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Working towards a Carbon-Neutral University

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The Sustainable Campus - Working towards a Carbon-Neutral University

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Abstract: The main task of a university is to conduct scientific research, accommodate scientific education, and transfer knowledge. Within this environment, new models, approaches, strategies and technologies can be tested and investigated safely. Simultaneously these processes can be monitored, evaluated and adjusted and enhanced when needed. Due to these characteristics, universities and other institutes of higher education can and should be at the forefront of sustainable development and climate action. Universities should pave the way for other organisations, companies, and cities and show how to reach the climate goals.
A Vision, Ambition and Action Plan with 5 specific goals for Delft University of Technology (TU Delft) and was adopted by the university's executive board. In 2030, the university wants all activities on and from the campus to be carbon neutral, circular and climate adaptive, and to contribute to the quality of life for its users and nature and demonstrate sustainable innovations on campus. This paper will show which steps TU Delft has taken to set these ambitions in place and how they want to become a Climate University and example for others. The main elements addressed are Sustainable Operations and Behavioural Change.

Keywords: Climate action, sustainable university, campus as a living lab, sustainable operations, carbon neutral

1. INTRODUCTION

The current global warming is likely caused by human actions between and within counties, and among individuals, which release greenhouse gases. The amount of emissions has increased over time and is still ongoing due to activities such as use of fossil fuels, land use changes, unsustainable lifestyles and the growth of consumption and production (IPCC, 2023). Changes can already be seen in weather patterns – more extremes – which has a negative impact on nature and people. In all sectors, immediate action is needed to reduce the amount of greenhouse gas emissions to stay between the limited warming of 1.5°C-2.0°C. These numbers will be exceeded if we do not take action and only follow the currently implemented policies (figure 1) (IPCC, 2023). The threat will become more complicated the longer we postpone action.

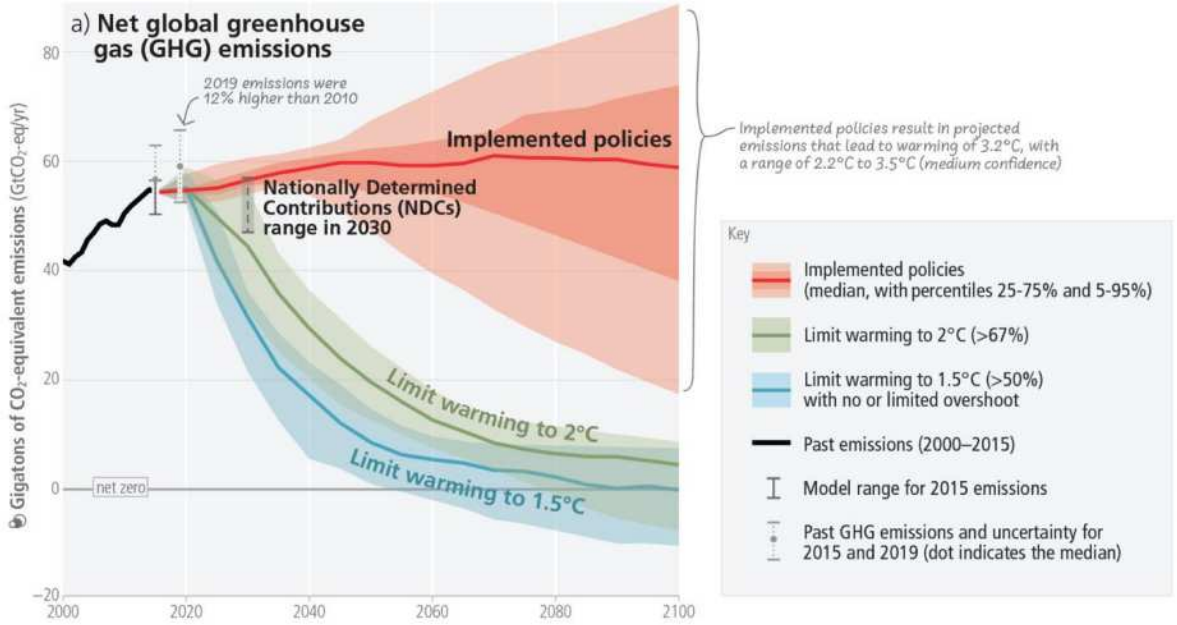


Figure 1. Limiting global warming to 1.5°C and 2°C involves rapid, deep and in most cases immediate greenhouse gas emission reductions (IPCC, 2023)

1.1. Pave the way

The main task of a university is to conduct scientific research, accommodate scientific education, and transfer knowledge. Within this environment, new models, approaches, strategies and technologies can be tested and investigated safely. Simultaneously these processes can be monitored, evaluated and adjusted and enhanced when needed. Due to these characteristics, universities and other institutes of higher education can and should be at the forefront of sustainable development and climate action. Universities should pave the way for other organisations, companies, and cities and show how to reach the climate goals.

1.2. TU Delft

In April 2019, The Delft University of Technology (TU Delft) published its vision on climate change and the need for drastic climate action. The university acknowledges that the living environment is changed by anthropogenic greenhouse gases and states that it will use its innovative character to power the transition. Climate action is both limiting the amount of greenhouse gases emitted – climate change mitigation – and adapting to the new environment, climate change adaptation. Together with climate science and climate governance, these are the four pillars the Climate Action Programme is focussing on.

Beside contributing to society by doing research on climate action the university also wants to become an example in its operations. In 2021, a Sustainability Coordinator and Sustainability Project Manager were appointed who set the ambition to become among other things carbon neutral[1] and climate adaptive. However, becoming sustainable does not only mean becoming carbon neutral and being able to adapt to the new environment. The university also wants to become circular, to reduce the depletion of rare earth metals and improve the biodiversity of nature and people. To reach these goals, new policies have been set in place.

[1] With carbon neutral or CO2 neutral the authors mean climate neutral, referring to all GHG Emissions.

2. TU DELFT'S SUSTAINABILITY APPROACH

2.1. Stepping stones

Vision on Climate Action and Climate Action Programme. In 2019 the university published its vision on climate action and acknowledged that climate change is also caused by human actions. This statement was the beginning of the Climate Action Programme that started in 2021. The university allocated 22 million euros for this programme. The programme focusses on four research themes: Climate Science, Climate Change Mitigation, Climate Change Adaptation and Climate Governance.

CO_2 Roadmap. The university expressed its intentions to become carbon neutral and circular by 2030 in the Strategic Framework 2018-2024 (TU Delft, 2018). To be able to become carbon neutral, an organisation must know its current footprint. To get a grip on this, a carbon analysis of the campus was performed focussing on energy, water, mobility, food, waste, buildings, and green (Blom and Dobbelsteen, 2019). The final result was an overview of the immense challenge we have as a university to become zero carbon, the CO_2 Roadmap for TU Delft.

Carbon accounting. The carbon analysis of van den Blom and Dobbelsteen (2019) was a one-time analysis to get a grip on the starting situation of TU Delft. However, to become carbon neutral and to be able to steer on these results continuous carbon accounting is needed. The university has delegated this task to the finance department, which is already used to producing similar annual reports. This department follows the 'CO_2-Prestatieladder', a Dutch translation of the International Greenhouse Protocol (Tax, 2020). The financial department took over the graphical visualisation of Blom & Dobbelsteen, an illustration that shows how much forest area TU Delft needs to sequester greenhouse gas emissions. This study shows that the campus of TU Delft should need a forest area of 1.5 the size of the city of Delft (figure 2).
However, during the carbon accounting of Blom & Dobbelsteen and the financial department, there was still insufficient information about procurement. Afterwards, Herth and Blok (2022) conducted an in-depth study into everything TU Delft purchased in 2019. The impact of procurement turned out to be equal to everything else together, doubling the forest area to a size of 3 times the city of Delft. At the moment, the university is working on a system that calculates the carbon footprint based on financial data. Everything the university consumes, uses, operates, or purchases can be traced back to the financial overview.

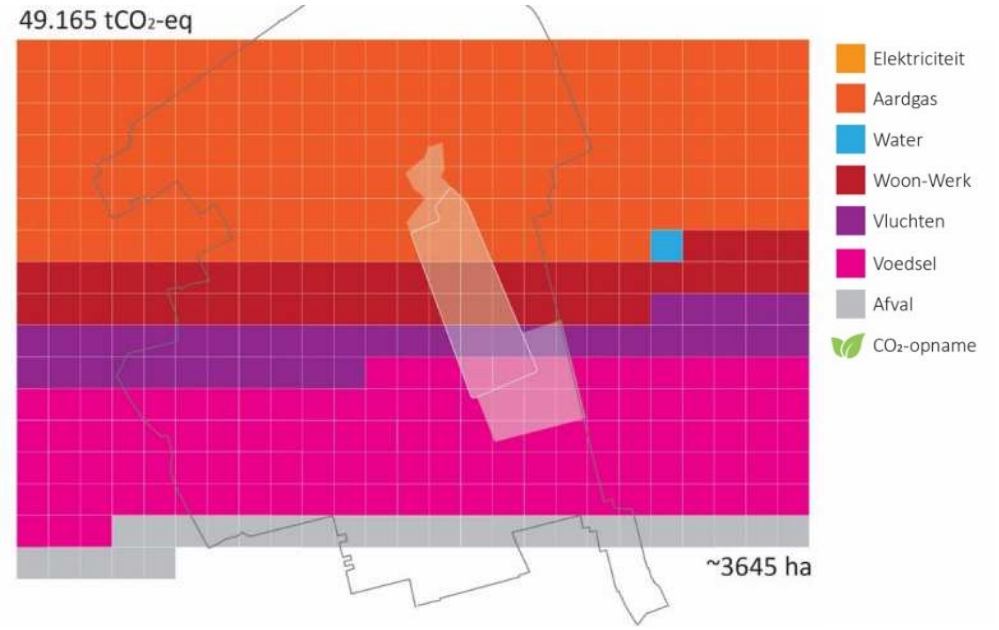
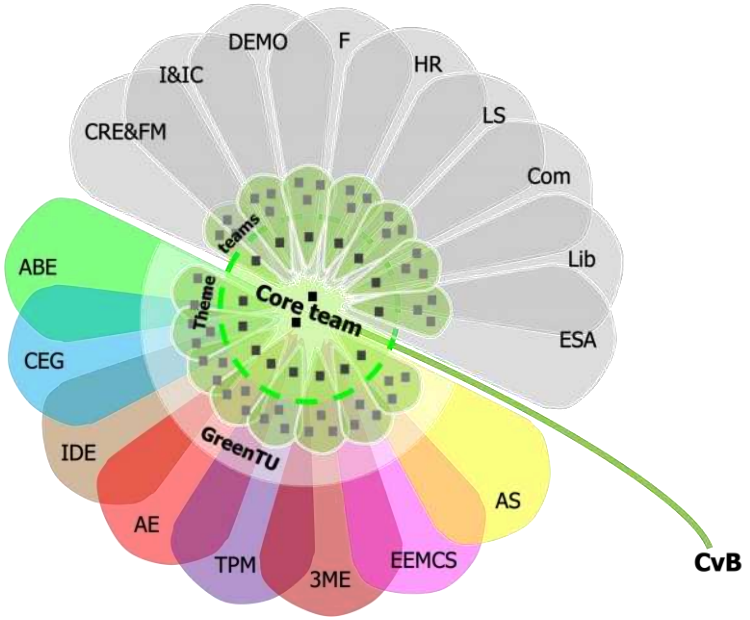


Figure 2. The carbon footprint of TU Delft in the year 2019, expressed as forest area needed to sequester all CO_2-equivalent emissions, with the city borders of Delft (grey lines) and TU Delft domain (white patch) visible underneath (Tax, 2020); procurement makes the area twice as large

Sustainability Coordination. At this point in time, the university has the ambition to become carbon neutral by 2030 and has an image of the current footprint. To reach these ambitions a Sustainability Coordinator was appointed from 2019-2020 who focussed on streamlining sustainability initiatives within the business operation and who coordinated GreenTU, a student association focussing on sustainability within the university. In January 2021, a new Sustainability Coordinator was appointed together with the Sustainability Project Manager who both directly work under TU Delft's Executive Board.

Action Plan. In the first year, the new Sustainability Coordinator and Project Manager developed a vision, ambition and action document (Dobbelsteen and Gameren, 2021). This report was subdivided into six elements: 1. Vision & Ambition, 2. Education, 3. Research, Valorisation & Technology Transfer, 4. Community, 5. Operations, and 6. Action. First, a clear overall ambition and vision were formulated, this ambition was then superimposed on the primary processes (education, research and valorisation), community and operations. The final chapter described the way forward. To be able to set up this document the Sustainability Coordination team developed a first governance structure (Figure 3) with a core team representing all students, faculties and university services. In addition, theme teams were developed from people with relevant academic knowledge and operational responsibilities from within the entire organisation. Their input and advice were used as content for the vision, ambition and action document.



The Figure 3. Flower illustrating the collaboration of TU Delft faculties (coloured petals) and supporting divisions (grey petals) in sustainability theme teams and the core team; students are organised under GreenTU (Dobbelsteen and Gameren, 2021).

Sustainability goals. The vision, ambition and action document of van den Dobbelsteen and Gameren (2021) states 5 main goals:

1. Carbon neutral by 2030
2. Climate adaptive by 2030
3. Circular by 2030
4. Contributing to the quality of life, including biodiversity
5. Demonstrating TU Delft's excellence and sustainability on the campus

Financial means. In January 2022, the report was officially approved by the Executive Board. The university showed that becoming sustainable is at the core of its heart. This was also the moment that the report could be shared externally. To realise these ambitions, the Executive Board allocated 100 million euro to the sustainability project in September 2022. The largest share, 95 million, is needed for the buildings and the energy system, a smaller part, 5 million, is allocated for awareness, innovation, food, etc. To stimulate innovations and living labs on campus, 20 million was set aside from the 95 million. A separate Campus Innovation Taskforce was created to fasten the procedural process and asses proposals. If a project is awarded the university will provide co-funding.

Line responsibility. Sustainability should be at the core of all activities to reach such high goals set by the TU Delft. These goals cannot be reached with a Sustainability Coordination team only. The goal of the sustainability team is to make themself redundant and to ensure sustainability is part of the daily tasks and activities of all employees and preferably done from intrinsic motivation. Faculties and University Services were made responsible for specific tasks. Deans and Directors were asked to appoint a Local Sustainability Coordinator (LSC) and to set up their own local sustainability action plan. The LSC works in close collaboration with the local GreenTeams and Faculty students councils. The Sustainability Coordination teams facilitated a first workshop to connect the LSCs, who are working on the same topic, and to create positive energy for this project. After that, workshops were set up on specific themes such as Mobility, Campus & Real Estate, and Education. For example, to realise sustainable

travel, multiple departments such as Legal, HR, and the faculties need to work together. Becoming sustainable cannot be realised by just one department, collaboration between departments is needed together with a conscious community. The appointment of an LSC at every faculty and university service stimulates to work pass these borders. In addition they are also the ones who know their community best and can inform and stimulate them to implement sustainability into their daily tasks and behaviour.

2.2. Steering CO_2 with TCO_2

To become carbon neutral a clear picture is needed of the current footprint of the university. These numbers can be seen within the vision, ambition and action document (Dobbelsteen and Gameren, 2021). For some elements, assumptions were made. To get this more accurate, TU Delft asks their suppliers in every new contract to report on the carbon emissions the university has for using or buying their product or service. In addition, steering on reducing carbon emissions is also needed. According to Peter Bakker of the World Business Council for Sustainable Development (WBCSD) (Buitenhof, 2023) a new economic model should be used that also includes other values than just financial profit. The university is implementing Total Cost of Ownership. This model looks at all costs and benefits of a service or product over its whole lifespan. In addition, the university wants to use a carbon price. First as shadow price and later as real price, possibly a carbon tax. After reviewing various scientific sources the university decided to calculate with € 150,- per tonne of CO_2-equivalent (Dobbelsteen and Gameren, 2021). At the moment the university is already considering to increase this value. TU Delft coined the combination of a carbon price and TCO, TCO_2. TCO_2 is used during the selection of suppliers but also as a bonus/malus for products sold on the campus. In addition, when suppliers do not reach their specific goals they need to pay € 150,- per tonne of CO_2-eq they emitted above the agreed baseline. TU Delft invests this money into carbon compensation such as planting trees and increasing biodiversity.

3. SUSTAINABLE OPERATIONS

Beside becoming carbon neutral in 2030 the university also states that it wants to demonstrate its actions regarding sustainability on campus. In other words “Practise what you teach and preach”. As a university, we can test new approaches, models and techniques on our campus and simultaneously learn from them by monitoring and measuring. The effect of these measures on operations can be made visible in such a way that the university can steer on it. This makes Sustainable Operations the focal point of the Sustainability Coordination group.

3.1. Theme teams

The coordination team developed multiple theme teams that focus on a specific theme related to operations. These teams consist of academic staff, supporting staff and students with different horizontal and vertical backgrounds from within the whole organisation. Every team tries to reduce the carbon footprint from that specific theme by for example testing and implementing new models, projects, or techniques.

EcoCampus. The university strives to become a natural, self-sufficient, biodiverse, climate-positive campus where people and nature can co-exist. The university should not be seen as a demarcated area but tries to embed and connect with the green and blue structures around it. By doing this the campus will become more climate adaptive and less affected by extreme weather conditions such as flooding, drought and heat. A positive consequence is that the

university also becomes more sustainable over time. The campus will be a living lab where students and researchers can test how the environment should be designed to withstand the changes due to climate change. Beside providing cooling and a place for insects and small animals, greenery also absorbs carbon and nitrogen. However, only a small percentage of the carbon footprint of TU Delft can be absorbed by greenery on campus. More should be planted elsewhere. Every year the university organises a tree planting day. During the last event thereof, 40 trees were planted. In addition, a biodiversity zero measurement study was done by Royal Haskoning BV. This study will be used to further increase the biodiversity on campus.

Construction & Renovation. The task of this team is twofold: construction of newbuilds and renovation of the current building stock. New buildings – faculties, laboratories and shared educational buildings – are currently developed on the South Campus. Constructing a new building has a higher carbon footprint than renovating an existing building (Blom and Dobbelsteen, 2019). That is why the Sustainability Coordination team prefers to renovate the current building stock instead of demolishing or repelling it. However, if a new building is needed it should comply with the highest sustainability standards: carbon neutral, climate adaptive, circular, and contributing to the quality of life of nature and health.
Most buildings on campus were built around 1970, which means they should be renovated within the coming years. For renovations the New Stepped Strategy from Zero-Energy Design (Dobbelsteen, 2021) is leading: research the local circumstances, reduce the demand by passive and smart & bioclimatic design, reuse residual flows, and produce from renewable energy sources. In addition, Fremouw et al. (2021) studied the potential of solar productivity of TU Delft. This research is currently being used by Campus & Real Estate department for the PV roll-out plan.

Energy System. The energy system should be capable to keep up with future demands, regulations and carbon neutrality. The university is looking into generating energy – heat, cold and electricity – on campus. Electricity should be generated by for example PV systems on the roofs, facades and parking garages. In addition, the university is also looking into the generation of electricity via hydrogen and wind turbines on campus. The basis of the university's heat demand will come from a geothermal heat system. The university started with the construction of the geothermal heat wells in June 2023. The high-temperate (HT) heat will be used for districts in Delft that are hard to renovate. The mid-temperature (MT) heat – the return temperature – and low-temperature (LT) heat will be used in the renovated buildings at the campus.
At the moment a large share of the electricity comes from Dutch wind farms on the North Sea. According to the CO_2 Prestatieladder, the carbon impact related to that is 0 tonne of CO_2-eq (Tax, 2020). The current carbon footprint related to energy comes from the purchase of gas. To become carbon neutral and independent the university is looking into renewable energy.

Mobility. Within the mobility team, the focus lies on 3 different types of travel: commuter travel of staff and students, business travel (national and international), and international student travel. Within the CO_2 Prestatieladder these emissions fall within scope 3, upstream and downstream. To become fully zero-carbon for mobility the university should avoid travel at all costs. Although this is impossible the travel frequency can be reduced and a more sustainable travel mode should become the standard.
Coming on foot or by (e-)bike should become the standard travel option for people that live near the campus. The standard option for people who live further than 25 km away should be public transport or a combination of foot or bike and public transport. The university is

looking into the possibility to stimulate those facilities within the employee arrangements with HR. In 2030, the campus will be a fossil-free area. In this case, if students, staff and suppliers want to use a car it should run on electricity or other forms of energy such as hydrogen.
International travel by staff and students, especially flying, has the greatest impact on carbon emissions. Currently, 3 faculties have implemented a new travel policy as a pilot. Focussing on travel time or travel distance. Within a certain period or distance the train should be the standard instead of the airplane. The university is looking into implementing a carbon tax if someone still chose to take the airplane. The carbon tax will be used for carbon-saving projects. A special train map is already made for students to help them compare different forms of travel within Europe (figure 4).

The Figure 4. Student travel map comparing time and emitted carbon emissions per location (TU Delft, 2021)

Food and Beverage. Food and beverage make up a large part of TU Delft's carbon footprint. Multiple studies show that animal-based food has a greater carbon impact than plant-based food, a recent study that confirms this comes from ten Caat et al. (2022). The restaurant in the Faculty of Architecture and the Built Environment was the first one to serve vegetarian and vegan products in its restaurant and banqueting map. This choice was made after participating several times in the 'Week without Meat' and in close consultation with students, staff and caterer. A study done by an external party at the request of TU Delft shows that the carbon footprint of the Faculty of Architecture is now half compared to a standard menu (Greendish, 2022). Recently, an extra luxury restaurant and a standard restaurant were opened which serve only vegetarian and vegan food.
In the year 2022/2023 the university worked on a tender for catering implementing multiple requirements regarding sustainability. One requirement is that the new catering should report monthly on the products they buy. Together the university and the caterer will

calculate the related carbon emissions. The contract stipulates that these emissions must decrease annually.

Procurement & waste management. 50% of the total footprint of TU Delft is caused by procurement which falls within scope 3. However, every organisation needs products and services to fulfil their work activities. The university proposed a new policy following the R-Ladder (RVO, 2020). The first step of the R-ladder is to avoid purchasing new products (figure 5). The question that should be asked is, do we need this? And if so, do we need this new or is it already somewhere on the campus? To make this work, an organisation wide inventory method is needed. As with the tender regarding food additional requirements regarding carbon accounting, circularity, and partnership are included in the new policy. Currently, the university is working on a new tender for waste management. Previous requirements are implemented into the document. To become carbon-neutral the entire supply chain should join our mission.

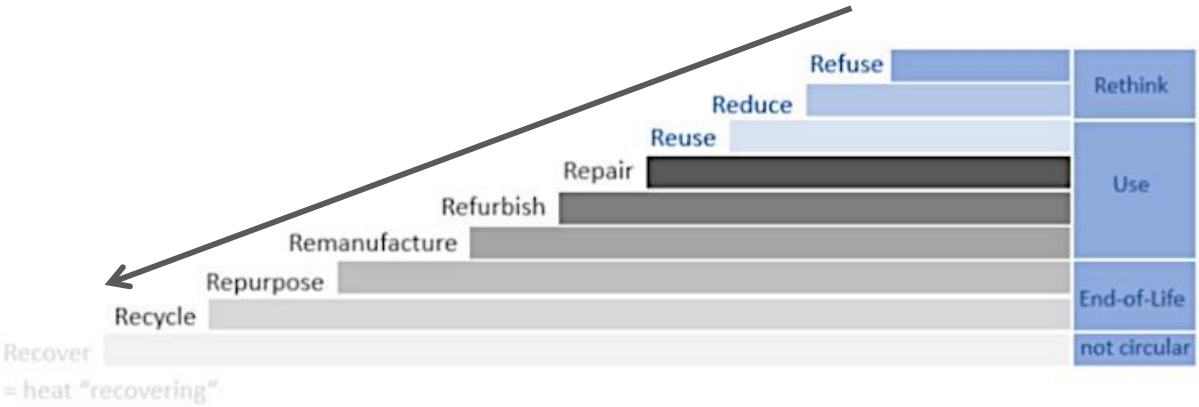


Figure 5. Graphic illustration of research and actions on the theme of mobility (RVO, 2020)

IT, AI & Data management. The positive side of IT, AI & Data Management is that it can make products and services more energy efficient and smarter. However, the process itself also uses a lot of energy. This team looks into the optimisation of both. The university wants to measure the current energy usage and when possible subdivided it per type of consumption, e.g. building energy versus user energy. It can be seen that for example, datacentres use more energy than educational buildings. To reduce energy usage, this team looks into computation processing, server management, and waste heat usage. Data management, looking into the amount and type of data that is stored is also needed beside monitoring and steering on energy usage. Other measures related to this theme are the collection of e-waste, providing e-learning facilities and deep learning.

4. BEHAVIOURAL CHANGE

To become a sustainable university implementing sustainability into the operations and the daily task of employees and students is not enough. The right governance and technical systems can be put in place but as the community does not act sustainable TU Delft will not reach its goals. A behaviour change is needed. TU Delft tries to establish this by informing the community about its goals and engaging them. De Vries (2019) states that the accumulation of hassle people encounter can lead to stress. That is why people often delay or do not show sustainable behaviour to prevent this from happening. The university should take this "hassle factor" into account and help its community to overcome this by giving clear, concise and credible information.

4.1. Communication

A collaboration between the different communication departments is set up to create a unified and recognisable flow of information regarding sustainability. Multiple platforms are used such as the sustainability website, TU Delft news(letter), and social media platforms such as LinkedIn, Instagram and Twitter, to teach and inform the community. It is important to engage the community, introduce them to the topic of sustainability, let them learn and discover at their own pace, and gradually make them aware of their behaviour.

4.2. Climate Conversations

To help the LSCs with engaging their community, the Sustainability Coordination team offered them to follow the Climate Conversations course. Within this course, the LSCs learn how to open up meaningful conversations about climate change. In the future, the LSCs will facilitate these kinds of conversations to create a safe place for the community to talk and learn about climate change and related feelings. Often, people engaged with climate change, feel that they are in a quandary. “I want to act sustainable but then I cannot fly anymore, I cannot, I cannot barbeque anymore, I cannot … anymore.” These conversations are a place to talk about those feelings and struggles with others. It could be a chance to change the thought of “having to” to “wanting to”.

5. NEXT STEPS

Becoming a Sustainable University or a Sustainable Organisation requires hard work. A lot of organisations are saying that they want to become sustainable but do not put their money where their mouth is, and then the ambition becomes greenwashing. This paper discusses the steps TU Delft is taking on Operations and Behavioural Change to become more sustainable and to set an example so that others can learn from it.

5.1. Lessons learnt

- Ambition and support from the highest level, the executive board
- People willing (change managers) to get the initial work done
- Measuring is knowing: a zero assessment as the starting-point
- A roadmap – preferably via backcasting – to reach the desired goal
- It is a technical and personal transition. Inform and engage the community
- Start small and share those small wins. This will reduce the resistance and create a ripple effect.
- Communicate in various ways to reach the whole community
- Be prepared for resistance and see this as something positive

5.2. The way forward

As stated in the beginning immediate climate action is needed to limit the warming of 1.5^{o}C-2.0^{o}C (IPCC, 2023). As starting-point, TU Delft focusses on reducing carbon emissions because this can be measured in numbers. The university also focusses on becoming circular, climate adaptive, and biodiverse but this is more difficult to express in numbers. A first-time schedule is made towards 2030 to showcase to the managers that action is needed now on all themes (figure 6).

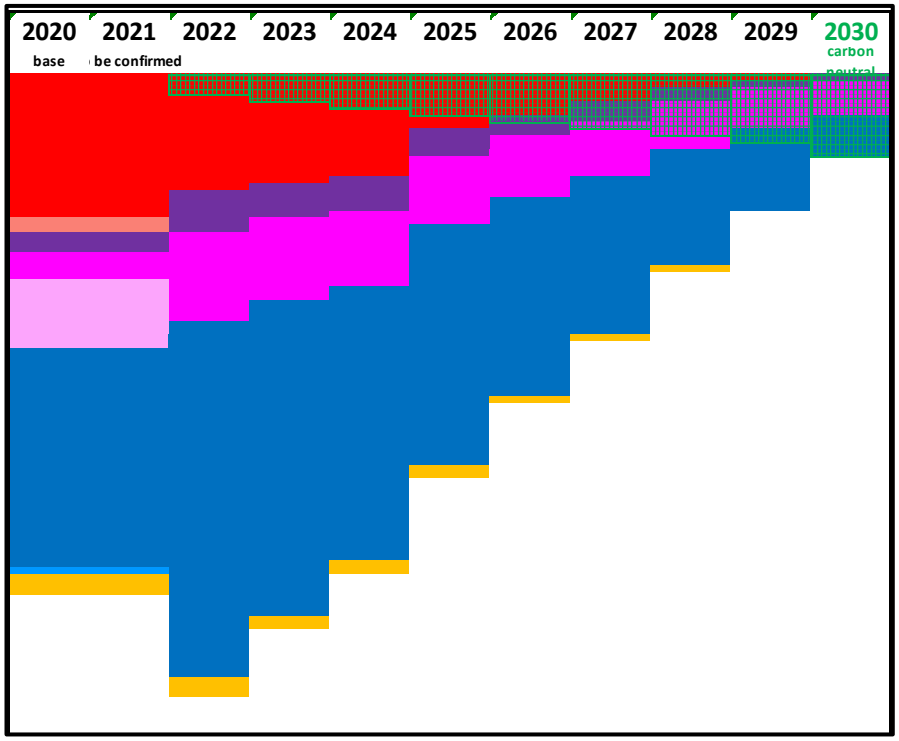


Figure 6. Carbon emission reduction towards the year 2030 (Dobbelsteen and Gameren, 2021)

It is impossible to be fully carbon neutral because there will always be unavoidable emissions. For example, even vegan food has a small footprint and there will always be a need to buy some new products. The university is going to compensate for those remaining emissions by means of reforestation in areas that need it. Currently, the university is having the final conversations with some candidate organisations that offer these services.

6. Conclusion and evaluation

It can be seen that TU Delft is striving to become a sustainable campus and wants to pave the way for other organisations, companies, and cities and show how to reach the climate goals. In 2019, the university acknowledged that the environment is changing by anthropogenic greenhouse gases and stated that it will use its innovative character to power the transition. This acknowledgement can be seen as the kick-off of the transition. After this acknowledgement, the university expressed its intentions in the Strategic Framework 2018-2024 and delegated the task of continuous carbon accounting to the finance department. To be able to reach the ambitions the executive board appointed a Sustainability Coordinator and Sustainability Project Manager who developed the 'Vision, Ambition and Action Plan' and created a team around them to execute the plans. The transition gained momentum when the Executive Board officially approved the report and allocated 100 million euros to realise these ambitions. By doing this, the Executive Board showed that becoming sustainable is at the core of its heart, which was an important signal to the community. We learned that the sustainability goals can only be reached when sustainability is part of the daily tasks and activities of all employees and students. The core team established this by making Faculties and University Services responsible for specific tasks and asked the Deans and Directors – with backup from the Executive Board – to appoint a Local Sustainability Coordinator (LSC) and to set up their own local sustainability action plan. The LSCs work in close collaboration with each other, the local GreenTeams, Faculty Student Councils and the Sustainability Coordination team. It is important to realise that sustainability is something that passes all

borders. Collaboration between every Faculty, University Service, supplier and municipality is needed.

The start of the transition can be subdivided into 7 important steps:
1. Acknowledging climate change by the highest management (the Executive Board)
2. Researching the current footprint (creating a baseline)
3. Continuing carbon accounting
4. Appointing a Sustainability Coordination team
5. Creating a vision, ambition and action plan
6. Setting clear goals
7. Allocating financial means

After these 7 steps, a first base is created to become a sustainable organisation. The sustainable transition can then be divided into two major tasks. 1. Become sustainable in operations and 2. Creating a sustainable community. As a technical university, we noticed that the second task is as difficult or maybe harder to establish than the first task. The right governance and technical systems can be put in place but as the community does not act sustainably, TU Delft will not reach its goals. The university tries to establish this by informing the community about its goals and engaging them. A collaboration between the multiple communication departments is set up to create a unified and recognisable flow of information regarding sustainability. In addition, the LSCs followed a Climate Conversation course, which helps them to open up meaningful conversations about climate change.

It can be seen that becoming sustainable is not something that can be achieved within a short time. It is a transition which needs the support and dedication of not only the top management but the whole community. In the past years, TU Delft focussed on the first task. It can be seen that sustainability is something taken on in every faculty and university regarding operations. At least at the management level. The next important step is to get the whole community involved.

7. Acknowledgement

The authors would like to thank TU Delft's Executive Board for recognising this challenge and their immediate action to appoint a Sustainability Coordinator and Project Manager and financially support the plans made by them. Although not everyone always agrees on the steps that need to be taken we are thankful for our community that is willing to listen and have an open dialogue about this important topic.

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