are instrumental and futuristic: they project visions of what is good, desirable, and worth attaining for a political community; they articulate feasible futures" (Jasanoff & Kim, 2009, p. 123). Imaginaries are firmly rooted in the present while simultaneously looking towards the future.

Over the last decade, scholars have conducted various studies on sociotechnical imaginaries in different areas of societal transformation, focusing on the energy transitions in many countries globally. These transitions have provided a rich ground for exploring the processes involved in envisioning future scenarios (Ballo, 2015; Burnham et al., 2017; Engels & Münch, 2015; Hirt et al., 2022; Höysniemi, 2022; Richter et al., 2017; Ryghaug & Toftaker, 2016; Santos Pereira et al., 2017; Schelhas et al., 2018; Smith & Tidwell, 2016; Wentland, 2016). However, it is essential to note that sociotechnical imaginaries are not restricted to the scale of nation-states. Organisations, organised groups, communities, and social movements can also disseminate such imaginaries (Jasanoff & Kim, 2009)

The empirical investigation of the local and regional dimensions of Jasanoff and Kim's concept remains understudied despite its significance. Strauss (2006) cautioned against homogenizing and reifying imaginaries and underscored the importance of contextualizing them in specific social, material, and actor-related conditions. Levenda et al. (2019) argued that exploring the local dimension of sociotechnical imaginaries is critical to understanding the origins of dominant collective visions of the future. Local specificities may arise from factors such as historical and geographical contexts, political identities, and cultural beliefs, which influence culturally and regionally specific social responses.

Sociotechnical imaginaries are infrastructures for envisioning and planning the future (Sismondo, 2020). Sociotechnical imaginaries serve as a backdrop, encapsulating the deep-seated ideals of what the future should be, what it should achieve, and how it can contribute to socially desirable outcomes. As performative visions, imaginaries connect aspects of the present with the past and the desirable future, thus potentially creating conditions to attain them. As Delina (2018) explains:

> Studying imaginaries entails being attentive towards how they can link past and future times, enable or restrict actions in spaces, and normalise ways of thinking about many possible future worlds. The power of imaginaries is so profound in that they can guide and coordinate action across techno-epistemic networks,

establish key political decisions, justify new investments in science and technology, promote certain development pathways, and even justify the inclusion or exclusion of certain actors in the decision-making process (Delina, 2018, p. 50).
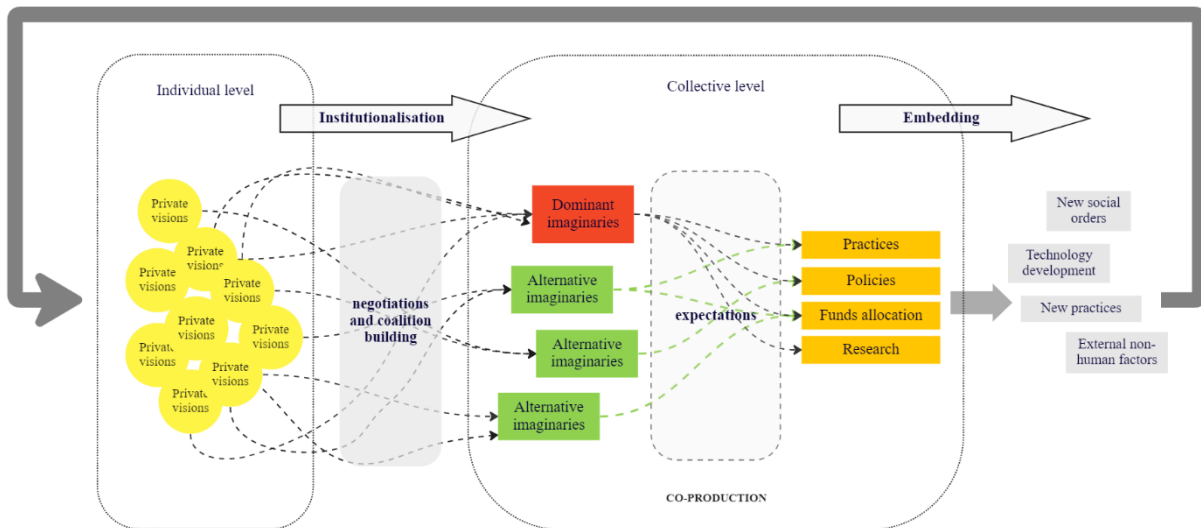
Hence, sociotechnical imaginaries, as defined by Jasanoff & Kim (2009), are "associated with active exercises of state power, such as the selection of development priorities, the allocation of funds, the investment in material infrastructures, and the acceptance or suppression of political dissent" (p. 425) and operates, therefore, between imagination and action, discourse and decision, and incipient public opinion and state policy.

2.4.1. *Sociotechnical imaginaries cycle*

In recent years, scholars have shown a growing interest in understanding how new imaginaries are formed and how they can shape societal transformations (Mukherjee et al., 2023; Cowell & De Laurentis, 2022; Rabiej-Sienicka et al., 2022; Rudek, 2022). Scholars have examined how new imaginaries can emerge and evolve in response to changing social, political, and economic conditions and how they interact with existing imaginaries. This focus on the emergence and evolution of imaginaries has highlighted the importance of the collective aspect of imaginaries, describing how individual views are impacted and inspired by external motivations and social and cultural contexts in shaping collective visions of the future.

In a recent scholarly investigation, Rudek (2022) introduced an integrated model (*Graph 2.2*) known as the "sociotechnical imaginaries cycle" to explicate the mechanisms underlying the influence of sociotechnical imaginaries on society. The author's proposed model elucidates how different private visions, subject to certain circumstances, such as collective negotiations and coalition building, can transform into sociotechnical imaginaries and attain institutional stability. Once such imaginaries reach institutional stability, they can shape future expectations through various channels, including policies, strategies, technology, capital allocation, and everyday practices.

Rudek's (2022) model proposes that the transition of private sociotechnical visions into institutionalised, collectively held visions of the future is primarily facilitated through negotiations and coalition formation. In the "sociotechnical imaginaries cycle," private sociotechnical visions are projected, institutionalised and consolidated into desirable and achievable goals. These goals trigger future expectations, mobilising resources and actors towards specific, goal-oriented tasks, projects, and social practices. As these practices become a part of society, they may lead to new social orders and technological developments, thus restarting the cycle. As noted by Jasanoff and Kim, sociotechnical imaginaries can originate from the visions of single individuals and gain traction through power or sustained coalition-building exercises. However, only when the originator's vision is communally adopted does it rise to an imaginary status.

Graph 2.2. Sociotechnical imaginaries cycle. Adapted from Rudek (2022).

Building on Rudek's (2022) model, the present study directs attention to the emergence of the alternative form of sociotechnical imaginaries in the formation and pre-stabilisation phase before institutional stability. The following section delineates the theoretical foundations of the study's scope of analysis, formed by three analytical components: *private sociotechnical visions*, *alternative sociotechnical imaginaries*, and *future expectations*.

Private sociotechnical visions

Sociotechnical imaginaries unify and institutionalise private sociotechnical visions and establish desirable and realisable communal objectives. In other words, imaginaries of social groups emerge when collective beliefs about desirable futures are formed through the convergence and coherence of shared private sociotechnical visions.

Rudek's (2022) notion of private sociotechnical visions is rooted in Berkhout's (2006) concept of future visions, which refers to communicable schemata that represent future objectives and how they will be achieved. Berkhout underscores the importance of embedding technology within a moral and institutional framework, aligning with technology and institutions' co-evolution. In essence, the private sociotechnical visions are grounded in future visions encompassing technology within an institutional and moral context. The convergence and consistency of these private sociotechnical visions culminate in shared visions of the future, eventually giving rise to collective imaginaries that steer and shape societal expectations and practices.

Berkhout (2006) distinguishes between private visions, which are not communicated or shared, and those that are shared and communicated. According to the author, shared visions must be codified to be communicable and may be disseminated through various channels, such as literature, political discourse, and organisational statements. Berkhout further notes that private visions that remain uncommunicated lack the capacity to motivate action and, therefore, are

unlikely to be socially significant, even if powerful social actors hold them. The boundary between private and shared visions is not always clear-cut and may be difficult to define.

Private visions are viewed as co-produced and incorporated into a cycle, implying that they can both impact and be influenced by the collective imaginary. As such, the notion that private visions are entirely private is questioned, given their interconnectedness with broader sociotechnical systems and their co-evolutionary dynamics. Consequently, any examination of the circumstances under which private sociotechnical visions can evolve into shared sociotechnical imaginaries must account for the historical context and dominant sociotechnical imaginaries of the past and the institutionalized context of the present.

Private sociotechnical visions, therefore, refer to individual visions about the role of technology in society will develop in the future and its potential impact on social and environmental issues. These visions are personal and subjective and may be influenced by various factors, including personal beliefs, values, experiences, aspirations, and historical and institutionalized contexts. Private sociotechnical visions can be vital because they can serve as the foundation for developing shared sociotechnical imaginaries. When individual visions converge and become coherent, they can create a shared vision of the future, which can be institutionalized and widely accepted by a social group. In this sense, private sociotechnical visions can serve as a building block for developing shared imaginaries that guide collective action towards a desired future.

Alternative sociotechnical imaginaries

Alternative sociotechnical imaginaries refer to collective conceptions or visions of desirable futures that describe and shape the way society imagines and values different social, technological, and environmental possibilities, challenging the dominant sociotechnical imaginaries. They represent alternative ways of thinking about the role of technology in shaping society and the environment and are often characterized by a critique of the status quo and a desire for change.

These imaginaries are not limited to technology but extend to broader societal goals, such as (Levenda et al., 2019)sustainable development, social justice, and democratic governance. They can be represented by various social groups and actors, including civil society organizations, social movements, local communities, niche technological innovations, alternative interest groups, or even pop culture art (Rudek, 2022). These alternative imaginaries can also be in productive tension with the dominant sociotechnical imaginary and can contest it, providing a critical perspective on the problems and limitations of the current dominant model (Marquardt & Delina, 2019). They challenge the dominant sociotechnical imaginary that currently dominates the technological and social progress discourse, which often prioritizes economic growth and technological innovation over social and environmental sustainability.

According to Levenda et al. (2019), understanding the emergence and influence of alternative sociotechnical imaginaries requires recognising shifting dominant beliefs. This recognition presents opportunities for alternative visions to take root and flourish, challenging prevailing cultural values linking science, technology, innovation, and public good. As such, identifying and recognising alternative sociotechnical imaginaries and their relationship with the dominant

sociotechnical imaginary are essential for promoting sustainability and transformative change in society.

Expectations about the future

Expectations refer to the beliefs, assumptions, and hopes about the future that individuals, organizations, and societies hold (Berkhout, 2006). Past experiences, cultural norms, and social and political contexts can influence expectations. They play a crucial role in shaping individual and collective actions and decisions, as they motivate and direct behaviour towards specific goals and outcomes. In the sociotechnical imaginaries context, expectations are seen as a catalyst for actors's actions and resource mobilization, as they are shaped and powered by the broader sociotechnical imaginary. Thus, they can be understood as more specific, project-related processes to fulfil the imagined desired future (Rabiej-Sienicka et al., 2022).

Berkhout (2006) argues that while visions of the future are ubiquitous and context-specific, "expectations are intrinsic to social action" (p. 299). Similarly, Rudek (2022) claims that while "sociotechnical imaginaries are much more stable and constitute a broader vision of the better and desirable future", "expectations are more local, project-, or industry-specific" (p. 226). According to the integrated model of Rudek (2022), once private visions are institutionalised through negotiation and coalition, the resulting sociotechnical imaginaries can consequently shape paths, development priorities, and actions in the form of policies, fund allocations, and specific practices and research directions. Therefore, triggered by sociotechnical imaginaries, expectations stimulate actors and mobilise resources for specific tasks and projects, making them more project- and goal-oriented (Rudek, 2022).

This concept of expectations is especially important for understanding and studying the performativity of sociotechnical imaginaries. Scholars use this concept to study how imaginations originate and become solidified through social norms and object performance (Delina, 2018). Sociotechnical imaginaries shape expectations, driving actions through collective desires. Therefore, the performativity of these imaginaries can be analysed by examining their influence on concrete actions such as political decisions, legal acts, and funding allocations for innovation, evaluating their ability to align behaviour and motivate action while justifying costs.

This concept also considers the co-production of visions of social order with science and technology. Sociotechnical imaginaries shape technology development and governance mechanisms through active state power. This is achieved by coalition-building in policy settings that shape objects, infrastructures, and institutions. Therefore, the performativity of sociotechnical imaginaries depends not only on the technology but also on its institutional and political context associated with governance mechanisms (Graf & Sonnberger, 2020). In order to evaluate it, it is necessary to examine how they shape technological deployment and related governance instruments while mobilizing resources towards specific goals.

This study does not aim to examine the performative aspects of the alternative imaginaries investigated in this research but rather to identify and explore a possible initial shift in

expectation triggered by these alternative imaginaries, which at a later stage may manifest in social practices.

The table below summarizes the definitions of the three analytical components of this study previously discussed.

Table 2.1. Summary of the definitions of the three analytical components of this study

Analytical component	Description
Private sociotechnical visions	Private sociotechnical visions are personal perceptions of what the future should look like and how technology can contribute to achieving that future. These visions are often grounded in experiences, values, and interests, the historical past and the institutionalized context of the present and are not yet widely shared or institutionalized. Private sociotechnical can be transformed into sociotechnical imaginaries when shared, negotiated and integrated with other private visions through co-production and coalition-building processes.
Alternative sociotechnical imaginaries	Alternative sociotechnical imaginaries refer to collective visions of desirable futures that describe and shape the way society imagines and values different social, technological, and environmental possibilities, challenging the dominant sociotechnical imaginaries. They represent alternative ways of thinking about the role of technology in shaping society and the environment and are often characterized by a critique of the status quo and a desire for change. These imaginaries are created by social groups and actors that offer different visions for the future based on distinct cultural, social, and political values. They represent a collective understanding of a desirable future and how society should achieve it, contributing to more sustainable, just, and democratic societies.
Future expectations	Shaped and powered by sociotechnical imaginaries, expectations are beliefs, assumptions, and hopes about the future that individuals, organisations, and societies hold that shape actions, decisions, resource mobilisation, and behaviour towards specific goals and outcomes. They serve as a stimulus for actors' actions and resource mobilization. Expectations are often triggered by the performativity of sociotechnical imaginaries, which refer to how these imaginaries are solidified in practice through the acceptance of social norms and the performance of objects. Expectations drive people's actions through collective, institutionally stabilized desires established by sociotechnical imaginaries.

3. Research Methods

3.1.   Case study

This study employs a case study methodology to understand a particular phenomenon's dynamics and explore complex issues within a specific context. This methodology is particularly beneficial when the phenomenon under study is context-dependent, as in this research. Furthermore, case studies allow the integration of qualitative and quantitative data and the incorporation of multiple sources of evidence, including interviews, surveys, and observation. These factors enable a comprehensive and detailed analysis of the phenomenon, which is crucial for achieving the research objectives.

3.1.1.   Eindhoven University of Technology

Eindhoven University of Technology (TU/e) is a renowned public higher education institution and academic research centre in Eindhoven, the Netherlands, specialising in engineering, science, and technology. Established in 1956 through a collaborative partnership between industry, local government, and academia, TU/e is widely recognized as a premier technical university globally. With a moderate size, the university enrols around 13,000 students and employs approximately 3,600 staff members. However, with the current university's Scale Jump Plan, master's degree graduates will double by 2032, and the total student population will expand from 13,000 to 21,000 by 2035. This initiative aims to meet the rapidly growing demand for engineers in the Brainport region.

One of the distinctive features of TU/e is its close collaboration with advanced industries. The university is situated in the Brainport Eindhoven region, an internationally renowned high-tech innovation ecosystem that is a hub for research and development (R&D) and manufacturing. The region boasts the highest number of patents in Europe and is home to global corporations such as Philips, NXP, ASML, DSM, and DAF Trucks, major corporate R&D centres and leading Dutch research institutes. As a result, TU/e has established partnerships with several public and private entities within the region, further promoting research excellence and industry engagement.

TU/e's research and education are characterized by a strong emphasis on technology, innovation, and collaboration with industry and other academic partners. This intense focus on technology is reflected in its campus infrastructure and facilities. The Eindhoven University of Technology is known internationally for its expertise in research on basic science, application-driven technology development and problem-solving in engineering and design. The key research areas are identified as energy, health and smart mobility. The university has state-of-the-art research facilities, including cleanrooms, wind tunnels, and labs for nanotechnology and photonics. TU/e is also home to several research centres and institutes, such as the Eindhoven

University of Technology High Tech Systems Centre, which focuses on developing advanced technologies in collaboration with industry partners.

3.1.2. Sustainability at TU/e

TU/e has a rich history in transition studies, which can be traced back to the collaboration between historians of technology and innovation scholars. Professors Johan Schot and Frank Geels are two prominent scholars who have played a crucial role in the birthplace of transition studies at TU/e. Their interdisciplinary approach towards studying technological change has paved the way for developing transition studies. This group has made significant contributions to the field of sustainability, and its research has been widely recognized and applied in practice. Therefore, TU/e's expertise in technology and innovation is not limited to the technical aspects but extends to technology's social and environmental aspects, making it a unique institution in engineering and design.

The TU/e Institutional Plan for 2020-2025 has identified sustainability as one of the major societal challenges the university intends to address through its education, research, and operations. TU/e has established diverse research groups and projects aimed at facilitating the transition towards a more sustainable society, with a particular focus on the Sustainable Development Goals related to "Good Health and well-being," "Affordable and Clean Energy," "Industry, Innovation and Infrastructure," "Sustainable Cities and Communities, Responsible Consumption and Production," "Climate Action," and "Partnerships for the goals." In addition to research, the university has taken various measures, such as separating waste, providing environmentally friendly catering, and promoting the use of renewable energy on campus. Sustainability is also incorporated into the education programs, with various elective courses dedicated to the topic.

3.1.3. The development of #sustainableTU/e

The #sustainableTU/e initiative was launched on September 1, 2021, with the appointment of Professor Anna Wieczorek as the Sustainability Ambassador. The initiative aims to enhance sustainability integration across four key areas: research, education, (campus) operations, and governance, with the overarching objective of institutionalizing sustainability and facilitating coordinated university activities. The initiative identified three primary objectives for the years 2021-2025, which the Board of Directors endorsed has endorsed:

OBJECTIVE 1 - Establishing an organizational structure to facilitate sustainability initiatives

OBJECTIVE 2 - Conducting a comprehensive sustainability assessment across research, education, campus operations, and governance

OBJECTIVE 3 - Developing a comprehensive shared vision to provide guidance to new and ongoing initiatives

This study focuses on Objective 3, supporting the #sustainableTU/e visioning process. The process seeks to develop a comprehensive shared vision of sustainability that can serve as

guiding principles for integrating sustainable practices at TU/e and inspire its strategic direction. This process aims to institutionalize sustainability at the university by creating a vision that can leverage existing efforts with a more precise and defined purpose. The process also intends to anticipate and position the university for the future by developing scenarios that explore the evolving landscape of research, education, campus operations, and governance, including their synergies and potential challenges. Ultimately, the outputs of the visioning process will provide valuable input to the university's strategic planning.

The participatory visioning process methodology integrates techniques of long-term visioning with backward goal setting (back casting) and forecasting to identify and verify short-term activities. The process aims to explore three horizons, divided into phases: (1) building on what is already working, (2) adapting to what has changed, and (3) shaping what is to come. During the first phase, a series of interviews were conducted with scholars and staff who had previously led sustainability-related activities to comprehend their vision of the changing role of the university and identify areas that needed more attention. In the second phase, the focus was on adapting to changes by preparing for them. Critical drivers for change were identified through scenario analyses, and their interactions were explored. Finally, in the third phase, aimed at shaping what is to come, a series of participatory visioning workshops were conducted with the broader TU/e community to collaboratively create inspiring images of what is desirable for the future of sustainability at TU/e.

This research was developed alongside the #sustainableTU/e visioning process, focusing on the specific research domain of sustainability in the third phase of the process. As such, this study's scope is limited to identifying and exploring desirable future trajectories for transformative sustainability research at TU/e. The participatory visioning workshops were held at the university between October 2022 and February 2023, with a total of 66 participants. The Data Collection and selection section provides a detailed explanation of the participatory visioning workshops.

3.2. Data collection and selection

The current study employs a mixed methods research approach (see *Graph 3.3* below for an overview of research methods), which integrates various research methods, to enhance the comprehensiveness and accuracy of the data collected. Using multiple research methods enables the researcher to triangulate the data, meaning that findings from one method can be corroborated or validated by findings from another, thereby enhancing the validity and reliability of the collected data (Carter et al., 2014). The data collection procedures for this study involve several techniques, including semi-structured interviews, empathy mapping, participatory workshops, and surveys. A detailed description of each method used is presented as follows.

QUESTIONS	DATA COLLECTION	DATA ANALYSIS	OUTPUTS
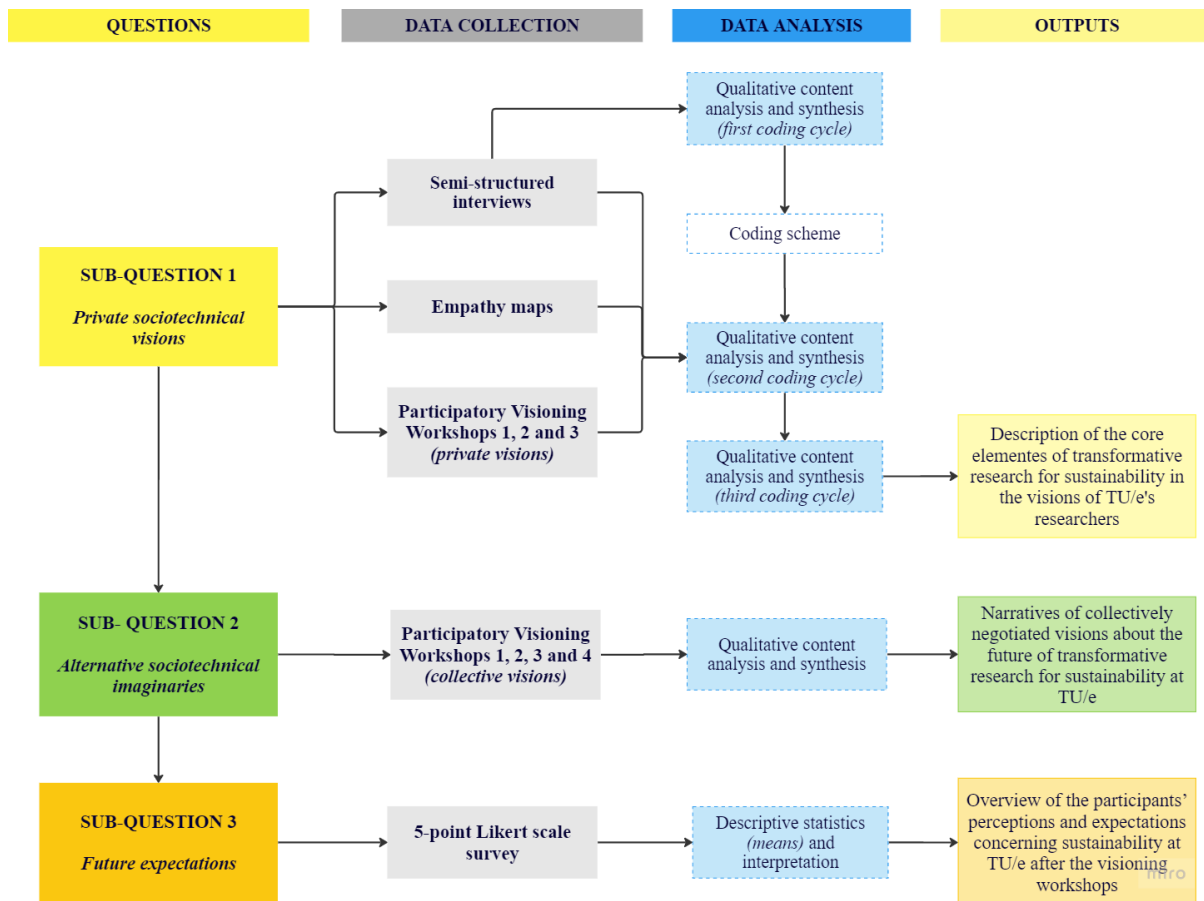
Graph 3.3. Overview of research methods

3.2.1. Individual semi-structured interviews

Individual interviews are the most often used data collection method in qualitative research (Busetto et al., 2020). Through individual interviews, researchers can acquire extensive information about a participant's opinions, beliefs, knowledge, and attitudes about a particular topic (Gill et al., 2008). Individual interviews usually involve a one-on-one, in-depth, and interactive conversation in which the researcher asks questions and directs the discussion with one specific participant at a time.

The general purpose of the semi-structured interviews in this study is to explore the individual perspectives, visions, and motivations of TU/e researchers concerning transformative research for sustainability. The data from 25 semi-structured interviews were collected to gather the most comprehensive insights for this research. A number of 17 interviews were derived from secondary data, meaning that the interviews were conducted and, therefore, the data were collected by other researchers within the #sustainbleTUe project. This approach employs secondary data to offer context and detail to the analysis while simultaneously avoiding unnecessary data duplication, saving time and research efforts (Cheng & Phillips, 2014).The other eight interviews were conducted primarily for this study.

The initial interview subjects were identified and selected due to their active involvement in or interest in sustainability research at the university, with additional interviewees suggested through a snowballing method. The selection included different levels of professors, students, and staff from diverse university departments. An overview of interview participants can be found in *Appendix A*. All the interviews lasted between 45 and 60 minutes and were conducted in person and online via MS Team. The interviewees were asked to read and sign the Information and Consent Form describing the interview's purpose and procedures. A copy of this form can be found in *Appendix B*.

The interviews were conducted using a semi-structured format and guided by three main questions with accompanying sub-questions. The interview guide was developed to achieve specific, predetermined objectives and comprised three distinct sections (see the table below).

Table 3.2. Three parts of the interview on transformative research for sustainability

Interview section	Main Interview Question	Objective
1) Defining Transformative Research	*What does it mean to you in your own research to be transformative for sustainability?*	Capture the participants' understanding of what transformative research for sustainability is in order to characterise transformative research in the university's context
2) Envisioning the Future	*How do you envision the future of the (transformative) research for sustainability at TU/e?*	Capturing the participants' visions regarding transformative research for sustainability at TU/e
3) Pathway: Gap-Spotting	*What do you think has to happen to make such a vision come true? What's standing in the way?*	Identify possible opportunities/enablers, challenges/limitations, and pathways to the visions for the future

During the interviews, the interviewer ensured that participants could explain and elaborate as much as possible on areas that the interviewee deemed relevant, and this ensured that rich and diversified information was gathered during these interviews. The complete interview guide can be found in *Appendix C*.

All the interviews were recorded on a mobile phone with an audio recording application. Each interview was transcribed and uploaded to the software NVivo for analysis.

3.2.2. Empathy mapping

There is a growing trend toward using data to better understand people and their behaviour. One such method is empathy mapping, which uses data to map people's emotions. In contrast to surveys and other quantitative methods, an empathy map is an imaginative exercise that voices participants' emotional experiences. In this way, an empathy map captures the emotional experiences of a group of people systematically.

Empathy maps usually have a simple visual format with open-ended questions designed to prompt reflection and expression of feelings (Pileggi, 2021). In this study, the researchers applied empathy maps to the workshop participants to identify the core concerns and capture the overall emotional tenor regarding sustainability at TU/e. Participants used empathy maps as a tool for reflective journalling, allowing them to express their concerns, worries, fears, and frustrations.

The empathy maps applied to the participants during the workshops were developed based on the following central question *"What do you hear, see, think, feel, say, and do regarding sustainability at TU/e?"* (see *Figure 3.1* below). Visualising what the participants say, do, see, and hear allows the researchers to understand the individual perspectives and identify both hopes and frustrations concerning how TU/e engages with sustainability. The empathy maps provided insights into current concerns rather than visions for the future.
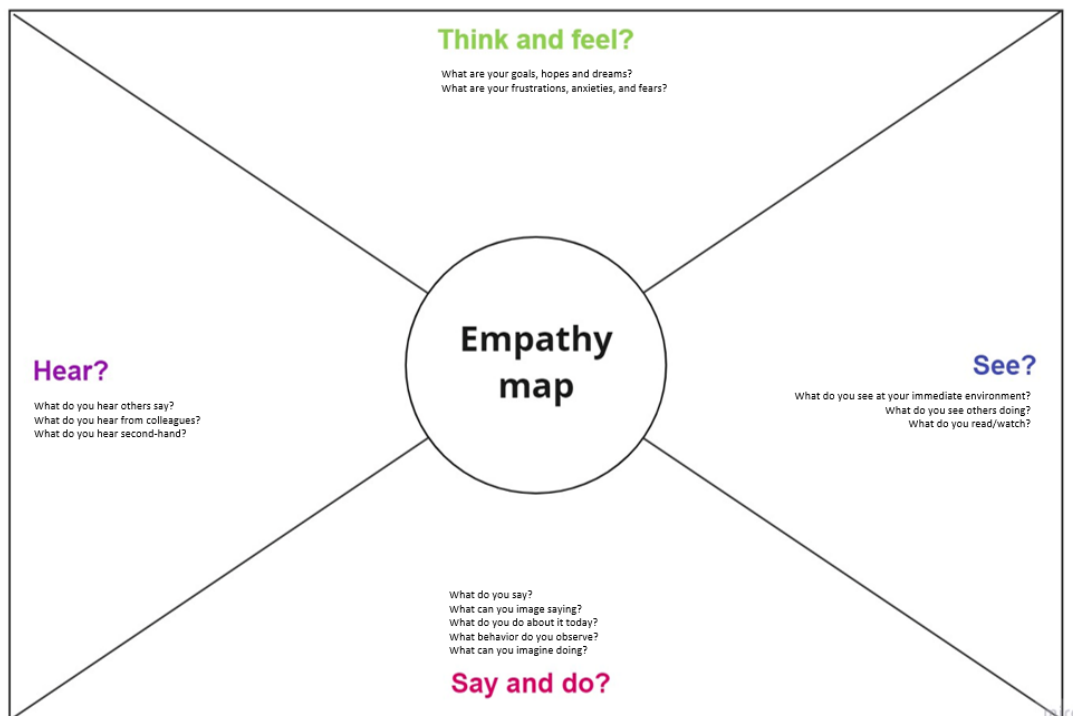
Figure 3.1. Empathy map form (#sustainableTU/e visioning process, 2022).

3.2.3. Participatory Visioning Workshops

Participatory visioning is a technique social scientists, planners, and other stakeholders use to engage people in imagining a different future or desirable state of affairs. It is a tool that has been used successfully to create momentum towards achieving specific goals, such as reducing poverty, improving access to education, and protecting the environment (Bibri, 2018). Participants discuss their goals and possible solutions to those problems in a participatory workshop format. This collaborative process helps people connect and work more closely with each other to identify new solutions and generate new ideas.

For this research, the #sustainebleTU/e Participatory Visioning Workshops were employed to obtain direct feedback from participants representing various segments of the university community. The primary objective of these workshops was to gain an in-depth understanding of the university's general community's perception of the future of transformative research for sustainability at TU/e. The study's success hinged on discussion and collaboration between diverse participants. Guided by the specific research question, *"How can the university catalyse transformative, world-changing research in sustainability?"* participants were invited to share their perspectives and discuss their aspirations for the university's future regarding sustainability. As the university-level planning and implementation require a long-term vision, the workshop discussions focused on a 30-year time frame (2052) to envision and develop the necessary changes to make the university a leader in transformative research for sustainability.

The primary objective of the participatory visioning workshops was to challenge the prevailing paradigms of the university that may not prioritize sustainability effectively. The workshops aimed to create space for alternative imaginaries and envision a more sustainable future for the university. The focus was on identifying what is missing and what the university should aim to achieve rather than determining what is already established and known.

Four workshops were held during the visioning process, three of which were dedicated to co-creating a desirable, inspiring vision for TU/e's engagement with sustainability, with a total of 51 participants. The fourth workshop was held to refine these visions collectively and develop and discuss possible scenarios, exploring the critical drivers for change and their interactions. This fourth workshop had 14 participants. An overview of workshop participants can be found in *Appendix D*.

Visioning Workshop design

The two-hour workshop was structured into three phases. In the first phase, the participants were introduced to the #sustainableTU/e initiative, the workshop objectives and the timeline, followed by an "activating activity" to activate creativity and openness.

In the second phase, "grounding in the present," the focus was on the present moment on an individual private level, where the participants were asked to journal in the Empathy Maps, reporting what they see, think, feel, say, and do concerning sustainability. A group discussion afterwards was performed.

In the third phase, "grounding in the future," the focus was first on individual visions. The participants were encouraged to develop ideas and visions for the desired future and identify the principles and actions needed to shape the university as a proactive agent of change capable of inspiring actions far beyond the campus. Thus, the participants were asked to reflect and write down, by hand using sticky notes, their personal ideas for the future of the university's upcoming 30 years regarding sustainability. At this moment, the participants were freer to be more generic in their ideas. In the second part of this phase, the participants had to collectively discuss their visions, moving from general and individual to more descriptive, elaborated, and collectively thought, trying to focus on the specific domain (research, education, governance, or campus operation) and make the vision as concrete, inspiring, and mobilising as possible, both in the sense of describing it and what it means to achieve it. In order to help in this process, a large paper with a funnel graph and guiding questions were used (see *Figure 3.2* below).
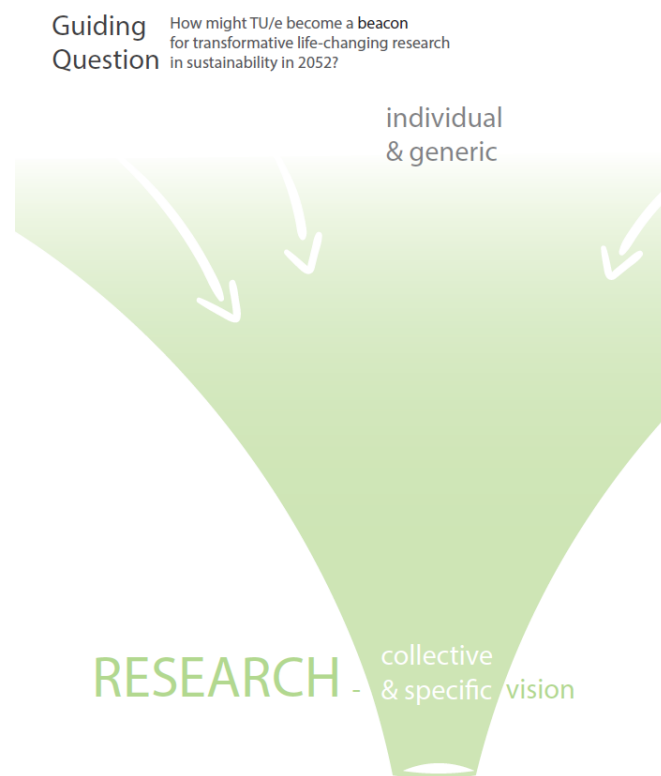
Figure 3.2. Visioning Workshop funnel graph (#sustainableTU/e visioning process, 2022).

During the entire workshop, participants worked exclusively in their assigned groups. The groups were formed according to the participants' interests in particular sustainability domains (research, education, governance, or campus operation). Each group was asked to focus on the visions relating to that specific sustainability domain and should not have more than six people. At the end of the workshop, a plenary discussion was held focusing on the visions elaborated by each group.

Throughout the workshops, an illustrator hired by the visioning process team was present to listen and visually capture the essence of the participants' discussions. The resulting illustrations are presented throughout this report and serve as a form of documentation, capturing key concepts and ideas discussed during the workshops, visually representing the discussions and contributing to a deeper understanding of the participants' visions on sustainability at TU/e. The presence of an illustrator was a distinctive aspect of the workshops, as it allowed for a more creative and engaging way of capturing the participants' thoughts and ideas.

3.2.4. 5-point Likert scale survey

Measuring a shift in perception or expectation can be a complex task, as these phenomena are subjective and may vary significantly from person to person. However, surveys and questionnaires can gather data on people's perceptions and expectations before and/or after an event or experience, and this can provide insights into how their perceptions and expectations have shifted over time.

There are several ways to collect data through a survey, but one that has become increasingly popular in recent years is using a 5-point Likert scale survey. Likert scales (Likert, 1932) are frequently employed in the social sciences to collect attitudes, behaviours, and opinions. This type of survey allows for more detailed and nuanced data collection, which can help understand the experiences and perspectives of a specific group of people and create better policy decisions in the future. It also provides a higher degree of objectivity to the analysis process, which can provide a more accurate representation of the data collected.

This study conducted a 5-point Likert scale survey to investigate the participants' perceptions and expectations concerning sustainability at TU/e after the visioning workshop. The survey was conducted online through MS Office forms and was sent via email directly to the workshop participants two weeks after the third visioning workshop (Survey 1) and a week after the fourth workshop (Survey 2). The answers were kept confidential, used only by the researchers in the #sustainableTU/e research projects, and destroyed immediately after processing. In total, 21 participants answered the first survey (response rate of 41%) and 7 in the second survey (response rate of 50%).

The survey had eight questions and took about six minutes to complete. The first four questions required objective answers regarding the participant's position at TU/e (student or staff) and the department they are located in, which workshop they participate in and which sustainability domain (research, education, campus operation or governance) they engaged in during the workshop. After that, in the survey's subsequent two questions, the participants were asked to rate specific statements on a 5-point Likert scale. One question with three statements regarding the participants' attitudes during the workshop. And one question with ten statements concerning the participants' perceptions after the workshop. On those questions, the respondents needed to indicate their level of agreement or disagreement with the statements on a 5-point Likert scale: 1) Strongly Disagree, 2) Disagree, 3) Neither agree nor disagree, 4) Agree, and 5) Strongly Agree. The statements were prepared to capture the participant's

experience of the sustainability vision workshop and their additional thoughts, feelings and expectations about sustainability at TU/e. At the end of the survey, two non-mandatory open-ended questions were added, allowing the participants to make additional comments and elaborate further on their opinion about sustainability at TU/e. The complete questionnaire can be found in *Appendix E*.

3.3. Data analysis

This section delineates the data analysis procedures conducted in this study. The data were analysed separately for each sub-questions as described as follows.

3.3.1. Sub-question 01

The first objective of the analysis was to investigate how researchers at TU/e conceptualize transformative research and its fundamental components. For this, a inductive coding process was applied, focusing on the initial part of the interviews. The first coding cycle aimed to condense the data into codes, sub-codes, and categories derived from the data, existing theories, and prior knowledge. This process resulted in a preliminary coding scheme. The initial codes pertained to the conceptualization elements of transformative research, which were further classified into sub-codes (collaboration, experimentation, technical and social science interaction, local action, long-term approach, positive societal impact, problem-driven, social and environmental responsibility, and transdisciplinarity). The initial coding scheme also included codes for the challenges, limitations, opportunities, and enablers associated with transformative research.

During the second coding cycle, the remaining data from interviews, empathy maps, and the outputs of the second phase of the workshops were analysed. This analysis aimed to investigate the private sociotechnical visions of TU/e researchers regarding transformative research. The goal was to identify the core constituent elements of these personal visions, how they were expressed, and how they differed from current university practices. Additionally, the analysis sought to identify the opportunities, enablers, challenges, limitations, pathways, and the general sense of optimism or pessimism, satisfaction or frustration associated with these personal visions. The materials were coded using the coding scheme of the first coding cycle. Additional codes and sub-codes were added when needed.

A third coding cycle was executed to cluster the previously identified core elements, associating them with the opportunities, challenges, and pathways for achieving those visions. An additional focus was placed on identifying any contrasting or dilemmatic points. This final coding of the data helped readjust categories and comprehend and assess the information within the context of the research question.

3.3.2. Sub-question 02

This study utilized a content analysis method to investigate data obtained from participatory workshops and develop narratives that depict the future vision of sustainability according to the participants' perspectives. The aim was to gain a better understanding of their visions and values. The narratives created captured the essence of the data and provided more profound insights into the collective aspirations and goals of the participants.

3.3.3. Sub-question 03

The 5-point Likert scale survey responses were analysed using the Likert scale's mean scores separately for each statement. First, the total scores on the Likert Scale were determined by multiplying the frequency (number of respondents) of each response statement by its corresponding Likert scale score.

$$\text{Total scores} = \Sigma \ (f \times \text{Likert scale score})$$

where:

f = frequency (number of respondents) of each Likert scale score

Likert scale score = 1 for Strongly disagree; 2 for Disagree; 3 for Neither agree or disagree; 4 for Agree and 5 for Strongly agree.

Second, the mean scores were determined by dividing the total scores by the total number of respondents.

$$\text{Mean Score} = \Sigma \ (f \times \text{Likert scale score}) \div \text{the number of respondents}$$

The mean scores were interpreted as strongly disagree in the point range of 1.00 - 1.79, disagree 1.80 - 2.59, neutral 2.60 – 3.39, agree 3.40 - 4.19, and strongly agree 4.20 - 5.00 (Pimentel, 2010) (see *Table 5.3*).

Table 5.3. Interpretation of 5-point Likert scale measurements

Likert-Scale score	Description	Interval
1	Strongly disagree	1.00 - 1.79
2	Disagree	1.80 - 2.59
3	Neither agree or disagree	2.60 - 3.39
4	Agree	3.40 - 4.19
5	Strongly agree	4.20 - 5.00

4. Results and Discussion

4.1.　Private sociotechnical visions

The first objective of this study was to identify and explore the 'private sociotechnical visions' commonly held by the researchers, individually, that concern (transformative) research for sustainability. The data analysis revealed a diversity of perspectives, but when clustered, it led to relatively few elements that could capture well the private visions of what transformative research for sustainability should look like at TU/e in a desirable future.

It is worth noting that the data collected through the interviews and workshops did not allow for a complete understanding of the researchers' private visions. However, the aggregating findings provide a glimpse into the most pressing concerns and the core elements of the desirable future of transformative research for sustainability on TU/e. The results presented in this study focus on critical elements of and for transformative research, including aspects of institutional research environments, research designs, mindsets, and skills, to support sustainability transitions.

4.1.1.　Core elements of transformative research for sustainability in the future visions

The participants of both interviews and workshops presented diverse perspectives on transformative research approaches for sustainability within the university setting. This section provides a summary and description of their core elements. It is essential to note that the list is not exhaustive and does not intend to be categorical, absolute, or neatly defined. Instead, it is a starting point for exploring the fundamental assumptions concerning the transformative research of the TU/e researchers' private sociotechnical visions. Each component is analysed based on the participants' overarching conceptualisations and the alignment with relevant literature.

At the end of this section, a table *(Table 4.4)* summarises the core elements of transformative research for sustainability future visions at TU/e.

Positive Societal Impact

Many researchers at TU/e care deeply about the societal impacts of their work. Expressions such as *"doing something meaningful"*, *"more significant and a more direct contribution"*, *"make a difference"*, and *"having a positive impact on society"* were present in multiple visions and can be considered the most predominant element of transformative research for sustainability in the future visions for TU/e. One interviewee summed up this sentiment by saying, *"We want to make a difference. That's what we want to do. We want to indeed make a*

difference in it. And we want to make sure that we're doing something tangible, and that is, it will be helping society as a whole."

Researchers strongly desire to impact society positively but feel constrained by the current academic system's lack of support. Researchers find it challenging to balance advancing in their academic pursuits and working towards solutions and societal impact. Some interviewees argued that the scientific activities that are valued by the scientific system, such as the focus on academic publishing, may hinder the ability to generate social impact.
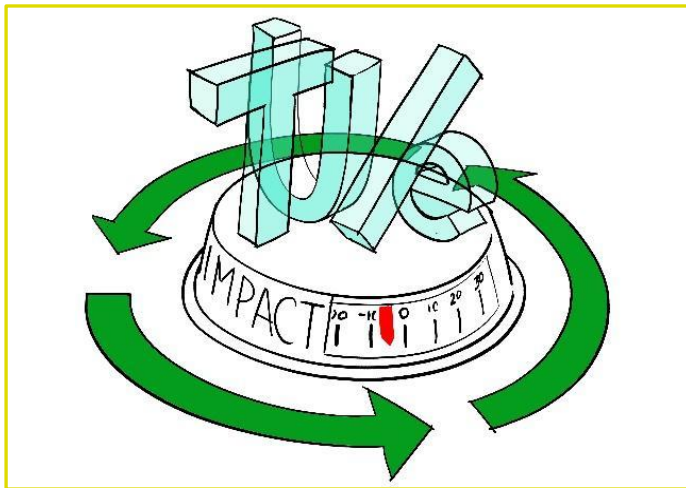
Figure 4.3. Impact – illustration based on workshop discussions (Helmich Jousma, #sustainableTU/e visioning process, 2022).

In this regard, Wittmayer et al. (2021) argue that producing knowledge in academic environments is often centred on academic output, citations, and publication counts. Frequently, societal impact is an afterthought. The linear way that disciplines develop knowledge leads to limited insights offered to the "outside" world through recommendations or other forms of popularisation. However, these do not reflect solutions to pressing, persistent problems, limiting their transformative impact. An interviewee said, *"**Research is about creating an impact, not just publishing**. Publications are a consequence of the research, not the main goal. It is about having a specific intervention happening somewhere, a real impact."*

To overcome this challenge, some interviewees suggested that researchers should focus more on solutions than justifying the problem. One interviewee pointed out that much of the research carried out at the university is not transformative and lacks social usefulness. One interviewee explained it: *"There is a lot of research being carried out, which I think is not terribly transformative. But I always have the impression that we conduct research that maybe social usefulness is marginal. I mean, the extra value that social value that we created is kind of marginal."* They emphasized the need for research to be more solution-driven and grounded in academic rigour without losing its academic basis. The workshop discussions also reflected a similar sentiment, the need to focus on solutions rather than justifying the problem.

Social and Environmental Responsibility

Along with making a positive difference in society, being socially and environmentally responsible and engaged was also pointed out as very relevant among the participants. Many of the researchers interviewed expressed their concerns about the negative impact of fossil fuels on the environment and society.

One of the critical areas of concern was that the university still conducts research on fossil fuels. The participants felt that this research was misguided and that the university's resources

should be directed towards projects that support the energy transition and address the issue of global warming. As one interviewee emphasised: *"We should **really divest ourselves from projects that go in the fossil fuel direction**, this is not a good idea, and we should divest from that as fast as possible."*

Another concern was the university's acceptance of funding from fossil fuel companies. Some participants expressed frustration with this situation and called for the university to take bold action and divest from projects aligned with the fossil fuel industry. They felt that the university had a responsibility to lead by example and to set a high standard for corporate responsibility and sustainability.

Figure 4.4. Ecological and social value – illustration based on workshop discussions (Helmich Jousma, #sustainableTU/e visioning process, 2022).

The participants also felt that the university should place more emphasis on the human and social aspects of its research. They noted that the university is primarily business-oriented and does not give enough attention to projects that do not pursue economic growth. The participants emphasised the importance of exploring research's human and social aspects for real societal impact. These visions express a desire for *"a university less focused on creating technological products but on **projects based on social challenges**,"* in which research has a transformative impact along combined social, economic, environmental, and technological dimensions.

To achieve this, the participants felt that the university must improve the technical and social sciences interaction. They called for more opportunities for dialogue between science and societal learning. They recognized that technology projects are not only technological but are always intertwined with social processes. Science and technology affect society, but society also affects science and technology. Therefore, it is essential for there to be opportunities for interaction and collaboration between science and society.

Scientific Cooperation and Transdisciplinarity

This core element that emerged from the participants' visions refers to the role that transdisciplinarity could play in triggering and fostering transformative research for sustainability. The results of interviews and workshop discussions revealed a strong belief among the participants that transformative research can only be achieved by involving collaboration between multiple academic disciplines and beyond. Participants acknowledged that solutions to complex challenges often lie at the intersections of different disciplines and that it is essential to bring these disciplines together to address them. It starts with common

goals and creates space for integration, where understanding and shared commitment to problems and solutions are fostered.

The participants also emphasized the need for interdepartmental cooperation and the importance of considering fields and subjects that are not commonly included in the research. They felt that by collaborating with people from different fields of expertise, they could contribute more to the research and achieve something more tangible and transformative. One participant explained it: *"The aspect is of bringing these various disciplines together, that's transformative, and organising them. Because usually, solutions are on the, let's say, where disciplines meet each other. Most of the **challenges need to be solved by a multidisciplinary approach**."*

The idea of an ecosystem was also discussed, where the university acts as a major player alongside other actors such as companies, community groups, and NGOs. Participants felt that it would be desirable to extend the university to the ecosystem and support collaborations between these different actors in teaching and research.

However, the participants also expressed concerns about opening themselves up to criticism from other disciplines, which may employ methods that are not acknowledged or valid in their field. To address this, the participants highlighted the importance of creating a safe learning space for trust building and learning, which would help researchers develop the skills and mindsets necessary for effective communication and collaboration.

The workshop discussion also touched upon the idea that students and researchers should be able to work with individuals from all different disciplines and fields in terms of knowledge and capacity for transdisciplinarity. This approach would help them understand how to collaborate with different disciplines and fields and increase their ability to co-create solutions to complex challenges.

As Hölscher et al. (2021) argue, transformative research needs to integrate multiple research paradigms and perspectives and collaborate with scientists from multiple academic disciplines and beyond to enhance the transformative potential of its collaborative research. Such research approaches are required not only to draw on knowledge from multiple disciplines for problem understanding and solution development but also to create space for dialogue and capacity building and to increase ownership, legitimacy, and accountability.

Experimentation

"Experimentation" was a recurring theme in the participants' visions in the interviews and workshops. By using terms such as *"experimentation"*, *"living lab"*, *"pilot facilities"*, *"hotbed for startups"*, and *"centre for testing"*, the participants emphasized the significance of a comprehensive approach to experimentation in fostering transformative research.

This vision expresses a desire for a campus fully engaged in experimentation, where every aspect of campus life serves as a hub of experimentation. It refers to an environment where research is put into practice to gain deep knowledge and experience about real-world applications of the field of study. By creating an environment where innovative ideas and

concepts can be tested, refined, and implemented, researchers and students can gain valuable insights into their research's practical limitations and applications and use this information to refine and improve their work.
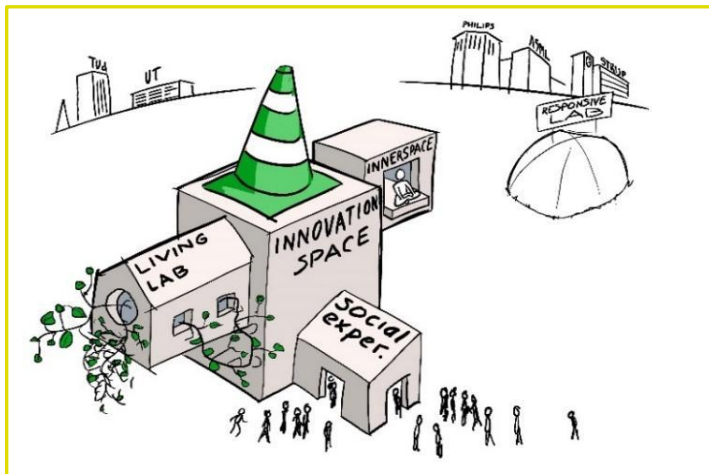
Figure 4.5. Experimentation – illustration based on workshop discussions (Helmich Jousma, #sustainableTU/e visioning process, 2022).

Additionally, the participant's perception of experimentation was characterized by an inclination towards unrestricted exploration and discovery of novel ideas, free from the influence of commercial considerations. They prioritized the intrinsic value of exploration and discovery over immediate commercial viability, exemplified by a participant's statement, *"I want to try solutions without regard for any market or sort of performance-related metrics."* This approach underscores the significance of taking risks and testing innovative concepts without being constrained by financial or performance-related metrics. The motivation to experiment without commercial constraints is rooted in recognising that some of the most substantial discoveries and innovations have emerged from "curiosity-driven research" that was not initially intended for commercial purposes. Encouraging exploration and discovery enables researchers to follow their intellectual curiosity and develop a profound comprehension of the phenomena they are studying, potentially leading to transformative discoveries and innovations with significant long-term societal impact.

Data analysis revealed that *"demonstrating that it works"* also integrates to the participants' views on experimentation. The idea of making research visible and accessible to a broader audience was highlighted as a means of showcasing the impact of research and inspiring others to get involved in transformative research initiatives. This can be accomplished by demonstrating larger-scale research projects and creating prototypes or pilot facilities, providing tangible examples of research work and its potential impact.

Moreover, the participants stressed that for this vision to happen, it is first necessary to incorporate experimentation into the university's culture and approach to research. This change involves creating a supportive environment that encourages researchers to take risks and pursue new ideas and ensuring that the necessary resources and infrastructure are in place to support experimentation and innovation in a supportive and dynamic environment. It also involves providing researchers with access to cutting-edge technologies, facilities, and equipment, as well as funding opportunities and technical support, recognizing and rewarding researchers for their contributions to experimentation and innovation, and creating mechanisms for disseminating and showcasing research outcomes.

Local collaboration

The visions express a desire for a university where knowledge is co-produced together with and for society. "Local collaboration" was a common theme during the study and highlighted the importance of operating at the local level in fostering transformative research. The interviewees and workshop participants strongly desired increased cooperation with local stakeholders, further strengthening previous calls for transdisciplinary research. In this vision, transformative research is conducted in an environment where new research questions are co-created, and solutions are found by working in partnership with stakeholders and broader society, from the local to the global scale.
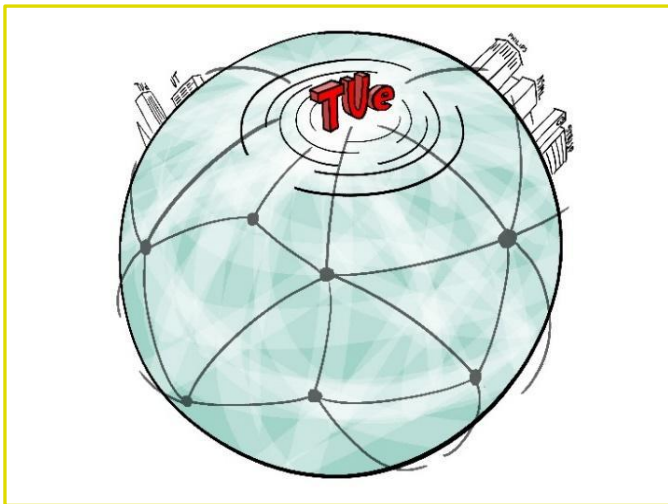
Figure 4.6. Collaboration – illustration based on workshop discussions (Helmich Jousma, #sustainableTU/e visioning process, 2022).

Interviewees regularly brought up the theme of "collaboration with societal stakeholders." However, a crucial insight here is that while the participants expressed a strong desire for increased collaboration with "societal stakeholders," they often did not clearly understand who these stakeholders were. In addressing this, an inductive coding scheme was applied, with the code "stakeholder" used to identify and categorize the different entities mentioned by interviewees. The analysis revealed that the interviewees perceived societal stakeholders as belonging to seven main categories: 1) local government (such as municipalities and provinces), 2) schools, 3) societal stakeholders, 4) society at large, 5) the local community, 6) various interest groups or parties, and 7) people. Only the first two, brought up in the same interview, are specific. On that occasion, an interviewee said: *"I would like that and then maybe work together more with municipalities or even schools or just to get more awareness of what your environment does to you."* The remaining five, on the contrary, could even be seen as what Laclau refers to as a "floating signifier" – words that have no upon agreed, fixed meaning. That highlights the complexity of the concept of "stakeholders" as perceived by the interviewees and suggests that there may be multiple, diverse perspectives on who should be considered a stakeholder for transformative research. To illustrate: interviewees often said, *"listen to what people, what the community out of Tu/e has to say"* or that solutions should "*ensure autonomy and resilience at local levels."*

In contrast to the findings regarding societal stakeholders, it was evident that the interviewees had a clear idea of whom they were referring to when it came to business stakeholders. As previously shown, in the interviews, participants frequently mentioned and criticized specific business stakeholders, such as fossil fuel companies. That highlights the contrast between the clear identification of business stakeholders and the more ambiguous understanding of societal stakeholders. This contrast may be interpreted as participants having clear ideas of the

undesirable present but not so much a clear understanding of desirable futures. It might also mean that participants have relied on an unconscious business-society dichotomy (for the relationship between the two, see Carroll & Buchholtz, 2014). In this dichotomy, businesses represent the unfavourable present, and society represents a desirable future. However, while there is some sense in saying that the entire society should benefit from one's work, it is sometimes unclear how society may express its needs for one's work.

Nevertheless, the workshop participants also emphasized their role in serving the community and not just business interests. For example, the university is still recognized as the place where fundamental knowledge (research) is produced through locally connected research hubs and locally rooted challenges. Knowledge still gets to expand to be shared globally; however, it should primarily address local issues. Furthermore, by positioning themselves as serving the community rather than business interests, the workshop participants also highlight their commitment to working towards transformative research that benefits all community stakeholders, including business and societal actors. As one interviewee explained: *"the best projects are those where the felt need and the initiative comes from there and not from us."*

Therefore, this research revealed that interviewees and workshop participants desire not only increased cooperation between departments and disciplines but also with the surrounding community and local stakeholders. They envisioned the university and its partners forming a research ecosystem for sustainability, covering a wide range of perspectives and focal challenges, experimenting with and putting into practice alternative solutions, and creating viable ecosystems for these. As one interviewee said: *"I think a lot of collaboration with stakeholders in society. With product developers with local government, you have to get access to living labs. So it's going to be very new dynamics for research (...), **with people around you**."*

Institutional, financial and administrative support

The most recurring theme that emerged from the interviews and workshop participants was the need for more time to focus on research and less on administrative tasks. The data provided a glimpse into the challenges researchers face, including the burden of non-research-related tasks and a lack of personnel to support them in these tasks. The academic researchers at TU/e felt that they no longer had time for research and experienced a sense of pressure and constraint. The participants expressed a strong desire for institutional, financial, and administrative support and a redefinition and revaluation of research in institutional structures.

As can be seen from these extracts from the interviews: *"sometimes research is not central"*, *"some sort of technical support is a bit lacking",* and *"**more support to take the burden of things that are not research related is needed**."* The interviewees emphasized the need to reduce the burden of writing research proposals and acquire more technical support so that they could spend more time on research. Furthermore, they wanted TU/e to help them deal with bureaucratic procedures, provide research support, and ensure that personnel is not limited. Similarly, the workshop discussion envisioned a safe space that is insulated from all the pressures of teaching, administration, and grant writing, where focus and time are spent solely on doing research. Participants desired institutional support to enhance mechanisms for

creativity, reflexivity, collaboration, and new skill development to pursue transformative research.

Other related themes from the workshop discussion and interviews are the need for more investment and resources for sustainability research, difficulties in obtaining funding, and challenges with the current grant system. The participants mentioned that research for sustainability needs more investment and resources and that it can be difficult for PhD students to secure funding for sustainability-based research. They also expressed that most of the funding comes from the Netherlands Organization for Scientific Research (NWO), which primarily focuses on fundamental research, whereas sustainability research requires applied research also. They expressed that the whole grant system is *"broken"* and suggested that giving money directly to the researchers without any administrative overhead might be a solution.

The importance of a long-term approach in research for sustainability is also highlighted. One of the participants noted that the current funding system requires researchers to guarantee results within five years, which can be difficult when working on issues related to sustainability. They mention that the grant system does not support long-term research projects, which could hinder the pursuit of this approach. They argue that focusing on early results can lead to a trade-off with sustainable results. The change that needs to be brought about through research is a complex and all-encompassing endeavour that requires a significant amount of time. The participants believe that a two-year funding period is insufficient to bring about transformational change and that a longer time frame would be necessary.

Table 4.4. Summary of the core elements of transformative research for sustainability in the future visions

Core Elements	Aspirations/Opportunities	Challenges/Barriers
Positive Societal Impact	Desire to impact society positively; more solution-driven research	Emphasis on publishing over social impact; lack of support; the academic system may hinder the social impact
Social Engagement and Environmental Responsibility	More socially-engaged research; directing university resources towards energy transition and addressing global issues; improving the interaction between technical and social sciences	Conducting research related to fossil fuels; limited interaction between science and society; university primarily focused on economic growth

Scientific Cooperation and Transdisciplinarity	More collaboration between disciplines and beyond; trust-building learning spaces for effective collaboration	Concerns about criticism from other disciplines; difficulty in bringing disciplines together; lack of incentives for interdisciplinary work
Experimentation	Exploring and discovering new ideas without commercial constraints; making research visible and accessible to inspire others; fully engaging the campus in experimentation	Opening up to criticism; ensuring resources and infrastructure for experimentation; encouraging risk-taking
Local Collaboration	Co-production of knowledge with society from the local to the global scale	Difficulty in balancing business and community interests; the complexity of local issues
Institutional, Financial, and Administrative Support	More institutional support for academic researchers; increased investment in sustainability research; enhancement of mechanisms for creativity, reflexivity, collaboration, and skill development; long-term approach in research for sustainability	The burden of non-research tasks; difficulty obtaining funding for sustainability research; pressure for short-term results

1.1. Alternative sociotechnical imaginaries

The second objective of this study was to identify and investigate the collectively negotiated visions about the future of transformative research on sustainability at TU/e that emerged from the #sustinableTU/e participatory visioning workshops. The #sustainableTU/e participatory visioning workshops involved a diverse range of actors from the university community, including professors, students, staff, and partners. This diversity of participants generated a comprehensive range of ideas and perspectives on sustainability and transformative research at TU/e. However, despite the diversity of participants, there was a high degree of agreement on the visions, indicating a shared understanding within the TU/e community regarding desirable futures related to sustainability and transformative research.

By conducting a content analysis of the workshop data, this study identified three shared visions pertaining to advancing transformative research in sustainability at TU/e. These visions represent an alternative future vision to the prevailing sociotechnical imaginary that currently guides TU/e's sustainability approach and have the potential to expand and contest this

imaginary. The three alternative sociotechnical imaginaries are presented in this study as narratives and are outlined as follows.

4.1.2. Narratives of the future

Collaboration, experimentation, and knowledge-sharing platform

The university has transformed into a platform for collaboration, knowledge sharing, and experimentation locally to globally. The university is a centre of experimentation for transformative research in sustainability and serves as a model for the community by practising what it preaches. The entire campus is engaged in experimentation, serving as a fully functioning living lab facility where research is conducted, experimented on, and exhibited in public. Examples of larger-scale research projects in action are used to demonstrate concepts to visitors.

The campus has an enormous amount of living labs and numerous touchpoints with the city, with responsive buildings helping to maintain the environment. The university operates as an open innovation campus, with institutes like Innovation Space, where students and researchers work together on systems and setups, blending teaching and research.

The campus is open up and functions as a research hub that collaborates closely with other universities, institutes, and the local community. The university is focused on scientific cooperation rather than competition, with research work prioritizing the repurposing and upcycling of locally available materials. The university prioritizes the use of locally available materials from obsolete products, with engineering capabilities focused on working with local materials and repurposing them.

The departments have clear goals for sustainability that rely heavily on collaboration, with students working on projects that directly benefit the campus and the local community. The university is connected to local people and is entirely distributed in the region in the form of knowledge hubs, with much more locally focused research. The university policy and system bring sustainability as a central subject in all departments, with human-centred design incorporated into all research projects.

Transformative solutions for impact

The university is a leader in finding non-conventional and innovative solutions to sustainability challenges and is known for creating a positive transformative impact on society. Instead of solely creating new knowledge, the focus is on filling in the gaps in the existing knowledge, anticipating problems and developing solutions that are adaptive and capable of changing in response to future needs. The university is a hub for sustainability and climate action research, attracting outside stakeholders looking for transformative solutions.

As a technical university, TU/e is well-connected to entrepreneurship, and sustainability is now a core component of this. The university offers a new business mentoring and advisory service that leverages its expertise and experience to address sustainability issues and maximize

external engagement and impact. This service support entrepreneur and businesses looking to integrate sustainability into their operations and positively impact the environment and society.
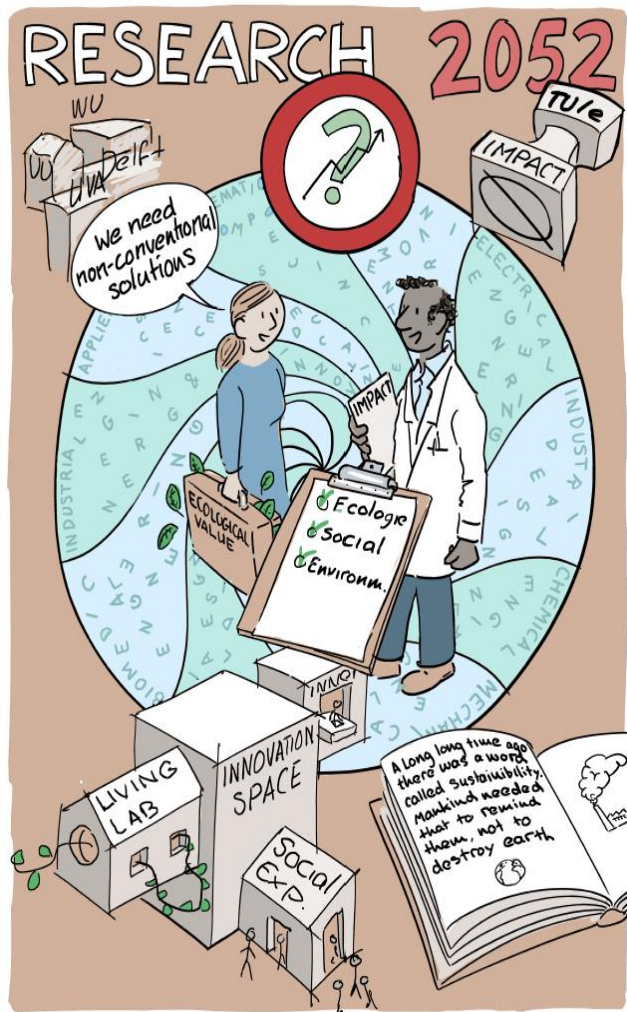
Figure 4.7. Transformative research TU/e 2052 - illustration based on the workshop discussions represents the collectively negotiated visions of what and how research at TU/e could be transformative for the environment and society (Helmich Jousma, #sustainableTU/e visioning process, 2022).

Sustainability at heart

The university is committed to promoting sustainability and making it an integral part of all its efforts. From education to research, sustainability is woven into all aspects of campus life, making it the new normal at the university.

The university values sustainability as a crucial pillar of its mission and operations. All technical departments are committed to finding solutions through sustainable processes and methods, and no resources are allocated towards research and development of unsustainable technologies. Sustainability is integrated into all research projects through embedded sustainability criteria, allowing for coordinated and cohesive efforts towards a sustainable future. The concept of sustainability is seen as a norm in the university and society as a whole. It has become a natural aspect of university operations, incorporated into the curriculum and research agenda. The university has shifted its focus to green tech instead of high tech, as its overarching agenda, with full circularity as the leading principle in its technical design courses. Sustainability is considered one of the four pillars at the university, alongside education, science, and tech transfer.

In recognition of the importance of sustainability, the university creates a department specifically dedicated to sustainability, with sustainability also playing a crucial role in research. Efforts are made to reduce the influence of the fossil industry on the research system and to consider the climate justice and global effects of these efforts. The university strives to promote "Sustainability at Heart", with transformative research in sustainability being woven

throughout all aspects of the university. All research projects are subject to sustainability approval, including a thorough assessment of their potential positive and negative effects.

The funding and organization of sustainability science at TU/e are designed to allow researchers to focus on what they do best, conducting research, rather than being bogged down by administrative tasks such as grant writing and acquiring funding. The university recognizes the importance of supporting its researchers in their work and has established systems allowing them to focus their time and effort on the research.

1.1. Future expectations

The last purpose of this study was to examine how the development of shared sociotechnical imaginaries can inform a shift in expectations regarding institutional responses to sustainability at TU/e. This shift refers to changes in participants' perceptions after participating in the #sustainableTU/e participatory visioning workshops, as reflected in their level of agreement or disagreement with survey statements distributed on two occasions. The first survey was conducted after the first three workshops, and the second was conducted after the final fourth workshop. The survey design utilized a Likert scale-based approach and was identical for both surveys, as detailed in the research design.

Table 4.5 summarises the mean scores of the participants' responses on their perception after the participatory visioning workshops regarding TU/e's sustainability efforts. The table shows the mean scores and mean scales for each statement in the first survey (S1) and the second survey (S2). In general, the mean scores for most statements of S1 to S2 indicated a positive perception of TU/e's sustainability efforts among the participants after the participatory visioning workshops, suggesting that they positively impacted the respondents' beliefs and beliefs and attitudes towards sustainability at TU/e.

Table 4.5. Summary of the means scores of perceived responses on the participants' perception after the workshop (question 6) in the first (S1) and second survey (S2)

Statements		(S1)		(S2)	
		Mean Scores	**Mean Scale***	**Mean Scores**	**Mean Scale***
1	My awareness of TU/e's commitment to sustainability has improved.	3.33	Neutral	3.57	Agree
2	My perception of TU/e's engagement with sustainability has changed.	3.14	Neutral	3.00	Neutral
3	I became more interested in the discussion about sustainability at TU/e.	3.48	Agree	3.57	Agree
4	I felt more hopeful about TU/e's sustainability efforts.	3.00	Neutral	3.71	Agree

5	I felt more concerned about TU/e's sustainability initiatives in the future.	3.43	Agree	3.29	Neutral
6	I felt more inspired and mobilized about TU/e's future possibilities regarding sustainability.	3.76	Agree	3.57	Agree
7	I felt more optimistic about TU/e's future institutionalized responses regarding sustainability.	2.81	Neutral	3.14	Neutral
8	I felt more confident about the idea that the topic of sustainability can become firmly embedded (a common practice) within TU/e.	2.90	Neutral	3.43	Agree
9	I believe it is possible to shape the terrain of choices and actions taken about sustainability at TU/e.	3.71	Agree	4.14	Agree
10	I believe TU/e can be a proactive change agent capable of inspiring sustainability actions within and beyond the campus.	3.95	Agree	4.29	Strongly Agree

*Mean = 1.00-1.79 (Strongly Disagree), 1.80-2.59 (Disagree), 2.60-3.39 (Neutral), 3.40-4.19 (Agree), 4.20-5.00 (Strongly Agree)

While evaluating the mean scores and scales captured the subtle variations in how the collective creation of sociotechnical imaginaries can shift individual expectations, each statement in the survey represents a distinct finding. However, these findings can be grouped based on their temporal orientation towards the future. Specifically, the first five statements pertain to expectations for the immediate future, while the remaining five form the second group concerning mid or long-term expectations.

Several findings are striking when data is observed this way. First, when observing S1 data, it is apparent that researchers had low hopes for the immediate or near future. Their awareness of TU/e's commitment, understanding of the University's engagement with sustainability issues, and hope regarding TU/e's efforts were neutral; the only agreed results were their interest in the topic and their concerns about the university's future sustainability initiatives. As the other five statements clearly show, such personal interest is often enough to feel hopeful about a more distant future, even when institutional efforts are not recognized as sufficient.

Probably even more significant is the previously asserted finding that the S2 after the fourth workshop positively influenced the increase of statements 1, 3, 4, 7, 8, 9, and 10, which can be attributed to the transition from a more abstract notion of "visioning" the future to concrete actions toward the envisioned future in the fourth workshop.

These results indicate that collective efforts through workshops organized for this research can influence outlooks in the near and distant future. Such findings are vital given the importance of agency and ownership, as followed discussed.

The awareness (1) and perception (2) of TU/e's engagement with sustainability remained mostly neutral

The statement regarding the awareness and perception of TU/e's commitment received an average score between neutral and weak agreement across both surveys. Given the relatively stable mid-scores for these statements, a reader may question their significance and what this implies for expectations. While there are several possible interpretations, one stands out: changing perception and awareness about something that does not exist or manifest itself can be challenging. Participants' comments supported this interpretation, highlighting the gap between good intentions and practice, and the technocentric paradigm and backwards-looking leadership at TU/e: *"I think TU/e has good intentions (...) but there is (...) a substantial gap between good intentions/talking about things/policies and practice"* and *"the fact that the climate protestors needed to occupy part of a building to persuade the TU/e management even to acknowledge the climate crisis exists highlights that TU/e leadership is, unfortunately, pretty backwards-looking, stuck in a desperately technocentric paradigm."* Additionally, the question itself may not have been crafted with sufficient care, as it did not indicate whether the change in perception was for better or worse. However, a deeper analysis of the data revealed that most respondents selected the "neither agree nor disagree" option, which to some extent minimised the error.

It is worth noting that the second survey (S2) focused on refining the previously elaborated visions and developing and discussing scenarios toward co-creating a sustainable TU/e. The fact that the mean scores for statement 1 increased after this workshop suggests that the participants were affected by the discussions that were closer to concrete actions, increasing their expectations and awareness regarding the TU/e's sustainability efforts in the near future.

Workshops are a way to develop individuals' interest (3) in sustainability further

Relatively high scores across both surveys (3.48 and 3.57, respectively) show that workshops successfully developed individual interests in topics on sustainability at TU/e. Due to the nature of these questions, actual interest might be slightly understated given that some participants might have already felt very interested and invested in sustainability, so the workshops neither increased nor decreased their interest. However, the repeated scores are already satisfying and represent a strong argument for creating workshops to create visionaries.

People felt more hopeful (4) and less concerned (5) about TU/e's efforts

The increase in mean scores for statement 4 (hopeful about TU/e's efforts) from "neutral" to "agree" in S2 may also be attributed to the participants' increased proximity to the tangible actions and solutions discussed during the fourth workshop. This change in perception indicates a shared commitment and motivation, which are crucial drivers of change arising from collectively shaped expectations. Additionally, the shift may have given participants greater

hope and confidence in embedding sustainability within TU/e, potentially due to discussions on sustainability principles and scenario analyses during the fourth workshop.

Furthermore, the decrease in the mean score for statement 5 (concerned about TU/e's sustainability initiatives in the future) from "agree" to "neutral" in S2 may also be related to the focus on concrete actions in the fourth workshop. Through exploring possible scenarios and critical drivers for change, the participants may have gained a greater understanding of the steps that TU/e is taking or can take towards sustainability, which may have mitigated their concerns about sustainability initiatives in the future.

1.1.2. Expectations regarding the distant future

The remaining five statements have in common that they are concerned with the distant future, and almost all record significant change. The feelings toward the distant future are embodied in words such as "inspiration," "optimism," "confidence," or "belief".

Workshops can inspire and mobilise (6) groups to collectively create imaginaries

In both surveys, statement 6, which measured the participants' level of inspiration and mobilisation concerning TU/e's future possibilities for sustainability, received a mean score of "agree," with a slightly lower score in the second survey. This level of agreement suggests that the workshop discussions and activities inspired and motivated the participants, who may have recognised TU/e's potential to make positive changes in sustainability and expressed eagerness to take action to support sustainability initiatives. The positive response to statement 6 indicates that the workshops successfully raised awareness about sustainability and generated inspiration and motivation among the participants, potentially leading to more active participation and involvement in sustainability efforts at TU/e and ultimately resulting in better sustainability outcomes. Consequently, it is essential to maintain and reinforce this positive perception to foster long-term change towards sustainability at TU/e.

Optimism (7) and confidence (8) regarding the institution drastically increase when the workshop feels closer to concrete action

Respondents were asked (7) how optimistic they were about TU/e's future institutionalised response regarding sustainability and (8) how confident they were about the idea that the topic of sustainability can become firmly embedded within the TU/e. The second workshop also significantly impacted the participants' responses to these statements. Although the level of optimism (7) remained in the "neutral" category, it improved significantly from 2.81 to 3.14, indicating a shift from almost negative to almost positive. Reasons for this neutral result could be that the participants were uncertain whether TU/e would take concrete actions to institutionalize sustainability or may not have been aware of the university's steps in this direction.

On the other hand, participants' confidence (8) that sustainability will become a salient topic, firmly embedded within the TU/e, increased significantly from 2.9 to 3.43, shifting from

"neutral" to "agree" in the second survey. These findings indicate that TU/e is not necessarily perceived as inherently negative but rather as an agent of social change that could do more. The workshops demonstrated that even minor changes could alter the researchers' perceptions and lead to more significant support and optimism about the university's role in sustainability. The participants recognized the university's current negative position within the system but did not entirely reject the possibility that it could be an agent of positive, sustainable change. These results are encouraging as they suggest that not much is needed to positively impact researchers' perceptions of the university's potential for sustainability.

Shared beliefs (9) (10) are the key to understanding shared visions

In light of the previous finding, it can be inferred that the shared visions that emerged during the workshops were based on shared beliefs among the participants. Among these beliefs, the notion that TU/e can positively affect change (10) was particularly strong, with a mean score of 4.29 after the final workshop and 3.95 after the first three workshops. This finding suggests that the workshops were perceived as a step in the right direction, providing evidence that TU/e can be a driver of change by initiating and facilitating sustainable projects that benefit both local communities and the wider world.

These findings are a particularly noteworthy result, as it indicates that the participants were not only motivated to take action themselves but also believed in TU/e's ability to inspire sustainability actions beyond the campus. That is a positive indication that the participatory visioning workshops effectively empowered the participants and created a sense of agency and ownership over sustainability initiatives. This encouraging finding suggests that the respondents are willing to take action toward sustainability and believe that TU/e has the potential to be a leader in this area.

It is crucial to note that the findings presented are based solely on this study data and may not represent the entire population at TU/e. Further research and initiatives may be necessary to fully understand and address sustainability issues at TU/e.

1.2.   Final discussion

In the context of the visioning process approach adopted by the Eindhoven University of Technology (TU/e), this study presents an empirical investigation of the emergence of alternative sociotechnical imaginaries and their role in the institutionalization of sustainability within the university. The research involved collecting and analysing data from four workshops and 25 interviews conducted with the #sustainableTU/e visioning process over the last six months. The findings of this study provide valuable insights into the shared understanding of desirable futures related to sustainability and transformative research within the TU/e community. These insights can inform the development of future sustainability strategies and initiatives, thus facilitating the institutionalization of sustainability at the university.

The data obtained allowed for sophisticated qualitative analysis, sensitive to sociotechnical imaginaries' formative and pre-stabilisation phases. Specifically, private visions and collectively negotiated visions were recognised in this research, and this division informed the first two research questions:

(Q1) What visions do individual researchers commonly hold concerning transformative research? How do they differ from the dominant imaginary that informs universities' current practises?

(Q2) What do collectively negotiated visions, captured in participatory workshops, reveal about alternative imaginaries for transformative research?

While the two first questions revealed an exciting transition from privately held to collectively held visions, the third research question allowed for the assessment of workshops' influence.

(Q3) How can these alternative imaginaries inform a shift in expectations concerning the TU/e's future institutionalised responses regarding sustainability?

The following sections will discuss findings related to the three main research questions and offer final reflections regarding the limitations and the overall study.

(Q1)

Regarding individual perspectives, the study findings revealed a combination of pessimistic and optimistic views among the researchers regarding sustainability. The pessimistic views were primarily rooted in the researchers' daily work difficulties and the frustration concerning the university's current institutionalized responses to sustainability. Conversely, the optimistic views stemmed from the belief in the potential for positive change in the future and the university's capability to achieve it. This mixture of perspectives demonstrates the multifaceted nature of sustainability transitions, which necessitates a critical appraisal of the present circumstances and a belief in the capacity to bring about beneficial change. Furthermore, the articulated visions for future sustainability frequently expressed a desire to transform these challenging affairs.

The study findings also uncovered divergent perspectives among researchers regarding the drivers of transformative research for sustainability. While some researchers pointed out the influence of institutional structures and funding mechanisms, others emphasized the significance of individual mindsets and practices. This finding underscores the intricate nature of transformative research and emphasizes the necessity of addressing multiple factors to facilitate substantial change. Moreover, the study emphasizes the significance of facilitating diverse individuals to critically reflect on their viewpoints, leading to mutually transformative collaborations. A collective examination of diverse approaches to combining multiple perspectives and goals is crucial to advancing transformative research for sustainability.

The interviews conducted in this study yielded valuable insights, revealing recurring themes among the participants. Specifically, researchers highlighted transdisciplinary cooperation, social responsibility, local collaboration, the need for experimentation, and improved funding

opportunities as critical elements of their envisioned futures. These findings align with the argument made by Hölscher et al. (2021) that transformative research requires integrating diverse research paradigms and perspectives and collaboration across multiple academic disciplines and beyond to maximize its transformative potential. Such research approaches are required not only to draw on knowledge from multiple disciplines for problem understanding and solution development but also to create space for dialogue and capacity building and to increase ownership, legitimacy, and accountability.

(Q2)

At the collective level, the investigation of the narratives enabled a more comprehensive comprehension of the shared aspirations and objectives for the future, providing valuable insights into the participants' priorities and values. The study identified three distinct sociotechnical imaginaries, each offering a unique perspective on the university's role in promoting sustainability through transformative research. The first imaginary considers the university as a platform for collaboration and experimentation, the second as a pioneer in finding transformative solutions for sustainability, and the third as committed to sustainability in all its efforts. Each of these perspectives contributes valuable insights into the university's potential to promote sustainability and should be considered complementary, as they address different aspects of the same overarching objective. These findings are relevant for informing decision-making, strategy development, and action planning towards realizing the collective vision for a sustainable future.

Through exploring these different sociotechnical imaginaries, TU/e can broaden its perspective and consider a range of potential solutions and strategies for promoting sustainability on its campus and beyond. Drawing on the strengths and priorities of each imaginary, TU/e can inform its future efforts towards sustainability. For instance, the first imaginary's focus on collaboration and knowledge sharing can encourage TU/e to increase its partnerships and engagement with the local community. In contrast, the second imaginary's emphasis on innovation and business mentoring can inform TU/e's efforts to support entrepreneurs and businesses in integrating sustainability into their operations. Similarly, the third imaginary's emphasis on making sustainability an integral part of the university's mission and operations can inspire TU/e to incorporate sustainability more comprehensively throughout its institutional practices and decision-making processes.

Regarding the methodology, the participatory visioning workshops employed a collaborative and inclusive approach to co-create a desirable and inspiring vision for TU/e's engagement with sustainability. The workshops' participatory format facilitated collective negotiations and coalition building, merging individual ideas of a desirable future while ensuring the representation of all perspectives in the final vision. The approach fostered a shift from individual, private thinking to collective, shared thinking, striking a balance between structure and avoiding inappropriate limitations on comprehension. The approach enabled engagement with diverse perspectives, promoting collective thinking about the future. Ultimately, this approach resulted in the development of broader visions that incorporated individual contributions and perspectives from other participants.

Another significant dimension of this research is that it took place at the university, representing a unique social setting. According to Longhurst & Chilvers (2019), civil society settings are critical in generating diverse sociotechnical imaginaries and fostering alternative models of progress, social change, and public participation. This perspective underscores the importance of collective practices and the context in which sustainability visions are co-produced and highlights the potential of participatory approaches to generate shared understandings and visions.

(Q3)

The study revealed that the collaborative workshops conducted for this research significantly impacted the participants' outlooks, highlighting the importance of agency and ownership. These findings align with Graf & Sonnberger' (2020) assertion that "desirable futures" can shape technological development and governance instruments, emphasizing the significance of "expectations." Additionally, Pereira et al. (2018) demonstrated that shared visions of the future could foster a sense of commitment, motivation, and direction for change. Collaborative efforts in sociotechnical imaginaries can enhance the capacity for systemic reform and direct research and initiatives towards a shared vision of a sustainable future. On the other hand, Sharpe et al. (2016) argue that active innovation processes may reinforce current systems, resulting in minor incremental advancements and limited change. However, contesting and pioneering practices can potentially impact and even replace dominant ones. Therefore, it is crucial to keep the individual agency in mind and the visionary mindset, capable of imagining new possibilities and pursuing them through pioneering actions, emphasising the importance of inspiration and mobilization of feelings.

Ultimately, the alternative sociotechnical imaginaries identified in the study can provide valuable insights and guidance for shifting expectations in TU/e's future institutionalized responses to sustainability. Firstly, these alternative imaginaries can help to challenge and broaden the dominant sociotechnical imaginary that currently shapes the TU/e's approach to sustainability. By highlighting the diverse range of perspectives and priorities held by different researchers (professors, students, staff and partners), these alternative imaginaries can help to break down narrow or limited views of what sustainability means and what actions are necessary to achieve it. Consequently, this can open up space for more inclusive, creative, and innovative approaches to sustainability that better reflect the needs and aspirations of the wider community.

Secondly, these alternative imaginaries can serve as a source of inspiration and motivation for individuals and groups who aim to promote sustainability at TU/e. By showcasing the potential benefits and transformative possibilities of sustainable practices and systems, these imaginaries can generate enthusiasm and support for sustainability initiatives and foster a sense of shared purpose and identity among TU/e's professors, students, staff, and partners. In turn, this can stimulate the momentum for change and create a more conducive environment for institutionalizing sustainable practices and policies at TU/e.

Finally, by providing various visions, these imaginaries can help create a sense of shared ownership and engagement among the TU/e community. By involving a wide range of actors in the co-creation of sustainable futures, the university can build a sense of collective responsibility and foster a culture of sustainability that is more likely to be sustained over time. Consequently, this can help to align expectations and resources with the specific challenges faced by the university and create a more project- and goal-oriented approach to sustainability.

Limitations

The current research was carried out within the context of the #sustainableTU/e initiative, which posed certain limitations warrant consideration. The participatory visioning process used in this research provided a unique opportunity to engage with diverse actors and generate rich data on their private and collective visions for transformative research on sustainability at TU/e. However, since the researchers were direct participants in the process, there is a possibility that their involvement could have influenced the data collection and analysis, leading to a bias towards the researcher's own perspectives and assumptions. Furthermore, the study was conducted within the pre-existing structure of the #sustainableTU/e initiative, which had a predetermined methodology, schedule, and specific sustainability objectives and goals, possibly limiting the available data collection and analysis options.

Another limitation of the study was the relatively small number of participants who attended the workshops. Despite attempts to recruit diverse individuals, logistical and scheduling constraints resulted in a limited number of attendees. This constraint may have impacted the study's ability to collect a representative, diverse, and robust sample. Additionally, the participatory visioning process did not provide an opportunity to engage with individuals and groups who are less receptive to sustainability initiatives. As a result, the workshops predominantly included sustainability-minded individuals who were enthusiastic about the collaborative visioning process. Consequently, the absence of critical perspectives may have resulted in a partial representation of the TU/e community's views. This limitation may hinder the findings' generalizability and the visions' applicability to other contexts.

The last limitation of this study concerns the analysis of the sociotechnical imaginaries' performativity. The study did not include an investigation of the performative aspects of these imaginaries due to restrictions in the research's timeframe and focus. Although the study successfully identified alternative imaginaries held by participants and their potential to inspire and guide more inclusive and innovative approaches towards sustainability, a comprehensive understanding of the potential impact of these imaginaries on shaping practices, policies, fund allocation, and research at TU/e require an exploration of their performativity.

Final reflection

Despite the limitations above, the participatory visioning process adopted in this research provided a practical framework for engaging with various actors from the TU/e community and generating rich data on their collective visions for transformative research in support of the university's sustainability institutionalisation. The process facilitated a collaborative and inclusive approach incorporating diverse perspectives in the final visions, generating interest

and mobilisation. Incorporating participatory approaches in sustainability planning can foster more inclusive and innovative processes that better reflect the needs and aspirations of diverse actors. This approach can stimulate momentum for transformative change and promote the development of more sustainable and equitable futures. Furthermore, the study results offer a profound comprehension of the desirable future researchers envision and the challenges they confront in pursuing transformative research for sustainability. These findings can guide TU/e and other universities and research institutions to develop strategies and initiatives that align with their researchers' visions and prioritize sustainability transitions.

* Upon completion of the study, the team involved in the #sustainableTU/e visioning process developed a set of foundational and domain-specific principles (see *Appendix F*). These principles were formulated in response to the concerns and aspirations expressed by the study participants. It is noteworthy, however, that the principles developed were not explicitly included in the analysis of this study, as they were beyond the scope of the research objectives.

2. Conclusion

The concept of sociotechnical imaginaries has gained significant attention as a means of understanding how society envisions and creates technological systems and their role in shaping social change. This study built on this concept and explored the phenomenon of the emergence of sociotechnical imaginaries and their role in transformative change as part of a broader effort to facilitate the institutionalisation of sustainability at Eindhoven University of Technology in the Netherlands.

The study's findings highlight the alternative sociotechnical imaginaries' potential to catalyse transformative change by providing a diverse vision of the future and challenging existing dominant structures. When collectively held, these alternative imaginaries can help catalyse a shift in expectations and institutionalised responses. They can inspire and guide more inclusive and innovative approaches that better reflect the wider community's needs and aspirations and build momentum for transformative change.

The study's results suggest the importance of considering the various future imaginaries that hold transformative potential when devising strategies that aim to promote desirable and sustainable futures. The three sociotechnical imaginaries identified in this research provide clear examples of how diverse visions can offer alternative perspectives on addressing sustainability and transformative research. Understanding the range of imaginaries and how they relate to one another makes it possible to identify common goals and values and build a more comprehensive and inclusive future vision towards more equitable and sustainable systems.

The research underscores the significance of the participatory aspect of this process. The study demonstrates that participatory visioning processes can provide a powerful means for communities to engage in the collective imagination, enabling the development of shared visions grounded in diversity and collaboration. These processes provide opportunities for participants to engage in dialogue and negotiation with others, leading to a greater understanding and appreciation of diverse perspectives and experiences. Through ongoing dialogue and reflection, participants can identify shared values and objectives that underlie the visions, which can help guide future actions and decisions. By actively involving participants in co-creating shared visions, these processes promote a sense of ownership and responsibility for the future, encouraging more significant commitment and engagement towards achieving the envisioned outcomes.

This study contributes to the growing literature on sociotechnical imaginaries and sustainability transitions in several respects. Firstly, the study develops shared, desirable, inspiring visions for the university that reflects various actors' diverse perspectives and values in the visioning process. These visions provide a detailed and aspirational outlook for the future, fostering a sense of ownership and agency and guiding research, policy, and practice.

Secondly, the study empirically explores sociotechnical imaginaries and their significant impact on developing and implementing more systemic and transformative change approaches towards sustainability as they shape the expectations and goals of individuals and organisations involved. By connecting with the broader literature on sociotechnical imaginaries, the study demonstrated this concept's relevance for understanding its practical, local implications. The study's empirical approach enabled a deeper understanding of how sociotechnical imaginaries materialise and operate in practice, contributing to the growing body of research on this topic.

Thirdly, the study identifies a previously unexplored connection between sociotechnical imaginaries and participatory visioning processes. By engaging a diverse range of actors in a participatory process, the study shows how alternative sociotechnical imaginaries can be co-created and negotiated, leading to the development of shared visions for transformative research on sustainability. By exploring this connection, the study contributes to understanding how sociotechnical imaginaries can be materialized and operationalized through participatory processes. It shows that these imaginaries are not static or predetermined but rather can be shaped and negotiated through ongoing dialogue and collaboration among diverse actors. This insight is essential for sustainability transitions because it emphasizes the need to involve stakeholders and foster inclusive processes that enable the co-creation of visions and the negotiation of values and goals that underpin them.

Furthermore, the study highlights the potential of participatory visioning processes to enable the development of more effective and sustainable sustainability initiatives. By engaging with diverse actors, these processes can generate rich data on collective visions for transformative research in support of sustainability institutionalization. This data can inform the development of more targeted and relevant sustainability strategies and actions that are aligned with the visions of the stakeholders.

Further research is recommended to advance the comprehension of the actual performativity of alternative sociotechnical imaginaries identified in this study. This performativity can be measured by assessing their impact on shaping and influencing practices, policies, and strategies. Additionally, researchers can examine how these alternative imaginaries challenge or reinforce existing structures of power and domination. This analysis may involve analysing the discourses and practices that sustain current power relations and assessing how alternative imaginaries challenge or transform these discourses and practices.

Previous studies have established the theoretical and empirical backgrounds for understanding sociotechnical imaginaries' performativity. However, further measures are required to accurately assess their impact on different aspects of practice, discourse, policy or strategy. Therefore, future research is also recommended to explore the mechanisms that enable specific sociotechnical imaginaries to be dominant and examine how alternative imaginaries challenge or reinforce prevailing power structures. This investigation will require an analysis of how imaginaries are created, maintained, and transformed over time and how they shape the actions and decisions of individuals and organizations.

By building on this study's insights and further investigating alternative imaginaries' performativity, researchers can better understand the dynamics between sociotechnical imaginaries and social change, which could inform more effective strategies for promoting sustainable futures. This type of research can also assist policymakers and other stakeholders identify the potential risks and benefits associated with different sociotechnical imaginaries, allowing them to make informed decisions about which ones to pursue or avoid. Ultimately, this can contribute to developing more equitable and sustainable societies that reflect the values and aspirations of diverse communities.

References

Aitken, R., Watkins, L., & Kemp, S. (2019). Envisioning a sustainable consumption future. *Young Consumers*, *20*(4), 299–313. https://doi.org/10.1108/YC-12-2018-0905

Baber, Z., Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1995). The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies. *Contemporary Sociology*, *24*(6), 751. https://doi.org/10.2307/2076669

Ballo, I. F. (2015). Imagining energy futures: Sociotechnical imaginaries of the future Smart Grid in Norway. *Energy Research & Social Science*, *9*, 9–20. https://doi.org/10.1016/j.erss.2015.08.015

Berkhout, F. (2006). Normative expectations in systems innovation. *Technology Analysis & Strategic Management*, *18*(3–4), 299–311. https://doi.org/10.1080/09537320600777010

Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. *Sustainable Cities and Society*, *38*, 758–794. https://doi.org/10.1016/j.scs.2017.12.032

Bibri, S. E. (2020). A methodological framework for futures studies: Integrating normative backcasting approaches and descriptive case study design for strategic data-driven smart sustainable city planning. *Energy Informatics*, *3*(1), 31. https://doi.org/10.1186/s42162-020-00133-5

Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: Towards a user's guide. *Futures*, *38*(7), 723–739. https://doi.org/10.1016/j.futures.2005.12.002

Burch, S., Shaw, A., Dale, A., & Robinson, J. (2014). Triggering transformative change: A development path approach to climate change response in communities. *Climate Policy*, *14*(4), 467–487. https://doi.org/10.1080/14693062.2014.876342

Burnham, M., Eaton, W., Selfa, T., Hinrichs, C., & Feldpausch-Parker, A. (2017). The politics of imaginaries and bioenergy sub-niches in the emerging Northeast U.S. bioenergy economy. *Geoforum*, *82*, 66–76. https://doi.org/10.1016/j.geoforum.2017.03.022

Busetto, L., Wick, W., & Gumbinger, C. (2020). How to use and assess qualitative research methods. *Neurological Research and Practice*, *2*(1), 14. https://doi.org/10.1186/s42466-020-00059-z

Carroll A. B., Buchholtz A. (2014). Business and society: Ethics, sustainability, and stakeholder management. Stamford, CT: *Cengage Learning*.

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014). The Use of Triangulation in Qualitative Research. *Oncology Nursing Forum*, *41*(5), 545–547. https://doi.org/10.1188/14.ONF.545-547

Cheng, H. G., & Phillips, M. R. (2014). *Secondary analysis of existing data: Opportunities and implementation. 26*(6).

Cidell, J. (2017). Sustainable imaginaries and the green roof on Chicago's City Hall. *Geoforum*, *86*, 169–176. https://doi.org/10.1016/j.geoforum.2017.09.016

Clark, W. C., van Kerkhoff, L., Lebel, L., & Gallopin, G. C. (2016). Crafting usable knowledge for sustainable development. *Proceedings of the National Academy of Sciences*, *113*(17), 4570–4578. https://doi.org/10.1073/pnas.1601266113

de Brabandere, L., & Iny, A. (2010). Scenarios and creativity: Thinking in new boxes. *Technological Forecasting and Social Change*, *77*(9), 1506–1512. https://doi.org/10.1016/j.techfore.2010.07.003

de Bruin, J. O., Kok, K., & Hoogstra-Klein, M. A. (2017). Exploring the potential of combining participative backcasting and exploratory scenarios for robust strategies: Insights from the Dutch forest sector. *Forest Policy and Economics*, *85*, 269–282. https://doi.org/10.1016/j.forpol.2017.06.007

Delina, L. L. (2018). Whose and what futures? Navigating the contested coproduction of Thailand's energy sociotechnical imaginaries. *Energy Research & Social Science*, *35*, 48–56. https://doi.org/10.1016/j.erss.2017.10.045

Duinker, P. N., & Greig, L. A. (2007). Scenario analysis in environmental impact assessment: Improving explorations of the future. *Environmental Impact Assessment Review*, *27*(3), 206–219. https://doi.org/10.1016/j.eiar.2006.11.001

Eames, M., & Egmose, J. (2011). Community foresight for urban sustainability: Insights from the Citizens Science for Sustainability (SuScit) project. *Technological Forecasting and Social Change*, *78*(5), 769–784. https://doi.org/10.1016/j.techfore.2010.09.002

Engels, F., & Münch, A. V. (2015). The micro smart grid as a materialised imaginary within the German energy transition. *Energy Research & Social Science*, *9*, 35–42. https://doi.org/10.1016/j.erss.2015.08.024

Fazey, I., Schäpke, N., Caniglia, G., Patterson, J., Hultman, J., van Mierlo, B., Säwe, F., Wiek, A., Wittmayer, J., Aldunce, P., Al Waer, H., Battacharya, N., Bradbury, H., Carmen, E., Colvin, J., Cvitanovic, C., D'Souza, M., Gopel, M., Goldstein, B., … Wyborn, C. (2018). Ten essentials for action-oriented and second order energy transitions, transformations and climate change research. *Energy Research & Social Science*, *40*, 54–70. https://doi.org/10.1016/j.erss.2017.11.026

Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: Interviews and focus groups. *British Dental Journal*, *204*(6), 291–295. https://doi.org/10.1038/bdj.2008.192

Graf, A., & Sonnberger, M. (2020). Responsibility, rationality, and acceptance: How future users of autonomous driving are constructed in stakeholders' sociotechnical imaginaries. *Public Understanding of Science*, *29*(1), 61–75. https://doi.org/10.1177/0963662519885550

Helling, A. (1998). Collaborative Visioning: Proceed With Caution!: Results From Evaluating Atlanta's Vision 2020 Project. *Journal of the American Planning Association*, *64*(3), 335–349. https://doi.org/10.1080/01944369808975990

Hermans, F., Roep, D., & Klerkx, L. (2016). Scale dynamics of grassroots innovations through parallel pathways of transformative change. *Ecological Economics*, *130*, 285–295. https://doi.org/10.1016/j.ecolecon.2016.07.011

Hirt, L. F., Sahakian, M., & Trutnevyte, E. (2022). What subnational imaginaries for solar PV? The case of the Swiss energy transition. *Technology in Society*, *71*, 102068. https://doi.org/10.1016/j.techsoc.2022.102068

Hölscher, K., Wittmayer, J. M., Hirschnitz-Garbers, M., Olfert, A., Walther, J., Schiller, G., & Brunnow, B. (2021). Transforming science and society? Methodological lessons from and for transformation research. *Research Evaluation*, *30*(1), 73–89. https://doi.org/10.1093/reseval/rvaa034

Höysniemi, S. (2022). Energy futures reimagined: The global energy transition and dependence on Russian energy as issues in the sociotechnical imaginaries of energy security in Finland. *Energy Research & Social Science*, *93*, 102840. https://doi.org/10.1016/j.erss.2022.102840

Jasanoff, S., & Kim, S.-H. (2009). Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea. *Minerva*, *47*(2), 119–146. https://doi.org/10.1007/s11024-009-9124-4

Jasanoff, S., & Kim, S.-H. (2015). *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*. University of Chicago Press. https://doi.org/10.7208/chicago/9780226276663.001.0001

Johansson, E. L., Brogaard, S., & Brodin, L. (2022). Envisioning sustainable carbon sequestration in Swedish farmland. *Environmental Science & Policy*, *135*, 16–25. https://doi.org/10.1016/j.envsci.2022.04.005

Kallis, G., Hatzilacou, D., Mexa, A., Coccossis, H., & Svoronou, E. (2009). Beyond the manual: Practicing deliberative visioning in a Greek island. *Ecological Economics*, *68*(4), 979–989. https://doi.org/10.1016/j.ecolecon.2007.07.002

Kläy, A., Zimmermann, A. B., & Schneider, F. (2015). Rethinking science for sustainable development: Reflexive interaction for a paradigm transformation. *Futures*, *65*, 72–85. https://doi.org/10.1016/j.futures.2014.10.012

Klein, J. T. (2014). Discourses of transdisciplinarity: Looking Back to the Future. *Futures*, *63*, 68–74. https://doi.org/10.1016/j.futures.2014.08.008

Laclau, E. (2007) Emancipation(s). London: Verso

Levenda, A. M., Richter, J., Miller, T., & Fisher, E. (2019). Regional sociotechnical imaginaries and the governance of energy innovations. *Futures*, *109*, 181–191. https://doi.org/10.1016/j.futures.2018.03.001

Longhurst, N., & Chilvers, J. (2019). Mapping diverse visions of energy transitions: Co-producing sociotechnical imaginaries. *Sustainability Science*, *14*(4), 973–990. https://doi.org/10.1007/s11625-019-00702-y

Marien, M. (2002). Futures studies in the 21st Century: A reality-based view. *Futures*, *34*(3–4), 261–281. https://doi.org/10.1016/S0016-3287(01)00043-X

Marquardt, J., & Delina, L. L. (2019). Reimagining energy futures: Contributions from community sustainable energy transitions in Thailand and the Philippines. *Energy Research & Social Science*, *49*, 91–102. https://doi.org/10.1016/j.erss.2018.10.028

McAlpine, C. A., Seabrook, L. M., Ryan, J. G., Feeney, B. J., Ripple, W. J., Ehrlich, A. H., & Ehrlich, P. R. (2015). Transformational change: Creating a safe operating space for humanity. *Ecology and Society*, *20*(1), art56. https://doi.org/10.5751/ES-07181-200156

Milkoreit, M. (2017). Imaginary politics: Climate change and making the future. *Elementa: Science of the Anthropocene*, *5*, 62. https://doi.org/10.1525/elementa.249

Mukherjee, M., Posch, K., Molina, S. J., Taymor, K., & Keller, A. (2023). Comparing

regulatory processes in genome editing and autonomous vehicles: How institutional environments shape sociotechnical imaginaries. Review of Policy Research. https://doi.org/10.1111/ropr.12532

Milojević, I., & Inayatullah, S. (2015). Narrative foresight. *Futures*, *73*, 151–162. https://doi.org/10.1016/j.futures.2015.08.007

Nasruddin, E., Bustami, R., & Inayatullah, S. (2012). Transformative foresight: Universiti Sains Malaysia leads the way. *Futures*, *44*(1), 36–45. https://doi.org/10.1016/j.futures.2011.08.005

O'Brien, K. (2011). Responding to environmental change: A new age for human geography? *Progress in Human Geography*, *35*(4), 542–549. https://doi.org/10.1177/0309132510377573

O'Brien, K. (2012). Global environmental change II: From adaptation to deliberate transformation. *Progress in Human Geography*, *36*(5), 667–676. https://doi.org/10.1177/0309132511425767

O'Brien, K. (2013). Global environmental change III: Closing the gap between knowledge and action. *Progress in Human Geography*, *37*(4), 587–596. https://doi.org/10.1177/0309132512469589

Pereira, L. M., Hichert, T., Hamann, M., Preiser, R., & Biggs, R. (2018). Using futures methods to create transformative spaces: Visions of a good Anthropocene in southern Africa. *Ecology and Society*, *23*(1), art19. https://doi.org/10.5751/ES-09907-230119

Piirainen, K. A., Gonzalez, R. A., & Bragge, J. (2012). A systemic evaluation framework for futures research. *Futures*, *44*(5), 464–474. https://doi.org/10.1016/j.futures.2012.03.008

Pileggi, S. F. (2021). Knowledge interoperability and re-use in Empathy Mapping: An ontological approach. *Expert Systems with Applications*, *180*, 115065. https://doi.org/10.1016/j.eswa.2021.115065

Pimentel, J. L. (2010). A note on the usage of Likert Scaling for research data analy. *USM R&D Journa*, *18 (2)*, 109–112.

Rabiej-Sienicka, K., Rudek, T. J., & Wagner, A. (2022). Let it Flow, Our Energy or Bright Future: Sociotechnical imaginaries of energy transition in Poland. *Energy Research & Social Science*, *89*, 102568. https://doi.org/10.1016/j.erss.2022.102568

Ravetz, R. (1993). *SCIENCE FOR THE POST-NORMAL*. 17.

Richter, J. A., Tidwell, A. S. D., Fisher, E., & Miller, T. R. (2017). STIRring the grid: Engaging energy systems design and planning in the context of urban sociotechnical imaginaries. *Innovation: The European Journal of Social Science Research*, *30*(3), 365–384. https://doi.org/10.1080/13511610.2016.1237281

Riedy, C., & Waddock, S. (2022). Imagining transformation: Change agent narratives of sustainable futures. *Futures*, *142*, 103010. https://doi.org/10.1016/j.futures.2022.103010

Robinson, J. (2003). Future subjunctive: Backcasting as social learning. *Futures*, *35*(8), 839–856. https://doi.org/10.1016/S0016-3287(03)00039-9

Robinson, J. B. (1990). Futures under glass. *Futures*, *22*(8), 820–842. https://doi.org/10.1016/0016-3287(90)90018-D

Rubin, A., & Kaivo-Oja, J. (1999). Towards a futures-oriented sociology. *International Review of Sociology*, *9*(3), 349–371. https://doi.org/10.1080/03906701.1999.9971322

Rudek, T. J. (2022). Capturing the invisible. Sociotechnical imaginaries of energy. The critical overview. *Science and Public Policy*, *49*(2), 219–245. https://doi.org/10.1093/scipol/scab076

Ryghaug, M., & Toftaker, M. (2016). Creating transitions to electric road transport in Norway: The role of user imaginaries. *Energy Research & Social Science*, *17*, 119–126. https://doi.org/10.1016/j.erss.2016.04.017

Santos Pereira, T., Carvalho, A., & Fonseca, P. F. C. (2017). Imaginaries of nuclear energy in the Portuguese parliament: Between promise, risk, and democracy. *Public Understanding of Science*, *26*(3), 289–306. https://doi.org/10.1177/0963662516662738

Schelhas, J., Hitchner, S., & Brosius, J. P. (2018). Envisioning and implementing wood-based bioenergy systems in the southern United States: Imaginaries in everyday talk. *Energy Research & Social Science*, *35*, 182–192. https://doi.org/10.1016/j.erss.2017.10.042

Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, *47*(9), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011

Sharpe, B., Hodgson, A., Leicester, G., Lyon, A., & Fazey, I. (2016). Three horizons: A pathways practice for transformation. *Ecology and Society*, *21*(2), art47. https://doi.org/10.5751/ES-08388-210247

Sheppard, S. R. J., Shaw, A., Flanders, D., Burch, S., Wiek, A., Carmichael, J., Robinson, J., & Cohen, S. (2011). Future visioning of local climate change: A framework for community engagement and planning with scenarios and visualisation. *Futures*, *43*(4), 400–412. https://doi.org/10.1016/j.futures.2011.01.009

Sismondo, S. (2020). Sociotechnical imaginaries: An accidental themed issue. *Social Studies of Science*, *50*(4), 505–507. https://doi.org/10.1177/0306312720944753

Smith, J. M., & Tidwell, A. S. (2016). The everyday lives of energy transitions: Contested sociotechnical imaginaries in the American West. *Social Studies of Science*, *46*(3), 327–350. https://doi.org/10.1177/0306312716644534

Sools, A. M., Tromp, T., & Mooren, J. H. (2015). Mapping letters from the future: Exploring narrative processes of imagining the future. *Journal of Health Psychology*, *20*(3), 350–364. https://doi.org/10.1177/1359105314566607

Stokols, D. (2006). Toward a Science of Transdisciplinary Action Research. *American Journal of Community Psychology*, *38*(1–2), 79–93. https://doi.org/10.1007/s10464-006-9060-5

Strauss, C. (2006). The Imaginary. *Anthropological Theory*, *6*(3), 322–344. https://doi.org/10.1177/1463499606066891

Swart, R. J., Raskin, P., & Robinson, J. (2004). The problem of the future: Sustainability science and scenario analysis. *Global Environmental Change*, *14*(2), 137–146. https://doi.org/10.1016/j.gloenvcha.2003.10.002

Vähäkari, N., Lauttamäki, V., Tapio, P., Ahvenainen, M., Assmuth, T., Lyytimäki, J., & Vehmas, J. (2020). The future in sustainability transitions—Interlinkages between the

multi-level perspective and futures studies. *Futures*, *123*, 102597. https://doi.org/10.1016/j.futures.2020.102597

van der Hel, S. (2018). Science for change: A survey on the normative and political dimensions of global sustainability research. *Global Environmental Change*, *52*, 248–258. https://doi.org/10.1016/j.gloenvcha.2018.07.005

van Vliet, M., & Kok, K. (2015). Combining backcasting and exploratory scenarios to develop robust water strategies in face of uncertain futures. *Mitigation and Adaptation Strategies for Global Change*, *20*(1), 43–74. https://doi.org/10.1007/s11027-013-9479-6

Vergragt, P. J., & Quist, J. (2011). Backcasting for sustainability: Introduction to the special issue. *Technological Forecasting and Social Change*, *78*(5), 747–755. https://doi.org/10.1016/j.techfore.2011.03.010

Wentland, A. (2016). Imagining and enacting the future of the German energy transition: Electric vehicles as grid infrastructure. *Innovation: The European Journal of Social Science Research*, *29*(3), 285–302. https://doi.org/10.1080/13511610.2016.1159946

Wiek, A., & Iwaniec, D. (2014). Quality criteria for visions and visioning in sustainability science. *Sustainability Science*, *9*(4), 497–512. https://doi.org/10.1007/s11625-013-0208-6

Wittmayer, J., Loorbach, D., Bogner, K., Hendlin, Y., Hölscher, K., Lavanga, M., Vasques, A., von Wirth, T., & de Wa, M. (2021). *Transformative Research: Knowledge and action for just sustainability transitions. DIT Working paper for positioning transformative research.* Design Impact Transition Platform, Erasmus University Rotterdam.

Appendix A – Overview of the interviewees

Position at TU/e	Number of interviewees
Assistant Professor	7
Associate Professor	1
Full Professor	7
Managing Director	1
Partner	1
Phd Candidate	2
Postdoc	1
Rector	1
Scientific Director	1
Student	2
University Researcher	1

POSITION AT TU/E
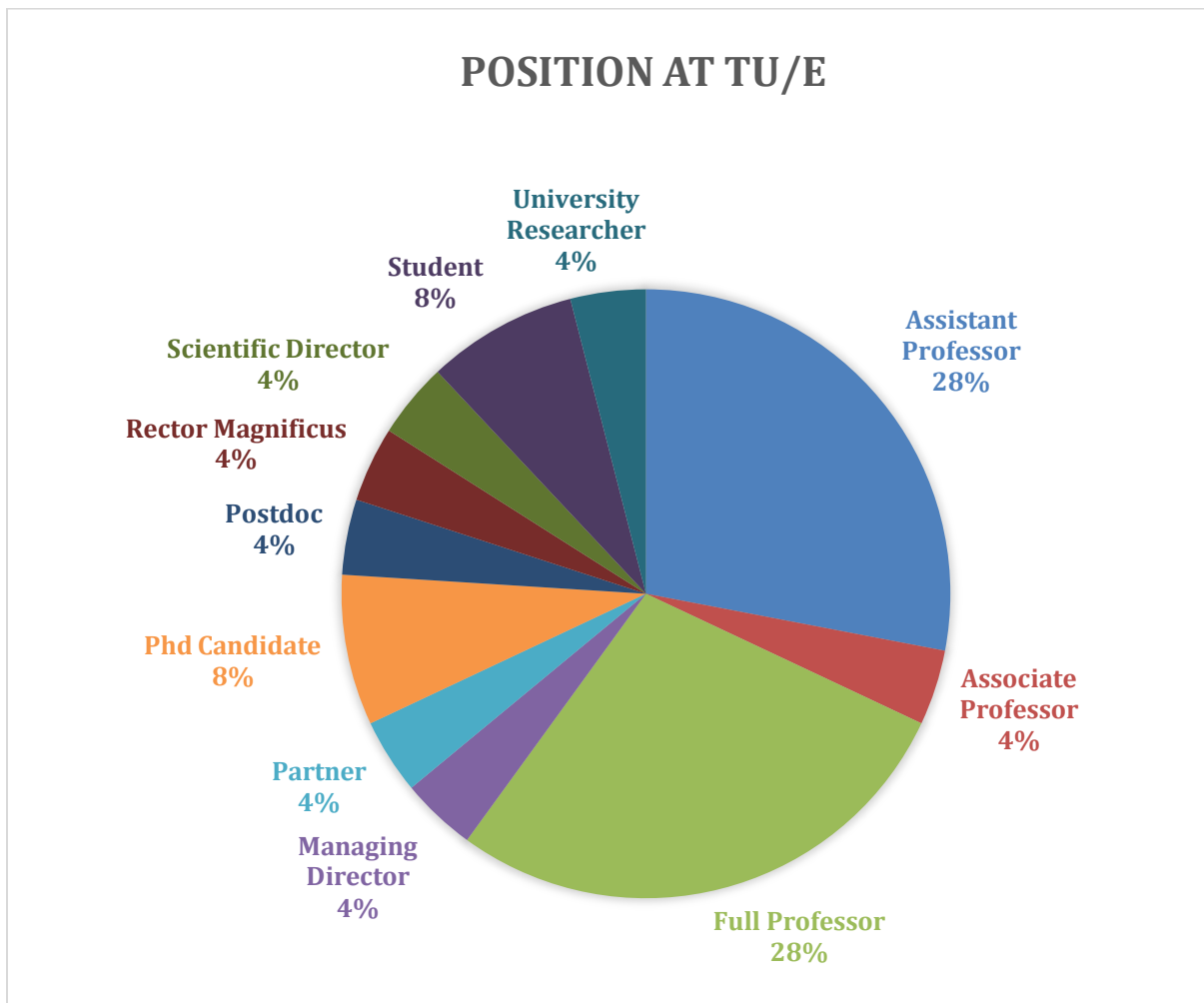
Departments	Number of interviewees
Applied Physics	4
Built Environment	1
Chemical Engineering & Chemistry	6
Partner	1
Electrical Engineering	3
Industrial Design	1
Industrial Engineering & Innovation Science	4
Mathematics & Computer Science	2
Mechanical Engineering	3

DEPARTMENTS

Mechanical Engineering 12%

Mathematics & Computer Science 8%

Industrial Engineering & Innovation Science 16%

Industrial Design 4%

Electrical Engineering 12%

Partner 4%

Chemical Engineering & Chemistry 24%

Built Environment 4%

Applied Physics 16%
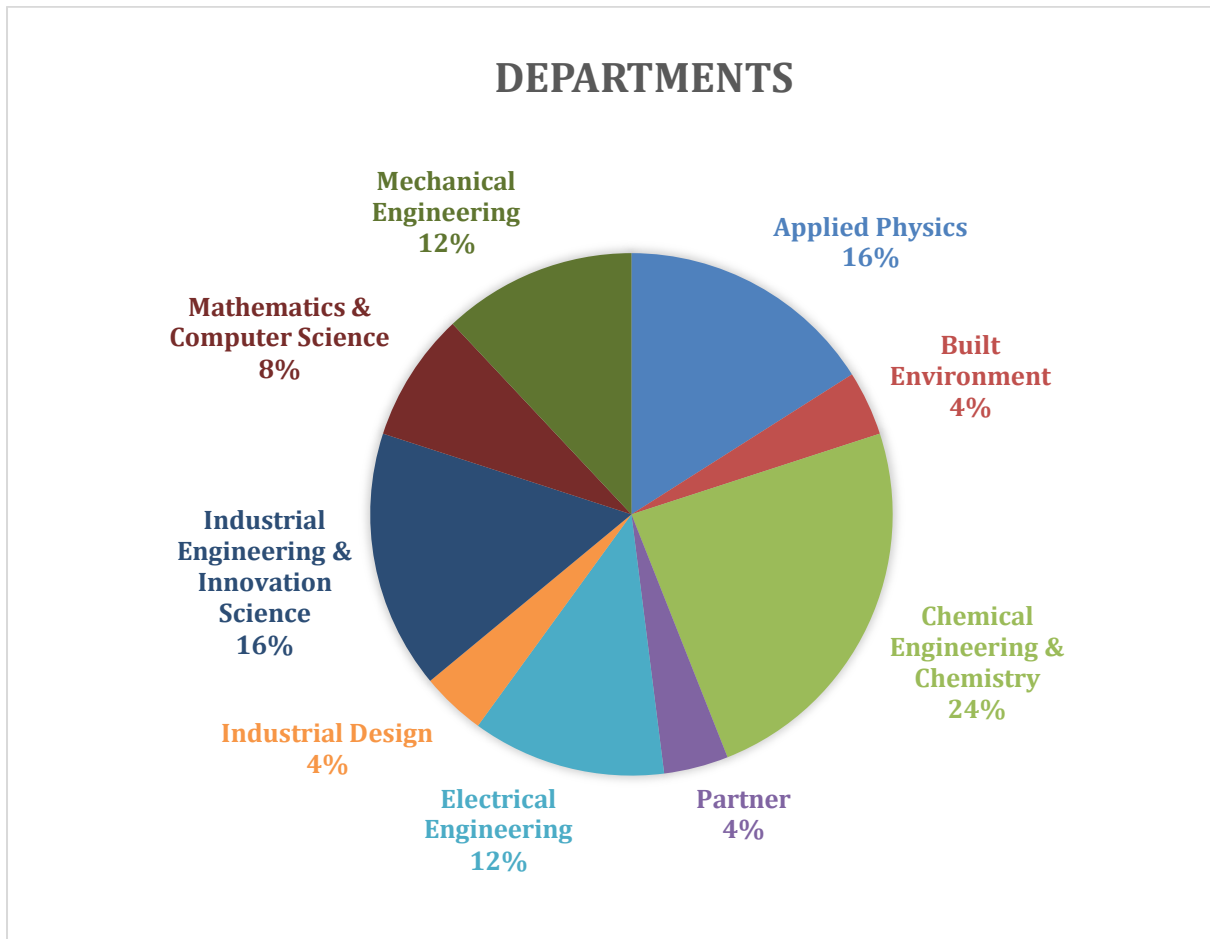
Appendix B – Information and consent form

INFORMATION & CONSENT FOR PARTICIPANTS

This information sheet invites you to take part in an interview for my study and to provide you with further information about the research.

About the Research

We are Master and Bachelor students at the Eindhoven University of Technology (TU/e) working on the #SustainableTue project. The project aims to coordinate a transition to a sustainable university in collaboration with the TU/e community. It is promoted by the TU/e's Sustainability Ambassador **Dr. ir. Anna Wieczorek,** supervised by **Dr. ir. Jonas Colen Ladeia Torrens**, and funded by the TU/e. You can find more information on the TU/e website.

Kerylaine's master's thesis aims to investigate how visioning processes can be used at the university to stimulate the creation of imaginaries (in terms of a shared and institutionalized vision of what the future should be) as an alternative to the dominant ones that do not necessarily give much attention to sustainability. The study focuses on transformative research, in particular, looking at visions as values, preferences, ways of thinking, and ideas about the best possible future in this particular domain.

Niek's bachelor end thesis aims to explore the TU/e as a research institute in ways to let it facilitate sustainability transitions. This particular study focuses on identifying the possibilities for transformative research to be conducted at the TU/e and ways that macro trends (e.g. the climate change debate) might influence TU/e's ability for transformative research to be conducted.

We define transformative research as research that seeks to address societal challenges and sustainability, challenging and reimagining current research structures, cultures and practices.

Your involvement

You have been invited to participate due to your active involvement or interest in sustainability research for transformative change and/or you are part of a research community related to the UN's Sustainable Development Goals (SDGs).

Your role will involve an audio-recorded interview of approximately 45'-1h where I will ask you open questions about your research, community and the TU/e. Also, we will make a transcript of the interview.

Controller in the sense of the GDPR

TU/e is responsible for processing your personal data within the scope of the research. The contact details of TU/e are:

Technische Universiteit Eindhoven
De Groene Loper 3
5612 AE Eindhoven

Potential risks and inconveniences

Your participation in this research project does not involve any physical, legal or economic risks. You do not have to answer questions which you do not wish to answer. Your participation is voluntary. This

means that you may end your participation at any moment you choose by letting the researcher know this. You do not have to explain why you decided to end your participation in the research project.

Withdrawing your consent and contact details

Ending your participation will have no disadvantageous consequences for you. If you decide to end your participation during the research, the data which you already provided up to the moment of withdrawal of your consent will be used in the research. Do you wish to end the research, or do you have any questions and/or complaints? Then please contact the lead researcher on: n.j.lotgerink@student.tue.nl and/or k.c.assis.magalhaes@student.tue.nl.

If you have specific questions about the handling of personal data you can direct these to the data protection officer of TU/e by sending a mail to: functionarisgegevensbescherming@tue.nl. Furthermore, you have the right to file a complaint with the Dutch data protection authority: the Autoriteit Persoonsgegevens.

Finally, you have the right to request access, rectification, erasure or adaptation of your data. Submit your request via: privacy@tue.nl.

Legal ground for processing your personal data

The legal basis upon which we process your data is consent.

What personal data from you do we gather and process?

Within the framework of the research project, we process the following personal data:

Category	Personal data
Contact data	*Name, e-mail address*
Job profile	*Job title, TU/e department and research group*

Within the framework of the research project your personal data will be shared with:
- *[Storage solution: SURF ResearchDrive, Microsoft (Netherlands)]*
- *[Transcription and data analysis tool: NVivo]*
- *[In-Person Recording software: Voice Recorder, Microsoft]*
- *[Online Recording software: Microsoft Teams]*

Confidentiality of data

We will do everything we can to protect your privacy as best as possible. The research results that will be published will not in any way contain confidential information or personal data from or about you through which anyone can recognize you, unless in our consent form you have explicitly given your consent for mentioning your name, for example in a quote.

The personal data that were gathered via bibliometric analysis, interviews and audio recordings within the framework of this research project will be stored on storage facilities that are supported by the ICT service of TU/e, storage facilities of TU/e with additional security measures (SURF ResearchDrive).

The raw research data (recordings) will be retained for 6 months (end of project), and the processed research data (transcriptions) will be retained for a period of 4 years (end of #SustainableTue project). Ultimately after expiration of this time period the data will be either deleted or anonymized so that it can no longer be connected to an individual person.

CONSENT FORM FOR PARTICIPANTS

This form aims to make sure you have been given the information about this research project (see Information Sheet), confirm that you know what the project is about and you are happy to take part as an interviewee.

Please check the boxes you agree with below and delete as appropriate where * is indicated:

I know what the #SustainableTUe project and associated study are about

I *consent* to participate in an interview and for the information, I provide to be used in the analysis for *both* these initiatives.

I wish to have my anonymity protected

I *consent* to the interview being recorded, and an *anonymous* record to be stored for research purposes in accordance with the data protection policy described in the "Information Sheet for Participants".

I understand the terms under which this record and any additional information I provide will be stored.

I am aware that I do not have to answer all the questions that I am asked, and I reserve my right to refuse or cease participation in the interview process and to request to keep certain materials confidential.

Please sign below to confirm the information given above is correct:

	Research Participant	Researchers
Name:		Niek Lötgerink and Kerylaine Cristina Assis Magalhães
Signature:		
Date:		

For any enquires about this research, please contact:
- Kerylaine Cristina Assis Magalhães – Master student – Industrial Engineering & Innovation Science, TU/e
  Email: k.c.asssis.magalhaes@student.tue.nl
- Niek Lötgerink – Bachelor student – Industrial Engineering & Innovation Science, TU/e
  Email: n.j.lotgerink@student.tue.nl

Appendix C – Interview guide

Interview Guide

INTRODUCTION: give a short presentation of what we are here for
1. (Introducing ourselves, the project and the reason for asking them for an interview)
2. *If consent form isn't filled in: print out and bring to interview*

OPENING: the researchers' relation or interest in research on sustainability
1. Tell me (briefly) about your work and its relation to sustainability research.

1) DEFINING TRANSFORMATIVE RESEARCH FOR SUSTAINABILITY: the researchers' perspective on transformative research for sustainability
1. What does it mean to you in your own research, but also in your research group, to be transformative for sustainability?
   a. Do you feel that your research is transformative and how? What's missing?
   b. Do you feel that the research conducted at TU/e, in general, is transformative
   c. and how?

2) ENVISIONING THE FUTURE: the researchers' vision for the future
2. How do you envision the future of "transformative research for sustainability at TU/e?
   a. (If the answer is about what he/she sees happing - possible future), ask: what would you like the future of research at TU/e to look like (desirable future)?
   b. What influences such vision? Why do you see/feel it like that?

3) PATHWAY: gap-spotting
2. How do you see the alignment between this future and current policies/strategies/ practices of the university?
      a. Why do these discrepancies exist?
3. What do you think has to happen to make such a vision come true? What's standing in the way?

CLOSING: any extra information
1. Do you feel like there is any gap in our questions or anything you want to add?

Appendix D – Overview of workshop participants

Participant position at TU/e	Number of participants
Assistant Professor	7
Associate Professor	2
Full Professor	2
Partner	1
PhD Candidate	8
Postdoc	1
Research Officer	1
Staff	20
Student	20
University Lecturer	3

POSITION AT TU/E

University Lecturer
5%

Assistant Professor
11%

Associate Professor
3%

Full Professor
3%

Partner
1%

PhD Candidate
12%

Postdoc
1%

Research Officer
2%

Staff
31%

Student
31%
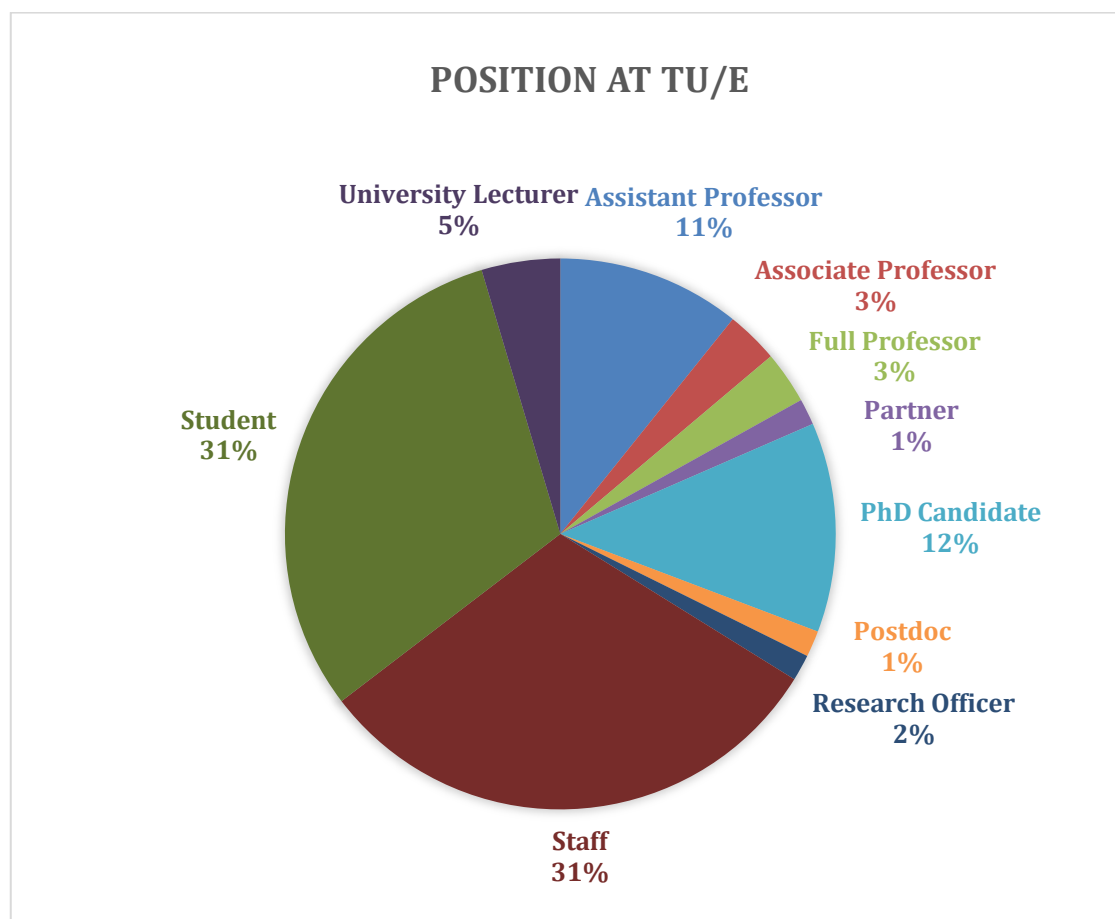
TU/e Department	Number of participants
Applied Physics	2
Built Environment	12
Chemical Engineering and Chemistry	7
Eindhoven School of Education	2
Electrical Engineering	1
Facility Management Centre	2
Finance and Control	2
Industrial Design	12
Industrial Engineering and Innovation Sciences	16
Innovation Space	1
Mathematics and Computer Science	4
Mechanical Engineering	2
Partner	1
Research Support and Valorisation	1

DEPARTEMENT
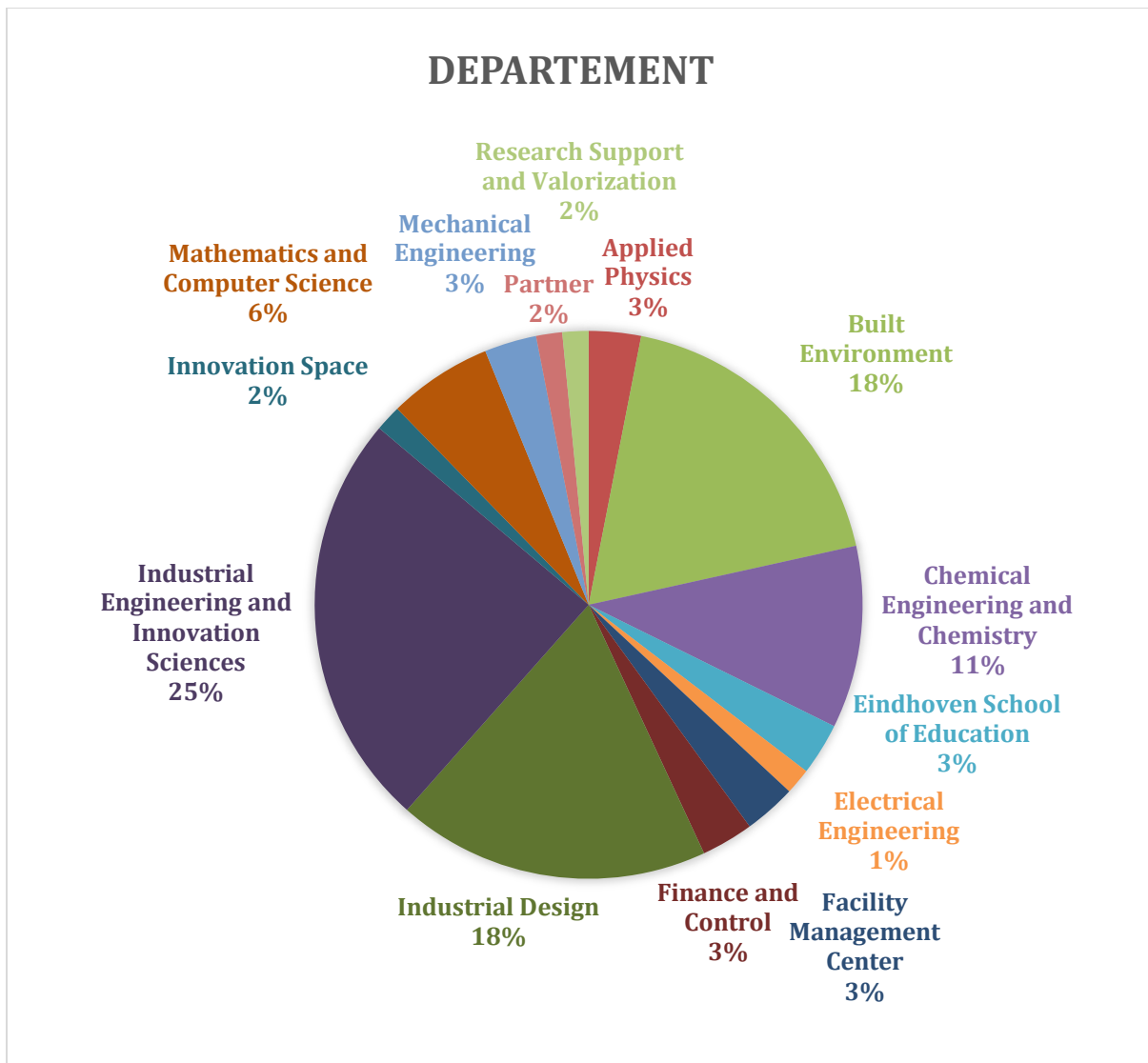
Appendix E – Survey

Sustainability Visioning Workshop Survey

Dear participant,

We want to hear about your experience at the Sustainability Visioning Workshop and your further thoughts and feelings about sustainability at TU/e.

This survey has 8 questions and will take around 4 minutes to complete. Your answers will be kept confidential, used only by the researchers in the **#sustainableTU/e** research projects, and destroyed immediately after processing. There won't be any private or personal information in the research results that could be used to find you.

For further information or feedback, please contact Kerylaine Magalhães via k.c.assis.magalhaes@student.tue.nl.

Thank you again for coming to the workshop and taking the time to complete this survey!

1.Are you?

TU/e student

TU/e staff

Other

2.Which department are you from?

3.Which workshop did you participate in?

4.Which TU/e sustainability domain did you engage in during the workshop?

Research

Education

Operations

Governance

5. **During the workshop...**

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
I engaged in all proposed activities.					
I felt comfortable expressing my opinion.					
I had enough space to input my views on the topics.					

3. **After the workshop...**

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
My awareness of TU/e's commitment to sustainability has improved.					
My perception of TU/e's engagement with sustainability has changed.					
I became more interested in the discussion about sustainability at TU/e.					
I felt more hopeful about TU/e's sustainability efforts.					
I felt more concerned about TU/e's sustainability initiatives in the future.					
I felt more inspired and mobilized about TU/e's future possibilities regarding sustainability.					
I felt more optimistic about TU/e's future institutionalized responses regarding sustainability.					
I felt more confident about the idea that the topic of sustainability can become firmly embedded (a common practice) within TU/e.					

I believe it is possible to shape the terrain of choices and actions taken about sustainability at TU/e.					
I believe TU/e can be a proactive change agent capable of inspiring sustainability actions within and beyond the campus.					

7. Do you see synergies or tensions between the multiple sustainability domains (research, education, operations, and governance)? How are those?

8. Please feel free to tell us anything else you think is important about sustainability at TU/e.

Appendix F – TU/e's Sustainability principles

0 FOUNDATIONAL PRINCIPLES

0 EMBRACING RESPONSIBILITY
TU/e commits to sustainability as a priority and communicates its achievements transparently.

0.1 STANDING UP FOR CHALLENGES
TU/e proactively recognises, anticipates, and acts on urgent environmental and grand societal challenges.

0.2 CONSISTENT & DELIBERATE
TU/e considers social, economic, and environmental aspects of sustainability in all its efforts and decision-making to have a positive impact.

0.3 SOCIALLY AWARE
TU/e treats technological development as inseparable from society, considering its impacts systemically.

0.4 MITIGATING INEQUALITIES
TU/e strives to mitigate social inequalities and their effects within and beyond the university's boundaries.

0.5 MOBILISING RESOURCES
TU/e mobilises the resources, support and collaborations needed to realise transformations towards sustainability.

0.6 COMMUNITY-DRIVEN
TU/e fosters safe, vibrant, and diverse communities and collaborative environments where multiple perspectives are welcome and valued.

0.7 PIONEERING & INSPIRING
TU/e uses its innovations to pioneer regenerative and sustainable futures and inspire others.

0.8 INTEGRATING PRIORITIES
TU/e combines entrepreneurship, diversity, and sustainability efforts to accelerate just and sustainable transformations.

0.9 HOPEFUL & REALISTIC
TU/e fosters a collective sense of hope and realism, supporting its communities in navigating the unprecedented challenges of our times.

2 RESEARCH PRINCIPLES

2 TRANSFORMATIVE RESEARCH
TU/e values, supports, explains, and disseminates transformative research for sustainability.

2.1 COLLABORATIVE & READY
TU/e and its research partners have ample capacities to engage with various societal challenges.

2.2 VIBRANT ECOSYSTEM
TU/e and its partners form a vibrant research ecosystem for sustainability, covering a wide range of perspectives and focal challenges.

2.3 VISIONARY & EXPLORATIVE
TU/e's research is farsighted and dynamic, constantly exploring novel solutions and problem framings to the hardest and most pressing sustainability challenges.