Improving the Efficiency of the Carré Building at the University of Twente through awareness

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Abstract

This report, part of the minor Energy Transition Challenges, explores strategies to improve energy efficiency at the University of Twente by addressing both major and minor energy transition challenges. It is framed by the question, “What tangible and innovative strategies can we implement to raise awareness about energy sustainability and inspire active participation at the University of Twente by 2026?” The proposed improvements aim to engage the university community in activities that promote the energy transition, reduce energy consumption, and encourage sustainable practices.

The recommendations focus on fostering a culture of sustainability through an integrated awareness campaign. By tackling these challenges, this project aspires to position the University of Twente as a model for environmental responsibility.

To address energy waste at the university, an experiment was conducted in the Carré building, which demonstrated the significant factors that impact the energy consumption and the overall energy efficiency of the institution. It also maps the bottlenecks that stagnate current progress towards energy efficiency.

Ultimately the goal is to reduce energy consumption, optimize resource use, and promote sustainable practices by considering both technical and psychological factors.

Uniquely, this project report not only outlines technical findings and actionable recommendations but also narrates the journey of how the project was developed. By weaving together the process, challenges, and insights gained in the course of ten weeks. This report tries to offer a holistic perspective that goes beyond conventional technical paper or report documentation. This approach aims to inspire further action while reflecting on the broader implications of sustainability efforts in academic environments.

Contents

1 Introduction

The Minor Energy Transition Challenges program is all about tackling energy issues right here at the University of Twente. It dives into creative ways to cut down on fossil fuel use, boost renewable energy, and tackle the social and technical hurdles we face in moving toward a sustainable energy system. The different approaches and the people with whom the Carré network consists of, have helped shape the plans for making the Carré building more efficient.

Built in 2010, the Carré building covers about 60,000 square meters and is home to the faculties of Technical Natural Sciences (TNW) and Electrical Engineering, Mathematics, and Computer Science (EEMCS). The Carré building is a major part of campus life, serving as a hub for learning, research, and collaboration. Its modern design and variety of spaces make it essential for the university's operations, featuring lecture halls, labs, and offices. However, like many buildings in institutions, Carré has its own energy efficiency and resource optimization challenges to deal with.
Carré already has notable systems in place such as:

- Centralized technical gases distributed to all laboratories, with specific gases locally installed.
- A helium return installation in the technical room.
- Centralized supply of industrial water, demineralized water, and process cooling systems.
- HVAC (Heating, Ventilation, and Air Conditioning) systems

The Carré building is already very sophisticated, but there is still potential for improving its energy efficiency. This report aims to identify and address the existing limitations and bottlenecks in order to then propose strategies that focus on technical upgrades as well as changes in occupant behaviour. By enhancing the building's efficiency, we can support the university's sustainability goals, lower operational costs, and create a more environmentally friendly campus. Additionally, this initiative can inspire occupants to adopt sustainable practices in their homes and other environments.[1] [2] [3]

2 Problem definition

The biggest challenge we currently face is raising awareness and encouraging participation. Over the past few weeks of the minor program, it has become increasingly clear that participants are motivated strongly, but the actual involvement is lacking. This lack of participation can be attributed to several factors. The past few weeks I have encountered many factors that stagnate and discourage energy efficiency. Most of these factors are common obstacles that efficiency improvement projects often face. To start off and to get an overview of the different categories, a few of the factors that I have encountered in the past few weeks can be categorized into Psychological factors, Technical barriers, and Management challenges and are further elaborated and categorized below:

2.1 Psychological Factors

- **Unfinished Projects:** Many projects and ideas are initiated but left incomplete. This leads to frustration, demotivation, and a lack of trust when new initiatives are proposed.[4]
- **Resistance to Change:** Employees often hesitate to adopt new processes or tools due to fear of failure, comfort with existing practices, or insufficient education about the changes.[5]
- **Lack of Motivation:** Efficiency measures may appear as additional work without immediate benefits, resulting in employee disengagement.[6]
- **Cognitive Overload:** Complex systems or processes can overwhelm employees, making them less likely to engage with efficiency improvements.[7]
- **Neglect of Detailed Improvements:** Small but meaningful improvements often go unnoticed because they are deemed unimportant or too time-consuming to investigate.[8]

The previous mentioned psychological factors differ from person to person. To gain a better understanding it is important to acknowledge these differences. For some people all of them apply while others are inert.

2.1.1 Differences Between Individuals

People respond differently to efficiency initiatives based on their personality, experience, and job role. Some employees take initiative and seek out solutions on their own. Others prefer clear instructions before they act.

Experience plays a role, too. More experienced employees may feel comfortable trying new methods, while those who are new might wait for direction. Job roles also matter; e.g. frontline staff may respond differently than managers, who might think more strategically about improvements.

Understanding these differences is important. Key differences include:

- **Proactive vs. Reactive Attitudes**: Some individuals take ownership of problems and seek improvements independently, while others only act when prompted by leadership. [9]
- **Risk Tolerance**: People vary in their willingness to experiment with new methods, with some embracing change and others avoiding uncertainty.[4]

- **Perceived Impact**: Employees who feel their contributions make a tangible difference are more likely to participate, while those who doubt their influence tend to disengage. [6]
- **Workload Prioritization**: Some employees consider efficiency improvements a core responsibility, while others see them as secondary to their daily tasks.

Getting a handle on these differences is important for developing strategies that can ramp up participation and keep people engaged over time. By understanding what makes each person tick, we can create an atmosphere that encourages more involvement and helps commitment and build lasting connections.

2.2 Technical Barriers

- **Legacy Systems:** Outdated infrastructure, such as inefficient sensors for heating-cooling systems, causes persistent irritations (e.g., temperature fluctuations) and limits progress in adopting energy-efficient solutions [10]. Older buildings often face challenges due to antiquated systems and materials, which hinder efforts to enhance energy performance [11].
- **Sensor Irritations:** Automated systems, such as motion or temperature sensors, may not work as intended, creating inconvenience for users (e.g., lights turning on unnecessarily or inconsistent temperature regulation) [12]. Issues arise continuously throughout the lifetime of a building and its systems, often due to a lack of knowledge and proper maintenance [12].
- **Outdated Time Intervals:** In many areas of buildings, such as labs, offices, hallways, and coffee rooms, lighting systems are not programmed to align with current usage patterns [11]. Lights remain on for extended periods, even in spaces with intermittent or minimal use. For example, coffee rooms often have lights that stay on unnecessarily long, leading to avoidable energy consumption. Many lighting systems and other automated features are installed but are not updated to reflect current usage patterns. For example:
  - Air circulation or HVAC systems may run at full capacity outside of active hours, leading to unnecessary energy consumption.
  - Heating within the buildings is often set to 22 degrees or more even when there are very few occupants within the building.
- **Cost Constraints:** Upgrading to more efficient systems often requires significant upfront investment, which is frequently deprioritized due to budget limitations or unclear costs [10]. Financial barriers, including limited budgets and regulatory constraints, can hinder efforts to enhance energy performance in older buildings [11].
- **Integration Issues:** New solutions often fail to integrate seamlessly with existing systems, leading to further delays and inefficiencies [13]. A lack of consistent and standardized solutions or integrated solutions to comply with new and different building standards can pose significant technical barriers [13].
- **Lack of Awareness and Education:** Users often lack understanding of the systems already in place, such as HVAC (heating, ventilation, and air conditioning)[12]. For example:

  - Inappropriate use of windows in summer disrupts cooling systems.
  - Insufficient knowledge about the operation of air-handling units leads to inefficient use, such as failing to press the ”home” button on entry to maintain optimal airflow.
  - General unawareness of the potential for optimization in lighting, temperature, and ventilation settings.[12]

2.3 Management Challenges

- **Bureaucratic Bottlenecks:** Large organizations, such as the University of Twente, often face delays in decision-making due to the involvement of multiple departments and lengthy approval processes [14]. For instance, coordination between CFM (Campus Facility Management) and the Carré faculties frequently faces delays, reducing responsiveness to identified problems. Research shows that multi-layered governance structures and hierarchical decision-making processes slow down the adoption of energy-efficient initiatives in academic and corporate institutions [15].
- **Poor Communication:** A lack of clear communication regarding the benefits and implementation of efficiency measures can lead to misunderstandings and resistance [16]. When employees are not adequately informed about new policies or system changes, they may fail to adopt energy-efficient behaviours or actively resist changes due to a lack of perceived benefit [17]. Furthermore, ineffective communication about energy-saving measures contributes to missed opportunities for engagement [18].
- **Communication Barriers:** Inefficient communication between faculties and administrative bodies leads to issues such as unresolved problems in shared spaces [15]. Energy efficiency projects require coordination between various stakeholders, including facility managers, academic staff, and students. However, without a structured framework for interdepartmental collaboration, information often gets lost or delayed [16].
- **Delayed Feedback Response:** Feedback from employees about recurring issues (e.g. sensor irritations or temperature inconsistencies) is often acknowledged but not resolved promptly, leading to frustration and the perception that concerns are ignored [17]. Studies indicate that organizations with slow response mechanisms experience disengagement from their workforce, as employees feel their input does not lead to tangible improvements [18]. Addressing feedback in a timely manner is crucial for maintaining motivation and participation in efficiency improvement programs [14].

2.4 Cost Management and Responsibility

- **Unclear Ownership of Costs:** Many efficiency projects are delayed or abandoned due to uncertainty about who bears the financial responsibility for implementation [19]. This lack of clarity can lead to delays in decision-making as stakeholders hesitate to take responsibility. For example:
  - Should CFM, faculties, or other specific departments cover the costs of systems that help reduce energy usage within offices?
  - Who is responsible for maintaining and optimizing existing HVAC systems for energy usage? Do the faculties have to inform the CFM, or does CFM have to

conduct the research to improve it, or both? These questions often remain unresolved, preventing the identification of effective cost-saving measures [20][21].

- **Prioritization of Resources:** Budget constraints often force decision-makers to prioritize high-profile projects, leaving smaller but impactful improvements (e.g., temperature regulation or energy-saving sensors) underfunded [22]. It is common for decision-makers to allocate resources to projects that yield immediate visible outcomes, while long-term energy-saving measures often take a back seat due to perceived lower priority [23].
- **Fragmented Accountability:** With multiple stakeholders involved, accountability for cost management and project outcomes becomes unclear, leading to inefficiencies [24]. As departments, such as CFM and individual faculties, manage different aspects of the building infrastructure, no single entity may feel fully responsible for the efficiency outcomes, leading to fragmented decision-making and missed opportunities for savings [25].

Many of these problems are interconnected. They form a network, and as you delve deeper into the smaller branches, you encounter more issues. Unfortunately, many of these smaller details are often overlooked or considered insignificant, leading to a lack of attention and investment. This is quite contradictory, as all these small aspects combined offer (significant) opportunities for improvement. Addressing these issues can not only save considerable energy in terms of gas and electricity but also result in substantial financial savings. In Chapter Four, we will explore the cumulative impact of these factors and in Chapter Seven (The Phantom Energy Project) discuss how this project initially began. But firstly;

3 Background on the motivation

In recent years, energy consumption on university campuses has become a significant concern. With rising energy costs and the environmental challenges associated with excessive energy use, it is essential for campuses to implement strategies to reduce their energy consumption. Increasing operational costs, driven by escalating energy prices, place additional financial pressure on universities, making energy efficiency both an environmental necessity and an economic priority. Furthermore, government budget cuts in education have limited available resources, prompting institutions to seek cost-effective ways to maintain operations while upholding their academic and research standards. This issue is not only about saving money but also about fostering a culture of sustainability among students, faculty, and staff. Energy awareness plays a crucial role in broader sustainability efforts, as a university serves as a pioneer as well as a role model for sustainable development. By implementing energy-saving initiatives, higher education institutions can lead by example. By demonstrating the best practices it can guide and inspire adoption across the country.

The Netherlands, like many other nations, is committed to achieving the climate targets set by the Paris Agreement for 2030. Universities, including the University of Twente, play an essential role in these efforts by continuously working towards greater sustainability. With strong global connections, the impact of these initiatives extends beyond Enschede, influencing a wider network of academic and industrial partners. In this context, my ETC minor contributes to the University of Twente's sustainability goals by equipping students with the skills to tackle energy challenges and develop innovative solutions. By fostering knowledge and expertise in energy management, students are prepared to address pressing sustainability issues, ensuring that universities remain at the forefront of the transition to a more energy-efficient and environmentally responsible future. Additionally, by increasing self-sufficiency, the university gains greater control over its resources, reducing its vulnerability to external economic and political shifts, and securing a sustainable future.

4 The Environmental and Cost Impact of Energy Usage

Universities contribute substantially to carbon emissions due to their extensive energy consumption. This includes the electricity required for illuminating classrooms and hallways, maintaining comfortable temperatures through heating and cooling, and powering a variety of electronic devices utilized for teaching and research. [26]. In addition to this, universities also consume various gases and materials for research activities, further increasing their environmental impact. By actively reducing energy consumption and implementing more sustainable practices, universities can play a crucial role in mitigating their carbon footprint. This shift would not only benefit the institutions themselves but also contribute significantly to global efforts aimed at combating climate change and promoting environmental sustainability.

The University of Twente (UT) is currently actively managing the rising operational costs associated with its commitment to sustainability and the green transition. As part of its efforts to reduce its carbon footprint and increase its energy efficiency, the UT has made substantial investments in renewable energy sources, including sourcing 100% of its electricity from green providers since January 2022, through Engie. Additionally, the university has entered into agreements with Vattenfall for its gas supply and Ennatuurlijk

for district heating, further aligning its operations with sustainable energy practices [27] [28] [29]. However, the shift to renewable energy and the associated infrastructure adjustments come with increased operational costs. While these efforts are essential for meeting the university's sustainability goals, they also require ongoing investments in maintaining and expanding energy-efficient systems, including smart buildings, energy-saving technologies, and monitoring systems. The UT must also navigate the financial challenges posed by rising energy prices, which are further compounded by the broader European context [30], where high energy costs have become a significant concern for both private and public institutions [26].

Moreover, the university faces additional pressures due to cuts in public funding for higher education. The Dutch government has been reducing its financial support for universities, making it more difficult for institutions like the UT to maintain their operations while continuing to invest in long-term sustainability initiatives. For the UT this meant reallocating funds that could have been invested in research, education, or student services. To this day this is still a problem but this is why the UT has to seek alternative funding sources. By streamlining operations and prioritizing energy-saving measures that reduce operational expenses over time this can be done. The university's approach involves optimizing energy usage across campus buildings, further implementing energy-saving technologies, and exploring opportunities to reduce energy demand without compromising the quality of education or research. Although the UT has made strides, the road ahead is long, and the university's efforts to address these issues will require continued innovation, collaboration, and investment in sustainable practices.

For now however, as the focus has largely been on large-scale projects and systemic changes, smaller, seemingly insignificant adjustments are often overshadowed or overlooked. At the UT, the financial impact of smaller cost-saving measures, such as reducing energy consumption in individual buildings or optimizing resource usage in specific departments, may seem trivial in isolation. For example, a saving of €10,000 per initiative can appear negligible when viewed in the context of the university's overall budget. Yet, when accumulated across various departments and initiatives, these smaller savings could add up to a significant amount over time. The challenge here is that the attention and focus given to larger, more visible projects have often overshadowed these smaller, but still impactful, efforts. In the rush to implement large-scale sustainability measures, the university may have unintentionally overlooked the power of small, incremental changes that can collectively contribute to achieving its sustainability and cost management goals.

The issue is not that the university isn't aware of these smaller opportunities, but rather that the large-scale initiatives—such as major energy-efficient upgrades or large renewable energy investments—tend to capture the most attention and resources. This has led to a narrowing of focus or tunnel vision, where the attention to detail that could yield substantial savings in individual areas is often forgotten. The challenge is to strike a balance between grand-scale initiatives and careful attention to the smaller, everyday actions that can cumulatively lead to significant outcomes.

To ensure that no opportunity is missed, the university must refocus and place renewed emphasis on optimizing these smaller, often overlooked areas. Encouraging departments to actively identify and address minor inefficiencies in energy use, resource management, and day-to-day operations can significantly contribute to both reducing operational costs and supporting the university's broader sustainability objectives. By fostering a culture where every euro and every kWh counts, the UT can make a meaning-

ful impact at both the micro and macro levels. This more holistic approach can drive the university's sustainability efforts, demonstrating that even the smallest changes, when collectively embraced, can make a substantial difference.

5 A Culture of Energy Awareness

Energy awareness and behavioural change are critical aspects of the energy transition. At the University of Twente, there is a broad recognition that actions need to be taken to improve energy sustainability. However, throughout my minor, it became increasingly clear that despite this motivation, many individuals face significant barriers that prevent effective change. These barriers range from organizational challenges and lack of understanding to communication gaps as previously mentioned in chapter Problem Definition
.

One of the challenges in reducing energy consumption on campus is the lack of awareness among its users. Energy usage has become so integrated into daily life that it often goes unnoticed. Lights are left on in empty rooms, computers run overnight, and heating or cooling systems operate unnecessarily. This unconscious behaviour results in significant energy waste [31, 32].

5.1 Challenges and Barriers

Although students and staff are aware of the need for sustainability initiatives, structural and procedural obstacles often hinder progress. Organizational complexities create bureaucratic delays, making it difficult to implement new solutions efficiently. Furthermore, misunderstandings about energy-saving measures and their impact contribute to a lack of engagement. Communication between different departments and stakeholders also plays a crucial role; misalignment of goals and priorities can slow down efforts toward meaningful change. Beyond organizational barriers, behavioural and psychological factors also influence energy use. Studies have shown that awareness of energy transition challenges does not necessarily translate into action. Economic concerns, convenience, and social factors often take precedence over sustainability efforts. Additionally, energy transition requires a shift in human behaviour, which can be difficult to achieve without targeted interventions. Fostering a culture of energy awareness requires education and engagement. Universities can initiate campaigns to remind individuals to turn off lights, unplug devices, and use energy-efficient appliances. Incorporating sustainability topics into the curriculum can further enhance awareness, empowering students to carry these habits beyond the campus [33].

5.2 The Role of Psychology in Energy Awareness

Psychological and behavioural research also plays a crucial role in understanding energy awareness and encouraging behavioural change. Psychological perspectives help in identifying barriers and motivators that influence decision-making regarding energy use [33]. Studies indicate that mere awareness of climate change and energy transition does not necessarily translate into action; instead, economic concerns, convenience, and social factors often take precedence [31].

5.3 Social and Cultural Dimensions

A significant challenge in promoting energy awareness is fostering inclusivity in energy transition initiatives. Research has shown that socioeconomic status, gender, and identity play a role in the adoption of energy-efficient behaviours [34]. A case study in Italy demonstrated how community collaboration and engagement with institutional actors can lead to energy-efficient practices [34].

5.4 Buildings and Energy Efficiency

Buildings are a key component of the energy transition, as they contribute substantially to energy consumption. Strategies to enhance energy efficiency in buildings must go beyond technological advancements and include behavioural interventions [35]. Feedback mechanisms and commitment-making strategies have been shown to be effective in reducing energy consumption in office settings [36].

5.5 Workplace Energy Culture

Organizational culture also plays an essential role in shaping energy consumption behaviours. A company's energy-saving culture influences employee engagement in sustainable practices [37]. Comparative studies suggest that interventions promoting collective responsibility and group feedback enhance energy efficiency [38].

To facilitate the energy transition, a multidisciplinary approach that includes psychological insights, community engagement, and organizational culture is essential. Behavioural research provides valuable insights into fostering sustainable practices beyond technical advancements. However, achieving a seamless integration of these practices requires a balanced synergy between cultural transformation and technological progress. The energy transition at the University of Twente is not hindered by a lack of motivation but rather by an array of barriers that need to be systematically addressed. By improving organizational structures, enhancing communication, and increasing practical understanding, it is possible to create an environment where sustainability efforts can thrive. Fostering a culture of energy awareness through education and engagement can help bridge the gap between motivation and action, ultimately contributing to a more sustainable campus environment.

While societal shifts lay the foundation for sustainable behaviours, technical innovations and systems offer the tools to accelerate and scale these changes. This healthy balance between culture and technology is vital for a successful energy transition. Building upon this, the next section delves into the role of technology and innovation in driving the energy transition, illustrating how they can complement and enhance the behavioural strategies discussed.

6 The Role of Technology and Innovation in Carré

Technology plays a crucial role in enhancing energy efficiency in buildings like Carré at the University of Twente. Implementing smart energy systems, such as motion-sensor lighting, automated temperature controls, and real-time energy monitoring, can significantly reduce unnecessary energy consumption.

However, technology alone is insufficient; it must seamlessly integrate with user behaviour. For energy-saving measures to be effective, they must be intuitive, adaptable, and aligned with how students and staff interact with the building.

6.1 Technical Barriers in Carré

Despite the potential of these technological solutions, several barriers hinder their implementation:

Legacy Systems: Much of Carré's infrastructure is outdated, making it difficult to implement modern energy solutions.

Sensor Performance Issues: Automated systems, such as motion sensors, often function inconsistently, leading to user frustration and reduced adoption.

Misaligned Scheduling: Lighting and heating systems operate on outdated time intervals that do not reflect current usage patterns.

Budget Constraints: Limited financial resources make it challenging to upgrade existing energy management systems.

Integration Challenges: Newer energy-efficient solutions do not always integrate well with older infrastructure, leading to inefficiencies.

User Awareness: Many students and staff are unaware of how the existing energy systems function, reducing their ability to use them effectively.

While these technological barriers exist, solutions must be designed with user interaction in mind. The systems should not dictate behaviour but rather support and encourage sustainable energy practices.

6.2 Balancing Automation with User Input

A crucial consideration in energy management is the balance between full reliance on automation and the need for user awareness and adaptability. While smart systems can optimize energy efficiency, they should not replace conscious decision-making. Overreliance on automation can lead to complacency, where users assume systems will always function optimally without their input.

To address this, Carré should implement hybrid systems that combine automation with manual controls. For example:

Adjustable Smart Controls: Allowing users to override automated settings when necessary ensures flexibility and responsiveness to real-time needs.

User Feedback Mechanisms: Providing interfaces where occupants can report system inefficiencies (e.g., malfunctioning sensors or incorrect temperature settings) fosters a collaborative energy management approach.

Educational Interfaces: Displaying real-time energy usage data on accessible screens can increase user awareness and encourage proactive energy-saving behaviour.

A well-designed energy system should serve as a guide rather than a rigid structure, empowering users to make informed decisions while benefiting from automation.

6.3 Potential Improvements for Carré

To overcome these challenges, Carré can adopt the following strategies:

User-Friendly Interfaces: Simplifying control panels and integrating real-time feedback can help users better understand and adjust energy settings.

Energy Monitoring Dashboards: Providing accessible energy usage data for students and staff encourages conscious energy consumption.

Automated but Adjustable Systems: Smart systems should adapt to real-time occupancy but also allow manual overrides when necessary.

Awareness and Education Campaigns: Informing users about the impact of their energy use can lead to more responsible behaviour.

Proactive Maintenance: Regular inspections and adjustments to automated systems can ensure their reliability and efficiency.

By implementing these improvements, Carré can enhance its energy efficiency while ensuring that technology serves as a facilitator rather than an obstacle. A balanced approach that combines technological advancements with behavioural insights will be crucial in making the building more sustainable.

6.4 System Dynamics in Energy Management

Energy operation and management in office buildings like Carré are dynamic processes that require continuous feedback. Over time organisations must implement strategies, observe their effect, and adjust accordingly, as energy consumption patterns change over time. Effective energy management requires ongoing measures rather than one-time interventions.

A few years ago, a research paper [37] used System Dynamics (SD) modelling to simulate the relationship between company culture, employee behaviour, and energy consumption. SD modelling is a computer-based simulation method that analyses complex interactions within energy systems and proposes effective policies. Widely used in building energy research, SD modelling helps predict consumption patterns and optimize energy management strategies. Although a lot of these strategies have been implemented at Carré as well it is been relatively dormant for the past few years. This is why this article is much of interest for Carré since many different components overlap.

The study followed four steps to get the model: factor identification, data collection, model development, and optimization strategy simulation. Results showed that improving a company's energy-saving culture significantly reduces office energy use. Different cultural strategies have varying impacts, and both the starting point of company culture and employees' behaviours play crucial roles.

By leveraging more of the SD modelling, Carré can develop a more adaptive and efficient energy management strategy. This approach ensures that technological solutions and behavioural changes work together, allowing them to better monitor, analyse, and refine their strategies to make an even bigger impact over time.

6.5 A Longstanding Issue with Dormant Action

The need for energy savings on campuses has been known for years. However, despite the clarity of what needs to be done, action has largely remained dormant. While strategies and technologies are well-documented see([39][40]), the attention and real action required to make meaningful progress have not been taken or have died down again. This lack of initiative underscores the importance of moving beyond plans and discussions to concrete implementations.

7 The Phantom Energy Project

This section is the narration about my minor project and how this came to be and the route I followed to eventually write this report. The transition to sustainable energy is not just about technology; it is about people. This project focuses on involving individuals and communities in shaping a future built on clean and renewable energy. The goal is to make the energy transition accessible and relatable by encouraging active participation, building awareness, and creating opportunities for people to be part of the change. For privacy reasons I have refrained from mentioning names but they are described in the project version handed in for the minor ETC.

7.1 Introduction to Phantom Energy and Standby Power

Phantom energy which can also be known as standby power or vampire energy is the energy that electronic devices consume when they are turned off or in standby mode. Even though these devices are not actively used they still draw power from the electrical grid. This leads to unnecessary energy consumption. Common examples of such devices are televisions, computers, chargers, microwaves, and various household or office electronics. While the power usage of each device may seem minimal on its own the cumulative effect can be significant. Especially in environments with a large number of these devices such as office buildings or university campuses.

The Appeal of Addressing Phantom Energy

Phantom energy is a significant energy efficiency challenge because it is often seen as an easy problem to tackle. Many people are familiar with unplugging devices when they are not in use or using power strips to conveniently disconnect multiple devices at once. At first glance, addressing phantom energy might appear to be a straightforward task that can have a noticeable impact on overall energy consumption. This simplicity makes it an appealing option for energy-saving projects such as this minor ETC. This is because it can yield immediate results that contribute to sustainability goals without requiring substantial upfront investment.

Moreover, the scalability of efforts to reduce phantom energy is another key factor in its attractiveness. The concept of addressing phantom energy can be implemented in virtually any setting—whether at home, in an office, or in larger institutions like universities. These efforts can be adjusted in scale depending on the size and complexity of the building or campus, which makes it an ideal project for both small and large-scale energy efficiency initiatives.

Why Phantom Energy Is More Complex Than It Appears

While the concept of reducing phantom energy may appear simple the reality of implementing it has proved to be more difficult. Especially in large institutions like the University of Twente it presents several challenges. The Carré building at the university is home to a wide array of devices and systems, including computer labs, offices, administrative spaces, and technical equipment. Each of these devices represents a potential source of phantom energy consumption. However, achieving a meaningful reduction in standby power usage within such a complex setting is not as easy as simply just encouraging individuals to unplug their devices or use power strips.

One of the main challenges with modern devices is that they are designed to remain in standby mode for specific reasons. This can be receiving updates, maintaining connec-

tions, or allowing for quick reactivation for remote work. For example, printers, servers, and other office equipment typically stay in a low-power standby state to ensure they can be quickly activated when needed. While this feature is convenient for users it also leads to unnoticed energy consumption.Specifically in a large building like Carré, there could be hundreds or even thousands of such devices, all consuming small amounts of power when not actively in use.

Additionally, many of these devices are connected to complex networks and are integral parts of systems that require constant monitoring or remote control. For instance, security systems, heating and cooling controls, and certain laboratory equipment may need to remain active at all times to ensure functionality or safety. This complicates efforts to reduce standby power, as these systems often cannot be easily turned off or disconnected without disrupting their operations.

The Carré Building: A Case Study

At the University of Twente's Carré building, efforts to reduce phantom energy consumption have proven more challenging than anticipated. The building accommodates various spaces and systems that require continuous energy this is even when not actively in use. For example, the server rooms, technical equipment in laboratories, and certain infrastructure related to building management systems. For example, the HVAC systems depend on a constant power supply to maintain functionality, lab conditions and comfort. These devices, often part of a larger network of interconnected systems, pose challenges regarding both energy efficiency and operational continuity.

In addition to the technical complexities of these systems, raising awareness among building users presents another hurdle. Many individuals are unaware of the energy consumption associated with devices in standby mode. While the solution may seem simple on paper by just turning off devices when not in use, changing the actual behaviour of occupants can be a slow process. To address this, it is essential to implement a comprehensive communication strategy to educate individuals about phantom energy and the importance of reducing standby power consumption. However, even with this increased awareness, there might be a reluctance to adopt energy-saving behaviours. This is especially the case if these actions are perceived as inconvenient or disruptive.

Furthermore, the Carré building functions as an academic environment. The priorities of various departments and research groups often take precedence over energy-saving initiatives. Balancing the demands for research equipment, teaching spaces, and administrative offices with the goal of reducing phantom energy consumption necessitates careful coordination and compromise. For instance, some research labs may need devices to remain in standby mode to conduct experiments or collect data overnight. Therefore, the flexibility of the systems and the building's infrastructure must be considered when planning energy reduction strategies.

7.2 Investigative Phase

During the Investigative Phase, the start of the project aimed to thoroughly understand the challenges related to phantom energy consumption in the Carré building at the University of Twente. The objective of this phase was to assess the extent of the ideas and gather essential data to inform the project's next steps. To start off this project, an energy analysis was conducted to identify devices contributing to standby power consumption. This research involved reviewing the building's infrastructure, which included office equipment, research labs, server rooms, and technical systems. Many of these devices, such as printers, monitors, and even vending machines, draw power even when not actively in use.

In addition to the initial energy audit, secondary research was done to understand existing knowledge on phantom energy consumption. Several articles and studies, such as [37], related to energy waste were reviewed. This is with a specific focus on energy consumption in office settings and large university buildings. This research helped to contextualize the findings and better define the scope of the problem within the Carré building. Additionally, I had access to the University of Twente's energy data platform[41, 42], which provided valuable insights into overall energy usage across campus. By analysing this data, I was able to identify potential trends in energy consumption patterns and further confirm that phantom energy was indeed a significant factor contributing to inefficiencies in the building. The platform also offered data on specific usage points such as heat, electricity and per building.

At some point, I reached out to one of the supporting technical staff for assistance in obtaining a device that could measure energy consumption more accurately. With this device, I tested various electronic devices in the Carré building to observe how much energy they consumed while in standby mode. The measurements clearly showed that these devices continued to draw power when not in active use, which confirmed that phantom energy was indeed a significant issue. However, the precise amount of energy consumed by each device, and the total consumption across the entire building, remained unclear at this stage due to an unclear error margin. This uncertainty regarding the total impact of phantom energy prompted me to move forward to the Engage Phase, where further measurements and collaboration with stakeholders would help refine the analysis. During this phase, I was already conducting interviews with key stakeholders, which became the foundation of my network. One of the first individuals I met was someone from TNW Supporting staff, who was instrumental in providing insights into energy usage across the buildings and helping me with expanding my network. His role involved conducting research similar to mine, and because we were both in the same field, our early conversations were crucial for understanding the existing infrastructure and challenges faced by the Carré building's energy systems. Afterwards, I met up with someone from a, for me unknown department, CFM (Campus Facility Management), who further guided me in shaping the project's direction. She played a key role in helping me with the idea of organizing a challenge before Christmas, which became a pivotal part of the project. She also introduced me to her network at the Center for Facility Management (CFM), which was invaluable for expanding the scope of the project and gaining support from relevant departments within the university.

In addition to the core focus on phantom energy, other innovative ideas aimed at reducing energy consumption and promoting sustainability were explored during the Investigative Phase. These ideas, though not directly related to phantom energy, presented potential opportunities for broader environmental impact across the university.

- **Phantom Energy Reduction**: The primary objective was to identify and reduce phantom energy consumption by devices left in standby mode. This involved researching automated systems designed to detect and eliminate unnecessary power drawn from equipment throughout the building. A comprehensive plan was developed to tackle phantom energy issues by utilizing smart technology and promoting behavioural change strategies.
- **Total Zero Day in Summer Event**: The proposal suggests organizing a university-wide event during the summer months to reduce energy consumption to zero for a single day. The initiative aims to raise awareness about energy usage and encourage the university community to be more mindful of their consumption habits. This event could be connected to the phantom energy reduction project by inspiring participants to turn off all non-essential devices and switch to energy-saving modes.
- **The Green Fridge Program**: This initiative aimed to replace the old, energy-intensive refrigerators and freezers in the Carré building with newer, energy-efficient models. These appliances are significant contributors to energy waste, particularly when left on continuously or when older models consume more power than necessary. This initiative aligns with the broader goal of reducing the building's energy footprint and is considered a complementary project to the phantom energy reduction plan.
- **The Bio Project: Boost Biodiversity**: This project aimed to enhance the surrounding environment of the building by promoting biodiversity through sustainable practices. While it does not directly address energy consumption, the initiative aligns with the university's sustainability goals and seeks to increase the ecological value of the campus. By introducing green walls, planting native species, and improving landscaping in energy-efficient ways, we can complement existing energy-saving initiatives and enhance the overall environmental impact of the Carré building.
- **Light Up Your Bike Program: BrightCycle**: This program aimed to promote cycling on campus by providing students and staff with free bike lights and offering a way to safely recycle old bike lights. By encouraging more people to use bikes rather than cars for transportation, this program would contribute to reducing the university's overall carbon footprint. Additionally, the initiative could help reduce the energy consumption of campus parking facilities and infrastructure by promoting a more sustainable mode of transportation.

Alongside the energy audit, research was carried out through initial conversations with key stakeholders such as university staff, faculty members, and building users. These discussions were critical for understanding the building's operational challenges and identifying areas of potential resistance or concern. Discussions with facility managers and technical staff revealed the complexities involved in maintaining energy-efficient operations within a building that has diverse needs. For instance, research labs require constant power to operate their equipment, while office spaces often have numerous devices left on standby overnight. This phase of the project provided a thorough understanding of both the technical and human factors at play, ensuring that the project could be designed with a clear awareness of the daily operational realities within the building.

These additional ideas and projects helped to frame the broader scope of sustainability initiatives within the Carré building and the university as a whole. While the main focus remained on phantom energy reduction, the exploration of these supplementary initiatives allowed for a holistic approach to improving energy efficiency and fostering a culture of sustainability across the university.

7.3 Main Question

Following the Investigative Phase, it became clear that the overall project needed to focus on broader sustainability efforts beyond just phantom energy. The insights from the previous phase showed that while understanding energy usage and pinpointing savings opportunities was essential, driving systemic change required addressing both technical solutions and behavioural shifts.

This led to the central question of the project: *"What tangible and innovative strategies can we implement to raise awareness about energy sustainability and inspire active participation at the University of Twente by 2026?"*

The main goal shifted towards creating strategies that would not only address energy savings but also promote long-term engagement with sustainability. This involved finding ways to raise awareness, encourage behavioural changes, and inspire collective action within the university community.

7.4 Engage Phase

Building on the insights from the Investigative Phase, the Engage Phase focused on establishing a network of relevant stakeholders and ensuring alignment with ongoing initiatives at the University of Twente. With a clearer understanding of phantom energy consumption in Carré, the next step was to engage those who could influence or be affected by the proposed solutions.

The first priority during this phase was to initiate discussions with facility managers, energy experts, and other key personnel across the university who had a vested interest in sustainability and energy management. These stakeholders played a critical role in understanding the current energy-saving initiatives already in place and determining how the project could complement or enhance those efforts. Collaboration was key, as many of these individuals were already working towards the university's broader sustainability goals, and it was essential to align the project with those objectives.

A series of meetings and workshops were held with the facility management team to discuss the feasibility of reducing phantom energy consumption in Carré. These conversations revolved around technical aspects such as the limitations of existing infrastructure, the potential for installing smart systems to manage standby power, and the challenges associated with automatically switching off devices in a building that houses diverse departments and functions. Feedback from these discussions highlighted the importance of finding solutions that would not disrupt the building's operations while still achieving significant energy savings.

Alongside the facility managers, discussions were also held with staff and faculty members in various departments. This engagement helped to identify concerns related to device usage and energy conservation. For example, research labs often require continuous power for equipment that cannot be easily powered down, while office spaces may benefit from simple behavioural changes like ensuring devices are turned off when not in use. By addressing these concerns and identifying specific needs, we were able to tailor the project's approach to ensure broad support across different stakeholders.

At some point, it became clear that I wanted to organize an energy reduction challenge before Christmas. However, the exact structure and details of the challenge were not immediately clear. The idea started to take shape when I first reached out to a new contact person from TNW, who was incredibly helpful with my project. She provided valuable advice and helped me refine my proposal, suggesting I send it out to higher-level management for further approval.

Following her guidance, I approached both managing directors at the university form TNW and EEMCS. I asked them if I could post my idea to the staff of TNW

and EEMCS, to gather support and participation for the challenge before the holidays. The open-door policy at the university, combined with the ability to send out my proposal via email, proved to be an efficient and effective approach. This allowed me to communicate my initiative to a broader audience in a relatively short period.

In addition to the outreach, I had to refine my elevator pitch each time I spoke with key stakeholders. The ability to quickly and clearly explain the purpose and impact of the project was crucial in gaining buy-in from those involved. The energy measuring device I had obtained earlier also played an important role in these interactions. It was extremely valuable for visually demonstrating the issue of phantom energy consumption. For instance, I showed that my laptop charger, even when unplugged from the laptop, still used 5 watts of energy. This immediate, visual feedback made the concept of phantom energy more tangible and helped emphasize the need for action.

As the Engage Phase progressed and with the Christmas holiday approaching, the focus shifted to finalizing the campaign materials for the energy reduction challenge. I wrote a post to introduce the challenge to the university staff and designed a poster that would promote participation in the initiative. The poster had to clearly convey the importance of reducing phantom energy consumption, while also making the challenge approachable and easy to understand.

In parallel, I worked with Xerox to arrange the printing of the posters. The logistical aspect of getting the posters printed and distributed across Carré required close coordination. I had to ensure that the posters would be printed in time for the holiday period, which was a tight deadline. Additionally, I needed permission from the service desk to hang the posters in various locations within the building. This required presenting the plan and obtaining approval for the distribution of the campaign materials throughout Carré.

The entire process went incredibly quickly, but the collaborative efforts and effective communication with both Xerox and the service desk made it manageable. At the same time, I got introduced to another project running in parallel, focusing on energy usage in the labs at the university. Two other students from TN and CSE were working on this project, which was quite interesting as it also aligned with the overall theme of energy efficiency across the university. These parallel efforts provided an opportunity for collaboration and the exchange of ideas, as both projects sought to tackle similar challenges in different areas of the university.

The combination of an effective outreach strategy, the support from key stakeholders, and the use of concrete data from the energy measuring device helped propel the project forward quickly. The knowledge gained during the Engage Phase laid a solid foundation for moving into the next stage of the project, where concrete actions and challenges would be implemented to reduce phantom energy consumption in Carré.

7.5 Acting Phase

The Acting Phase was the stage where all the groundwork laid during the Investigative and Engage Phases came together into concrete actions. With a network of stakeholders established and increased awareness of phantom energy consumption, the focus shifted towards creating tangible results that would bring about measurable change in energy usage at the Carré building.

One of the first concrete actions was the organization of a public presentation, an idea that emerged from the growing interest and support within the university community. It became clear during the Engage Phase that there was significant interest in the project and a desire for a clear, consolidated view of the findings. Many individuals and departments expressed a willingness to see the results of the research and explore potential solutions together. The presentation was designed to connect different departments and stakeholders, serving as a forum to discuss energy-saving practices and the challenges of reducing phantom energy consumption.

In preparation for the presentation, I worked closely with a few of the gained stakeholders, who provided valuable guidance on organizing the event and who played a crucial role in spreading the invitation to as many people as possible also through the scientist4future newsletter and email invitation, ensuring that the event attracted a broad audience. Thanks to those efforts, we were able to gather key stakeholders from across the university, including staff from both administrative and technical departments, to create a diverse audience that could offer various perspectives on the issue.

To further ensure the success of the event, I enlisted the help of my teacher, who assisted in reserving the room for the presentation. This logistical support was invaluable in securing the appropriate venue for the presentation and ensuring everything ran smoothly. I also worked with my other teacher, who helped refine the content of the presentation for stakeholders. Together, we created a presentation structure that would be presented to the available stakeholders.

The main goal of the presentation was to highlight the challenges of phantom energy consumption and to connect the various issues that had been identified during the earlier phases. Although many attendees were already aware of the ongoing energy-saving initiatives at the university, the presentation provided an opportunity to bring all the pieces together. For the first time, people from different departments saw the broader picture of the energy issues facing the Carré building, and this collective understanding sparked meaningful discussions about potential solutions. It was encouraging to see how the presentation helped to uncover gaps in knowledge and foster collaboration among stakeholders.

The presentation was designed not only as an informational session but also as an interactive workshop. During the session, I led a “sparsession,” where participants were invited to engage in open discussions about the challenges and opportunities related to energy savings. This interactive approach proved to be highly successful, as it allowed participants to express their views, share ideas, and identify key areas where improvements could be made. The discussion highlighted the already identified issues, such as the difficulty in managing energy use across departments with different needs and the challenge of implementing technical solutions without disrupting building operations.

The Acting Phase was also marked by the continued expansion of the project’s network. With the success of the presentation, new connections were made, and ideas were shared that would further inform the next steps of the project. The discussions during the presentation served as a catalyst for deeper insights into the problem and its potential showed. The project’s scope broadened as additional stakeholders became involved, and new opportunities for collaboration were clearly visible.

7.6 Concluding phase

The Acting Phase resulted in the realization on how crucial it was to connect the various faculties, departments, and stakeholders within the University of Twente. The insights gathered through the presentations and discussions in the previous phase leads to the next step: fostering collaboration and inspiring active participation.

From the public presentation, it became clear that a central challenge was ensuring that different departments and faculties not only understood the importance of energy sustainability but also actively participated in efforts to reduce consumption. The presentation revealed that there was a significant interest across departments, with many attendees eager to see results and contribute to the university's sustainability efforts. However, the key insight was that the different faculties and stakeholders needed to be connected and made aware of one another's work, as many were working on similar issues without collaborating or sharing resources or bottlenecks.

One of the tangible strategies that emerged from this phase was the importance of creating a network that facilitated direct communication and collaboration between the various departments. For example, faculty members from energy-intensive departments, such as research labs, were introduced to facility managers and sustainability experts, enabling them to discuss the specific challenges of their workspaces.

The presentation also highlighted the potential for cross-departmental collaborations. By encouraging conversations between different stakeholders, such as facility management, employees, and faculty members, we created a sense of shared ownership over the project's outcomes.

Additionally, the Acting Phase revealed the need for a more structured approach to information sharing. With various stakeholders coming together, the presentation underscored the necessity of a central communication hub or platform where all parties could exchange ideas, discuss ongoing initiatives, and share best practices. This could take the form of a dedicated energy sustainability platform within the university, where stakeholders could access resources, track progress, and collaborate on new projects.

As the presentation came to a close, it became clear that fostering a culture of collaboration and mutual support would be crucial to raising awareness about energy sustainability and ensuring long-term participation at the university. The network established during the presentation was an essential first step, and it laid the groundwork for future efforts to engage the university community in reducing energy consumption and promoting sustainable practices.

A key part of the project was ensuring that the findings and initiatives reached the right audience, both within the university and beyond. In total, there were **eight** outreach deliverables designed to raise awareness, engage stakeholders, and encourage participation in energy-saving efforts.

7.7 The Outreach

This is a short summary of the types of outreaches tried during the minor.

The Outreach Before the Christmas Holiday Before the holiday break, the following deliverables were completed:

- **Poster:** A visually engaging poster was created to highlight the core issues around phantom energy consumption and encourage action. This was displayed in key locations across the university.
- **Site Publication:** An article was published on the university's website, making information about the project easily accessible to a broad audience. This was only not the case since the placement. on the site was not easily findable
- **Faculty Email:** A direct email was sent to faculty members to inform them about the project and invite on giving feedback.

Outreach After the Christmas Holiday
Following the holiday break, additional outreach efforts were undertaken:

- **Public Invitation Mail:** An open invitation was sent out, encouraging attendance at the public presentation and engagement with the project's findings.
- **Scientists4Future Newsletter Post:** The project was featured in the Scientists4Future newsletter, reaching a community actively working on sustainability and scientific advancements.
- **Public Presentation & SPAR Session:** A live presentation was held to share the project's results with an engaged audience. This included a **SPAR session**, allowing for discussions, questions, and valuable idea exchanges.
- **Shared Report:** A comprehensive report detailing findings, challenges, and recommendations was distributed to key stakeholders.
- **Upcoming CFM Post:** The Center for Facility Management (CFM) will publish a post about the project, further extending the reach and emphasizing the importance of energy efficiency within university infrastructure.

With these deliverables I tried to ensure that the project's message was widely disseminated and acted upon by different groups within and outside the university.

7.8 Project chapters

Pitching the Idea: The project was pitched to stakeholders to gain support and feedback. This included presenting the idea to university staff, providing clear communication on the potential benefits of the project, and outlining the expected outcomes.

Baseline Reduction Challenge: To establish a baseline for this research, a reduction challenge was conducted. The challenge involved:

- Gathering a network of stakeholders, including building managers, occupants, and energy experts.
- Setting up an awareness campaign within a short timeframe.

- Conducting an experiment to measure energy consumption reductions during the campaign.

This initiative provided valuable insights into current behaviours and the potential impact of targeted interventions.

The Christmas Challenge and Shift in Focus: During the Christmas period, the project's focus shifted from the initial goal of reducing phantom energy consumption to addressing bottlenecks encountered in the Carré building. This shift was prompted by feedback and new insights gained during the outreach phase.

Response After the Holidays: Following the holiday period, stakeholders provided feedback on the project's progress and outcomes. This feedback was incorporated into the next steps, refining the approach to the bottleneck issues identified earlier.

Setting Up the Presentation: In preparation for the final presentation, key findings, project outcomes, and the network's contributions were compiled. The setup involved organizing the presentation content, rehearsing, and ensuring that the presentation would be impactful for the audience.

The Presentation Itself: The presentation was delivered to a group of stakeholders, including faculty members and administrative staff. Key results, including reductions in energy usage and lessons learned, were highlighted, as well as future recommendations for sustainable energy practices in the Carré building.

Publication of the Presentation Invite: To ensure that the presentation reached the right audience, an invitation was published. This included an announcement sent to stakeholders, promoting the event and encouraging attendance to further engage the university community in sustainability efforts.

Report for Stakeholders: A comprehensive report was prepared for stakeholders, summarizing the project's phases, outcomes, and recommendations. The report served as a formal document to provide transparency, share findings, and outline future actions for sustainable energy initiatives.

7.9 The Gained Network

A crucial aspect of this project was the establishment of a strong and diverse network of stakeholders. Initially, I started with a piece of paper, but then I transitioned to working on an Excel sheet because the list kept on getting bigger. The network consists of facility managers, sustainability officers, lab managers, and other key personnel from different departments within the University of Twente. Using the Excel sheet proved to be very helpful, especially when sharing it with stakeholders. This allowed them to see who I had contacted and the reasons behind those communications. Although it was my first time trying this approach, it has turned out to be beneficial. Through regular meetings, discussions, and outreach initiatives, I was able to bring together individuals from various fields who share a common interest in energy efficiency and sustainability. The continuous collaboration within this network allowed for knowledge exchange, problem-solving, and a better understanding of the practical challenges involved in implementing energy-saving measures. Their involvement ranged from sharing technical insights and providing institutional support to helping me get a better insight into how everyone is connected. This network will continue to be valuable beyond the project's time frame, as it lays the foundation for future sustainability initiatives at the university.

8 Solution Design and Implementation

8.1 Proposed Solution

At the University of Twente within Carré, the building is at the forefront of efforts to reduce energy consumption. Through technological solutions such as the smart energy management systems, automated lighting, and the HVAC systems Carré is already on the good path. However, these innovations alone will not lead to the desired outcomes unless they are supported by effective communication and clear coordination across departments and individuals.

While the technical aspects of energy efficiency are often discussed and implemented in detail, it's vital to recognize that their success mostly depends on collaboration across various teams. Facilities management, faculty, students, and external partners must be aligned in their goals and actions to make a difference. A lack of communication between those can easily result in missed opportunities or wasted resources, hindering efforts to optimize energy use.

Clear communication channels are essential to ensure that everyone involved is on the same page regarding energy-saving strategies, timelines, and responsibilities. Therefore in the future it is important that departments must be kept informed about the latest advancements and how these can be integrated into their workflows. Additionally, fostering a culture of awareness and responsibility among all building users can significantly enhance energy-saving efforts.

The proposed solution for Carré integrates technological innovation with behavioural change, emphasizing the need for cross-departmental collaboration. To achieve this, it is crucial to engage different departments by encouraging them to read and discuss this report. The success of these initiatives depends on active participation from all teams. The insights gathered during the final sparring session revealed significant variations in the thoughts about energy use, costs, and challenges across departments.

To bridge these gaps, I propose an inclusive series of conferences at the Waaier at the start of the academic year. Rather than holding a single event, multiple sessions throughout the week will ensure accessibility and participation for everyone. During this presentation, the goals achieved from the previous year will be presented. The presentation will also outline the goals for the upcoming year focusing on further enhancing the energy efficiency. For example, presenting new technologies and foresight. This will provide an opportunity to engage all staff, faculty, and students, encouraging active participation in the ongoing efforts. Attendance should be mandatory for staff and strongly encouraged for students, with personal invitations and incentives to boost engagement.

Moreover, friendly competition between buildings or faculties can be introduced, with real-time energy savings displayed on digital screens. Many building occupants that I have spoken with expressed enthusiasm for such competition and highlighted the importance of visible progress to maintain engagement and drive action. The top-performing department could receive a meaningful reward, adding further motivation, and to sustain momentum and motivation, these competitions can be held multiple times per year. By keeping this subject alive in the informal conversations around coffee stations it can play a significant role in fostering engagement and a building shared commitment to sustainability.

Importantly, this initiative requires minimal financial investment it relies instead on creativity, communication, and a collective commitment to action. By emphasizing personal involvement, transparent results, and friendly rivalry, Carré can drive substantial

energy savings and set a standard for sustainability across the campus. This combined approach through both technology and psychology will not only reduce Carré's energy footprint but also reinforce the university's culture of sustainability, demonstrating that collective action can lead to meaningful change.

9 Results and Analysis Holiday Challenge

The images shown on the next page are screen shorts taken from the data platform since the raw data could not be exported at the time of writing[41].

Analysis of Energy Usage During Holiday Periods (2023 vs. 2024) In these two graphs, a clear difference can be observed between the holiday periods of 2023 and 2024. Although more energy was used during the 2023 holidays compared to 2024, the overall energy consumption for the same period in 2024 was higher. This may seem counter-intuitive at first, but several factors could explain this outcome.

One possible reason is increased baseline consumption due to new equipment or extended operational hours in certain areas of Carré outside of the holiday period. Additionally, changes in heating or cooling demands such as a colder winter could have contributed to higher overall consumption despite reduced usage during the holidays. Another factor could be occupancy patterns, such as more staff or researchers working between holiday periods in 2024 compared to the previous year.

During the Christmas holiday period of 2024–2025, Carré achieved a significant milestone by recording its lowest energy consumption in years, dropping to an impressive level of under 5,000 kWh in a single day. This suggests that improvements can be made to reach this more often.

This trend underscores the importance of continuous monitoring and adaptive energy management strategies. Understanding these variations helps identify effective strategies and areas for improvement to drive Carré's energy consumption lower in the future, as well as optimize energy usage for gas and heat.

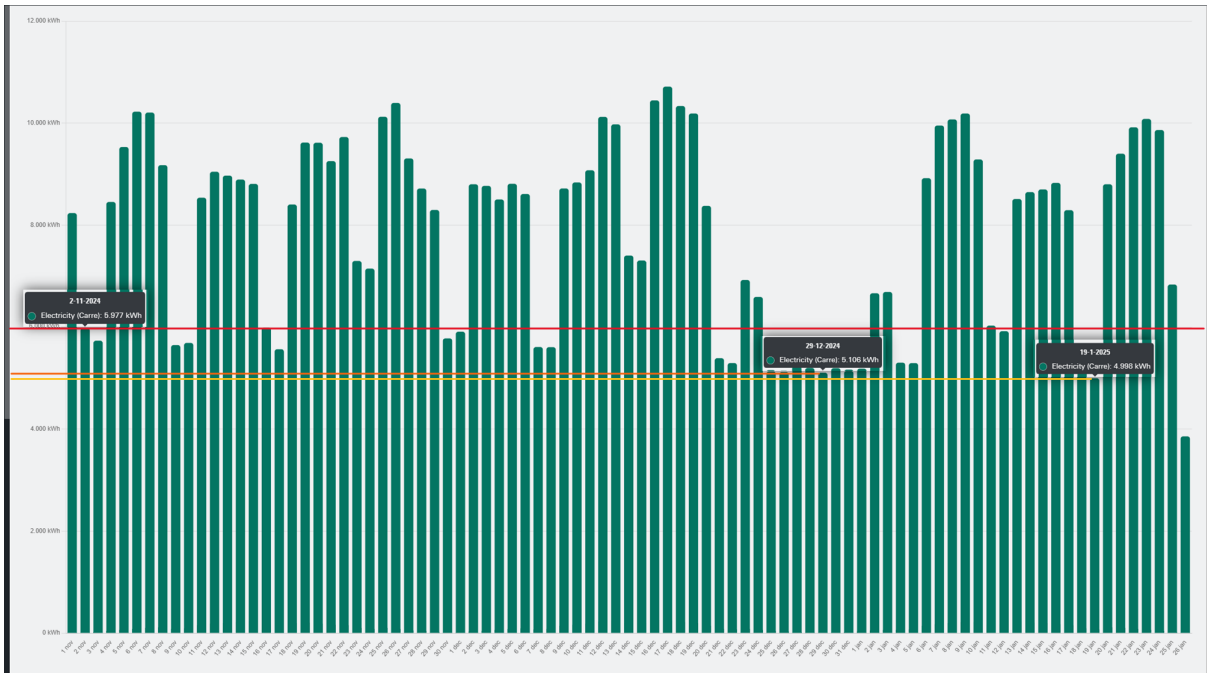

Figure 1: Christmas holiday 2024-2025

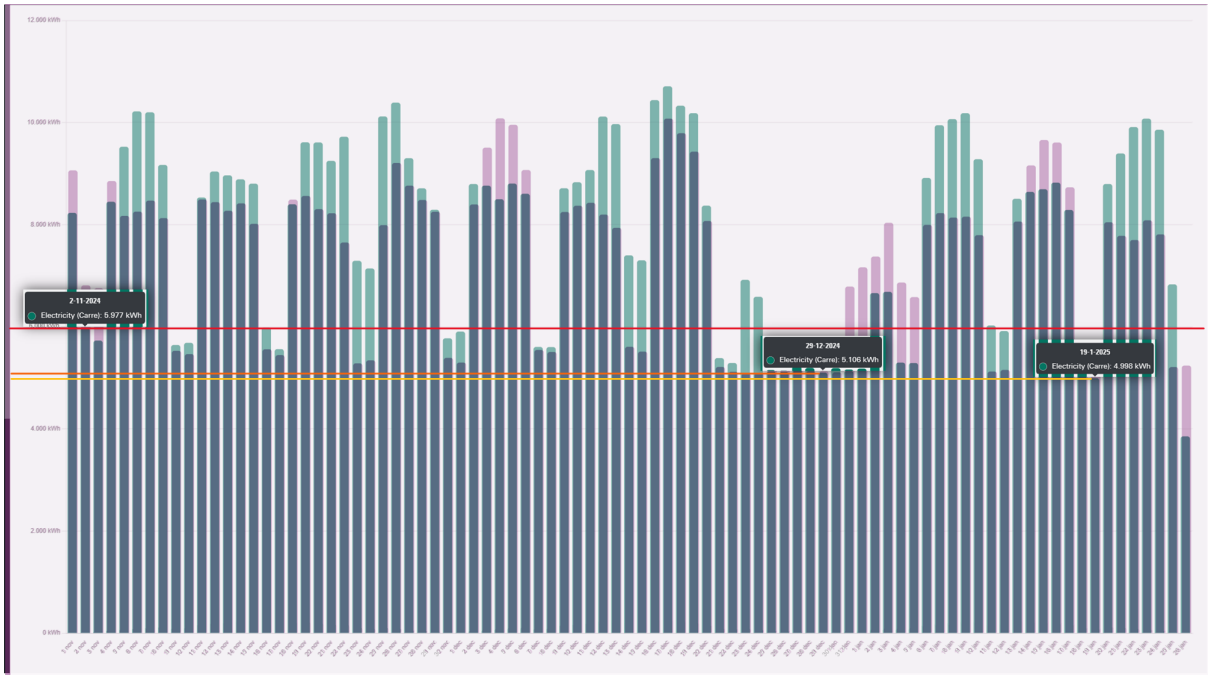

Figure 2: Christmas holiday 2023 (purple) compared to 2024 (green)

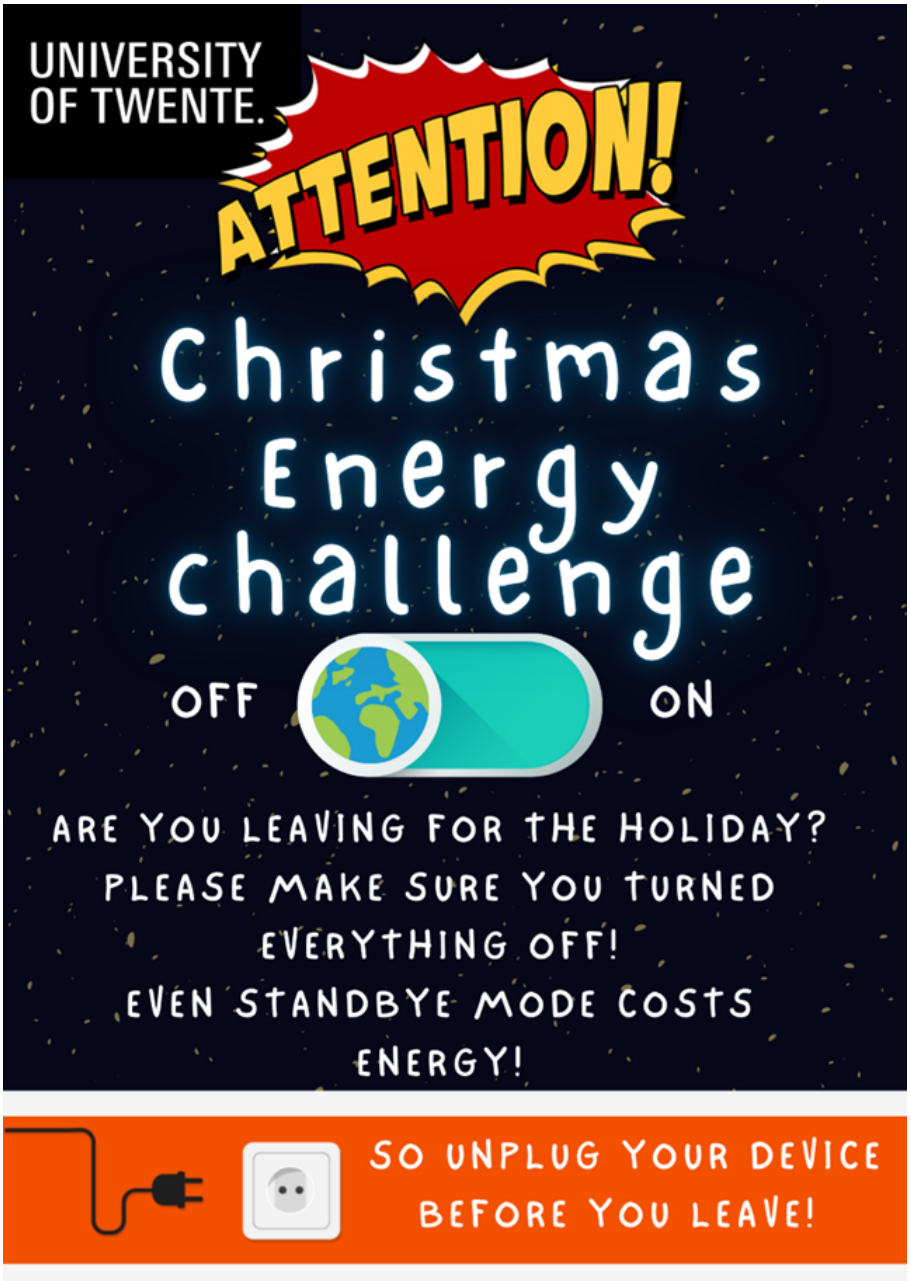

Figure 3: Enter Caption

10 Discussion

This project was conducted over a 10-week period, with 8 weeks dedicated specifically to its development. Despite being an individual effort, this project highlights the significant impact one person can make when fully committed to driving change. While the report provides a comprehensive overview, there is potential for even more depth and detail if undertaken by a team. Nevertheless, this work demonstrates that meaningful progress can be achieved through individual dedication and effort.

This project aimed to answer the question: *“What tangible and innovative strategies can we implement to raise awareness about energy sustainability and inspire active participation at the University of Twente by 2026?”* The findings from the project project highlight the complexities and challenges involved in raising awareness and promoting participation in energy sustainability efforts at the University of Twente. A significant observation was the gap between motivation and action: while many participants expressed interest and support for energy-saving initiatives, their actual engagement remained low. Several interconnected factors contributed to this situation, which can be categorized into psychological barriers, technical challenges, and management issues.

A recurring theme was the tendency for large-scale initiatives, such as major technological upgrades, to overshadow smaller but cumulatively impactful actions. Despite the university’s awareness of these smaller opportunities, they often lacked attention and investment. This tunnel vision on large-scale projects results in missed opportunities for incremental improvements that could collectively lead to substantial energy and cost savings. Addressing these smaller inefficiencies requires a cultural shift, where every individual is encouraged to contribute to sustainability efforts in their daily routines.

Furthermore, the Acting Phase of the project demonstrated the power of collaboration across departments. Our outreach initiatives, including public presentations, newsletters, and SPAR sessions, revealed a strong interest in sustainability but also highlighted a lack of communication between stakeholders. Departments working on similar issues often operated in isolation, unaware of each other’s efforts. The creation of a central platform for sharing ideas, resources, and progress updates emerged as a crucial strategy to foster cross-departmental collaboration and maximize the impact of sustainability initiatives.

The project’s outreach efforts, such as posters, faculty emails, and public invitations, succeeded in raising awareness but also highlighted areas for improvement. For example, while an article was published on the university’s website, its placement made it difficult for users to find, limiting its effectiveness. This underscores the importance of strategic communication and accessible platforms for information sharing.

Additionally, the proposal for friendly competitions between faculties, with real-time energy-saving displays and meaningful rewards, was met with enthusiasm from many building occupants. Such initiatives leverage gamification to maintain engagement, foster a sense of community, and drive measurable outcomes. These competitions, combined with regular progress updates, can sustain momentum and encourage ongoing participation.

11 Conclusion

In conclusion, the project highlights that raising awareness and inspiring participation in energy sustainability at the University of Twente requires a multifaceted approach that combines technological innovation with behavioural change. While smart energy systems and other technical solutions are vital, their success hinges on user engagement and cross-departmental collaboration. The insights gathered emphasize the importance of addressing not only large-scale projects but also smaller, everyday actions. Creating a culture where all university members feel responsible for energy efficiency is crucial. This can be achieved through initiatives such as mandatory annual sustainability conferences, cross-departmental workshops, and real-time energy-saving competitions. Moreover, effective communication strategies, such as a centralized sustainability platform and regular outreach campaigns, are essential for keeping stakeholders informed and engaged. Building a strong network of collaboration between faculties, facilities management, and students will facilitate knowledge sharing and collective problem-solving.

Finally, a combination of creativity, transparency, and collective commitment can drive significant progress towards the university's sustainability goals. By integrating technological advancements with behavioural strategies and fostering a culture of participation, the University of Twente can set a standard for sustainable practices and inspire lasting change within its community.

12 Disclaimer on the Use of AI Tools

With the writing of this report, I have used the assistance of AI tools such as Grammarly and ChatGPT. These tools have been used to refine language, improve clarity, and structure arguments logically. However, all content, analysis, and conclusions are based on original research and critical evaluation.

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