TU Delft

GREENTU DELFT'S

VISION ON SUSTAINABILITY

A REVIEW AND STRATEGY 2020-30

TU Delft GreenTU

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Energy Club
Center For Sustainability
Food Sharing Delft
Students 4 Sustainability
IEAS Shift

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PREFACE

The academic year 2019-2020 marks as an important mile stone in the world's progress towards sustainable development. From the call by the United Nations for the 'decade of action' on Sustainable Development Goals (SDGs) to the various movements on climate change and climate action, this year has embarked an important role in creating awareness on the topic of sustainability. This year has also seen some significant steps taken by the Delft University of Technology towards climate action and sustainability. These steps include the expansion of the board of GreenTU Delft, appointment of Mr Gerrit Kahlman as the sustainability coordinator, the new CO2 Roadmap report by Prof Andy van den Dobbelsteen and many new initiatives and projects.

The current report is an attempt made by GreenTU to show the progress of the university towards SDGs and to draw a vision and a roadmap to achieve the targets set by TU Delft. These goals include contributing to SDGs through education and research and building a campus which is carbon neutral and circular by 2030. The report focuses on four main portfolios which are sustainability in education, research, operations and social engagement. The report is intended to show various possibilities to achieve the sustainability goals and it does not imply that TU Delft claims or commits to these ideas. The work is a based on a quantitative research depending on the available data, interviews, literature review and experiences of the authors and other stakeholders of the university.

I would like thank Mr Gerrit Kahlman for commissioning this report and for the valuable suggestions during the journey of making this document. And I also extend my sincere thanks to Mr Gilbert De Nijs for the support, suggestions and the interview. A special thanks to Ms Lisa Marie Talia for the time and effort in building the simulation model, for the discussions and suggestions during the course of the report. I would also like to thank our research team comprising of Saraf, Thomas, Adarsh and Rushil for their contributions. I thank my colleagues Marijn, Lauren, Sarah and Sharina for their suggestions and help during the making of this document. And finally, I would like to thank Jessy, Noa, Tamar and Wouter from the new board of GreenTU Delft 2020-21 for the support in completing this report.

This report is a first and honest attempt in showing what TU Delft is doing with respect to sustainability and what more can be done in the coming future. My colleagues and I have tried to keep the report free from errors, but please feel free to contact us in case of any discrepancies. The report does have some assumptions made which are well stated and supported with literature where reliable data was not found. I see this as a first guiding book for the future boards of GreenTU and would like to pass it on to my successors to constantly improve it with supporting feasibility studies and with more accurate and reliable data. This report is expected to be a living document getting better every year. The making of this report was great learning experience for all the involved members. We will cherish this journey and thank Mr Gerrit Kahlman and TU Delft for this opportunity.

Sushanth Amanaganti
Secretary, GreenTU Delft

A WORD FROM THE SUSTAINABILITY COORDINATOR

Delft University of Technology contributes to a better, sustainable society. She does this through Education and Research, but also by showing this in her own experience "practice what you preach". Observations by Randers (2012), von Weizsacker (2018) and Pope Franciscus (2015) show developments with regard to population growth and consumption, energy generation and CO2 emissions, predictions about food and the ecological footprint, and also about the non-physical future. The present report shows, from the perspective of GreenTU, what the university is doing in the field of sustainability and what could be done. A number of cases, scenarios have been developed in which the direct impact of this is made visible. I am grateful to GreenTU and especially Sushanth Reddy Amanaganti for the tremendous amount of time and energy they have put into this wonderful report.

GERRIT KAHLMAN

1.INTRODUCTION

With the United Nation's call for the Decade of Action towards achieving Sustainable Development Goals, as a due responsibility, governments, public and private institutions and corporate companies are aligning themselves towards realising these targets. Among the 17 goals specified by the UN, the 13th goal for addressing the climate action has been given the highest priority. Presently, the momentum for sustainability and climate action is in its peak and is only expected to grow in the next 10 years. This climate action goal, in accordance with the Paris agreement, aims to limit global warming to 1.5 degree centigrade and reduce the global carbon emissions by 45% by 2030 compared to 2010 levels [1].

In agreement to this, the Dutch government has signed its climate policy on 28th June 2019 committing to reduce the emissions by 49% by 2030 [2]. Along these lines, TU Delft has published its vision and mission for climate action and is committed to be a carbon neutral campus by 2030 and support the world climate mitigation and climate adaption [3].

"Attracting the best minds of the world, TU Delft has an immense potential to be a torch bearer for climate action and let this begin here...."

TU Delft's Strategic Framework for 2018-2024 with a motto "Impact for a better society" has set the university's vision to be a 'Flagship university' or 'Civic University' [3]. Striving for academic excellence and societal impact for the most challenging problems, TU Delft has aligned its ambitions with the UN Sustainability Development Goals. Being an internationally acclaimed university with its alumni spread all across the world, TU Delft can play a significant role in preparing its engineers to fight climate change and to build a sustainable environment. To make it possible, sustainability should be integrated in education and research across all the departments. In addition to this, it is TU Delft's due responsibility to practise what it preaches and start its climate action from the university campus.

The purpose of this report is to convey GreenTU Delft's vision on sustainability at Delft University of Technology. This vision focuses on realising the United Nations Sustainable Development Goals (SDGs) and to become carbon neutral by 2030. This report reviews the current progress of the university in sustainability and suggests strategies for improvements. The concept of sustainability is addressed across four pillars, education, research, operations to align with the SDGs applicable at the and social engagement.

To the present date, there are multiple studies and reports at TU Delft which concentrate on different aspects like the 'carbon neutrality' (CO_2 roadmap 2030) [4], 'circularity' (Circular campus roadmap 2050) [5], mobility roadmap [6] and etcetera. The current report brings together various suggestions from the above mentioned documents, draws inspiration from the sustainability practises of the best universities across the world and suggests some technological and social innovations to tackle sustainability.

Based on the this study, the authors propose a sustainability development strategy for the coming decade (2020-30) in which GreenTU intends to show various ideas for building a sustainable campus. The ideas are also backed up by graphic representations of various scenarios based on a behavioural model that was developed to support this report. The work is completely carried out by GreenTU and no commitments have been made by any individual or department go TU Delft with regards the claims in the report. The work is only intended to show the wide range of possibilities to achieve TU Delft's sustainable development goals.

Methodology

This report is based on literature research of the documents published by experts in TU Delft and a background research on best universities around the world with respect to their sustainability initiatives. The analysis and proposals are based on the above research and on the data available till date.

The authors used the World 3 prediction theory to develop a mathematical model to suit the conditions of TU Delft and predict the future scenarios for carbon emissions.

For this report, sustainability will be dealt in terms of education, research, operations and social engagement. The analysis and the resulting strategies will be classified in terms of these areas.

Scope and Limitations

This report is based on the current availability of the data and any assumptions made are based on scientific results and are only intended to show a particular impact in a behavioural way than to exact numbers.

The mathematical model will be a close approximation to the future emissions and is limited to parameters like changes in the population but does not take into account the future technological developments or any unforeseen activities.

Structure

The report introduces the TU Delfts commitments towards sustainable development in chapter 2 along with the focused SDGs. Then chapter 3, concentrates on reviewing the current state of sustainability in TU Delft based on its four pillars of education, research, operations and social engagement. In chapter 4, a prediction of future emissions is made and explained using a Vensim model. The chapter 5 focuses on knowing the student opinions on sustainability at the university and performing a SWOT analysis to analyse the scope of improvements. Based on the review and the analysis, the authors define a Vision for Sustainability in chapter 6. Then to understand what is happening around the world on the concept of sustainability and to draw inspiration, a research on various sustainability initiatives at acclaimed universities can be found in chapter 7. Finally, in chapter 8 the authors present a Sustainable Development Strategy for 2020-30 starting with organisational strategy and covering the four pillars. The ideas in the strategies show various possibilities from GreenTU's perspective and are supported by the mathematical model. Finally, chapter 9 will give the conclusions and recommendations to be implemented for the TU to be a sustainable university.

2. UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

The United Nations has proposed 17 Sustainable Development Goals for building a better future. To attain these goals, UN suggests progress in the areas of financing, resilience, more effective institutions, local action and others [7]. With a call for the decade of action to deliver sustainable development, UN invites action at three levels; global action, local action and people action [7]. Global level includes international cooperation to achieve the goals, local action involves the governments, educational institutions, research organisations, corporates and others to align towards SDGs and finally people action calls for involving the youth, academia and civil society.

With its huge potential in terms of resources and the knowledge pool, TU Delft can play an important role in contributing to the local and people action. To make an impact for a better society, it's the need of the hour for TU Delft to bring necessary changes to fight these most challenging problems. Being the engineers of the future, the graduates from TU Delft need to have an understanding about sustainable development along with their strong technical and analytical background. The authors envision sustainable living to be the way of life for TU students and their skills should be utilized to build a better tomorrow for future generations.

Figure 1: UN Sustainable Development Goals ; Source: United Nations

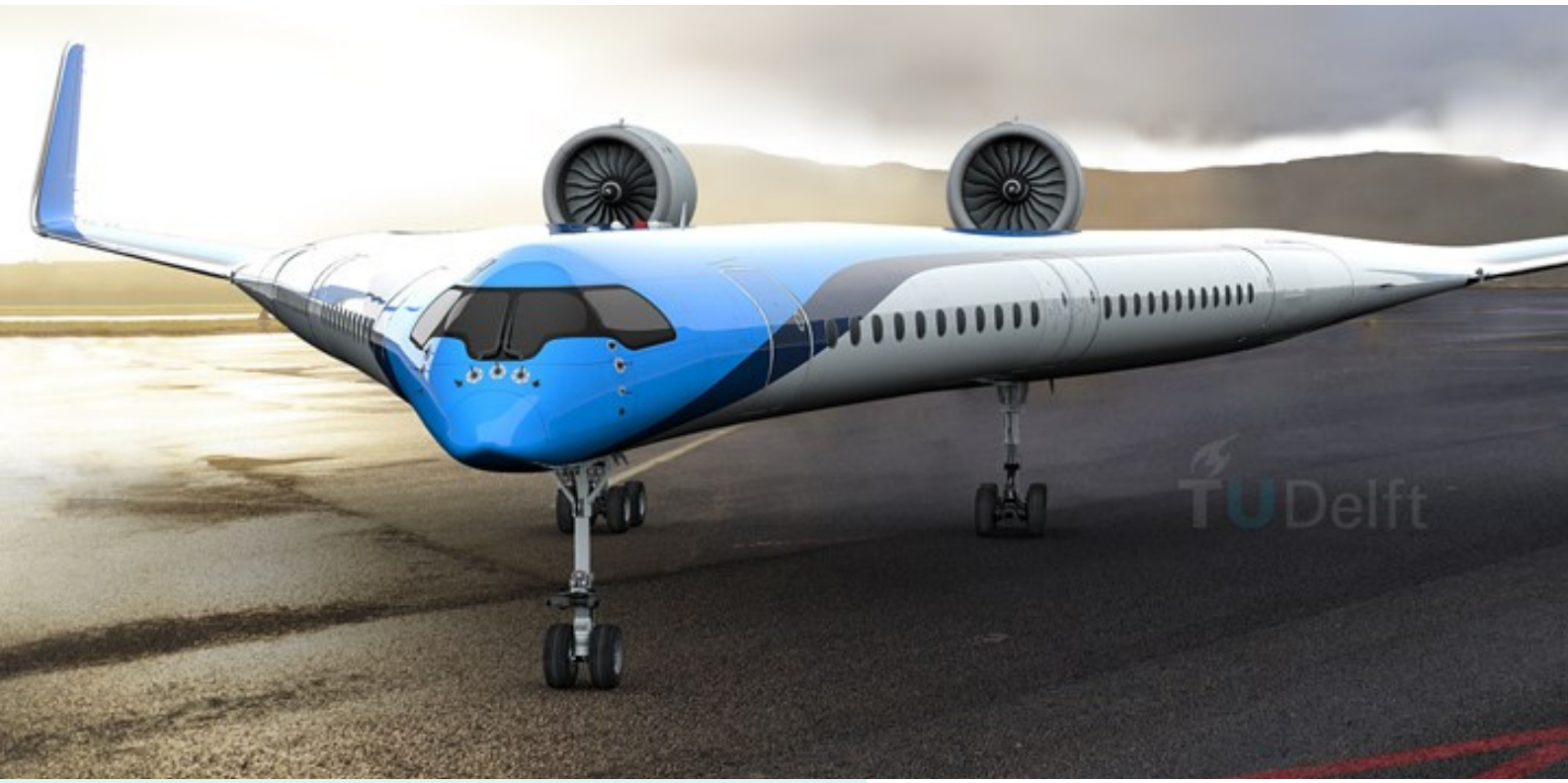
To be in the frontier of future science and technology, TU Delft should take swift action to generate and pursue the momentum towards this sustainable development in all its activities.

Of the 17 goals, the core objectives for 2020-30 are no poverty, women and girl empowerment and climate emergency [7]. But, not all of them are applicable at the university level. The authors have identified 10 goals and two core objectives which can be addressed by the universities and to which TU Delft can make a substantial contribution.

The figure below shows the 10 SDGs for TU Delft and the report concentrates on the core objectives of women and girl empowerment and climate emergency.

Aligning with the motto of the UN SDGs, "for people, for planet", the authors call for the decade of action "for people, for planet and for TU Delft"

Figure 2: UN Sustainable Development Goals for TU Delft



3. TU DELFT'S CONTRIBUTIONS TO SDG

Being one of the pioneers of modern education in engineering and sciences, TU Delft values its position in making an impact on the future society. With world class education programs preparing the engineers of tomorrow and cutting edge research focusing on numerous frontier fields, TU Delft is already a front runner in facilitating a sustainable world. Although there is much more to be accomplished, the commissioning of this report shows the commitment towards sustainability. In addition to this, the university also values its commitment towards making the campus carbon neutral and circular by 2030 as mentioned in the TU Delft Strategic Framework 2018-24 [3].

"TU Delft focuses on four pillars for sustainability, education, research, operations and social engagement"

Collective effort is what takes to achieve these futuristic goals. Along with the technology and the capital, the social responsibility and engagement of all relevant stake holders plays a very important role. In line with this idea, Communication with external and internal stakeholders about out sustainability initiatives is a key factor. The recently updated sustainability website and the present report mark the beginning of this. This chapter reviews the present progress of the university in its four pillars for sustainability.

3.1 EDUCATION

This section will give an overview of various educational programs related to sustainability that are currently offered in TU Delft. Though most courses at TU Delft bring in the concept of sustainability in some form, but this report concentrates on explicit master programs, master tracks, minors and MOOCS on sustainability.

Full Master Programs

MSc Sustainable Energy Technology

The Master of Science in Sustainable Energy Technology is one of the best courses in the university in terms of bolstering sustainability. The program focuses on preparing the engineers to be system integrators for energy transition. With a focus on six clusters namely, solar, wind, biomass, storage, power and economics, students are offered different profiles with a wide range of choices to explore and pursue the degree in the domain of their choice.

Achieving a future with sustainable energy needs professionals who are capable of developing, optimising and integrating various technologies. Also the knowledge of the energy market, business models and policies for sustainable energy are important to accelerate the energy transition. This MSc program at TU Delft aims to produce such engineers who are capable to be pioneers in tomorrow's energy transition and sustainable future.The program also offers various electives like Geothermal energy and applications, PV Materials processing & characterisation, Fuel cell systems, Clean tech business study which also focus on sustainability.

MSc Industrial Ecology

With a prime focus on sustainable co-existence of the technosphere and the environment, the Master of Science in Industrial Ecology at TU Delft offers it's engineers a toolbox for sustainable development. The program promotes a scientific discipline with a systemic approach to human problems with an integration of technical, environmental and social aspects. The program is offered in collaboration with Leiden University, thus bringing the best expertise together. The students learn about the efficient use of materials, energy systems, waste streams along with concepts like circular economy thus building their capabilities to design a sustainable future with a socio technical approach.

With courses like Design of sustainable technological systems, Sustainable innovation and social change, Urban environments and infrastructures, Circular economy, Environmental input-output analysis, the master program strongly boosts the practice of sustainability among students.

Partnered Courses

MSc European Wind Energy

The European Wind Energy Masters (EWEM) is a joint master program offered in collaboration between TU Delft, Technical University of Denmark, Norwegian University of Science and Technology and Carl Von Ossietzky Universität Oldenburg. The program focus on different aspects of wind energy technology with tracks in Electrical Power Engineering, Offshore Engineering, Rotor Design and Wind physics. The second semester of these tracks is offered at TU Delft along with the best in class research opportunities for master thesis in wind energy field.

MSc Metropolitan Analysis, Design and Engineering

The Master of Science in Metropolitan Analysis, Design and Engineering (MADE) is a program with focus on sustainable development of cities. The program is offered by Amsterdam Institute for Advanced Metropolitan solutions (AMS) which is formed by TU Delft in collaboration with Wageningen University & Research. The course prepares students to deal with the complex problems arising due to urbanization including issues like mobility and logistics, water and waste management, energy and food security.

Master Tracks

Environmental Engineering

Environmental Engineering is a track in MSc Civil Engineering with an emphasis on fighting the challenges of climate change and transition from linear to circular economy. This program focuses on equipping its engineers with interdisciplinary knowledge in the fields of designing environmental processes, understanding of the interaction between humans and natural environment, and the closing of water and resources loops. The track has two specialisations called Environmental Technology and Environmental Science. The former concentrates on solving local environmental problems with technological interventions and the latter focus on environmental processes at a global scale.

Water management

The master track water management is a part of the MSc Civil engineering which focuses on producing engineers who have the knowledge and skills to address the challenges of water scarcity, water pollution and climate change. It focuses on understanding and management of surface and groundwater flows and further control and utilisation of these flows for society in an efficient way. Almost all the courses for the track of Water Management focus or touch on the concept of sustainability. Hydrology, ground water treatment, GIS and Remote Sensing are some of the prime focuses in the track.

Aerodynamics and wind energy

The track of Aerodynamics and wind energy is offered in the MSc Aerospace Engineering. This track focuses on the development of new analysis techniques and applying the them in the design of new age wind turbines combining the disciplines of aerospace and wind energy systems. For the Wind energy profile, it is pretty well integrated with sustainability given the fact that various aspects of the design of wind turbines and applications of this renewable source is well taught in the courses. While in the profile of Aerodynamics, Aircraft aerodynamics touches upon on sustainability.

Urbanism

The track on Urbanism is offered by the MSc program in Architecture, Urbanism and Building technology. The track focuses on integrating the concepts of urban design, landscape architecture, spatial planning and engineering which is an important part of Dutch traditional architecture. Students in this program learn to address the global trends like globalisation, climate change, demographic trends and the energy transition. The engineers get a new perspective to develop solutions which are efficient and sustainable.

MINORS OFFERED BY TU DELFT
(OR IN COOPERATION WITH A PARTNER UNIVERSITY):

Faculty of Mechanical, Maritime and Materials Engineering

ELECS (Engineering for Large-Scale Energy Conversion and Storage): All about sustainable energy sources and the future ahead focusing on integrating storage systems.

Faculty of Architecture

Cities, Migration & Social Spatial Inequality: Deals with various aspects related to sustainable development and SDGs like 6, 9, 11, 13 and others.

Sustainable Urbanism - The Green-Blue City: Entirely focussed on how to adapt cities to the changing climate and how to mitigate environmental problems.·

Faculty of Civil Engineering and Geosciences

Delta Expert, Water for the Future: Contributing to the SDG 6, courses really embrace the role water plays in sustainable development and not just focus on the technical problems of delta works.

African Dynamics (LDE): The courses cover a wide range of SDGs focusing on the African context.

Environmental Engineering and Sustainable Design: Provides insight into processes and how to design for minimal environmental impact.

Geo-resources for the Future (LDE): Links the exploitation of geo-resources to the environment, social issues, politics, and the path to a circular economy.

Faculty of Electrical Engineering, Mathematics and Computer Science

Electrical Sustainable Energy Systems: Focus on sustainable energy and energy transition, contributing to SDG 7.

Faculty of Industrial Engineering:

Designing Sustainability Transitions: Focuses on interdisciplinary challenge of a sustainable future and the transition is examined on different levels/scales·

Faculty of Technology, Policy and Management

Responsible Innovation (LDE): The course gives a very holistic view of innovation focusing on many of the SDGs.

Frugal Innovation for Sustainable Global Development (LDE): The course explores frugal business models for sustainable development with a focus on various SDGs.

Faculty of Aerospace Engineering

Offshore Wind Energy: Focussed on sustainable energy technologies and also includes a TPM course on energy systems which is very much related to sustainability.

MOOCS

Faculty of Aerospace:
Offshore Wind Farm Technology: Design, Installation and Operation
Introduction to Wind Turbines: Physics and Technology
Design of Lightweight Structures I: Composites & Metals
Faculty of Architecture & Built Environment
Healthy Ageing in 6 Steps - Let your Environment do the Work
Nature Based Metropolitan Solutions
Managing Building Adaptation: a Sustainable Approach
Circular Economy for a Sustainable Built Environment
Co-Creating Sustainable Cities
Sustainable Urban Development
Zero Energy Design: an Approach to make Your Building Sustainable
Energy Friendly Renovation Processes
Urban Design for the Public Good: Dutch Urbanism
Faculty of Civil Engineering and Geosciences:
Sustainable Urban Freight Transport: A Global Perspective
Beyond Engineering: Building with Nature
Water Management
Introduction to Water and Climate
Drinking Water Treatment
Sustainable Urban Freight Transport: A Global Perspective
Geoscience: the Earth and its Resources
Hyperloop: Changing the Future of Transportation
Faculty of Electrical Engineering, Mathematics and Computer Science
Energy Demand in Buildings
Energy Supply Systems for Buildings

Buildings as Sustainable Energy Systems
Smart Grids Integration and Modeling
Sustainable Energy: Design A Renewable Future
Electric Cars: Policy
Solar Energy: Photovoltaic (PV) Systems
Solar Energy: Integration of Photovoltaic Systems in Microgrids
The Transition to the Decarbonised Economy of Tomorrow
Solar Energy Engineering: Comprehensive Exams
The Economics of Energy Transition
PV Modeling, Simulation and Analysis
Photovoltaic Material and Device Modeling
Energy Markets of Today
Solar Energy: Photovoltaic (PV) Technologies
Solar Energy Engineering
Solar Energy: Photovoltaic (PV) Energy Conversion
Understanding Nuclear Energy
Faculty of Industrial Engineering
Waste Management and Critical Raw Materials
Circular Economy: An Introduction
Engineering Design for a Circular Economy
Faculty of Technology, Policy & Management
Circular Product Design Assessment
Inclusive energy systems - Exploring Sustainable Energy for All
Sustainable Packaging in a Circular Economy
Responsible Innovation: Building Tomorrow's Responsible Firms

3.2 RESEARCH

The research at TU Delft is aligned to various Sustainable development Goals with aim to create an impact for a better society. The research at the university is broadly clustered into four Delft Research-based Initiatives (DRI);

1. Delft Health Initiative
2. Delft Energy Initiative
3. Delft Global Initiative
4. Delft Deltas, Infrastructure and Mobility initiative

These schools of thought are the four strong pillars of TU Delft's scientific contribution to society. These themes are in line with the UN SDGs and broadly concentrate on eight goals. The main aim of these DRIs is to solve societal problems with a multidisciplinary cooperation and in partnership with other research organizations, governments and other corporations. Another feather in the crown is TU Delft's commitment to be a test bed and a living lab for facilitating these research ideas.

Focused SDGs

Good health and well-being - 3
Clean Water and Sanitation - 6
Affordable and Clean Energy -7
Industry, Innovation and Infrastructure - 9
Sustainable Cities and Communities -11
Responsible consumption and Production - 12
Climate Action -13
Partnership for Goals - 17

The four research themes are composed of various research institutes and departments with different expertise and specialisations. Though the current report summarises the research areas which are closely in line with the 8 SDGs, TU Delft encourages interdisciplinary research which brings together the entire research community to contribute towards these goals. A few of these interdisciplinary projects will be briefed later in this section.

Rankings:

TU Delft is ranked very high for its research output in the areas related to the SDGs. The highly ranked areas are mainly focused on technical innovations that the TU is knows for. For example, according to the research data of Elsevier [8], TU Delft ranks first in the Netherlands and Europe and forth in the world for its contribution towards Industry, Innovation and Infrastructure (SDG 9). TU Delft's current ranking in the areas related to the SDGs is further in this section.

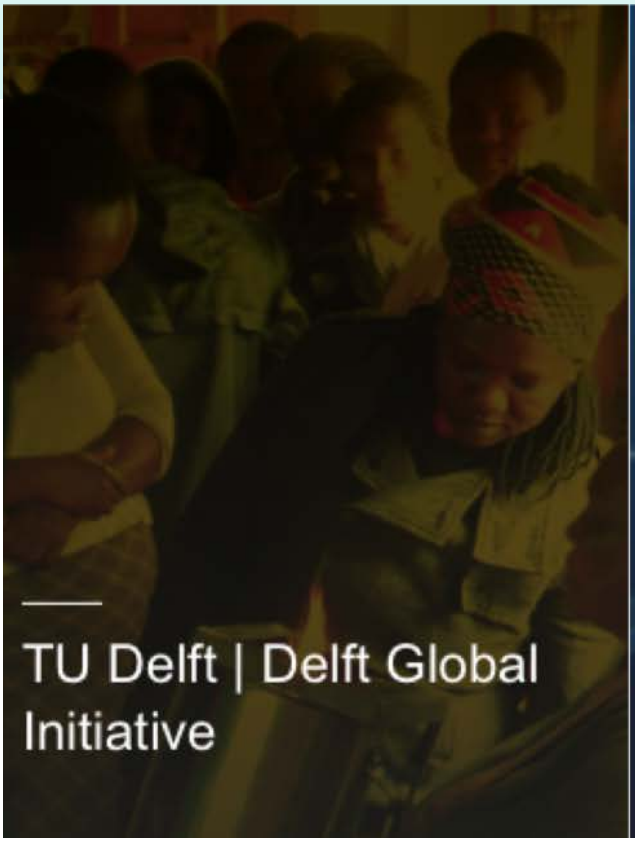
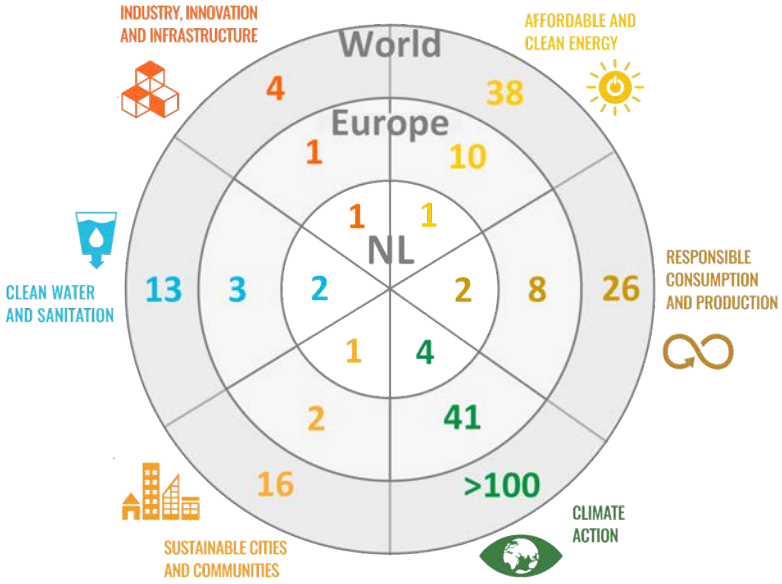


Figure 3: Ranking for TU Delft's research output with respect to the SG



Source: Elsevier, 2020 [8]

Furthermore, the TU ranking with regards to the various research topics is shown in te below table. The data is taken from Elsevier research repository [8].

Topics	Relevant SDG	Netherlands	Europe	Worldwide
Storm water, storm sewers, rainwater	SDG 6	1	3	12
Waste water reclamation	SDG 6	3	10	35
Drinking water (disinfection, coagulation)	SDG 6	1	3	20
Desalination (Reverse osmosis)	SDG 6,11	1	7	35
Water; Water Resources; Water Management	SDG 6,11	6	19	44
Wetlands, Mangroves	SDG 6,13	5	13	54
Rainwater harvesting	SDG 6	2	28	>100
Ground water, Groundwater Resources; Aquifers	Clean Water and Sanitation	3	>100	>100
Photovoltaic cells, solar energy	SDG 7,9,13	2	47	>100
Nuclear energy, power	SDG 7,9,13	1	8	30
Renewable energy, Sustainability and environment	SDG 7,9,11,13	1	5	35
Proton exchange membrane fuel cells, electrolytic reduction	SDG 7,9,13	2	>100	>100

Topics	Relevant SDG	Netherlands	Europe	Worldwide
Geothermal energy and resources	SDG 7,9,13	1	8	35
Biomass, Biofuels, Bioenergy	SDG 7,9,11,12,13	4	50	>100
Wind turbines, Asynchronous generators	SDG 7,9,13	1	5	8
Hydroelectric power plants	SDG 7,9,13	1	17	47
Urban design (Planning and building)	SDG 9 &11	1	9	15
Sustainable development, urban underground	SDG 9 &11	1	7	16
Traffic control, transportation	SDG 9 &11	1	1	6
Logistics, freight transportation	SDG 9 &11	1	3	4
Sustainable urban transportation	SDG 9 &11	1	6	20
Socio-technical energy transitions	SDG 7,9 ,11	2	3	3
Electric vehicles, cars	SDG 7,9 ,11,12	1	10	23
Solar home, rural areas	SDG 7,9 ,11	2	16	41
Municipal solid wastes	SDG 9, 11	4	56	>100
Bicycle sharing	SDG 9,11,12	1	2	7
Heat islands on roofs of buildings	SDG 9, 11	1	8	36
Residential location and land usage	SDG 9, 11	1	2	7
Electric power distribution	SDG 7,9,11	1	11	47
Hybrid vehicles, fuel economy	SDG 9, 11	2	58	>100

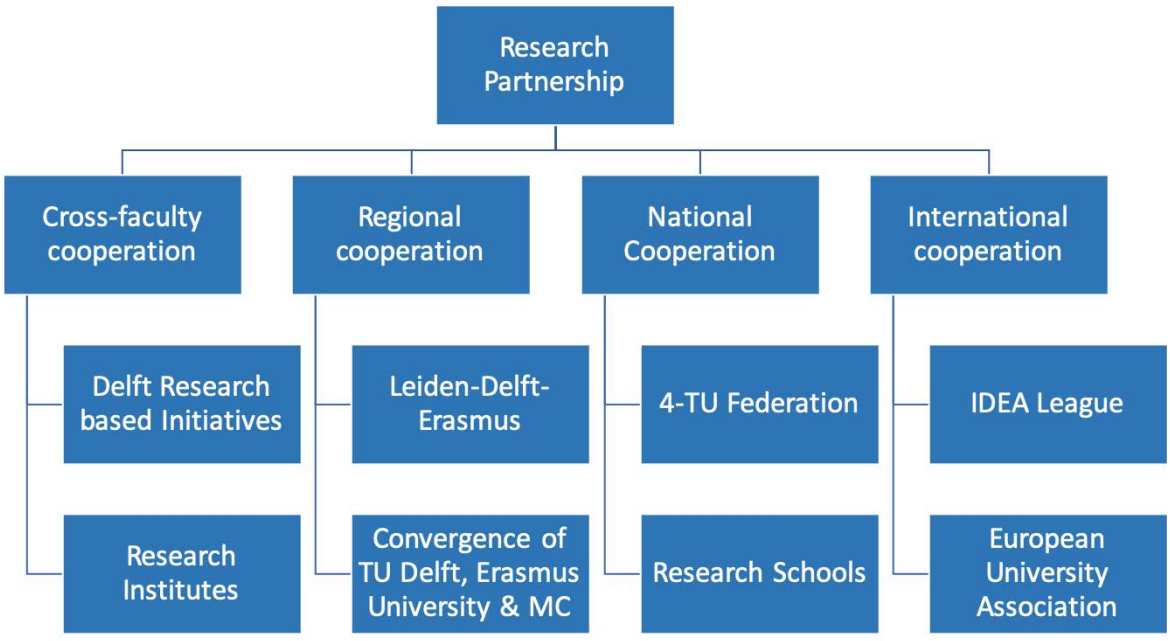
RESEARCH PARTNERSHIPS:

TU Delft values its partners in all its research endeavours. These partners include national and international universities, research institutes, governmental organisations, corporates and start-ups. The research partnership in the TU is classified as seen in the figure 4. The Delft research based initiatives and the research institutes play a major role in the internal collaborations between various faculties and research groups. Then there are regional partners which are Lieden university and Erasmus university, Rotterdam which have close cooperation in many projects. These two universities also offer courses together with TU Delft encouraging exchange of students and teachers. The 4-TU Federation comprising of TU Delft, TU Eindhoven, University of Twente is another national level coorperation for education and research. The MSc Sustainable Energy Technology course is a part of the 4-TU network where students can choose to do courses or thesis in any of these universities.

Also TU Delft is a part of many international collaborations and exchange programs for both research and education. One of this is the IDEA League with top universities like ETH Zurich, RWTH Aachen, Chalmers University of Technology, Politecnico de Milano and TU Delft.

TU Delft is also one of the first universities along with Cornell University, California Institute of Technology and others to be the member of the International Universities Climate Alliance [9]. This networks aims to support the global efforts in carbon emission reduction and climate action research.

Figure 4: TU Delft's research partnerships



3.2.1 DELFT ENERGY INITIATIVE

Delft Energy Initiative is a platform for facilitating education, research and innovation related to futuristic energy technologies at TU Delft. It acts as a catalyst for various internal and external collaborations for scientists and students working in the field of energy. The initiative consists of four main pillars:

1. Wind Energy Institute
2. Urban Energy Institute
3. Power Web Institute
4. E-Refinery

"All four institutes have their focus on sustainability, mainly focusing on clean energy, infrastructure, sustainable cities and responsible consumption and production and ultimately climate action, i.e SDG 7, 9, 11, 12 & 13"

Wind Energy Institute

TU Delft Wind Energy Institute (DUWIND) aims to bring a multi-disciplinary character to wind energy education and research. With a focus on developing world class technology for sustainable energy, DUWIND focuses on multiple areas of innovative research. Some of them are lighter materials, cost-efficient design, smart operations & management processes, optimal grid integration, alternative wind energy, wind farm optimisation, recycling of turbine materials. This research is carried out in collaboration with various international partners and brings together experts from six different faculties and thirteen research groups in the TU, each with their own expertise. Three main themes that the institute works on are:

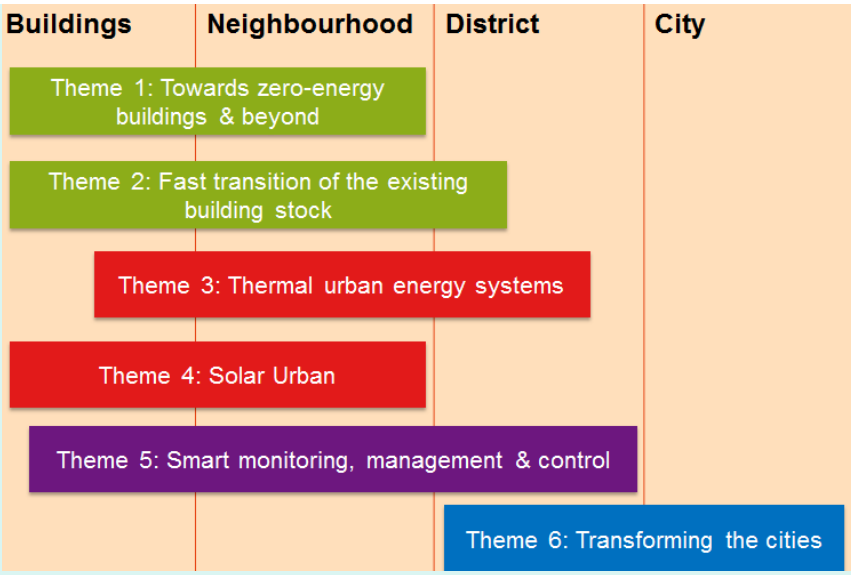
- Wind in sustainable power supply
- Wind power stations
- Wind energy convertors.

Urban Energy Institute

The Urban energy institute at TU Delft mainly focuses on facilitating energy transition to a carbon free urban energy system in Netherlands by 2050. The research is carried out in collaborations with research groups from all the faculties of TU Delft contributing with their own expertise.

The research carried out is broadly divided into six themes:

1. Towards zero energy buildings and beyond
2. Fast transition existing building stock
3. Thermal urban energy system
4. Solar urban
5. Smart monitoring, Management and control
6. Transforming the cities



Source:
Urban energy institute

Some of the projects undertaken by this institute include rooftop and grid-related PV potential in Amsterdam and PV potential on TU Delft campus. There are also cross border projects like SHIFFT, running from 2019-22 between the Netherlands, Belgium, France and the United Kingdom focusing on developing low carbon technologies.

Power Web Institute

Developing solutions to the changing electricity markets with an integral study of underlying physical systems (hardware), the design of smart energy management systems (software), and the study of smart grids in relation to their societal and economic environment (peopleware). They aim to model and design future power systems which are robust and can handle the penetration of renewable energy sources. MIGRATE is a major EU-wide research project that is facilitated by this institute, focusing on mitigating the operational challenges in the power system due to integration of massive power electronics by 2040.

E-Refinery

E-Refinery is a TU Delft research institute with the vision to accelerate the transition towards sustainable production of chemicals and fuels. The institute is supported by five faculties. The scientists focus on converting sustainable electricity to fuels and chemicals. The institute is focused on solving three main challenges:

- Carbon-neutral fuel
- seasonal energy storage
- Defossilized chemical industry

3.2.2 DELFT GLOBAL INITIATIVE

This initiative has a truly global spirit with a societal impact towards a sustainable future. The projects are aimed towards achieving the SDGs in developing countries with expert knowledge from TU Delft scientists. Scientists at the TU partner with local experts to realise these projects promoting a strong global partnership in solving global challenges.

The projects are broadly classified into five themes;

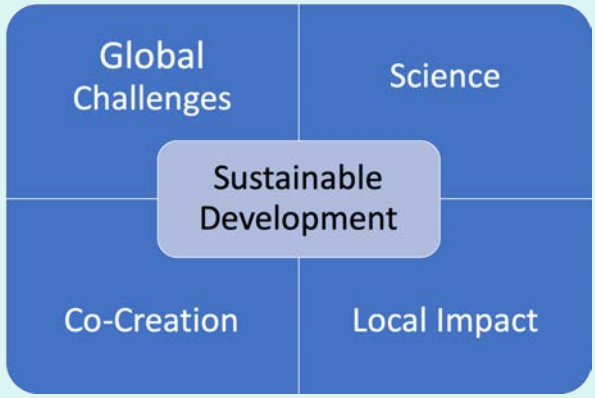
1. Healthcare
2. Water
3. Energy
4. Disaster relief and response
5. Urbanisation

Some of these projects include plastic-free rivers in Asia and Africa, a global urban lab focusing on solving spacial challenges in growing cities and global drinking water program.

"TU Delft Global Initiative has a truly global spirit with societal impact towards achieving the sustainable development goals"

This initiative has a multi-disciplinary approach focusing on:

- Global challenges
- Science
- Co-creation
- Local impact



3.2.3 DELFT HEALTH INITIATIVE

The Delft Health Initiative was started with a mission to "Integrate science, engineering and design for sustainable healthcare based on innovative technologies." Around 30% of the scientists in TU Delft are involved with health care related research in some way ranging from bionanoscience to sustainable medical technologies. TU Delft partners with the Erasmus Medical Center offering complementary resources and expertise to various challenges.

"Integrate science, engineering and design for sustainable healthcare based on innovative technologies".

The research is focused on four main themes:

1. Medical imaging
2. Cure and care
3. Targeted molecular therapy
4. Rising stars

3.2.4 DELFT DELTAS, INFRASTRUCTURE AND MOBILITY INITIATIVE

Delft Deltas, Infrastructure and Mobility Initiative works on developing solutions for societal problems related to infrastructure for water safety and smart mobility. This initiative comprises of various disciplines which work together in developing integral solutions. They follow the Delft approach of 'Integral, Innovative and Down to earth'

Currently, three major areas of focus are:

1. Urban infrastructure
2. Deltas of the future
3. Airports of the future

TU DELFT CLIMATE INSTITUTE

The TU Delft Climate Institute is active across all eight faculties of the university. Through data-based climate knowledge, the institute aims to be an authority on mitigation, adaption, and policy. In doing so, a focus is put on initiating interdisciplinary research programs and national infrastructure programs.

Currently, the Climate Institute is structured along five research themes:

- Urban climate
- Radiation balance
- Ice & sea level change
- Water cycle
- Geo-engineering

Urban climate

The Urban climate Institute strives towards solutions to complex issues like rising temperatures, rainfall, water scarcity and work towards development of climate-resilient cities.

Radiation balance

The Earth's surface and atmosphere form an intricate system that climate models aim to capture. One focus point of the Climate Institute is refining these models through the study of clouds. More particularly, the lifecycle and behaviour of clouds is studied using radar, lidar, special airplanes, and models using supercomputers and advanced 3D visualisation techniques.

Ice & sea level change

By either measuring regional changing in Earth's gravity or precisely determining the height of glaciers, oceans, and land, changes in glacial mass and sea level can be observed. A functional way of doing this through the use of satellites looking down at Earth as they orbit our planet. At TU Delft, researchers work on the propulsion, sensors, and data processing required to allow for this climate science.

Water cycle

Climate change has a profound impact on precipitation patterns, as do population growth and urbanisation. How this impact expresses itself and changes over time is crucial to water management. At TU Delft, many elements of the water cycle like precipitation, run off from cities or rivers, condensation and cloud formation is studied. This allows TU Delft to position itself as a leading expert in the field of hydrology.

Geo-engineering

TU Delft supports research focussed along two geo-engineering topics: Solar Radiation Management (SRM) and the capture/use of CO2 emissions.

SUSTAINABILITY RELATED DEPARTMENTS

Electrical Sustainable Energy

The main objective of the Electrical Sustainable Energy department is to accelerate energy transition. The research activities include renewable energy production, transmission, distribution and storage. Some topics include photovoltaics, wind energy, power electronics, high voltage DC transmission and improving energy efficiency. The technical, economic and social concerns of the future power systems are addressed.

Delft Subsurface Storage

Subsurface storage is a multidisciplinary theme of the department of Geosciences and Engineering working on societal challenges related to energy, water and environment. Currently, the main focus is to develop solutions for storing renewable energy in subsurface formations in the form of green fuels, compressed air and hot fluids. The team's expertise includes characterisation, modelling, simulation, monitoring and assessing sub surface formations.

Climate Design and Sustainability – Architectural engineering and technology

The mission of this department is to design comfortable and healthy climate, in and around the buildings. Their main expertise is to integrate sustainable climate concepts into architectural design and urban planning. The research is classified into three areas:

1. Comfortable and healthy environments
2. Climate integrated design
3. Low energy design

Sustainable Aviation

The Sustainable aviation department is focused on three areas: reducing energy consumption, sustainable energy and sustainable aviation operations. The new world-renowned Flying-V aircraft concept developed at this department would save 20% of fuel consumption. There is also work in progress on electric aircraft and on producing green aviation fuels to make aviation carbon neutral. They also work on optimising the flight routes to reduce air and noise pollution.

CLEAN TECH START UPS AT YES! DELFT

YES! Delft is one of the leading Tech incubators in Europe, situated within the TU Delft Campus. It helps students and researchers to turn innovative ideas into successful businesses entities. A few of these startups in the clean tech (sustainability) field are shown below:

Physee

PHYSEE is a Delft start-up aiming to unleash the complete potential of clean building facades. To accelerate the transition to the future of energy neutral buildings, PHYSEE works on providing SmarkSkin for buildings. This SmartSkin controls the building climate and saves energy use while also producing energy.

Solar Monkey

Solar Monkey is a start-up that was founded in 2014 by TU Delft master students. Inspired by the rapidly growing, but inefficient solar energy market, the founders came up with the idea of enabling installers to grow faster by simplifying their processes using solar panel software. This software enables the installers to design a full system remotely within a minute, improving efficiency and boosting the market.

Kite power

Kitepower is another renowned start-up, focusing on airborne wind energy, developing innovative and cost-effective substitutes to existing wind turbines by using kites to generate electricity. Its patented technology uses 90% less material, while being twice as efficient as existing technology. Unlike conventional wind turbines, the Kitepower system does not require resource-intensive towers or heavy foundations and is thus easy to transport and deploy. It connects stronger and more tenacious winds at higher altitudes, allowing for capacity factors greater than 0.5 and in return cost-effective electricity generation.

Circularise

Another start-up working on taking a step further into the sustainable world, Circularise works with leading industry corporates, government, start-ups and several research organizations to bring transparent and trusted data sharing to global supply chains. The company works on the acceleration of the transition to a circular economy. It aids reliable and standardised flow of information about materials and components within the supply chain using blockchain technology.

DREAM TEAMS

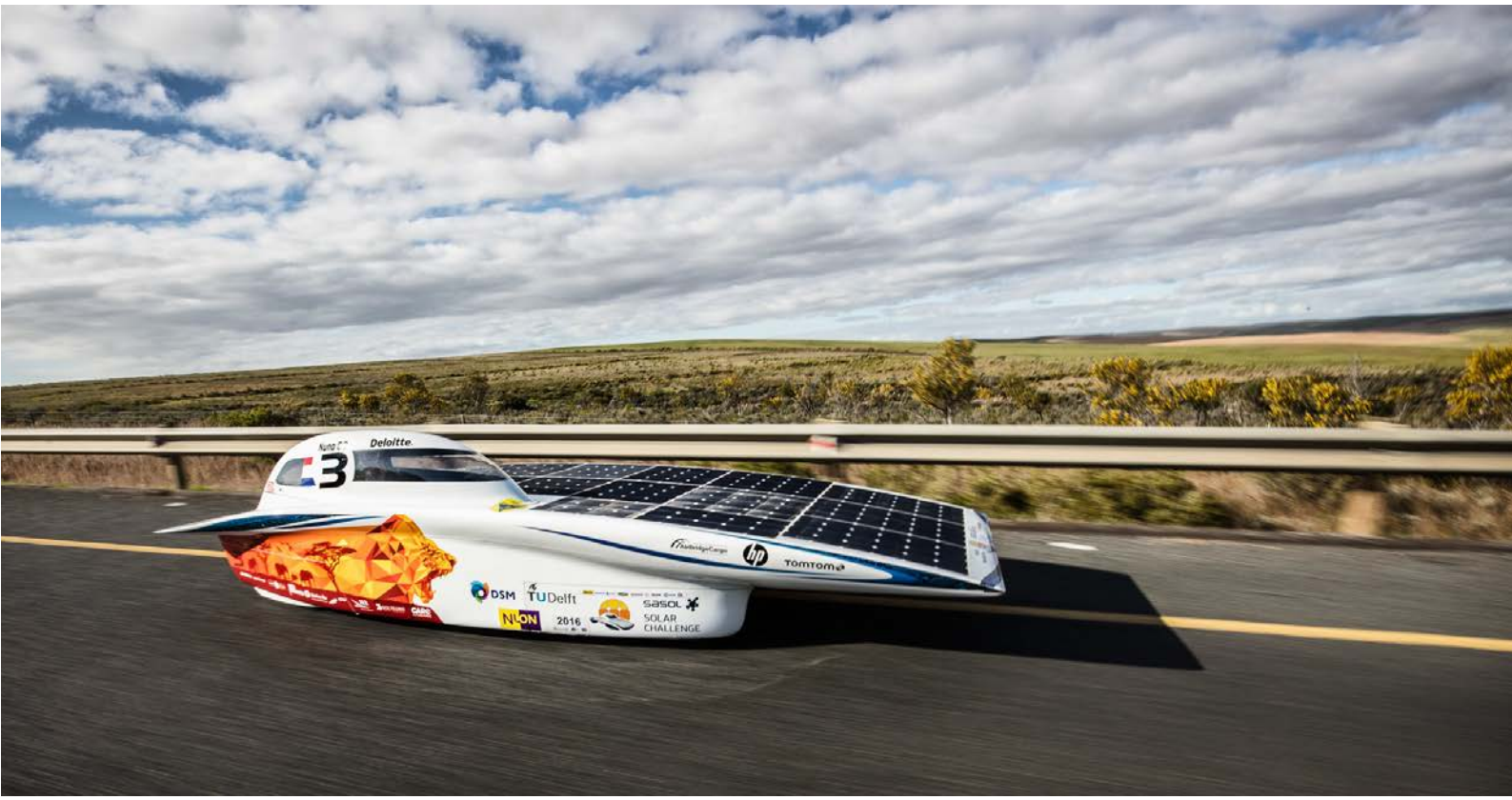
The Dream teams at TU Delft are another great place for sustainable innovation and development of future technologies. These dream teams, filled with competitive spirit, represent TU Delft at various international competitions. Some of these teams will be discussed briefly in this section.

Eco-Runner Team Delft

It is the hydrogen endurance racing team of the TU Delft consisting of 25 students from different faculties. The objective is to design, produce and race the world's most efficient hydrogen-powered city car. Thereby, the team wants to promote a sustainable future. The team achieved a third place in Shell Eco-Marathon 2018 in London. Additionally, the team was awarded with the Vehicle Design award.

Delft Hyperloop

Delft Hyperloop is the team participating in SpaceX's hyperloop competition to contribute in changing the future of transportation towards cleaner, faster and more efficient. Hyperloop is a high-speed transportation system using near-vacuum tubes in which pressurized vehicles travel. Due to low air resistance in the tubes, the vehicles can travel with speeds of over 1000 km/h while being more energy efficient, environmentally friendly, and convenient than airplanes.



Vattenfall Solar Team

The goal of the Vattenfall Solar Team is to inspire the world in the field of high-end technology and to promote sustainability using renewable energy. In 2001, the Alpha Centauri Team, as the Vattenfall Solar Team was called at the time, participated for the first time with great success in the race across Australia. This race covers approximately 3,021 km. The team managed to win the World Solar Challenge four times in a row from 2001 to 2009. In 2013 and 2015, Nuna7 and Nuna8 respectively managed to take the World Cup back to Delft. After the first four-wheeled edition of the World Solar Challenge in 2017, the team was able to take the 7th world title to the Netherlands.

Solar Boat Team

The objective of the team is to work together with the maritime sector on a transition to renewable energy. The team consists of 28 ambitious students from ten different studies at TU Delft. Every two years, a completely new boat is designed and built. In 2019, the team designed a solar boat for the open sea and with this boat, they became world champions in the Offshore Class in Monaco.

Nova Electric Racing

Nova Electric Racing is an international group of students from the Delft University of Technology and the Universities of Applied Science. Objective is to demonstrate that renewable energy will play a major role in the future of motorsport racing, without compromising on performance. Developing a fully electric racing motorcycle is a goal of the team. The motorcycle can go from 0 to 100 km/h in 3.1 seconds, with a top speed of 220 km/h backed up by 140 kW of power.

AeroDelft

AeroDelft is a TU Delft student team with a goal to prove that emission-free aviation is possible by developing the world's first liquid-hydrogen powered aircraft. To do so, in early 2019 a team of students from Delft University of Technology, Utrecht University and Willem de Kooning Academie embarked on Project Phoenix: a project to design and manufacture the world's first aircraft powered by a liquid-hydrogen fuel cell

Forze Hydrogen Electric Racing Team Delft

Forze Hydrogen Electric Racing Team Delft is the pioneer hydrogen racing team of TU Delft that has been promoting hydrogen powered mobility since 2007. The ultimate goal is a clean, zero-emission future of transport. Forze raises awareness for clean mobility by combining motorsport and sustainable technologies. For this reason, the Forze VI was built: world's first racecar powered by hydrogen. With this car, Forze has set the fastest lap record on circuit Zandvoort. With a lap time of 2:04:51 minutes, the Forze VI beat the Tesla Roadster.

The Delft University Wind Turbine (DUWT)

A young student team of TU Delft competing at the International Small Wind Turbine Contest, organised by the Hanze University of Applied Sciences, Groningen. The team started off with an international, multidisciplinary group of 12 students, in January 2019. The aim of the team was to build a small, urban–friendly wind turbine. The team has been supported by the TU Delft Wind Energy Institute and values the integration of SDGs in the design and construction of the turbine. This team is not a dream team yet but soon aims to be.

THE SYMBIOTIC URBAN MOVEMENT

Symbiotic Urban Movement (SUM) is a student-led team from TU Delft that aims to achieve a mutual and beneficial relationship between the user, the community and the environment: a symbiosis. Currently, SUM consists of 44 enthusiastic students with 15 different nationalities, the team will use the platform of the Solar Decathlon Europe competition to accelerate this vision. The Solar Decathlon is a student competition for resource-responsible and energy-efficient architecture and engineering. The competition focuses on the revitalisation of urban building stocks and challenges participants to design, build and operate a solar-powered and energetically self-sufficient home equipped with advanced technologies, designed to the highest standards of sustainability.

SUM aims to craft resource-responsible and resilient neighbourhoods. By addressing this typology, SUM has the opportunity to create a generic system that can be used across the Netherlands and even Europe. Furthermore, this creates the opportunity to contribute to the environmental task of being energy-neutral in 2050 and to the Dutch government's goal of constructing one million homes by 2030. In addition to the focus on modularity, circularity, and sustainability, SUM also looks for solutions that contribute to a more successful urban and social living environment. SUM aims to create a community based on sustainable habits, using this opportunity to create a major impact on our social and environmental footprint.

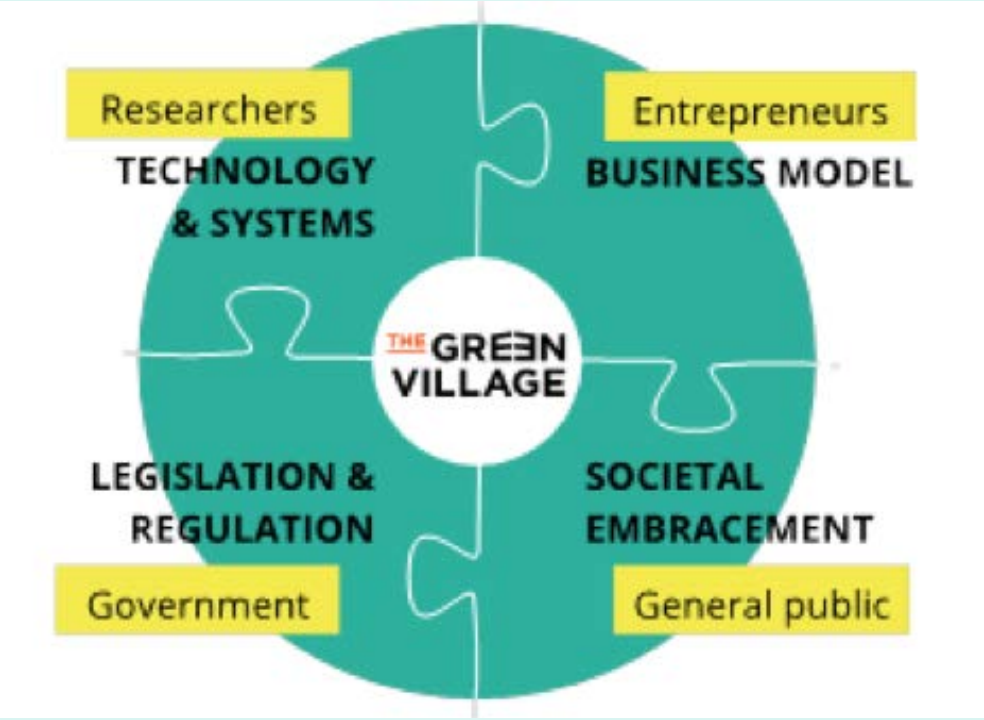
THE GREEN VILLAGE

THE LIVING LAB FOR SUSTAINABLE INNOVATION

The Green Village is the living lab for sustainable innovation at TU Delft. It helps to accelerate the development and implementation of several green innovations, providing a platform for scientists, engineers, corporates and the government to collaborate and experiment in a real-life setting. It serves as a medium to grow from fundamental research to large-scale applications. The Green Village is an initiative of TU Delft and Stichting Green Village. The platform is supported by the European Regional Development Fund, the Province of South-Holland, the municipality of Delft, Alliander, Gasterra, and many others. Some of the notable current projects are:

- Windows for the future: An innovative solution to address the increasing demands for air-conditioning and sun-shading for buildings.
- Converge: Where passive climate control is used for heating, ventilation and cooling.

One of the most successful projects of the organization is the Delft X Water Tank, which is an underground water tank consisting of pipes that collect rainwater during showers to be used to spray land during dry times. The Green Village is also a hub for ideas like the DreamHüs aimed at creating sustainable and affordable living. It is a collaborative experiment between WoonFriesland, Bouwgroep Dijkstra Draisma, YES! Delft and De Bowonersraad Friesland. Furthermore, the Green Village has several innovation programs in areas of water, circular economy, building technology, power conversion and sustainable mobility to bolster the SDGs.



3.3 OPERATIONS

With its mission towards 'Impact for a better society', TU Delft must value its position in being a pioneer to build a sustainable future. This needs to start from the TU campus, which is known for its rich heritage and modern outlook. With a combination of historic monumental buildings, modern education and learning spaces, hi-tech research facilities, cafeterias and others, TU Delft has a great challenge head to transform into a sustainable and future proof campus. The growing reputation of TU Delft is attracting more and more students every year and the current facilities are reaching their maximum capacity.

Addressing this issue, the TU Delft strategic framework 2018-2024 commits to redevelop the campus to be well equipped to face the future challenges of demographics, digitisation and internalisation.

TU Delft strategic framework 2018-2024 calls for developing a smart, sustainable, inclusive and living campus, which inspires people to work, think and be creative. Educating the engineers of tomorrow and being forerunner in modern research, TU Delft needs to accelerate its action on practicing what it preaches.

“ CO2 neutral and circular campus by 2030”

With a vision towards contributing to the UN Sustainable development goals, TU Delft commits to build a

“ CO2 neutral and circular campus by 2030”

The ultimate goal is to transform TU Delft into a ‘living lab’ to solve societal challenges and contribute towards building a sustainable world.

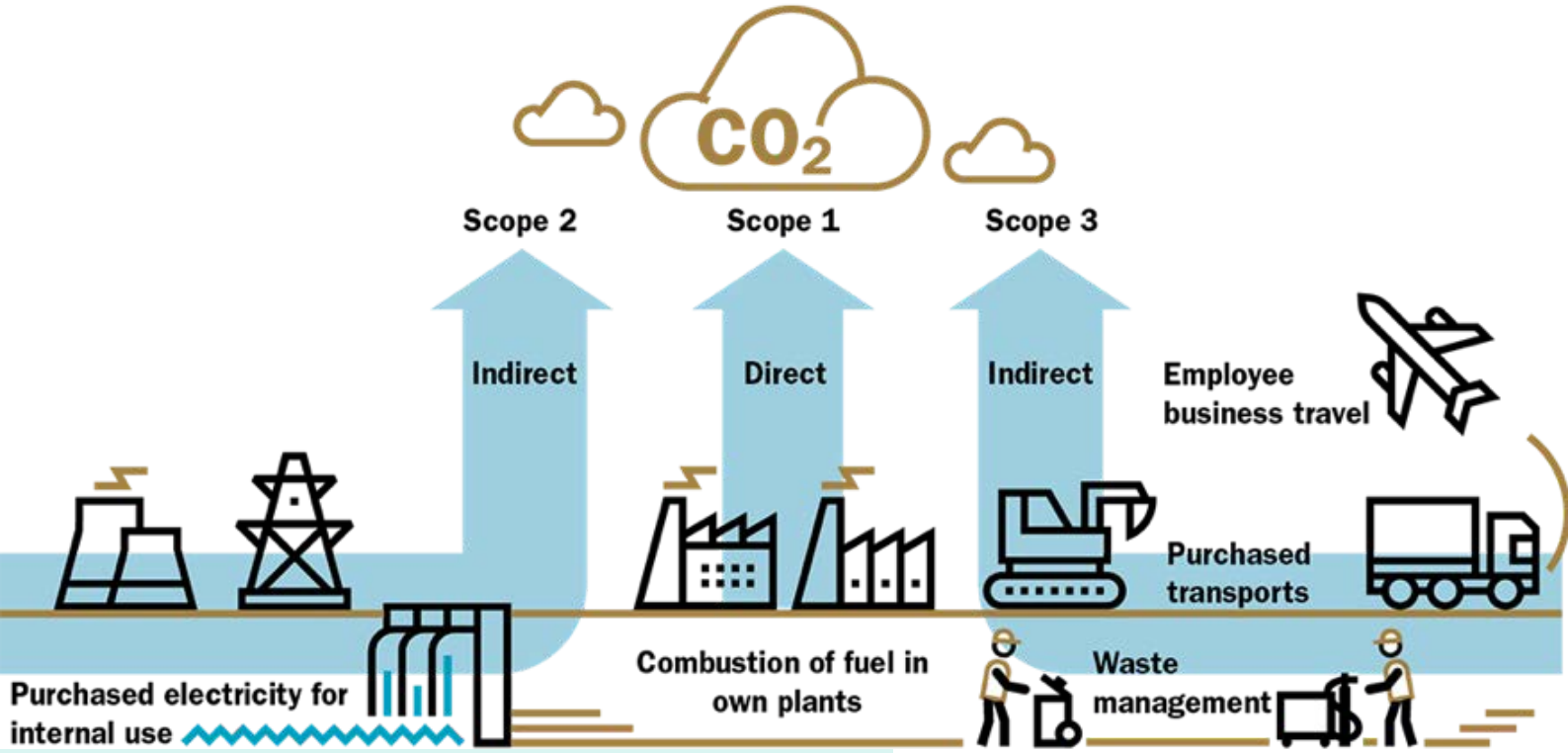
CLIMATE ACTION COMMITMENT

In April 2019, TU Delft published its vision on climate action [10] , which stated that;

“There is no doubt that the anthropogenic emissions of greenhouse gases are changing our living environment through their impact on the global climate system. TU Delft will harness its innovative powers to support the world-wide transition to non-fossil energy, and adaptation of the living environment to the consequences of global warming.”

With this commitment, TU Delft has taken the social responsibility to contribute towards climate change and this must start from the TU campus.

The first step in realising these goals was developing the CO2 Roadmap [4] of TU Delft by Prof Andy van den Dobbelsteen and Ms Tess Blom. In addition to this, the Campus Real Estate (CRE) has developed a Roadmap for Circular campus 2030 [5]. The present report reviews the state of sustainability in campus operations at TU Delft campus and gives an overview of the above reports.



CO2 NEUTRALITY

CO2 neutrality means to achieve zero emissions of harmful gases into the atmosphere. This includes direct and indirect emissions broadly divided into 3 scopes as shown in the figure. The Paris agreement 2015 [1] calls for immediate action to reduce the emissions to the levels below pre-industrial levels to control climate change.

Though CO2 neutrality is mostly measured in terms of scope 1 and 2 emissions, this report also concentrates on scope 3 emissions, which are a major part of today's human lifestyle and needs to be addressed.

WHAT DOES THIS MEAN FOR TU DELFT?

The CO2 Roadmap 2019 [4] defines CO2 neutrality as,

"the CO2 neutral TU Delft campus is interpreted as a sustainable campus. It means that no CO2 or other greenhouse gases are emitted as a result of the direct activities and facilities (scope 1 and 2). Expanding CO2 to all greenhouse gases because CO2 is a small part of the total. This means energy for electricity and heat from renewable resources. This also applies for the energy needs for research"

CIRCULARITY

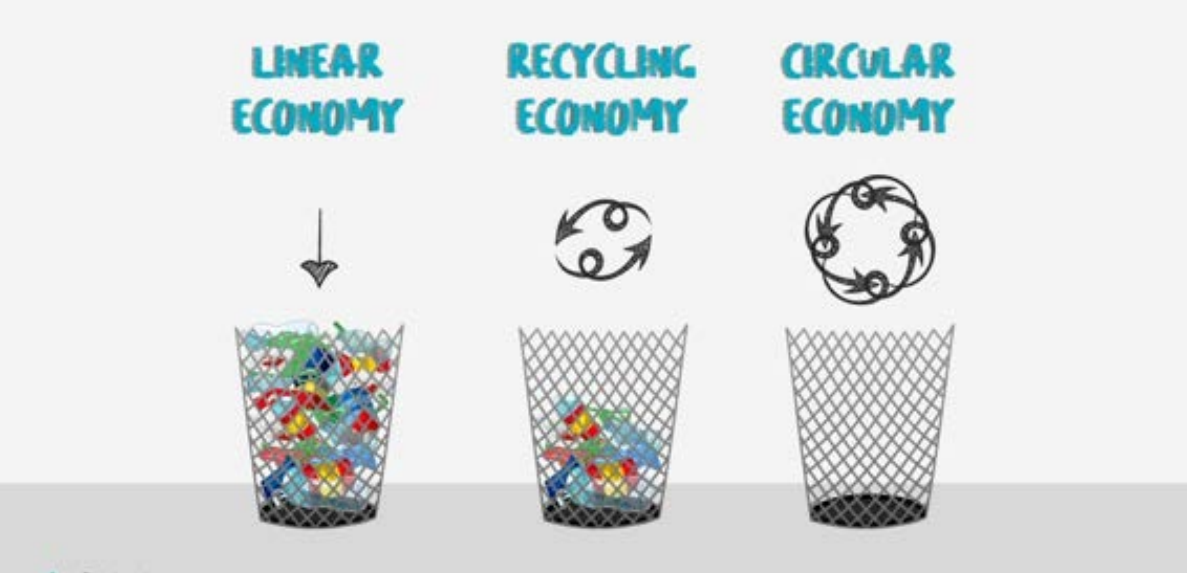
Circularity is to achieve the shift from linear to circular economy. It means to close the material cycles and reduce the wastage of resources. As depicted in the figure, circular economy aims to reduce the material output to zero encouraging full utilization of resources. This resource utilization needs implementing the R-ladder in which the value of the material is retained or increased during its lifetime. This R – ladder includes actions like refuse, reduce, reuse, refurbish etcetera. The below figure explains the concept briefly.

WHAT DOES THIS MEAN FOR TU DELFT?

In its report Roadmap for Circular campus 2030 [5], CRE envisions Circularity as follows;

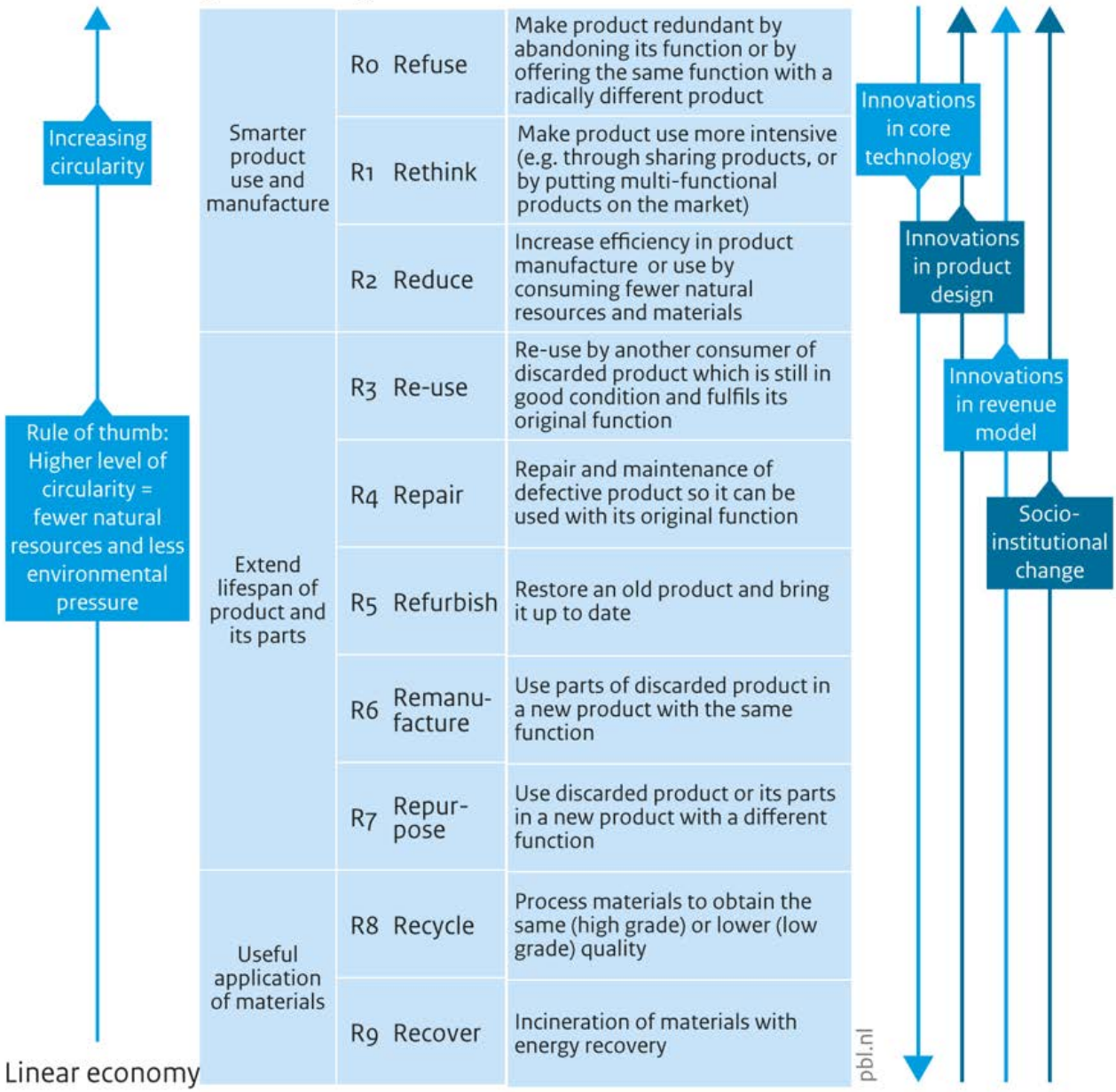
"TU Delft is currently on linear economy and needs to close its material cycles with a goal towards circular economy. This includes new materials or products contracted or purchased needs to be sourced sustainably with full utilization of these resources during their lifetime without harmful emissions to the environment".

Currently TU Delft is estimated to be 5 to 15% circular based on the present availability of data [5].



Source: École des Ponts business school

Circularity strategies within the production chain, in order of priority



Source: PBL (www.pdl.nl)

3.3.1 CURRENT STATE OF C02 EMISSIONS

"TU Delft accounts for emissions of about 47,957 tonnes of CO2 equivalent"

The year 2019-20 plays a very important role for the future of sustainability at TU Delft. In addition to the various initiatives and projects taken up by the Campus Real Estate (CRE), the caterer (Cirfood), the student sustainability department (GreenTU) and the sustainability coordinator (Gerrit Kahlman), an important milestone which supported everything was the CO2 Roadmap developed by Prof Andy van den Dobbelsteen and Ms Tess Blom.

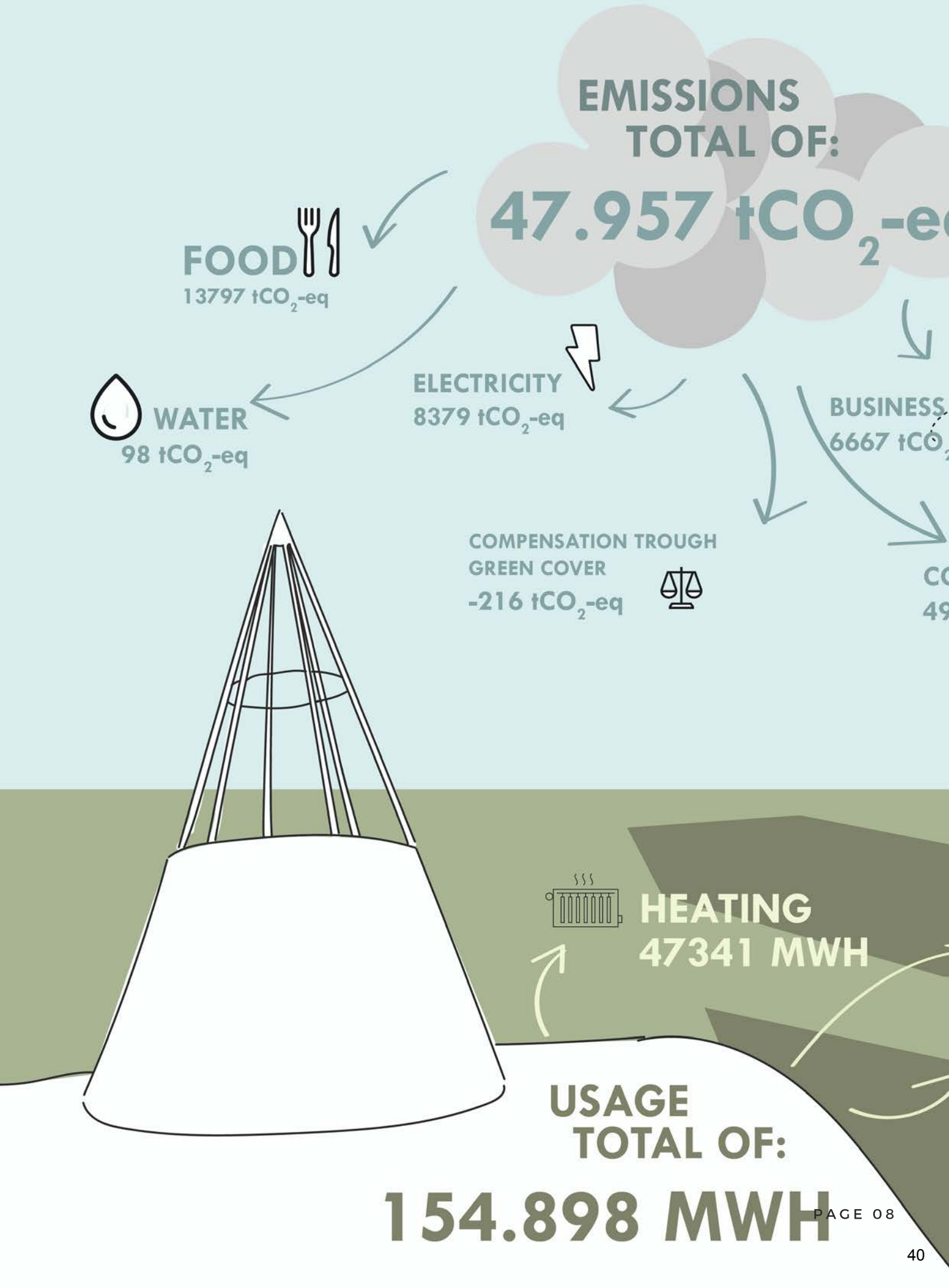
In this section, the various sources of emissions explained in the CO2 Roadmap are shown and the current progress in reducing these emissions highlighted.

This CO2 Roadmap is the first hand approximation of emissions in scope 1, 2 & 3 at TU Delft. Though these values are not fully accurate, it gives a fairly good idea of the TU's emissions. According to this estimate TU Delft accounts for emissions of about 47,957 tonnes of CO2 equivalent [4]. The highest contributors to this are the usage of gas for district heating and the emissions from food. Due to the lack of availability of data, the emissions arising from procurement are not accounted yet but are expected to play a significant role.

In general, the term carbon neutrality refers to the emissions from scope 1 and 2. But in the present report, scope 3 emissions are also addressed concerning their huge impact. The data available for scope 1 and 2 is available but scope 3 emissions have been evaluated based on theoretical research and scientific or third party data. But these values give a good idea of what the current state is and how it can be improved.

In addition to the emission count, the amount of resources being used is also an important metric that defines responsible consumption. Currently, TU Delft campus consumes around 154898 MWh of energy including heating, gas and electricity for TU Delft buildings and third parties. The consumption of TU Delft buildings amounts to 127281 MWh with about 67907 MWh of electricity, 16056 MWh of gas and 43317 MWh of heating [4].

The electricity usage is distributed as 56% for academic and office use and another 44% for research purposes. The major consumption is for lighting which accounts for 30% of the total electricity used on the campus [4]. The infographic on page 44 shows the various emissions and energy usage in the TU.

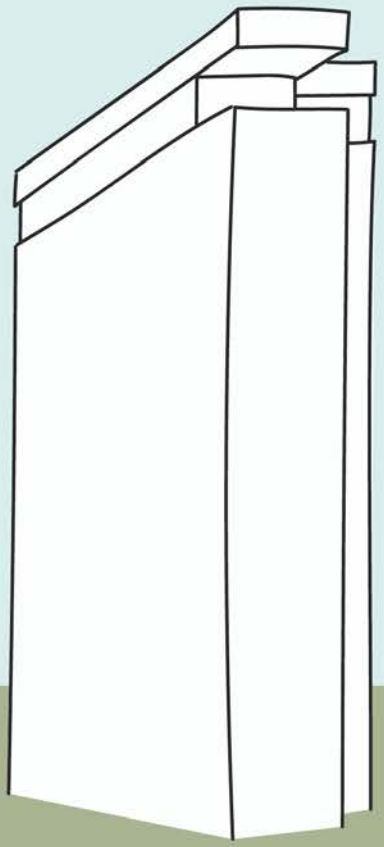

EMISSIONS
TOTAL OF:
47.957 tCO2-eq
FOOD
13797 tCO2-eq
WATER
98 tCO2-eq
ELECTRICITY
8379 tCO2-eq
BUSINESS
6667 tCO2
COMPENSATION TROUGH
GREEN COVER
-216 tCO2-eq
HEATING
47341 MWH
USAGE
TOTAL OF:
154.898 MWH

NATURAL GAS
13361 tCO_2-eq

WASTE MANAGEMENT
908 tCO_2-eq

-TRAVEL*
$_2$-eq

OMMUTER TRAVEL
963 tCO_2-eq



GAS
24981 MWH

ELECTRICITY
82567 MWH

44% FOR RESEARCH PURPOSES

56% FOR ACADEMIC AND OFFICE PURPOSES

*flights only

3.3.2 ENERGY

ELECTRICITY

To reduce the scope 1 emissions arising from electricity and gas, TU Delft has taken major steps towards achieving a carbon neutral energy system by 2030.

One of the important achievement is the use of wind energy for electricity purposes. From January 2017, TU Delft procures 78% of its electricity from off shore wind plants at the Dutch coast from the distributor Eneco. Around 1% of the energy obtained from the PV panels on the roofs of the TU buildings. The rest of the electricity is from the CHP plants.

"Currently, 78% of the electricity consumed by TU Delft comes from wind energy."

In addition to the procured wind energy, the researchers and the energy team at TU Delft are also exploring options to set up a wind energy plant with small wind turbines on the south campus and the feasible roof tops of the buildings.

TU Delft has around 4000 solar panels installed on its roofs with a capacity of about 1.1MWp

The energy team is exploring more feasible locations on the TU campus to increase the solar energy production on rooftops and empty lands to setup a solar plant.

HEATING

- For district heating, 3 gas fired boilers and 2 CHP boilers are used [4]

- The CHP plants are only used when the temperature of the district heating system falls below 85 degree C which generally is between 100-130 degree C. Hence only 41% of the heat that we use is generated using the CHP plants [4]

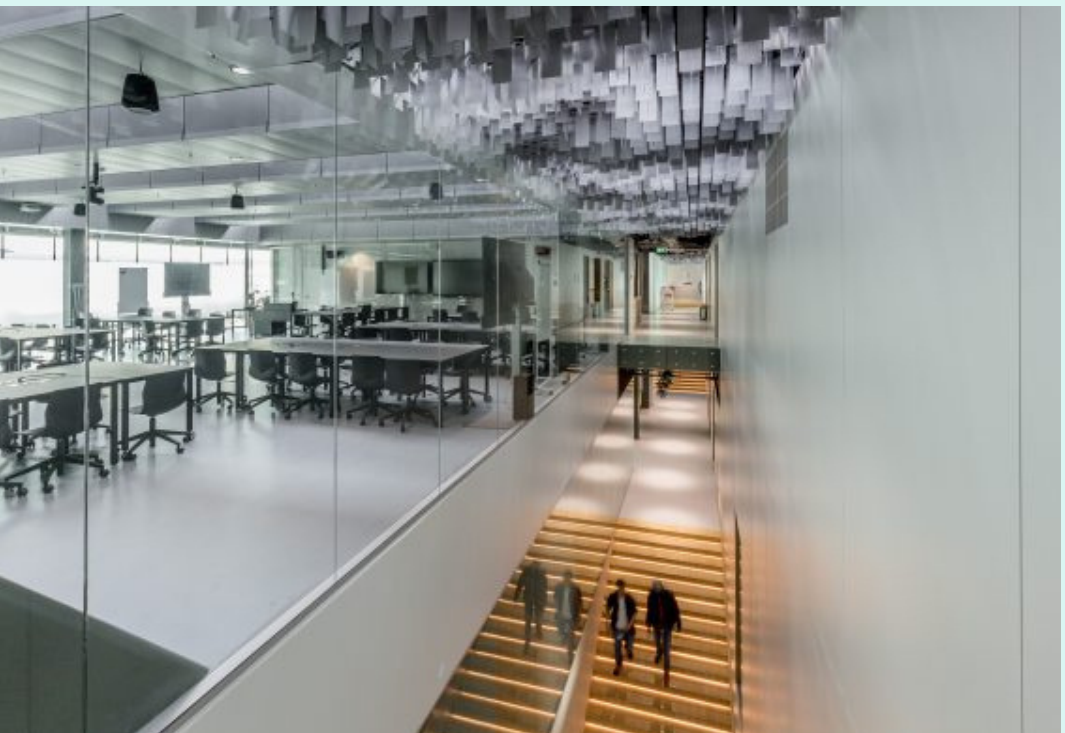
- To reduce emissions and the dependence on conventional sources, TU Delft is currently investigating the possibilities of having geothermal source connecting to the network. The decision was made in July 2018 and few locations on the campus have been identified.

- In addition, TU Delft has 13 thermal storage systems which are functional. Excluding the system in PULSE and ECHO, the rest have delivered a total of 24,600 GJ for heating and 31,300 GJ of cooling in 2017 [4]

Source: CRE [11]

ECHO

With the growing demographics, the need for education and research facilities on TU campus is increasing. In line with the sustainability theme of Campus Development Strategy, Echo will be the second building after Pulse to be a completely sustainable building WITH BREEAM standards. Echo will be a cross-faculty building with modern educational infrastructure. The construction of the building has begun in summer of 2019 and the end is to be defined definitely.



PULSE

ENERGY NEUTRAL BUILDING

PULSE is the new education building inaugurated in 2018 on TU Delft campus and is the first energy neutral building with an A++++ energy label [11]. It is the central space created for interactive learning and collaborative work. The building has infrastructure to support new age education methods like flipped classrooms, video conferencing and seminar halls. The building also houses number of food and beverage facilities.

Highlights [11]:

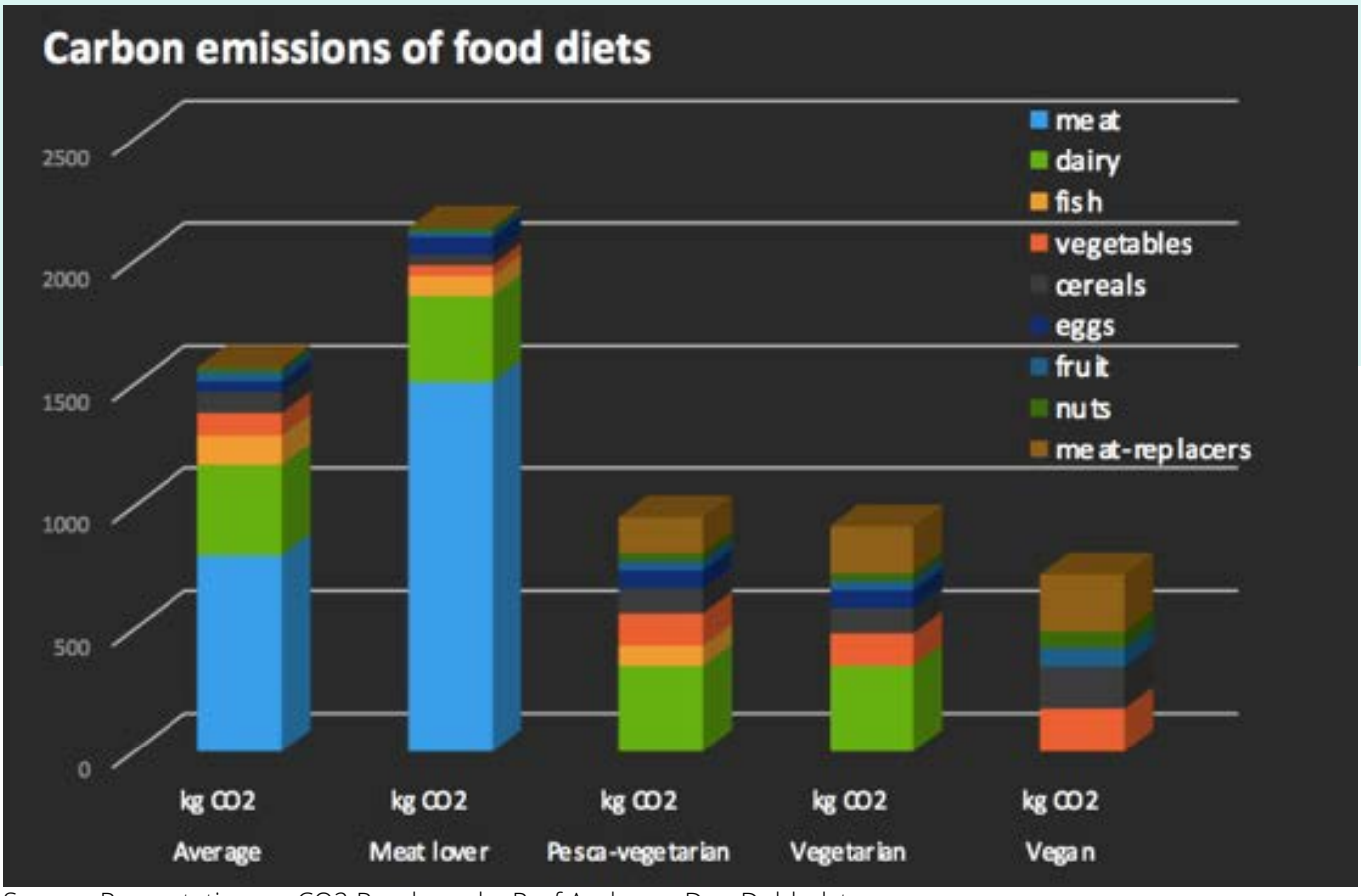
- Pulse has around 490 rooftop solar panels with an annual yield of 150,000KWh
- The building is equipped with underground thermal storage
- It is completely fitted with super-insulating glass
- The design allows maximum use of daylight, reducing the energy use
- Equipped with intelligent building management system to control ventilation, cooling and heating
- The building provides sustainable and pleasant working environment
- The project is developed by Ector Hoogstad Architecten with support from DC systems, Energy conversion and Storage research group and Prof Andy van den Dobbelsteen, Professor of Climate Design & Sustainability

3.3.3 FOOD

Since there is no accurate data from the caterers available yet for all faculties, the below data is based on general approximation of average Dutch diet which results in emission of 1575 kg CO2-eq per year person [4]. And with an approximation that 50% of this is consumed during the working hours.

Based on this study, TU Delft accounts for 13,800 t CO2-eq per year [4]. It is nearly 29% of the total emissions from the TU. Meat based food is the main reason for this and would pose a major challenge in the years to come with increasing demographics.

Having seen these high numbers, GreenTU Delft's first mission in the year 2019-20 was to address this issue and start the emission reduction. The Operations Coordinator of GreenTU Delft along with the Sustainability Coordinator have brought all the relevant stakeholders together and organised a brainstorming session to get ideas and develop strategies to reduce emissions from catering. This brainstorm focused on banqueting and the restaurants on campus. It has yielded in ideas like changing the banqueting website, No Meat Week, Meatless Mondays and initiatives for sustainable cutlery and packaging.



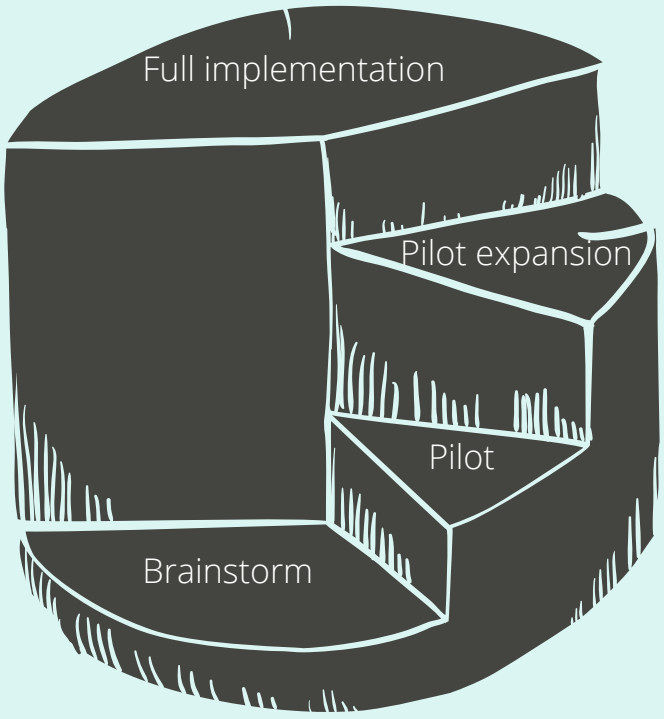
Source: Presentation on CO2 Roadmap by Prof Andy van Den Dobbelsteen


IT'S NATIONAL NO MEAT WEEK !
@ KETELHUIS
THIS WEEK BY NOT
OFFERING
ANY MEAT WE SAVE
9th to 13th
March 2020
630 kg of CO²
350000 litre of water
GreenTU

INITIATIVES IN 2019-20

In order to implement some of these ideas, the restaurant of the Faculty of Architecture and Building Environment has lend itself to become a pilot location. This pilot location is called the BK Foodlab. Within this foodlab, multiple pilots have been or are going to be implemented, focusing on multiple aspects of catering. Unfortunately, due to corona crisis in 2020, only one pilot was actually implemented: the No Meat Week.

GreenTU Delft in collaboration with Cirfood, the caterer of TU Delft, has come up with the first pilot project of No Meat Week, which was organised in the Ketelhuis cafeteria in the Faculty of Architecture from 9-13th of March 2020.



The collaboration from Food&More and BKGreen added great value to reach out to more students to participate in this initiative. To understand the impact of this initiative, the project committee of GreenTU Delft along with the operations coordinator performed an analysis of the CO2 footprint from this cafeteria. The analysis can be found in the appendix. The result showed that the no meat week could save 630 kg of CO2-eq and 350000 litres of water.

Mostly all customers saw the new vegetation options that were presented during No Meat Week as an improvement and the caterer is willing to implement these options throughout the university, which will reduce the meat supply in the restaurants. Without affecting the financial aspects of the caterers, this initiative proved that it is definitely possible to reduce the footprint from the catering.

3.3.4 MOBILITY

Business travel in flights

This is another major cause of emissions by the university. It is recorded that people from TU have flown 33 million km in 2018 alone contributing to 6667 tones of CO2 emissions. This number includes local, continental and intercontinental flights [4]. This data is obtained from travel agency associated with the TU and excludes flights booked by flyers themselves. So the actual number could be even higher.

Commuting to and from the campus (student & Employees):

There is no concrete data recorded for the purpose of analysis neither from employees nor students. The current data is an approximation based on the residences of students and employees. Based on these approximations, the total estimated emission from commute is 3378 (employees) + 1585 (students) CO2-eq.

INITIATIVES IN 2019-20

The mobility project has started with an expert session on reducing business travel Delft stakeholders. This session was originally organized on 16th of June.

The experts during this session were:

- Gerrit Kahlman, sustainability coordinator TU Delft
- Andy van den Dobbelsteen, Sustainability Design and Architecture professor at the faculty of Architecture and building environment
- Joris Melkert, Professor at Aerospace Engineering
- Jan Anne Annema, Logistics professor at TPM
- Koen Flapper, projectmanager at TU Delft

During this open session three topics were discussed:

1. Reducing the amount of travels
2. Alternatives to flights (trains)
3. Compensation for air travel

A couple of ideas have come out of this session and are currently worked out in a plan. But the first step of making a project group that involves employees, teachers and students will help in creating support for future adjustments on the mobility policy.

In the coming academic year, there will be another expert session mainly concentrating on daily commute of staff and students from and to the campus.

3.3.5 WASTE

The emissions from the waste generated is estimated based on how the waste is treated. The data is take from Renewi, waste management company of TU Delft. A total of 2,788,757 kg of waste was produced in the TU campus for 2018 which is equal to 92.6kg per person [4]. Of which 47% is unprocessed waste [5].

Though the emission count is still very low, the quantity of material wastage and loss of product life cycle is very high.

The material flows and the product life cycle is an important aspect of building a sustainable campus and achieving circular economy. This aspect of waste as a loss of material will be discussed in the next section of circular economy.

The TU Delft already implemented some projects regarding waste separation. The separation of coffee cups is one of these projects. Special bins are placed all around campus in order to collect as much coffee cups as possible.

EXISTING INITIATIVES

Special bins are placed all around campus in order to collect as much coffee cups as possible. These bins are checked for different waste and collected. The eventually bales of paper cups are processed by Renewi. The ink from the cups is used again as an element in the corrugated cardboard industry, like the ones IKEA uses. The thin layer of plastic on the inside of the cup to prevent the drink from leaking is reused for example as material for silicone nozzles. In the end, the cups are turned into paper towels for industrial use or toilet paper.

INITIATIVES IN 2019-20

In addition to this, this year two locations on campus have started with the waste separation pilot. During this pilot all regular bins are replaced with recycling islands; including the small bins in offices and lecture halls. Within a 30 seconds walking distance people will always find a recycle island. The recycle island will separate paper, PCD (plastic, cans and drink cartons), and other waste. The catering facilities will also have an extra bin for food waste. This pilot will run for 6 months in total, starting from May. After the pilot, the waste separation will continue, and will be expanded to all buildings on campus.

3.3.6 CIRCULAR TU DELFT

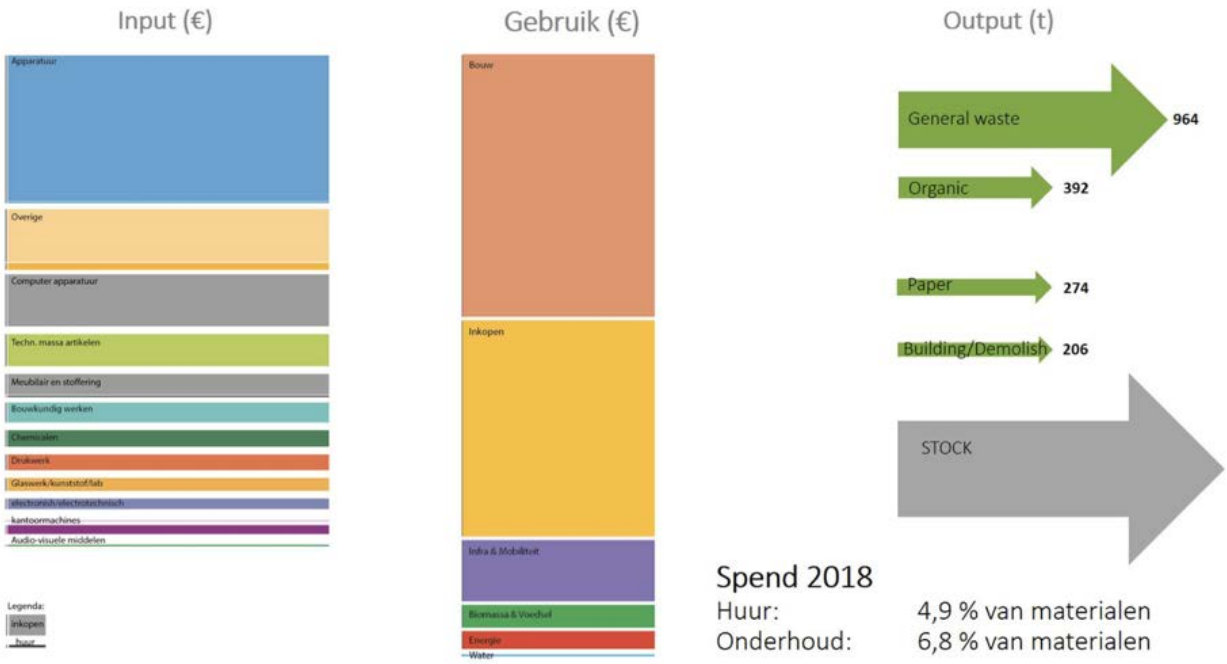
In addition to being a CO2 Neutral campus, TU Delft also set a goal to be Circular campus by 2030. In a broad sense, CO2 neutral campus needs commitment and participation from all the stake holders, especially for addressing scope 3 emissions. Procurement activities are one of the major scope 3 emissions and becoming a circular campus is a way of reducing these emissions. Circularity is something that needs to be addressed at an organisational level and involves participation from number of vendors who are part of the value chain. For example, TU Delft has around 10000 vendors supplying different products for various uses. To bring all of them on board to supply sustainable product is a very challenging task. To make the transition from linear to circular economy, the Campus Real Estate (CRE) made a base scenario.

To evaluate the base line scenario, CRE has commissioned a Roadmap for circular campus by 2030 [5]. The report was based on intensive literature review and interviews with experts. This report gives a good first hand estimate of the current state of the TU campus but is not accurate and appropriate way of evaluating due to unavailability of data for analysis [5].

"To evaluate the base line scenario, CRE has commissioned a Roadmap for circular campus by 2030"

Then the lack of knowledge about circularity among the staff is also an important concern that was identified [5]. Overcoming these challenges and envisioning a circular campus, the roadmap has drawn KPIs and developed a toolkit to achieve it [5].

The roadmap has identified six categories to draw KPIs and they are General, Buildings, Procurement, Infra & Mobility, Biomass & Food and Water. The circularity was measured using a Material Flow Analysis (MFA) which shows the materials that are entering the campus, what goes out and what is being reused within the system. The MFA is performed based on the expenditure of TU Delft on buying various products.



Source: Roadmap for circular campus 2030 [5]

The above figure shows outcomes of MFA with the inputs, use and the output of the materials. The use is greater than the input because the missed products and materials entering TU Delft are recorded in another way than procurement. And the stock in the output depicts those materials which are not used up/ thrown away in the time span of MFA [5].

We observe that the major inflows are equipment for use in education/research, computer equipment and others. The main use of these materials is for construction and procurement which includes packaged food & drinks, paper & printing, computers etcetera. And the highest outflow is the residual waste which is not separated on campus.

From this analysis, it is approximated that TU Delft is currently 5-15 % circular [5]. It is difficult to narrow down to the exact number because of lack of data, but it is identified that some materials are reused after leaving the TU system. For example, 41% of the raw materials were extracted from the collected waste in 2017 [5]. But the collected waste is only a small part of the total output. An important concern to be addressed is to evaluate the emission from procurement. The CO2 Roadmap does not account for the scope 3 emissions from procurement, which could be a very large number considering the amount spent, number of suppliers and products purchased.

3.4 SOCIAL ENGAGEMENT

Achieving sustainable development is a collective effort. Despite of the various initiatives taken up by the university management and the organizations like GreenTU, it is important that people believe in the cause and make their individual contributions to it. Prior to this report, this aspect was mainly dealt under the name of Communication. But to analyse a broader perspective of bringing together all the stakeholders of the university, the authors define Social Engagement as the fourth pillar for evaluating and achieving a sustainable development.

The authors define social engagement to be evaluated and addressed with respect to four areas;

- Communication (internal and external)
- Stakeholder engagement
- Events
- Inclusion

These areas will allow us to show the progress made by the university on this topic, to inspire more people to be cautious while making their life choices and work together in building a sustainable university.

Communication:

The topic of communication mainly addresses how TU Delft is communicating about the various initiatives being undertaken for sustainable development. One of the important contribution to this is the new sustainability webpage on the TU Delft website [12]. This page gives an overview on various activities related to sustainability in education, research and operations of TU Delft. In addition to this, as the official organisation for sustainability, GreenTU Delft uses its social media channels to keep its followers informed about the different activities on sustainability along with inspiring infographics to engage more people into this topic.

Events:

Organising events plays a prominent role in engaging people to particpate in sustainability. They provide an informal and fun way to explore new possibilities and see how they create an impact on the planet. The various sustainability related organisations in TU Delft are quite active in organising events with workshops, lunch lectures, excursions and may other fun activities promoting sustainability. One of the many event organised in collaboration with all major sustainability organisations is the Day of Sustainability.

Stakeholder Engagement:

Stakeholder engagement deals with inspiring and working together with various sustainability enthusiast among students and employees. There are many organizations within the TU who are promoting sustainability and engaging the students in their activities. These organizations are;

- GreenTU Delft
- Energy Club
- Center For Sustainability
- Foodsharing Delft
- Students4Sustainability

Also the study associations like Delft SEA and IESA Shift are active in sustainability.

Another major addition to dwell into the concept of sustainability at faculty level are the GreenTeams. These GreenTeams function as the de-central Green Offices addressing sustainability in education, research and operations tailoring their initiatives to a particular faculty [12]. The last one year marked the setting up five new GreenTeams making a total of seven teams across seven of the eight faculties in TU Delft. The last GreenTeam is expected to be setup in the year of 2020-21.

The above mentioned organisations and their activities in the past one year will be introduced in this section. Also the new sustainability hub, The Hive! will be can seen further in this section.

INCLUSION

A sustainable campus can only be achieved when all the stakeholders feel inclusive and are free to express and participate in a dialogue with their colleagues. In TU Delft, the concept of inclusiveness addresses SDGs like 'Quality education', 'Gender equality' and 'Partnership for the goals'. Being a global university with people from different cultures, TU Delft has a high regard for openness and diversity.

The Diversity Office at the university ensures that the every one at the university is well treated and the population if well balanced and integrated in terms of gender and their cultural background. The diversity team and theDiversity Officer are shaping the diversity policy for the university.

"TU Delft considers it important that all of its students and staff feel at home and valued, regardless of their sex, age, background, sexual orientation or disability. And where individual differences are accepted. In this way, everyone's involvement is increased and everyone is happy to be themselves" - Diversity Office, TU Delft

Another important network within the university working towards ensuring inclusiveness is DEWIS. This network of women scientists help in attracting more women and in creating a safe environment for them to grow and succeed in the academic field. TU Delft also developed its Integrity policy with a roadmap to solve any issues pertaining to social integrity. WIth many other policies and initiatives, TU Delft takes a strong stand on building an inclusive campus.

TU Delft
GreenTU

A YEAR IN REVIEW 2019-2020

THIS IS US!

WHY?

GreenTU Delft believe that universities ought to be inspiring and innovative to lead society in making our world more sustainable. We trust in students' willingness and ability to affect this change.

WHAT?

GreenTU Delft is is a student organization (part of TU Delft University Corporate Office), devoted to stimulating sustainability in education, research and university operations.

Outreach:
Facebook: 1630 followers
Instagram: 1400 followers
LinkedIn: 640 followers
Committee+Board: 20

EVENTS & ACHIEVEMENTS

SECRET SANTA ON CAMPUS

In collaboration with LDE-CfS and ISA we organized a christmas gift sharing with reused items, which participants brought from their homes

NO-MEAT WEEK AT BK CANTEEN

We proudly succeeded in a collaboration with the canteen at BK faculty to offer no-meat products for one whole week in March. The experience was so positive for participants and stakeholders that this will happen again!

RECYCLING PILOT

Finally also TUDelft is going to differenciate and recycle its waste, thanks to the pilot started at BK faculty, thanks to a collaboration between us and the faculty!

GREETEAMS ESTABLISHMENT

This year we expanded the presence of decentralized sustainabilityy offices-the GreenTeams- to new faculties! Now 7 out of 8 faculties have their own GreenTeam! We also presented this concept in occasion of an international online session regarding sustainability!

ZERO WASTE CHALLENGE 2020

Due to the circumstances we had to move our Zero-Waste Challenge online, but we did it in great style! Participants who enrolled to our website would get challenges in their daily habits, and provided with funny and interesting tools to reduce their waste!

SCHOOLS & SATELLITES

This lecture was held in collaboration with TUDelft Library. Participants learned about how rainfalls can be predicted though AI and learned to construct their own rain gauge, to take measurements of rainfalls like the project 'Schools & Satellites' does in Ghana.

COLLABORATIONS

LDE-Centre for Sustainability ; ISA Delft; Shift; Food&More, CIRFood, BK Faculty, Energy Club, TUDelf Library; Erasmus University Green Office; Stay Rotterdam & more

Contact us!

In case you have any idea for a lecture or workshop
In case you have a sustainable ideato implement

ENERGYCLUB
TU Delft

A year in review: 2019-2020

Students empower sustainability!

WHY?
We believe that students can have a positive impact on the energy transition!

WHAT?
We provide a solid platform for students to connect to the industry, policy makers and researchers in the field of energy.

EXCURSIONS

COLLABORATIONS

LUNCH LECTURES

WORKSHOPS/ MASTERCLASSES

Outreach:

- 3496 Facebook Followers
- 578 Instagram Followers
- 1292 Twitter Followers
- 482 LinkedIn Followers
- 325 Active members

Lunch Lecture Series

Geo-political Aspects

POWERPLAYS

Technical Advancements

TECHBITES

Financial Perspectives

MONEYTALKS

ACHIEVEMENTS

Launch of *PowerPlays*, *TechBites* & *MoneyTalks* lecture series ● New *Website* and *Membership* ● New *Logo* ● Professional Videography ● Inclusion of the *8 Pillars* on the website ● More *Interships and Job opportunities* ●

Supports 8 DEI Pillars:

- Powerweb Insitute
- Urban Energy
- Wind Energy Institute
- E-refinery
- Social Innovation
- Ocean Energy
- Energy Access 4 all
- Hydrogen at Sea

www.energyclub.nl
Jaffalaan 5, DELFT
@DelftEnergyClub
info@energyclub.nl
TU Delft Energy Club
tudelftenergyclub

SCAN ME

Our Vision

Foodsharing Delft at TU Delft aims to raise awareness about how to reduce food waste around Delft. We hope to be a building block towards a sustainable food system that can provide food for all and minimize waste.

In 2019, Dutch households wasted an average of 34.3 kg per person, totalling to 590 million kg of food [1]. On the other hand, all the world's hungry people could be fed on less than a quarter of the wasted food in the US, UK and Europe [2]. Nearly 11% of all greenhouse gas emissions that come from the food system could be reduced if we stop wasting food.

Foodsharing Delft wants to increase sustainability, reduce planetary emissions, change the mindset of our throw away society. It is important to appreciate the hard work and resources that go into growing the food we buy.

Foodsharing Initiative

Weekly pick ups

Foodsharing Delft picks up 'wasted' food that can no longer be sold from local shops and cannot be accepted by the Voedselbank. This food is then distributed throughout the community.

Monthly events

We host monthly No-Waste dinners using the wasted food to raise awareness about food waste, share cooking skills and build our community.

Social media

We use our social media to promote our weekly pickups and monthly No-Waste dinners. Furthermore we use our platform to inform our followers about food waste reduction by sharing tips, recipes and other facts.

Foodsharing Progess

About 20kg of food saved every week

Free 'No-waste' dinners monthly.
500 meals provided in 2019.

12 public events

6 collabs

51 members

Foodsharing Future Plans

Community Fridge

In collaboration with IChange, we have introduced a community fridge and pantry in the centre of Delft. This allows the whole community to drop off and store unwanted food, available for anyone that wants to help reduce food waste to pick-up at any time.

Foodsharing App

Another goal is to create an app where TU Delft and other participants can add pinpoints on a Delft map indicating locations where there is food left-over. Examples of this would be sandwiches offered by the university left over from lunch lectures or larger events.

Outreach and/or Collaborations

Foodsharing Delft aims to collaborate with other societies at TU Delft to raise awareness about reducing food waste around campus. We hope in the future to place food waste-reduction as an important point on the agenda of student representatives at TU Delft and the local government.

[1] Van Dooren, Corné, et al. „Measuring food waste in Dutch households: A synthesis of three studies." Waste Management (2019).
[2] ROFF SMITH. "How Reducing Food Waste Could Ease Climate Change." 2015 https://www.nationalgeographic.com/news/2015/1/150122-food-waste-climate-change-hunger/

Sustainability report 2019

Centre for Sustainability Students
Leiden•Delft•Erasmus

Our mission is to accelerate the transition to a circular economy to achieve a sustainable society.

About us

Collaboration between Erasmus, Leiden University & TU Delft.

The student board is responsible for creating events to raise awareness of sustainability among students.

Events and workshops are designed to have an educational element.

Board of 2019-2020

From the Day of Sustainability Symposium

Contact us!

Centre for Sustainability Students

LDE_SustainabilityStudents

LDECfSStudents@gmail.com

Events in Delft 2019

Docubate 2019

An event focusing on the threat of water scarcity and possible solutions to this challenge. This event resulted in some new perspectives on water scarcity in the world and the Netherlands.

Day of Sustainabilty 2019

As a part of the Day of Sustainability Symposium 2019, we organised a workshop where you could learn the fundamentals of gardening. By the end of the workshop everyone got to take their newborn plant home.

Secret Santa 2019

This event was a result of a collaboration between several organisations on TU Delft Campus. Here students donate items they did not need anymore to become useful for someone else.

Other events

We also organise events in Leiden, Den Haag and Rotterdam!

All our events are open to anyone who is interested in learning about sustainability!

During this year we have collaborated with many organisations at TU Delft. We are always open to new ideas and collaborations!

Shift

Industrial Ecology Study Association

A year in a review: 2019- 2020

We are the study association of the joint master's program Industrial Ecology. Our goal is threefold:

- **Education: motivate and support students**
- **Social: strengthen the IE community**
- **Professional: Prepare students for their career**

Education

- 3 Lunch lectures
- 5 Workshops

Dandelion Honey workshop

Social

- Network drinks
- Study trip visiting companies

Studytrip

Professional

- 6 company visits
- Annual Career Day

Company visit

Contact information

iesashift.nl
communication@iesashift.nl
iesashiftie
iesa_shift

Outreach:
428 followers on Facebook
87 followers on Instagram

With **511 members**, and **5 committees**, we also did a lot of other things!

30 Events

13 Collaborations

We are involved in the following topics

- Climate Change
- Circularity
- Urban Development
- Food Production
- Industrial Symbiosis
- Sustainable Solutions

STUDENTS 4 SUSTAINABILITY

S4S offers students the change to realize their ideas on a global scale in the form of a development project. On the one hand by offering them financial support for prototyping, on the other hand by sharing experience and knowledge. This way, we try to build bridged between Western countries and developing countries through technology.

25+ COUNTRIES

880+ DONORS

150+ PROJECTS

BOARD 2019-2020

Our goal of our foundation is to motivate TU Delft students to apply innovative technologies in real life, thus facilitating the transition to a more sustainable world.

PROJECTEN

@students4sustainabilitydelft

@Students4Sustainability

Students4Sustainability

info@students4sustainability.nl

Students4Sustainability.nl

ACTIVITIES 2019 - 2020

LECTURE

MOVIE NIGHT

PHOTO COMPETITION

ED WINTERS

GALAPAGOS

A HELPING HAND

COMMITTEES

SYMPOSIUM

S4S WEEK

FESTABLE

DE GROENE PINT

GREENTEAMS

GreenTeams are decentral Green Offies that are being set up at a faculty level to address sustainability. These are bottom up student initiatives conceptualized and set up by the GreenTU. The GreenTeams Coordinator from the board of GreenTU is responisble for coordinating these teams.

The first GreenTeam was established by students in the Faculty of Mechanical, Maritime and Materials Engineering (3ME) under the name Green-mE in 2016. They focused mainly on sustainability in education and made an inventory report. Following the success of Green-mE, the students in the Faculty of Architecture set up the BKGreen team which focused on sustainability in education and operations within the faculty. With these successful initiatives, the Executive Board saw the importance of the teams and GreenTU was directed to set up a GreenTeam in all the faculties of the TU.

For the year 2019-20, the plan was to set up three teams. But due to an overwhelming response from the deans and the directors of education, there was a great acceleration in the process. By the end of the year, five new GreenTeams were set up at the Faculties of EEMCS, Applied Science, Aerospace, CiTg and TPM.

The last team for the Faculty of Industrial Design is expected to be finalised in the year of 2020-21. The GreenTeams are funded by the respective faculties along with some contributions from the GreenTU.

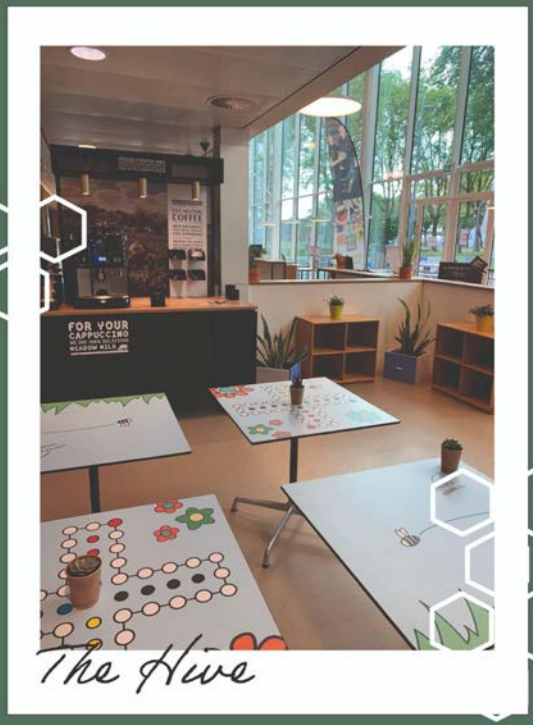
The teams that were started in 2019-20 had their first assignment to make an inventory report on the present state of sustainability in the faculty. This includes investigating into education, research, operations and communication. In addition to reviewing the current state, the reports also suggested a plan of action to improve sustainability within the faculty. The implementation of these ideas will be taken up by the future boards. The Greenteams are also quite active in organising events and initiatives within the campus. For example the BKGreen helped in the organisation of No Meat Week and they set up a stall for collecting and reusing things used for the various projects and assignments.

The success of Greenteams can also be evidently seen from the requests pouring in from other universities to help them in setting up these teams, The Greenteam coordinator of 2019-20 has presented about the teams in various platforms like Students Organising for Sustainability International (SOS) and International Sustainability Campus Network (ISCN).

The Hive!

TU DELFT'S SUSTAINABILITY HUB

The Hive! is the newly opened sustainability hub in TU Delft. It will be used as an office space for the GreenTU Delft board and a hangout place for sustainability enthusiast in the university. The Hive is located in the Fellowship building of the university and people can drop by to have a cup of CO2 neutral coffee, play a game or read and exchange knowledge on sustainability.



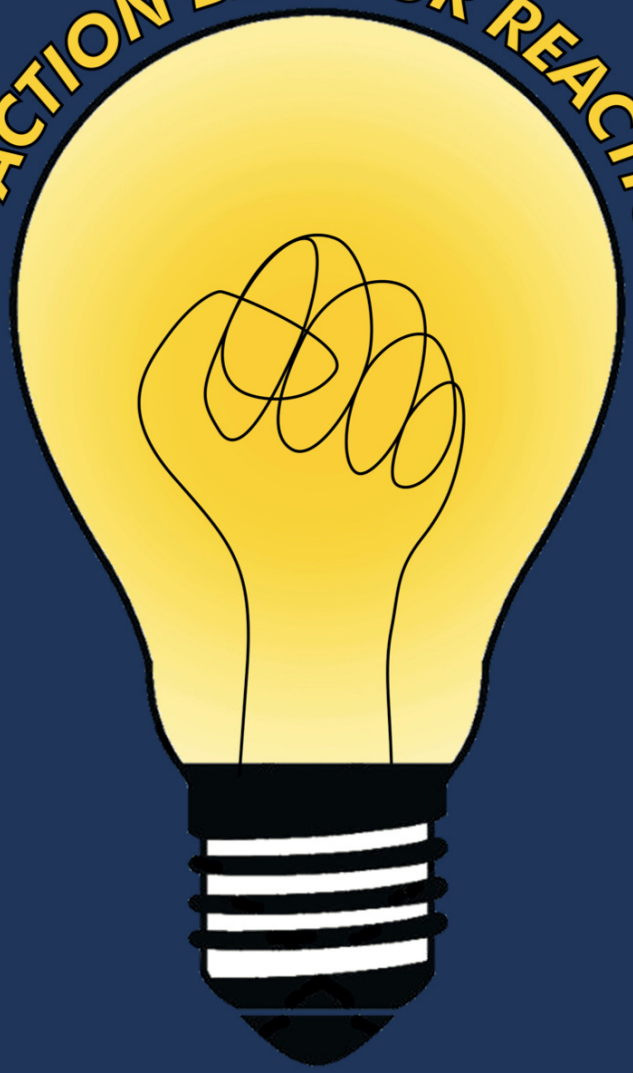
DAY OF SUSTAINABILITY

Since 2018, TU Delft has been celebrating the National Day of Sustainability in October, to bolster a sustainable mindset, bring out innovative green ideas and encourage students to explore the varied sustainable options in terms of both daily chores and career. Together with other student association supporting sustainability, such as the Center for Sustainability, Students for Sustainability, TU Delft Energy Club, Dispute Water & Environment Sustainable Committee, Delft Sustainable Energy Association, IESA Shift, Lijst Beta etc, GreenTU leads the event every year, gathering organisers, sponsors and students. The last two editions have been a huge success for the university with the 2019's event hosting around 200 students, in collaboration with X TU Delft, supported with monetary benefits from the Gemeente Delft, STUD, Studium Generale, GreenTU and YES!Delft Students.

In 2018, the theme was 'From Global to Local', whereby the three most important domains of sustainability- Water, Waste and Energy, was explored via lectures and workshops from relevant companies, lecturers and industry, concentrating on both global and local scales. 2019's day decided to focus more on 'Let Action Be Your Reaction', whereby the Keynote started with a global overview on sustainability, followed by lectures in provincial perspective and finally being concluded with 2-hour long workshops where students can get personally involved. It was a very well received event because of the attention that was paid to the extra sustainable details such as edible flyers, no plastics during the event, sustainable beers, cricket snacks, unwrapped plants for gifts, recycled name badges etc. The event has hosted speakers from various companies including International Energy Agency (IEA), Gemeente Delft, Renewi, DAREL, EBN, Coppe8 etc.

DAY OF SUSTAINABILITY

LET ACTION BE YOUR REACTION



9th October 2019, 12.30-19.00
@X TU Delft, Mekelweg 8-10

A symposium with inspiring speakers, hands-on workshops and drinks!

Register here:

/GreenTUDelft

YES! DELFT STUDENTS · SG · STUD STUDENTS FOR WORK FOR STUDENTS

GreenTU · Centre for Sustainability STUDENTS Leiden·Delft·Erasmus · Dispuut Water & Environment · Delft S.E.A. · Shift · S4S · Energyclub TU Delft

4.FUTURE SCENARIOS

In the earlier chapters of this report, the present state of sustainability has been reviewed. As stated in section 3.3, TU Delft is responsible for carbon emissions of around 47000 t CO2 eq. But with the increasing population of the university, the needs and the facilities being provided also increase. This leads to a continuous increase in the carbon emissions. For this report, the time span ten years from 2020 to 2030 is considered.

Currently TU Delft has a population of within 30000 with approximately 25000 students and 5000 employees. With a current population growth rate, the numbers are increasing at a very high rate. But, based on a rough approximation the current facilities accommodate the TU cannot accommodate more than 36000 people (30000 students and 6000 employees). This can be seen already with the limited availability of study spaces during peak times. Also, the age of buildings is limiting their use and thus creating a congestion in the remaining buildings. Hence, the increase in population at the current rate will need rapid adaptation and building of new facilities.

Since the future growth rate and the situation of expansion of facilities is not clear, in the current report on the current facilities and their limitations will be accounted. Based on the current population growth rate, the limit of 36000 would be met by 2024.

To analyse the growth and the increase in the emissions in the coming years a mathematical & behavioural model was build using Vensim software.

Model description:

Vensim platform models can be useful tools for a visualisation of cause-effects links of reality phenomena. For the current report, this Vensim model is used to evaluate the future environmental impact of TU Delft in terms of carbon emissions expressed in Co2 equivalent terms. The models aims to;

- Drawing curves representing how CO2 emissions of campus have been increasing or decreasing over the past years. Year 2012 has been chosen as initial year since most of the data was available starting from then.

- Predicting outcomes of different future scenarios and strategies being represented in this report

The overall model takes into account 6 main factors;

- Electricity
- Heat
- Mobility

- Food
- Waste
- Water

Additional CO2 emissions may also be seen in Procurement and is expected to be a significant part of scope 3 emissions, but for now only estimated data exists on this topic.

These 6 factors are the main contributors to the creation of equivalent kg of CO2 and can be modelled thanks to existing data and logic links constructed. Each variable has some factors which determine the final outcome of the variable, which can be modified by the user to represent different scenarios. As an example, when computing the CO2 equivalent outcome that the factor electricity has, parameters can be changed to model a situation in which more PV panels are installed, thus a bigger proportion of the total electricity would be PV produced.

This model is population based, which means all quantities are described to be unit/capita. This choice has been made since it is important to notice that each individual has an impact on the total and that the whole impact of the campus is the sum of the overall behavior of each of its student and employee. The model starts with a small flow based model which aims at predicting the amount of students and employees present at campus in the future.

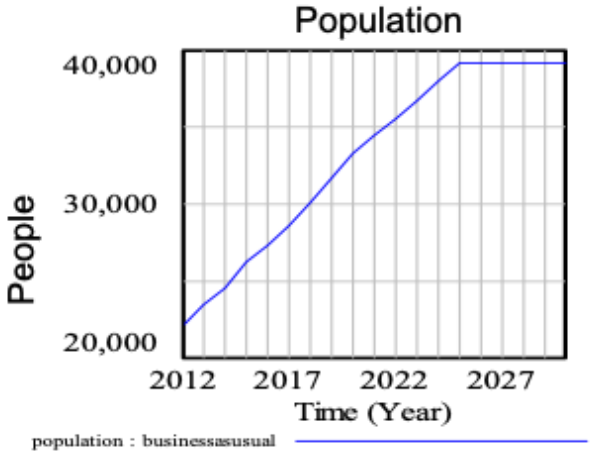
Limitations:

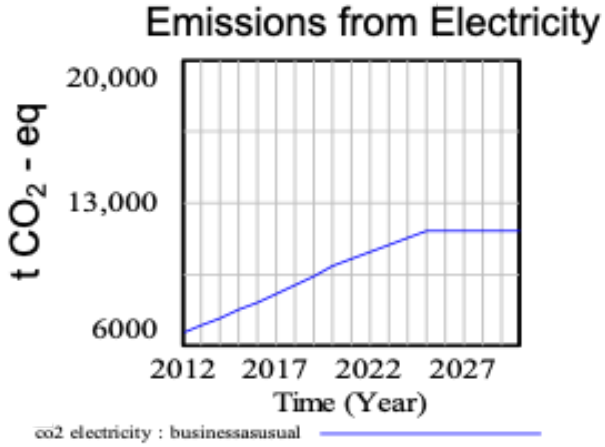
Outcomes are to be considered behavioral curves. The aim is indeed not to draw precise number estimations, but to let readers understand the kind of impact the application of a particular strategy can have on the modification of the curve for future prediction. As an example, thanks to this tool one would be able to observe which kind of impact a sustainable initiative can have on the emissions of the university.

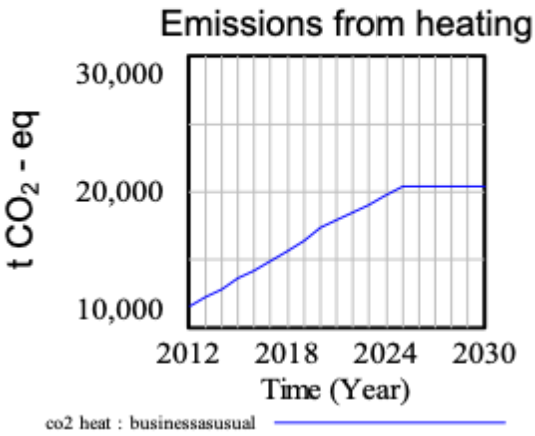
Future Scenario from 2020-30

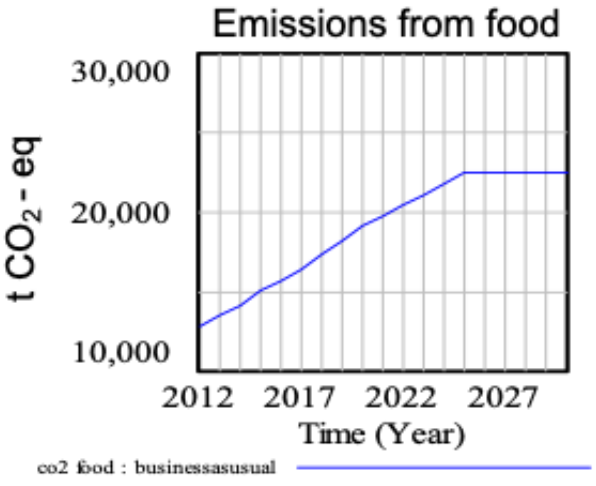
Based on this model, the CO2 emissions are expected to be .... by 2024 when the TU reaches its near maximum capacity. This will be considered as the business as usual case without any further plans for improvement. This amount emissions is alarming and needs to be addressed as soon as possible. With the proposals for implementing carbon tax in coming years, these emissions will also be a financial burden to the TU. Hence this report suggests various ways in which the carbon emissions can be reduced the model will be used to show the impact of these strategies.

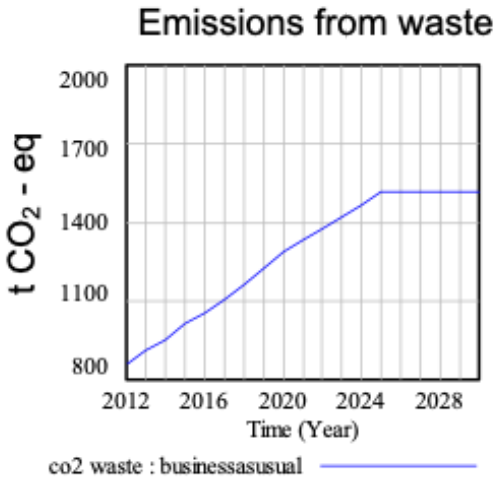
The business as usual case will be treated as a base case scenario for the rest of the report. The business as usual scenario calculated using the model is show below.

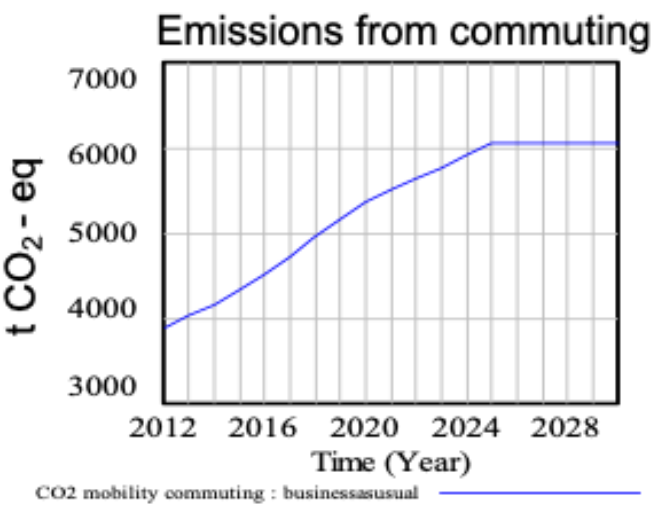

Population
40,000
30,000
20,000
People
2012
2017
2022
2027
Time (Year)
population : businessasusual

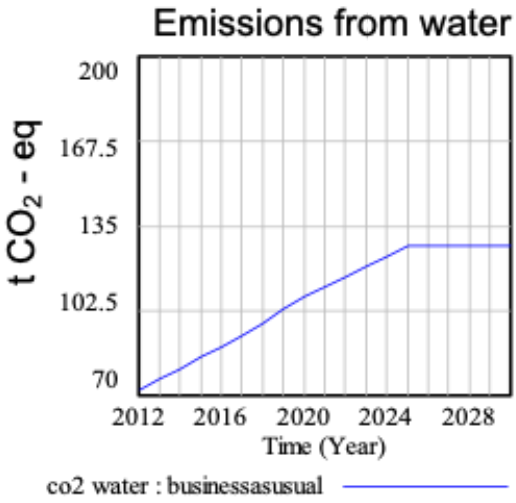

Emissions from Electricity
20,000
13,000
6000
t CO2 - eq
2012
2017
2022
2027
Time (Year)
co2 electricity : businessasusual

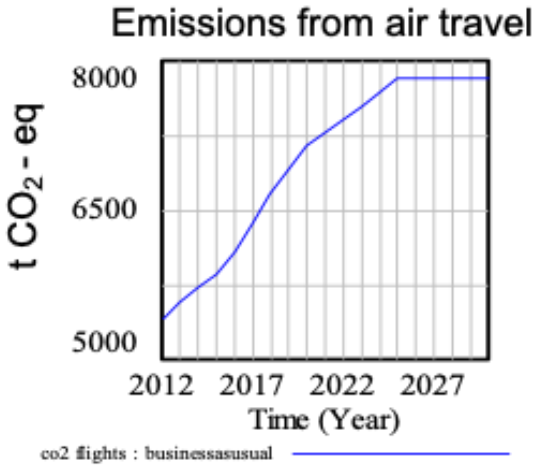

Emissions from heating
30,000
20,000
10,000
t CO2 - eq
2012
2018
2024
2030
Time (Year)
co2 heat : businessasusual


Emissions from food
30,000
20,000
10,000
t CO2 - eq
2012
2017
2022
2027
Time (Year)
co2 food : businessasusual


Emissions from waste
2000
1700
1400
1100
800
t CO2 - eq
2012
2016
2020
2024
2028
Time (Year)
co2 waste : businessasusual







Based on the various conversion factors, the business as usual scenario is calculated using population of the university as the main factor influencing the emissions. As mentioned before the population is assumed to increase to a maximum of 36000 at a rate of 3.6% and 1.8% per year for students and employees respectively. Considering the current levels of usage of different resources, the emissions of TU Delft are expected to rise to nearly 70000 t CO2-eq by 2030. If no further steps are taken, the emissions from electricity will rise to nearly 11650 t CO2-eq and from heating will be almost 20400 t CO2-eq by 2030.

With emissions from food being the highest contributor for scope 3 emissions, they are expected to rise as high as 22500 t CO2-eq by 2030. The emissions from mobility and waste would increase to 12700 t CO2-eq and 1050 t CO2-eq respectively. This total of 70000 t CO2-eq emissions will be very significant the TU has to pay a carbon tax. Considering only the scope 1 and 2 emissions, based on the projected carbon tax of 55 EUR per t CO2-eq by the EU [13], TU Delft will have to pay an annual tax of nearly 1.8 million EUR. If scope 3 are also considered in the coming year, the tax amount be as high as 4 million EUR (excluding emissions from procurement).

5. SCOPE FOR IMPROVEMENT

In this chapter, the scope for improvements is analysed based on student opinions and SWOT analysis for the four pillars of sustainability in TU Delft. In chapter 5, it was shown that with the present growth rate, the emissions are going to be as high as ... This calls for an action on these issues and start analysing and taking performed steps towards improvement. With the present momentum on this topic, it is also important that students are well aware about the issues of sustainable development and climate action. To understand what students are expected, the authors have performed a remote survey on various aspects of sustainability.

Survey results:

Around 100 participants have submitted responses for the survey from various programs and different faculties. Though this does not represent all the another of people, it relatively gives an idea on the mindset of students and their opinion towards sustainability. Some of the interesting results are;

- 61 percent of the students highly value sustainability in education and another 29 percent would be interested to have it.
- Only 44 percent say that sustainability is well integrated in their study programs

- Around 71 percent of the students suggested having Honours programs and 56 percent of the students suggested to have more elective courses focusing on sustainability.
- very interestingly, about 86 percent of the respondents would like to include the topic of sustainability in the Bachelor or master thesis.
- Coming to operations; around 95 percent people suggested that more recycling bins needs to be installed in the TU campus.
- For food being served in the cafeteria, around 80 percent respondents suggested that more vegetarian and vegan options should be made available.

Open questions also gave some interesting insights into what people think and what they are willing to adapt to. Their responses to the part on sustainability in education and operations and shown the figures.

Hence this shows that the interest in the topic of sustainability is quite high and is expected to grow in the coming years.

To analyse the current opprtunities and the barriers for becoming a sustainable university, the next section will show a SWOT analysis for sustainability in education, research, operations and social engagement.

SWOT ANALYSIS - EDUCATION

STRENGTH:

- Two full master programs dedicated to sustainability
- Two partnered master programs
- Four master tracks focusing on sustainability
- Sustainability-related MOOCS
- Practical education through living labs
- Home to renowned experts in various fields of sustainability
- Best in class infrastructure, labs and resources to support education in the field of sustainability

WEAKNESS:

- No policy on sustainability in education
- Lack of information on what is offered by the university for sustainability
- Lack of awareness amongst students and teachers
- Generally, bachelor programs do not put a focus on sustainability
- No representative to oversee education related to sustainability

OPPORTUNITIES:

- Growing interest among students to learn more about this topic
- GreenTeam inventories from every faculty which show the improvements that can be made in the curricula
- Online repository
- Ongoing Master restructuring
- Importance for sustainability in student projects and thesis
- Developing more MOOCS
- Introducing honours programs related to sustainability
- Train teachers through workshops/lectures to encourage student participation in sustainability

THREATS:

- Poor rankings for sustainbility in education
- Sustainability becoming one of the most alarming topic around the world and TU Delft engineers lacking knowledge in this area
- Effects the university brand value
- TU Delft's motto, "Impact for a better society", can not be achieved without focusing on sustainability in education

SWOT ANALYSIS - RESEARCH

STRENGTH:

- Ranked very well in research related to SDG 6,7,9,11 & 12
- All four Delft research-based initiatives focus on sustainability
- TU Delft published its vision on climate action with a commitment to extend its research activities in climate action
- TU Delft global initiative supports research for sustainable development in developing countries
- Green village at TU Delft is wokring as a living lab
- Dream teams
- Clean tech start-ups at Yes Delft!

WEAKNESS:

- Ranked 101 world wide for research on climate action
- No policy for research related to sustainability/climate action
- No action plan for vision on climate action
- Limited thesis opportunities for students from non sustainability related masters
- No representative to over see the research related to this field
- Lack of communication within and outside the university
- Limited interaction between Green village, students and researchers

OPPORTUNITIES:

- Further push in few research areas like sustainable energy, sustainable aviation, sustainable architecture and sustainable medical technology
- Improve communication and visibility
- Common platform to facilitate research, student projects & thesis related to sustainability
- Online repository
- Evaluating rankings in each domain and aim for improvements

THREATS:

- Rankings effecting the TU Delt brand value
- Student interests are compromised
- No plan of action might lead to lost vision
- TU Delft could be out of the race in some fields though there is potential
- Living lab not fully explored to meet the student interests

SWOT ANALYSIS - OPERATIONS

STRENGTH:

- Support from the executive board
- Positive outlook of the sustainability teams (CRE, Sustainability coordinator and GreenTU)
- Low emissions from electricity due to 78% wind energy usage
- Cooperation of partners like Cirfood and Renewi in taking up sustainable initiatives
- Financial capabilities
- Support from students to follow sustainable habits
- Success of no meat weak and waste separation pilots in Faculty of Architecture
- Newly commissioned buildings are fully sustainable

WEAKNESS:

- Emissions from heating are very high
- Heating issues cannot be addressed easily because of old buildings
- High investments for becoming carbon neutral by 2030
- Unwillingness of individuals to change food habits
- Offering vegetarian options is not profitable for caterers
- No guidelines for organising any events which is leading to lot of food wastage
- No conditions on limiting business travel. TU Delft accounts for 33 million kms travel during 2018

OPPORTUNITIES:

- Success of pilots on no meat and waste separation
- Geothermal energy possibilities on campus
- Available expert knowledge from professors and researchers
- Strategies mentioned in CO2 Road map
- Opportunities through the Circularity roadmap 2030
- Willingness for change by most operational departments
- Increasing awareness and psychological changes among the stakeholders
- Campus as living lab

THREATS:

- Rankings effecting the TU Delft brand value
- No governing body to oversee sustainability in operations
- Present contracts effecting the future planning and initiatives
- No official policies defining the goals, standards and guidelines for sustainable practices

SWOT ANALYSIS - SOCIAL ENGAGEMENT

STRENGTH:

- Formation of GreenTU Delft is a great start for starting a dialogue on sustainability
- The new sustainability page o TU Delft website is a great communication medium
- The commissioning of the current report paves way for better communication both internally and externally
- The presence of GreenTeams and sustainability related organisations
- A critical attitude towards sustainability among all the stakeholders
- Willingness of people to change their lifestyle to build a sustainable campus
- Vision to be a global university where everyone feels included

WEAKNESS:

- The university is not publicising the vision and achievements towards SDGs
- Lack of official policies and documents related to sustainability
- Lack of communication between student organisations working on sustainability
- Less involvement of employees on sustainability related activities, initiatives or events
- GreenTU is still not known to many stakeholders
- The resources like the TU website, TU Delta and other media channels are not fully utilised to raise awareness on sustainability

OPPORTUNITIES:

- Connect all the stakeholders working on sustainability
- Collaborative events to increase the audience
- Direct engagement with students to get their opinion and increase participation
- Improving the sustainability website and making it more dynamic to attract people
- Involving employees in the dialogues on sustainability
- Encouraging women during high schools to take up technical studies
- More women speakers and organisers for events
- Efficient use of various communication channels of TU Delft

THREATS:

- The brand value being effected due to statements made but lacking enforcement
- The university rankings on sustainability are being effected because of lacking policies
- Personal/political stands on sustainability are rising among many student groups
- People assuming that there is nothing happening with regards to sustainability

6.VISION ON SUSTAINABILITY

In this chapter, the authors define GreenTU's vision for sustainability in TU Delft for portfolios of education, research operations and social engagement.

6.1 VISION ON EDUCATION

As the engineers of tomorrow and to make an impact on society, it is the need of the hour that the TU Delft students understand the concept of sustainable development so that they design, build and facilitate a better future. This can be envisioned as follows:

1. All students should have (roughly) the same basic knowledge concerning sustainability.
2. Students should be given the opportunity to explore sustainability if they have a specific interest.
3. Students should be provided with the opportunities to become an expert on sustainability.

"Every TU Delft student should have a basic understanding of sustainability and should be given an opportunity to explore and become an expert in any of the domains of sustainability"

Basic knowledge:

Since sustainability is a multi-disciplinary issue, not one faculty or program can solve it by themselves. Therefore students need to be able to collaborate with other disciplines and have the same basic grammar concerning sustainability (e.g. know what a CO2 footprint is and how you can calculate it). Integrating this into the regular education can be done in several ways like, providing a common mandatory course to educate on sustainability, by touching upon the topic through course projects or assignments.

Explore sustainability :

If the above mentioned 'basic knowledge' has triggered or inspired students to do more with sustainability and gain additional knowledge on this topic, TU Delft must provide opportunities to take these ambitions to the next level. This can be done with tracks or courses in bachelor or master programs and also through programs like honours, professional courses or minors. Learning about these topics through projects , assignments or theses should be encouraged.

Becoming an expert in sustainability:

TU Delft's engineers must have a holistic approach in dealing with technology and the environment. The field of sustainability has gained a great momentum in recent times and TU Delft needs to be in the front line of this transition by training skilled professionals who can handle the technical, business and policy aspects of sustainability. Hence we need to have more specialised programs where students can become an expert in the field. As of now there are to full time master courses on this topic, namely: MSc Sustainable Energy Technology and MSc Industrial Ecology.

6.2 VISION ON RESEARCH

Being one of the best technical university in the world with experts working on varied topics and possessing world class research facilities, TU Delft has a great potential to contribute to the global research on sustainable development. TU Delft's research output is already contributing towards the sustainable development goals with its renowned research in the areas of sustainable architecture and construction, sustainable energy, water management, health care, aviation and so on. For the coming decade it is quite important that the university promotes this research and expands its contributions to the areas that are not fully explored despite the potential.

"TU Delft needs to explore new areas of research, create a centre for sustainability and promote the concept of living lab"

1. Explore new and inter-disciplinary research areas related to sustainability and encourage researchers to contribute to them
2. Create a common platform to facilitate sustainability related research for all the stakeholders of the university
3. Promote the concept of campus as a living lab connecting researchers, operations team and students

Explore:

The current report shows the various research initiatives of TU Delft and the contributions that are being made towards the various SDGs. There are still a few areas where the potential has not been fully explored. There is a need for thorough investigation into these areas, evaluation of the progress, and the identification of opportunities. Research on sustainability cannot be an isolated frontier; there is still lot of room for collaborations on inter-disciplinary research projects between multiple research groups working in different faculties. Therefore there is a need to explore these opportunities and put them into action in the coming decade.

Create:

With the topic of sustainability gaining more and more importance every day, there is a need to provide a common platform to engage the stakeholders who are interested in this field. This includes professors, researchers, students, companies and other external partners. Thus there is a need to develop a Centre for Sustainability, which can connect these stakeholders to develop sustainable solutions and provide a path for the societal transition.

Promote:

The main aim is to transform TU Delft into a 'living lab' to solve societal challenges and make a sustainable and responsible contribution to the world. The concept of living lab is not new for TU Delft as the Green Village has been quite active in promoting this idea. But the opportunities are enormous and can be further explored. There is a need to engage more students and researchers working on these practical projects at the living lab. There are many topics which can be experimented by using the campus as a test bed to transform innovations to market ready technologies. These new innovations can also contribute to sustainable campus operations when when expanded further.

6.3 VISION FOR OPERATIONS

TU Delft's strategic frame work 2018-2024 calls for developing a smart, sustainable, inclusive and living campus, which inspires people to work, think and be creative. Educating the engineers of tomorrow and being a forerunner in modern research, TU Delft needs to accelerate its action on practicing what it preaches. With a vision towards contributing to the UN Sustainable Development Goals, TU Delft commits to build a

"CO2 neutral and circular campus by 2030"

In April 2019, TU Delft published its vision on climate action and with this commitment, TU Delft has taken the social responsibility to contribute towards tackling climate change and starting this from the TU campus.

- Energy transition vision:

  a. Reflect TU Delft's expertise in the campus operations
  b. Build a sustainable, reliable, affordable and future proof energy system
  c. Develop a system to monitor, evaluate and track the progress

- Sustainable catering vision:

  a. Define healthy and sustainable food standards for all the restaurants
  b. Reduce scope 3 emissions from meat and dairy, packaging, cutlery and food waste
  c. Create awareness among the consumers for alternative options

- Sustainable mobility vision:

  a. Evaluate the number of people using gasoline vehicles
  b. Encourage alternative means of transport
  c. Reduce the emissions from business travel by TU Delft employees by traveling only when important or using sustainable means of transport

- Sustainable waste management vision:

  a. Ensure responsible collection of waste in the entire campus
  b. Consider circular materials and products and reduce the waste streams
  c. Avoid single use materials and e-waste

- Sustainable procurement

  a. Evaluate the amount of emissions from procurement of various materials and products
  b. Develop centrally agreed standards for procuring circular and responsible products
  c. Achieve 100% circularity by 2030

6.4 VISION FOR SOCIAL ENGAGEMENT

The progress in sustainable development is only possible when people participate and contribute their bit to making a change. Hence authors identify engaging the TU Delft community in starting a dialogue on sustainability is quite important. As show in section 3.4, social engagement can be addressed as based on communication, stakeholder engagement, organising events and by building a inclusive campus.

The authors define the following vision for social engagement:

1. Improve the communication on sustainability within the university and to the outside world
2. Engage students and employees to be part of building a sustainable university
3. Build an inclusive campus where every one is happy, healthy and prosperous

Improve communication:

The current report marks a great start to communicate TU Delft's commitments and to show the progress being made on achieving the sustainable development goals. But it is important that this is taken further and will reach out to all the stakeholders of the university. There are no official reports or policy documents that the TU has published related to this topic. With the present momentum on sustainability, many people and organisations are interested to know what is happening and what is planned ahead. Therefore it is important that TU Delft will focus on improving the means and channels of communicating about sustainability. This needs to be addressed to reach out to all the stakeholders within the university and also for the external audience.

Engage:

Engaging dialogue be a part of the dialogue on sustainability is quite important to motivate and share knowledge about this concept. This includes making both the students and employees to be involved in the various initiatives, to suggest new ideas and in executing the projects. As sustainability is currently a bottom up initiative in TU Delft, the engaging of people would contribute a lot in accelerating the change. This can be done by organising events, inspiring audience through social medias and by creating awareness among them through lectures, workshops etcetera. This can be facilitated by various student initiatives like GreenTU or other sustainability related organisations.

Build:

In addition to environmental sustainability and coming together to achieve out goals, it is also important to build an inclusive campus. The UN SDGs also mention inclusiveness to be an important part of sustainability. The concept of inclusiveness can address SDGs like quality education for all, gender quality, good health and wellbeing and finally partnership for goals. As a global university, TU Delft has a diverse mix of people. It is important that the university stands by this diversity and makes sure everyone is treated equally and with mutual admiration. Building such an inclusive campus creates a happy and healthy learning environment. This is also a great way to prepare the students to be responsible professionals in their future work place.

7. INSPIRING SUSTAINABILITY INITIATIVES

The concept of sustainability and ultimately saving the planet are global goals that the world needs to address together. TU Delft has always been a premier institute contributing to the innovations, technology and the science required to tackle these issues. With the present momentum on climate action and the urgency in dealing with these problems, there is a need for collaborations, seeking inspiration from fellow organisations and more importantly reinventing and adapting to new norms.

With this idea, the current chapter shows some interesting goals, initiatives and achievements of some best universities around the world in the field of sustainability. This research mainly aims to seek inspiration for setting goals, to adapt feasible initiatives and for benchmarking. The research on these top universities has shown that the change towards better future has already begun and it has started from the right place where the future society is being nurtured.

For this research, the universities were selected based on their QS & THE rankings some from the United States of America and from different countries in Europe. Their progress and initiatives were also considered for this selection. Another important criteria for the selection is their communication platform and the data available to study the university. Most of these universities have dedicated sustainability related webpages or sustainability reports. Though each of them have a different approach and organisational structure, the common goal and the commitment towards building a better tomorrow can be clearly seen.

The present findings are based on literature survey of the universities based on the available data on their webpages and various reports that are published with open access. All the material in this chapter is a copyright to the respective university.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

"Solving global sustainability issues at a local level"

The MIT Office of Sustainability is the umbrella department that oversee's all the activities related to sustainability.

Working groups are formed with focus on specific sustainability topics like food, waste, energy, reporting and so on.

Recommendations of Student leadership in sustainability working group:

Campus Collaboration and Project Support

- Student Sustainability Governance Council which brings together various sustainability organisations
- MIT sustainable activation fund for improving the campus community

Bridging Classroom and Campus

- MIT should provide each student, regardless of degree program, with access to sustainability education.
- Create a Sustainability Information Portal for students focusing on Sustainability in Career Development, sustainability career fairs and sustainability Career Mentoring Programming that engages alumni.

Student Culture and Experience

- Incorporate sustainability into key cultural events
- Create a model sustainable living community
- Promote transparency of utilities data

Sustainability Data and Metrics:

To analyse the current situation and to track the future progress in sustainability, data and metrics play an important role. From accounting the carbon emissions to measuring the performance of various systems related to energy/waste, the data helps is defining specific KPIs and make sustainability plans. The MIT's Office of Sustainability has started its first project in 2013 and now automated the collection of data and analysis. The measurements include water and materials consumption, waste treatment, energy efficiency and social issues like health, equity, and well-being.

Currently, a Sustainability Data Hub is under development. This will act as a central data repository for sustainability related information such as greenhouse gas emissions, waste, energy usage, and food & dining.

Reports & Strategies:

- Pathway to Sustainability Leadership by MIT
- Sustainability Working Group Recommendations
- MIT GHG Reduction Strategy
- GHG inventory

Greenhouse Gas Inventory:

MIT has completed its greenhouse gas inventory to measure and track the future reduction in emissions. With its goal to reduce the emissions by 32 percent by 2030, MIT is using its greenhouse gas inventory to develop its carbon strategy. The inventory measures the carbon footprint of the univeristy using the Greenhouse Gas Protocal developed by World Resource Institute (MRI) and World Business Council on Sustainable Development (WBCSD). This protocol sets standards for measuring, managing and reporting the emissions. The caculations are performed using the Campus Carbon Calculator which is based on the above protocol.

Six Greenhouse Gases are measured:

- Carbon dioxide
- Methane
- Nitrous Oxide
- Hydro fluorocarbons
- Sulphur Hexa fluoride
- Perfluorocarbons

Sustainability workplace certification:

This program is developed for encouraging individual responsibility in implementing the carbon strategy and various practises to make their own workspace more sustainable. These practices and recommendations are provided using short handouts for things like energy, procurement, waste management, etcetera. Based on the performance of the employee/student, the work place is certified depending on a checklist of things.

Mobility Initiatives:

- Free and unrestricted usage of Subways for MIT faculty and staff with MIT pass
- 50-60% commuter rail subsidy for students, faculty, and staff
- Ride sharing initiatives:
  - Carpool – employees sharing the vehicle
  - Zipcar – emergency car use
  - Vanpool – hire an enterprise for shared shuttles

Energy Initiatives:

- Capital projects (new construction and major renovation)
- Lighting upgrades
- Building retro-commissioning
- Mechanical system improvements
- Utility distribution system insulation
- Building continuous commissioning (MBCx)
- Equipment replacement incentives

Summary of MIT Greenhouse Gas reduction plan:

		Contribution to Overall Reduction Objective			
Mitigation Strategy	Current Working Scenario Contribution to 2030 GHG Reduction Goal	I. Reducing energy use	II. Reducing the use of fossil fuels	III. Increasing the use of renewable energy	IV. Minimizing fugitive emissions
Investments in Building Energy Efficiency and Operations					
Existing Building Energy Efficiency Measures	5%	Yes	Yes	No	No
Commissioning/Re-commissioning Processes	1.5%	Yes	Yes	No	No
Operational Strategy Improvements	6%	Yes	Yes	No	No
Utilities Distribution Improvements	1.5%	Yes	Yes	No	No
New Campus Growth	-10%	No	No	No	No
Central Utility Plant Upgrade Project	10%	Yes	Yes	No	No
On-Site Renewable Energy	1%+	No	Yes	Yes	No
Off-Site Renewable Energy	17% +	No	Yes	Yes	No
Other Strategies: Fugitive Emissions, Fleet, Leased Space	<1%	Yes	Yes	No	Yes
TOTAL	32% or more				

STRATEGIES:

Building strategies:

- Achieve LEED v4 Gold Certification for all new construction and major renovation projects on campus
- Meet the energy efficiency goals outlined in the Stretch Energy Code set forth by the City of Cambridge
- Engage in an integrated design process to benefit from the expertise of diverse stakeholders
- Optimise every aspect of every project to improve performance and find productive intersections
- Learn from each project, apply those lessons to future work, and share what we've learned with the campus and the wider world
- Create greener labs that minimise energy and water use, reduce waste, and minimise hazardous materials where possible

Energy strategies:

- Scale up campus-wide investments in energy efficiency across existing buildings while investing in new construction that maximises performance
- Reduce our baseline emissions by 10 percent by replacing our combined heat and power system and making upgrades to the utility distribution systems
- Invest in renewable energy systems on campus and off—the purchase of solar energy equivalent to 40 percent of our present electricity use will neutralise emissions by 17 percent
- Create living labs that leverage faculty and student research, improve operations, identify new energy strategies, and promote community adoption and investment in sustainability efforts

Mobility strategies:

- Expand the use of alternative fuels in MIT vehicles, optimise vehicle sizes, and improve transit routes and scheduling
- Research and apply greenhouse gas management strategies and data collections to MIT's transportation practices
- Advance an integrated transit system that encourages the use of public transportation, ride sharing, and non-motorised transport
- Promote active modes of commuting, such as walking and biking
- Optimise the connectivity among different modes of transport—hub-way, subway, shuttles, walking, and bike paths
- Promote the use of low-emission and zero-emission vehicles
- Collaborate with local cities and towns, the private sector, and social organisations on infrastructure improvements, shared solutions, and public awareness

Procurement strategies:

- Promote use of re-usable goods in place of single-use items
- Develop a visible and accessible online re-use marketplace for surplus materials
- Seek partnerships with our suppliers to promote environmentally preferred products and alternatives
- Develop guidelines for purchasing materials that are made from renewable resources
- Evaluate and factor in the lifecycle of materials during the purchasing process
- Purchase materials that are less toxic and made from renewable resources, contributing to a safer workplace
- Collaborate across departments to purchase in bulk, reducing energy use in the delivery of goods
- Support local economies and women- and minority-owned businesses

Campus Sustainability Incubator Fund

This fund is mainly developed for providing financial assistance to members of the MIT community to test their ideas using MIT campus as a test bed or living lab. This includes ideas for sustainable operations, management and design. The funds are as follows;

1. MIT Clean Energy Prize
2. MIT IDEAS Global Challenge
3. MIT Water Innovation Prize

HARVARD UNIVERSITY

Harvard university is one of the front runners in contributing to sustainability through its education & research and also campus operations. The main highlights include its governance structure which shows the importance given to sustainability in every aspect of the university. In addition to this, their data hub, reporting activities and guidelines and tip sheets for various activities are some interesting initiatives. This section will summarise few of these initiatives. Harvard has set its climate action goal to be;

"fossil fuel-free by 2050 and fossil fuel-neutral by 2026"

Governance:
The sustainability activities are executed by the Office of Sustainability headed by the Vice President of the university who plays a major role in decision making. The Office of Sustainability connects the various stake holders like students, faculty, staff and sustainability management council.

The sustainability management council comprises of;

- Facility management
- Strategic Procurement
- Campus services
- Information technology
- Planning and project management

Then there is Council of student sustainability leaders, Working groups and committees that work on bottom up initiatives.

Harvard believes in transformational changes all across the organisation with common and bold goals for all departments with strategic action plans using all the resources within their influence. With a data driven approach with regular review of the progress, they try scaling up every small initiative.

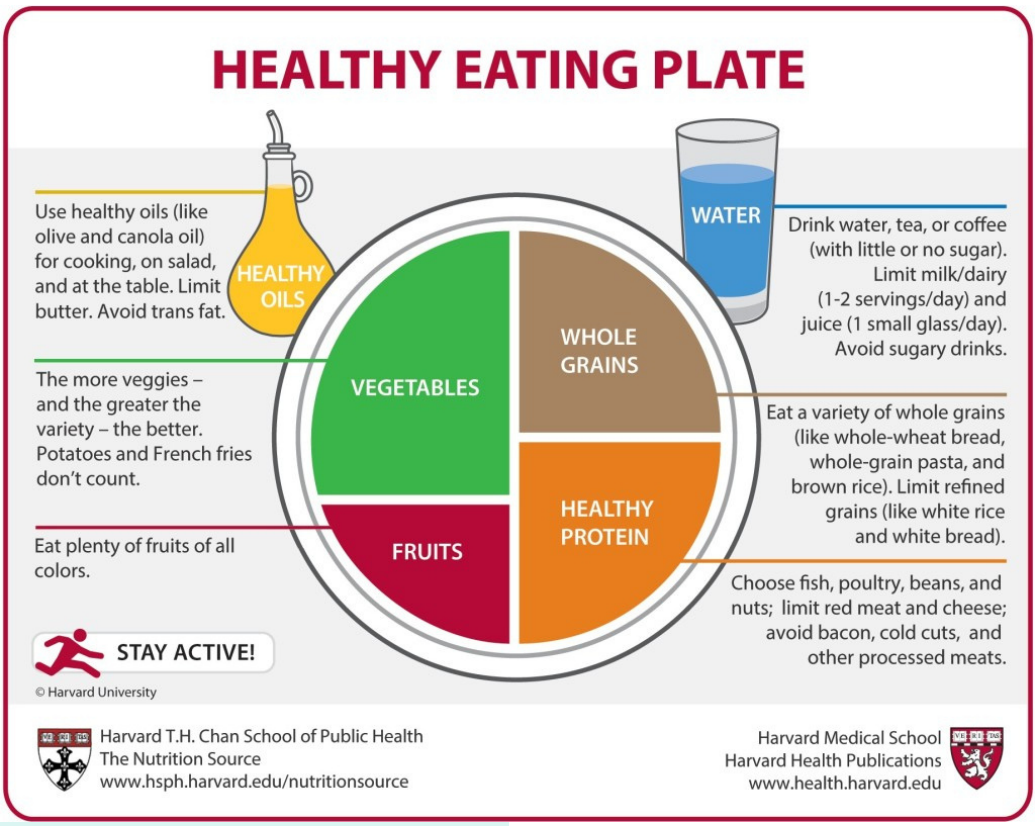
Data and Reporting:

Harvard has set up its Sustainable Data Hub which is an online platform with interactive maps that allows all the stake holders to see the progress the university is making in sustainability. The data includes metrics for energy, waste, water usage and emissions arising from them. Another interesting aspect is the data that os processed is actively being used in various student projects and other research activities. The annual sustainability report is published online and in addition Harvard has commissioned the following documents which can be found in appendix ;

- Harvard university sustainability plan
- Guidelines for sustainable events
- Guidelines for sustainable procurement
- Harvard sustainable food standards

Energy Initiatives:

- Harvard has set up onsite PV plants and solar thermal facilities with a capacity of 2 MW
- Geothermal installations for heating
- The buildings are LEED certified
- New district heating facility which uses efficient low temperature hot water system and a thermal storage tank of 1.3 million gallon for storing chilled water. The facility is a source of heating, cooling and electricity



Food Initiatives:

- Harvard started the food network pilot aimed at reducing the food wastage after events by offering them to the community
- Developed food standards with health and sustainability as primary concerns
- Encouraging farmers markets and community gardens
- Developed the 'menus of change guide' with research into sustainable food concentrating on plant based food, ethnicity, nutrition and sustainable procurement

Harvard seeks the following through its food standards:

1. Align food providers around a shared vision and common set of evidence-based aspirations and principles.

2. Quantify the environmental and health impacts of the campus food system through reporting.

3. Optimize the campus food system for well-being, climate and community.

4. Drive changes in the marketplace through partnerships and by leveraging purchasing power.

5. Enhance food literacy across the Harvard community, and beyond.

They developed the sustainable meeting and event guide for catering which specifies the various menus for different occasions and meals along with information of prices.

Waste treatment Initiatives:

- Organising recycling events for electronics
- Leftovers from events, dining services and restaurants is given to local families via non profits

Mobility Initiatives:

- Transit pass discount of about 50% for eligible employees
- Zimride and Zipcar are carpooling and ride sharing networks used by employees

Ecosystems:

14 Green-roofs are developed to be used for promoting biodiversity, prevent storm water run off and to save energy.

Green Revolving Fund:

This is funding for departments to reduce their environmental impact. Departments can apply for this 12 million dollar loan fund to invest in projects that aim in reducing the carbon foot print of their department. The repayment will be done by the amount saved by this project like operational costs.

LIVINGLAB

Education:

In addition to various master and bachelor programs, Climate solutions living lab is a multi disciplinary course for graduate students with prime focus on developing feasible and scalable projects related to zero fossil use.

Living lab and research:

- Campus sustainability innovation fund to encourage research on developing solutions to fight climate change. Student projects in science, social sciences and humanities $1 million per year for 7 projects with total funding on $7 million
- Sustainable innovation fund of about $700000 to promote testing new technologies for global sustainability challenges on the campus
- Climate leaders program to engage students interested to work on sustainability projects along with annual fair to showcase these projects

STANFORD UNIVERSITY

With a vision to create a healthy environment and more possibilities for future generations, Stanford has committed itself to lead in research, education and practising environmental sustainability. They envision developing solutions for their region and to the world. Stanford's primary goal is to be;

"80 percent carbon neutral by 2025 and zero waste (90 percent diversion from landfill) by 2030"

The Department of Sustainability and Energy Management (SEM) is responsible for the sustainability related initiatives in portfolios like energy & climate, water, transport, waste, dining and building operations. The governing organisation is very structured and ensures participation from all departments and stake holders

Governance:

The Office of Sustainability and Business Services (OOS) in the Department of Sustainability and Energy Management (SEM) is responsible connects the different departments and steers the sustainability initiatives. The sustainability programs focus on seven key areas:

- Infrastructural planning support
- Assessments, evaluations, and reporting
- Business systems
- Conservation programs
- Communications, training, and education
- Collaborative governance
- Envision effectiveness

In addition to this there are Sustainable design teams and working groups. The design teams focus on fundamental and applied research with a faculty team to develop solutions for the region, nation and the world and aims to build Stanford as a living lab. The working groups are responsible for policy making, planning and recommendations for implementing sustainable practices on campus.

Strategy:

Stanford commissioned and developed Sustainability 3.0, a strategy report for the future of sustainability. The strategies quoted in Sustainability 3.0 are:

- Ensure that sustainability is a top and lasting priority for Stanford University in research, teaching, and action.
- Establish clear policies for implementing sustainability in every part of campus: implement, monitor, and achieve.
- Educate and train the Stanford community to work towards sustainability goals and build a fully committed and engaged community.
- Reach beyond Stanford. Influence sustainability research, education, and action beyond the university.

Areas of work & Achievements:

a. Infrastructural support and planning:

1. Develop long term plans to improve the campus operations and infrastructure
2. Planning of Sustainable Energy System Innovation (SESI) project
3. Developing a Zero waste plan and feasibility study to support efforts in reaching 90% waste reduction target
4. Responsible purchasing guidelines

b. Assessment, Evaluation and Reporting:

1. Annual GHG emissions inventory as a primary indicator of sustainability performance
2. Involving the campus community through Cardinal Green Office and Green Labs
3. Data driven approach with in-house sustainable building rating system to evaluate
4. Sustainability review reports from 2008
5. Energy and Climate action plan : first, second and third addition in 2009, 2013 and 2015 respectively
6. Zero waste by 2030 plan
7. Guides and fact sheets for various initiatives

c. Conservation campaigns:

1. Creating awareness and individual action for conserving resources and reducing utility bills
2. My Cardinal Green program launched in 2017 to allow individuals to track their usage and get rewarded for their progress in conserving resources
3. The programs mainly aims towards behaviour changes of the stake holders

d. Business systems:

1. This initiative mainly addresses the integration of data from various utilities and managing the resources efficiently.
2. Aims to improve the business process by a data driven approach and offers analytical tools to optimise efficiency of the campus operations.

e. Communication, training and education:

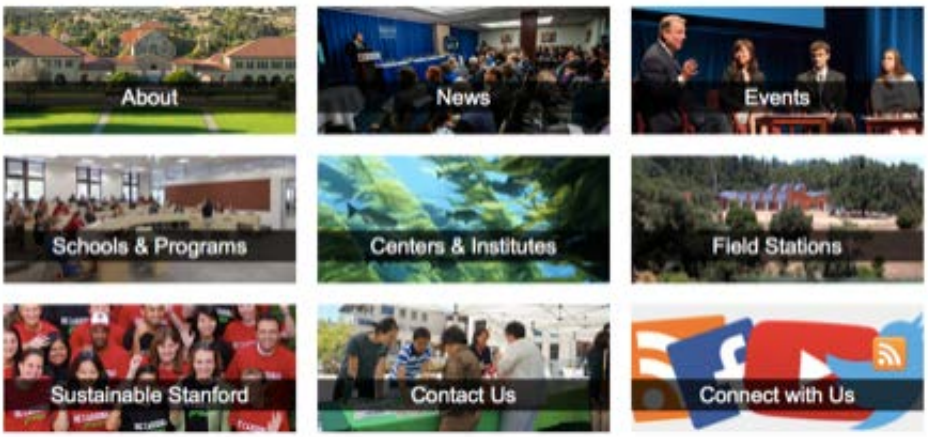
1. Managing the sustainability website that serves as the main source of information about all the initiatives and their progress
2. Cardinal Green newsletters

f. Collaborative governance:

1. The administrative departments, faculties and students are well integrated and support in Stanford's mission towards sustainability in education, research and outreach
2. Each department contributes to the common goals and the Office of Sustainability ensures and benefits from this framework

g. Organisational effectiveness:

The Sustainability and Energy Management (SEM) department ensures the organisational effectiveness in collaborating and integrating various sustainability initiatives and services on campus.



Education and Research:

Stanford offers many study programs and research projects related to sustainability. Some of these interdisciplinary programs are;

- Emmett Interdisciplinary Program in Environment and Resources (E-IPER)
- Global Climate and Energy Project (GCEP)
- Precourt Institute for Energy (PIE)

The main highlight is the environmental portal which is a home for all the information related to various educational and research activities concerning sustainability in Stanford. It gives the information about different schools and their programs, research centres, environmental events and stories. It holds a repository about everything related to sustainability in Stanford.

Operations:

Stanford prioritises the availability of data and analytical approach to decision making. For this they set up monitoring systems and dashboards to track the performance of various utilities shown in figure...

Energy Initiatives:

Stanford aims to use 100% renewable energy by 2021
Energy conservation incentives program to reward those who save energy.
Winter closure which mandates shutting off the energy use during the two week winter vacation
Integrated controls and analytics project focusing on central control systems which is saving 40% of energy annually since 2018

- Lab air flow management to reduce the frequency of air changes in the labs during unused hours
- Stanford Energy System innovation (SESI) comissioned in 2015. This system along with the solar power has reduced the emissions by about 72% from peak levels and saved 18% of the water.
- Guidelines issued for future buildings, for sustainable IT infrastructure, energy saving measures in work stations.

Building Initiatives:

All the buildings are annually evaluated for sustainability ratings and new measures are taken. The occupants are rewarded if conservation methods are implemented effectively.

Some of these measures include:

- Installing smart power strips for computer equipment
- Following sustainable purchasing guidelines (appendix)
- Training and certification sustainable office space
- LEED certified buildings
- Sustainable demolition

Food Initiatives:

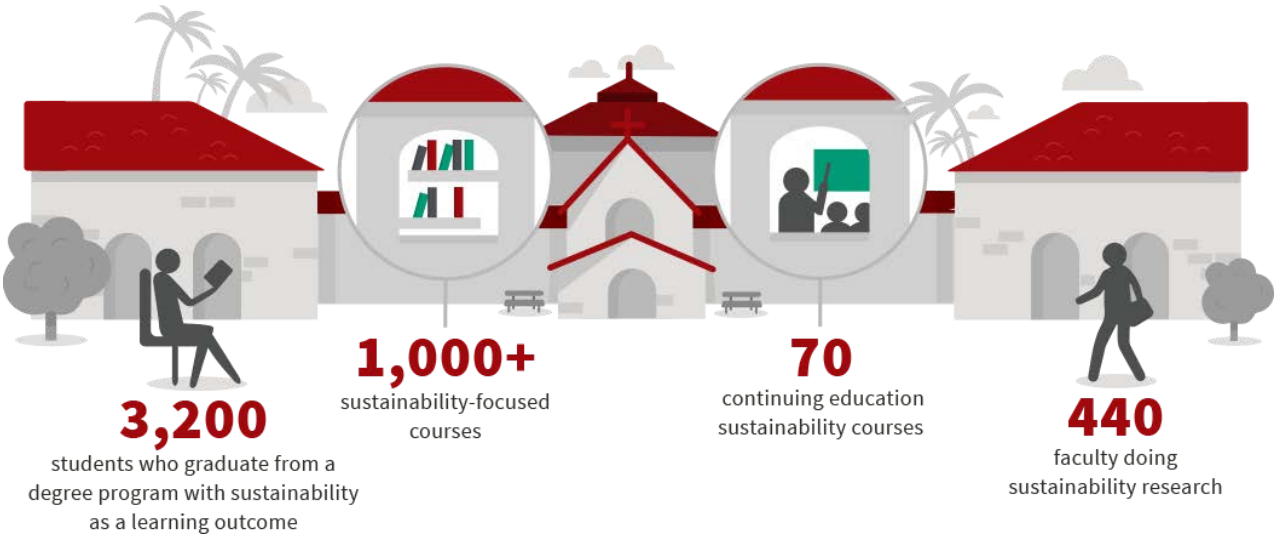
- Education & research on making better food choices during their time at Stanford
- Sustainable food purchasing guidelines called Sustainable food ethos
- Purchasing from local farm partners
- Zero food wastage by reducing waste, donating food, composts and recycling when ever possible
- Monitoring systems in all dining halls to keep track of food waste

Waste management Initiatives:

- Performed a zero waste feasibility study to achieve the target of sending only 10% of the waste to the landfills
- Desk-side paper recycling and mini–trash can program
- 122 compost collection points funded by different departments
- 450 people working on the campus are trained in waste sorting , recycling and composting practises through waste reduction classes
- Stanford Surplus Sales' furniture reutilisation program, aimed at collecting and selling unwanted furniture. This program processed 118 tones of electronic waste in 2018.

Reports and guides:

- Yearly sustainability report
- Sustainability 3.0
- Energy and Climate action plan 2015
- Zero waste sustainability report
- Stanford sustainable guidelines
- Some of the guides issued include;
  - Responsible procurement
  - Workstation energy saving
  - Use of smart strips
  - Improving printer efficiency
  - Zero waste
  - Green Events



Source: Stanford University [16]

KU LEUVEN

With three values of creating value for stakeholders, social cohesion and good management, KU Leuven aims for;

"becoming sustainable and carbon neutral by 2050"

The sustainability related initiatives are headed by the Vice rector and the university's strategic plan entitles, "On crossroads, for a sustainable society" and is based on five themes;

- Truly international
- Future-oriented education
- Going Digital
- Interdisciplinary
- Sustainability

KU Leuven aims for sustainable management and a commitment to United Nations Sustainable Development Goals in both research and education

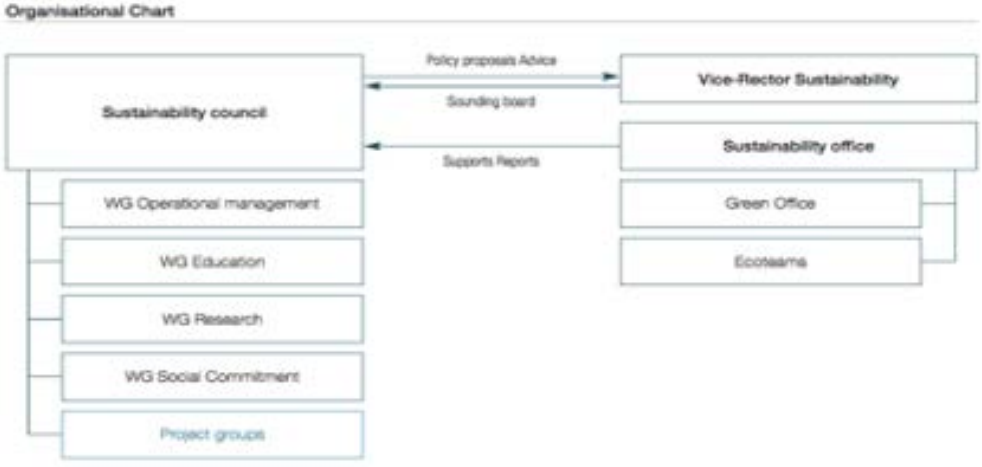
Sustainability policy:

The university aims to aligh UN SDGs in education, research, management and societal engagements. The policy outlines five targets;

- KU Leuven considers sustainability as one of its core values.
- KU Leuven strives to become a CO2-neutral university, and in the coming years will continue to focus on reducing greenhouse gas emissions and combating global warming by setting a good example in its own business operations.
- KU Leuven integrates sustainability into its various study programs, so that all students acquire the knowledge and skills needed to foster sustainable development.
- KU Leuven encourages leading and high-end interdisciplinary research for and regarding sustainability.
- KU Leuven actively interacts with society, and makes a commitment to help it in the search for sustainable solutions and shape the transition to a sustainable society at the local, regional, and international level.

Governance:

Sustainability Council: Governance structure dedicated to sustainability and is assisted by 4 working groups. Responsible for preparing and implementing sustainability policies at KU Leuven.



Working groups: Groups that work on education, research, management and societal engagements

Green Office: Student initiative which aims to inform, inspire and encourage students to participate in the subject of sustainability. The office has 10 working groups working on various subjects

Achievements of Green Office:

- Installation of water taps
- Distributed 5000 reusable bottles
- 1118 broken phones collected
- 312 trees planted
- Supporting living lab thesis projects
- Established repair hub

Ecoteams: This is an employee lead bottom up initiative participate in sustainability related activities. They conduct a Green Impact challenge where teams have a friendly competition to reduce as much emissions as possible.

Education:

KU Leuven's commits to integrating sustainability in education and envisions that;
"A university should offer students the necessary knowledge and skills, not just to be able to be a successful individual in a complex society, but also to be able to help build a more sustainable and global society."

The working group on education is further developing this vision and its implementation plan.

The KU Leuven Sustainable Education Network was created to form a netrwork of teachers who come together to discuss how to integrate sustainability in education.

The university offers 8 Masters' and 229 courses which are explicitly related to sustainability.

Also, a Honours program with transdisciplinary insights is offered focusing and promoting sustainability.

The Green Office and Young Research Society facilitates thesis projects for master students in topics related to sustainability.

Sustainability in innovation and entrepreneurship is also a major focus.

Research:

Leuven Sustainable Earth (LSUE) is an inter and trans disciplinary expertise centre in the area of sustainability at KU Leuven

Sustainability related research in KU Leuven varies from technical subjects like energy , architecture to social subjects like equality , justice and welfare. Few of these projects are;

LIVING LAB: BUILDING CARE AND ENERGY OPTIMIZATION IN HISTORICAL RESIDENTIAL AREAS

URBANISM AND LANDSCAPE APPROACHES FOR SUSTAINABLE CLIMATE CHANGE ADAPTATION IN RAPIDLY DEVELOPING CITIES

SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES TO BENEFIT THE LOCAL COMMUNITIES OF NORTHERN TANZANIA

EQUITY, EQUALITY OR NEED? PUBLIC OPINION ON DISTRIBUTIVE JUSTIC IN THE CHANGING WELFARE STATE

Carbon footprint:

KU Leuven has started various initiatives in areas like energy, waste, mobility and food.

Energy:

The management team is working together with academic and research experts at the university for the energy transition projects. The university is aiming for complete green energy, replacement of old heating systems and systematic refurbishing of old buildings. They are also working on increasing the energy efficiency of laboratories.

Waste:

- General “household” waste, PMD, and paper is collected separately but whereas glass, metal, wood, styrofoam, and electronic waste needs to be deposited at designated places near every building
- Developed a website for students and staff to find information related to the use of sustainable materials and waste management at KU Leuven
- Website for reusable goods
- Sustainability is explicitly integrated as a criteria for procurement
- Digital pay slips
- Reusable plastic cups for event

Mobility:

- Sustainable travel policy focusing on taking train instead of flying and offsetting CO2 emissions when flying is unavoidable.
- Wednesday Bike Day
- Car Free Day
- Reimbursing travel in public transpot and offering free transport to staff

ETH ZURICH

ETH Zurich has been very engaging in sustainability related initiatives and has four fields of action for sustainable development. These include education, research, campus and dialog. The university can be mainly acclaimed and can inspire with their commitments towards sustainable buildings, energy, reducing business travel and for actively advocating gender equality.

ETH has set 41 goals across 15 different categories related to environmental subjects like energy, mobility waste, etcetera to achieve sustainable development. Few of these goals are;

- Strengthen collaboration of engineering and natural science disciplines with the humanities and social and management sciences in fields relevant for sustainable development
- Offer a diverse summer and winter school programme on sustainable development at ETH Zurich
- Offer innovative activities and events for students and other members of ETH Zurich to learn about sustainability
- Develop an overview that describes cross-departmental sustainability and critical thinking-related educational activities at ETH Zurich
- Preserve diversity among students and staff of ETH Zurich
- Increase gender balance on all levels of the academic career
- Implement MINERGIE®-ECO standard (or similar) in new buildings and MINERGIE® standard (or similar) for renovations
- By 2025, 50 percent of the total heating requirements on Campus Zentrum (incl. external consumers) will be covered by waste heat.
- Implement first phase of “Masterplan Energy” at Campus Zentrum
- Reduce direct CO2 emissions on Campus Hönggerberg by 50 percent by 2020 (4,600 t CO2eq per year) through the implementation of the “Energy Concept Campus Hönggerberg” based on geothermal storage systems (base year 2006)
- Development of recommendations for catering companies to reduce packaging and advance the substitution of disposable dishes with reusable dishes

Management:

ETH Sustainability department which reports directly to the vice president of the university supports all the initiatives, projects and individuals working towards sustainability

The unit is directed by a Steering Committee comprising the Associate Vice President for Sustainability (Chair), the Vice President for Research and Corporate Relations, and six ETH Zurich professors who conduct research in fields related to sustainability.

SSHE: Security, safety and health. Advices and trains people on how to deal with risks and hazards in dealing with people, infrastructure and the environment.

Environmental commission of ETH Zurich is responsible for environmental management at ETH Zurich

Real Estate Management develops and manages the university's real estate portfolio.

SSC – Student Sustainability Commission: Student initiative to promote sustainability. It represents the student interests in sustainability activities to the Executive board and the other bodies.

Global engagement and reporting:

The Sustainability report 2017/18 of ETH is prepared in accordance with the Global Reporting Initiative (GRI) standards and the ISCN sustainable campus charter. The report received the Swiss ethics award for the sustainability reporting.

ETH has international partners and is an active participant in global alliances like;

International Alliance of Research Universities (IARU)
International Sustainable Campus Network (ISCN)
Global University Leaders Forum (GULF)
World Economic Forum (WEF)

Education:

Master programs like Sustainable water resources, Development and Cooperation and Integrated Building Systems focus mainly on sustainability.

ETH Sustainability Week is organised to give students the opportunity to analyse and reflect important societal problems.

ETH Sustainability summer/Winter School offer students the opportunity to work on current topics related to sustainability in interdisciplinary and intercultural teams.

NADEL: Center for Development and Cooperation

Was setup in 1960, and from then on NADEL has been preparing the graduates of ETH to get experience and learn how to solve problems with a focus on sustainable development. The SDGS focused are poverty reduction, quality education, reducing inequalities and partnerships. This program gives a hands on experience with the theory and practice of sustainable development.

Research:

Among the 8 Competence centres, four of them are actively involved in sustainable development research. Some important areas of work are;

- Energy: New materials for sustainable, low-cost batteries
- Climate systems: Increasing model resolution
- Future Cities: Cooling Singapore

Virtual conferencing:

Noting the emissions arising from conference tourism of the universities, ETH Zurich's sustainability team and University of Zurich under the patronage of International Alliance of Research Universities (IARU), have conducted a virtual conference on 'University Air Miles Reduction'. This conference was a proof of concept to avoid emissions from conference travels. ETH is now improving its facilities for video conferencing with best in class systems.

Campus:

Engagement: ETH has been actively involved in bridging the gender gaps and promoting opportunities for women. The university quotes;

" Representation matters: Visibility is key to improving gender equality"

Gender Action Plan (2014): Adopted by the executive board to achieve higher participation from women in all the academic levels. It aims to enable men and women to unfold their full and true potential. The GAP has four main focus points;

- Careers and career development within academia
- Integration of gender-specific aspects in research and education
- Reconciliation of studies, work, and family
- Prevention of and combat against sexual harassment and discrimination on the basis of gender.

Gender monitoring:

This initiative by the Office for Equal Opportunities of ETH Zurich reports the development of women in various departments with a focus on specific themes like "Women as Role Models" (2017/2018) and "The visibility of women in scientific research at ETH Zurich" (2016/2017)

Emissions:

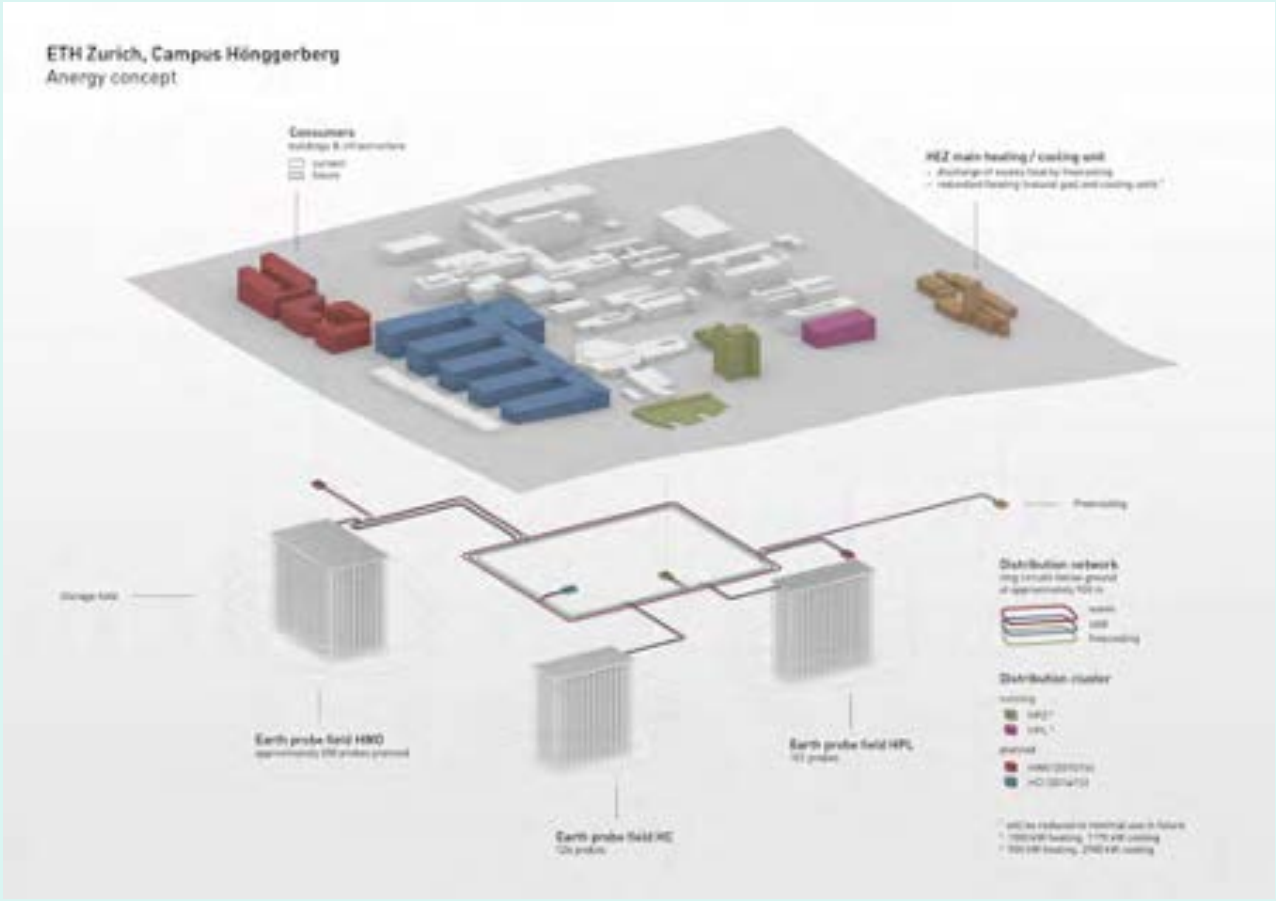
The monitoring of emissions is based on the guidelines of Greenhouse Gas Protocol. And this includes emissions from operations, electricity purchased, business travel, etc.

Buildings:

- MINERGIE®-ECO for new buildings and MINERGIE® standards for renovations
- SGNI sustainability standard is implemented for laboratory buildings.
- Life cycle analysis for every major investment projects and assets and for energy usage. The calculations are repeated and monitored regularly to check the progress.

Energy:

- All electricity being consumed from 2016 is sourced from renewables
- Anergy grid, an underground storage system being build to reduce the emissions from heating and cooling.



- The project aims to decrease the CO2 emissions from an initial value of 9,200 t CO2eq per year (baseline 2006) to 4,600 t CO2eq per year

Mobility:

A mobility platform aimed at providing information about how can the stakeholders reduce their emissions. Provides active support for air travel project, public transport, bike sharing and e-mobility. Currently half of the emissions are due to air travel and goal set to decrease this by 11 percent from average of 2016-2018 levels.

Food:

- Developed criteria for assessing climate friendliness of the dish.
- Reduce packaging and substitution of disposable dishes with reusable dishes
- ETH Climate program for gastronomy was launched to encourage all the caterers to reduce their emissions by 10 percent in a period of three years.

Waste:

- Divert as much of the waste from mainstream disposal into recycling streams.
- Providing infrastructure for collecting biogenic waste and use for energy generation.
- Recycled paper increased from 11.3 million A4 to 29.5 million A4 sheets.
- Increase in environmental awareness, double sided printing and use of electronic devices.

KTH ROYAL INSTITUTE OF TECHNOLOGY

The university developed a Sustainable Development Policy with the following commitments;

- Integrate ecological, economic and social sustainability at all levels of strategic and operational activities.
- Have an identity and brand associated with sustainable development.
- Be characterised by openness, democracy and respect for equality and equal living conditions.
- Provide education of the highest quality that prepares future professionals with knowledge, commitment, critical thinking and practical tools that will enable them to contribute to a sustainable society.
- Produce research of the highest quality that contributes to sustainable and innovative solutions to societal challenges.
- Create value by disseminating and supporting the implementation of technology, methods and approaches as well as actively participate in public debate in order to contribute to sustainable development.
- Systematically work for the continual improvement of KTH:s environmental and sustainability performance.
- Take preventative measures with the intention to protect the environment and prevent environmental impacts from KTH:s operations.
- Comply with applicable legal requirements and other requirements that the organisation is subject to.
- Encourage, educate and create conditions for staff and students to contribute to sustainable development within and outside KTH.
- Work with partners that contribute to a sustainable development and promote sustainable development in collaboration with local and global actors.

Education:

Masters like Environmental Pathways for Sustainable Energy Systems (SELECT) is offered in collaboration with five European Universities is very acclaimed.

The university offers special courses on sustainability in ICT like:

- Sustainability and Media Technology - to understand how today's development and use of media and information and communication technologies (ICT) have both positive and negative effects on sustainability

- Sustainable Information and Communication Technology (ICT) in Practice - critically value/evaluate projects in terms of ecological, social and economic sustainability, and describe how ICT organisations work with sustainability-related questions today.

Also, annual courses and workshops for are organised for teachers to learn about sustainable development. Topics like life cycle perspectives, material selection and sustainable business models are covered.

Collaborations:

In addition to the various initiatives and the progress being made in sustainable development, the university aims to convey to the world that KTH is a leading university in sustainability through communication, dialogue and collaboration with surrounding society.

KTH is also a part of various international sustainable development related initiatives like;

- SDSN-NE
- The Nordic network NUAS
- The international network ISCN for sustainable campuses. KTH also hosted the ISCN annual conference

Campus operations:

Few of the important goals set by KTH for building a sustainable campus are:

- KTH's energy use shall be reduced by 10% (electricity, district heating, cooling) per annual work units, full-time equivalent student and per square metre.
- The highest possible environmental performance shall be pursued in new construction and reconstruction.
- KTH shall increase knowledge of, and have safe and well-functioning processing of dangerous waste.
- Opportunities for waste sorting into relevant waste categories shall exist throughout KTH, the amount of waste shall decrease per person and the proportion of sorted waste collection shall increase

Initiatives taken to improve the operations:

- Research projects on reducing food waste from restaurants
- Grants for projects on shared bicycles
- Bike day
- Demand controlled lighting and ventilation
- Sleep mode on computers & monitors and switching off projectors automatically when not in use
- Educating the staff about travel free meetings through manuals and videos
- Interviews with people who had highest official travel
- Investigating into setting up a 'Climate fund'

WAGENINGEN UNIVERSITY & RESEARCH

Wageningen University & Research's (WUR) is constantly ranked as one of the most sustainable university (SustainaBul, Green Metric and THE). The university publishes their progress annually showing their achievements and future plans. WUR values Corporate Social Responsibility (CSR) activities and focuses on six areas of energy, waste, construction, catering , procurement and mobility.

The Annual report structures the following;

- Environmental impact over the previous year.
- Measures and studies taken up or modified to further reduce the emissions.
- New additions to the environmental policy
- Incidents and significant disruptions and complaints about sustainability issues and how they have been solved

The carbon emission inventory is carried out in accordance with ISO 14064-1:2006 (E), 'Quantification and reporting of greenhouse gas emissions and removals,' which was based on the Greenhouse Gas Protocol

Achievements in2018:

- 48% reduction in the carbon footprint compared with 2010.
- The minimum annual reduction target for energy consumption is 2%. In 2018, there was a 2.2%
- A total of 677,052 GJ of energy was sustainably generated, of which 563,100 GJ was wind energy (more than 62 million kWh).
- Water consumption was reduced by 10.4% compared with the previous year.
- Following a significant increase in the amount of waste in 2016, the amount of waste produced practically remained the same (-0.2%) in this reporting year
- The Pianoo criteria for sustainable purchasing were used for 97% of purchasing processes.

Education and Research:

Almost all the courses and research activities in WUR are linked to sustainability in connection with one of the 17 SDGs.

Energy & IT:

The WUR 2030 Energy vision outlines 3 strategies for energy efficiency;
1. Reducing energy consumption
2. Generating sustainable energy
3. Compensating for CO2 emissions.

- Currently 100 percent of the electricity is purchased from the CertiQ-certified green wind and bio fuels are being used to run the CHP plants for heating purposes
- Warm Sweater Week: Encouraging students and staff to wear warmer clothes and thereby reduce the usage of centralised heating. Purportedly resulted in a 10% reduction on the normal energy use in the buildings where it was implemented in 2018.

Waste :

Recognised 3 waste flows, industrial waste, paper waste and hazardous waste and prioritising the most environment friendly processes for waste treatment.

- 96% of the waste is used in some other new application
- 44 percent is recycled and 52 percent is useful applications
- Students have performed a MFA to get an idea of material flows

Catering:

- Weekly opportunities for students to prepare and sell vegan/vegetarian meals (retaining the entire revenue)
- This encourages students to get involved with their and their peers' food choices while also avoiding extensive negotiations with catering companies.
- Previous initiatives include Meatless Mondays as well as discounts on reused cups
- Caterers use regional products and purchase at least 40 percent from non-GMO organic farms
- Sustainable packaging material should be used as much as possible· The waste needs to be separated at the source·

Mobility:

- Use of public transport with in Netherlands is encouraged and employees could use NS business cards
- Public transport is advised for visiting nearby destinations in Europe
- Encouraging the use of video conferencing to save travel time and the emissions

Purchasing:

- WUR developed its own purchasing policy in accordance with the sustainability criteria mentioned in the Pianoo.nl. This includes procurement of construction materials, coffee cups, cleaning and etcetera.
- Encourage purchasing from regional suppliers. WUR follows the Responsible Innovation (MVI) growth model

Green Office initiatives:

- Warm sweater week
- Green teacher awards
- Conscious consuming week
- Workshops on Entrepreneurship for sustainability
- Student cooking corner
- Collect, fix and share
- Developed a check list for organising sustainable events at WUR

TU EINDHOVEN

With its motto of 'Practise what you preach,' TU Eindhoven has a comprehensive approach to sustainability with focus on education, research and campus operations.

Vision as stated by the university:

Education:

TU/e educates tomorrow's engineers. They are aware of the challenges we face worldwide. This is why TU/e strives to include sustainability in the curriculum of every study program. In addition, TU/e provides courses at Bachelor's, Master's and PDEng level with a special focus on sustainability.

Research:

Sustainability enjoys an important position in the research conducted at TU/e. There are three specific areas on which TU/e focuses its attention: Energy, Smart Mobility and Health. As an experimental garden for sustainable innovation, TU/e uses its campus for research ('Living Labs') in the area of sustainability.

TU/e campus:

The TU/e campus is green and sustainable. Our buildings are heated and cooled by means of one of the biggest Aquifer Thermal Energy Storage (ATES) installations of Europe. For new buildings and renovation, sustainability is an essential requirement.

Our internal operational management gives maximum consideration to Planet, Profit, People. Besides, the TU/e campus is green and leaves ample space for pedestrians and cyclists.

Education and Research:

- Bachelors: courses and certificates focused on sustainable design·
- Masters: electives can be chosen in sustainability·
- Research: Living Lab is a domain of research focused on the sustainability of the campus itself. Researchers can therefore use the campus for experiments, for example in lighting or mobility

Buildings:

- Aquifer Thermal Energy Storage (ATES) is used in combination with a control system so that the buildings are intelligently cooled and heated. This has removed the need for boilers in 70% of the TU/e buildings.
- Growing independence from gas. Presently, three buildings have no gas connections
- BREEM measurement standards for ongoing constructions and future projects

Energy:

- 'Greening' sources of energy using either Guarantees of Origin or afforestation projects.

- In 2015, the campus became climate neutral with all electricity and gas use being totally greened.
- Would like to be energy neutral and generate half of the energy by itself by 2030
- The university will be following the NEN-EN 16001 standard for energy management. This standard specifies the requirements for organisation, implementation, maintenance and improvement of an energy management system

Waste·

- Waste bins with 6 streams; paper, paper cups, compostable, carton, plastics, rest·
- Other waste streams (wood, glass, scraps etc.) are sorted at a recycling centre·
- Caterer separates waste streams as well, including oils and swill

Procurement:

In general, Netherlands Enterprise Agency (RVO) policies are applied to purchases, for example:·

- Paper: must have EU Ecolabel, contribute to sustainable forest management
- Vending machines: coffee must have a Rainforest Alliance hallmark

Caterer:

- Caterer Eurest prevents waste by not only responding to demand, but residue processing and discharging waste through a separate stream so it is then fed to pigs ('swill')
- Offer 'festival cups' - reusable hard-plastic cups that event organisers can borrow for free. Lost cups cost €1. Since the beginning of 2018, 25 events in the country have used these cups

Events and contests:

Event certification – event organisers can apply to the Green Office to be certified at different levels of sustainability depending on which actions they are willing to undertake. The event can then advertise this, and the Green Office will feature the event on its website.

- Numerous one-off events (often in collaboration with Studium Generale) which create awareness and enthusiasm about sustainability amongst students, e.g. zero-waste workshop, Q+A marketplace, healthy/environmentally friendly recipes.·
- E-waste competition, print-less contests, student house energy race contests used again to create enthusiasm about sustainability issues.

Mobility:

- Promoting the use of NS Business cards for travel within Netherlands and in Europe
- University's vehicle fleet to be fully electric by 2025

- In 2015, the campus became climate neutral with all electricity and gas use being totally greened.
- Would like to be energy neutral and generate half of the energy by itself by 2030
- The university will be following the NEN-EN 16001 standard for energy management. This standard specifies the requirements for organisation, implementation, maintenance and improvement of an energy management system

Waste·

- Waste bins with 6 streams; paper, paper cups, compostable, carton, plastics, rest·
- Other waste streams (wood, glass, scraps etc.) are sorted at a recycling centre·
- Caterer separates waste streams as well, including oils and swill

Procurement:

In general, Netherlands Enterprise Agency (RVO) policies are applied to purchases, for example:·

- Paper: must have EU Ecolabel, contribute to sustainable forest management
- Vending machines: coffee must have a Rainforest Alliance hallmark

Caterer:

- Caterer Eurest prevents waste by not only responding to demand, but residue processing and discharging waste through a separate stream so it is then fed to pigs ('swill')
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Mobility:

- Promoting the use of NS Business cards for travel within Netherlands and in Europe
- University's vehicle fleet to be fully electric by 2025

UNIVERSITY OF OXFORD

The University of Oxford focuses strongly on the issue of Environmental sustainability, considering it as one of the most pressing concerns of the society of today.The university works with the motto;

'Changing behaviour for the better'

The university has its own Environmental Sustainability Team, consisting of 13 individuals (employees of the university), who sit within Estates Services, one of the central administrative departments of the university.

Strategies & Policies:

- The university aims to reduce CO2 emissions by 50% within 2030
- University seeks to reduce waste production by reusing and recycling.
- The volume of water used is reduced by using more efficient flushing mechanisms including 'greywater' where freshwater is unnecessary.
- Furthermore, the university has started to encourage staff to use more video conferencing rather than travel to reduce emissions from vehicles.

The policies related to sustainability in the university are renewed every year, underlining the need for efficient use of university space, switching to sustainable design and refurbishments, promoting the research within the university about the environment and planet and bolstering local initiatives.

Reporting:

Despite having more buildings and population, the university has managed to reduce its carbon emissions per square meter in recent years.

Annually, the progress is reported in the annual environmental sustainability review which showcases the performance of the institution in areas of energy usage, carbon management, water management, sustainable travel, biodiversity, research, education and knowledge.

Furthermore, as an active member of the International Sustainability Campus Network (ISCN), the university also produces an annual Charter Report about this progress.

Initiatives:

- The University of Oxford encourages staff and students to take sustainable transport means while coming to or going from the university. Recently, the university has started to provide a new shuttle bus linking most of its scientific sites.

- The university engages in sustainable procurement, recycling schemes and efficient management of energy, water and wate in all the departments.
- The university has recently started to transition towards designing more building according to the Passivhaus 'green' standard. Passivhaus is at the cutting edge of low energy design. The Hub, consisting of the university Common Room and the Hub Café, is the university's first Passivhaus certified building, supported by an eco-friendly philosophy. Most of the packaging used here is compostable. Furthermore, the coffee comes from a local coffee company, the Jericho Coffee Traders, who support coffee growing farms in Africa and South America. Most of the ingredients here are locally sourced and most products consist of biodegradable packing.
- The university has a 'Green Impact' environmental accreditation scheme whereby the colleagues can work together to complete a set of green objectives, upon successful completion of which, they receive a bronze, silver or gold award at the end of the year. Until date, over 3000 sustainable actions have been realised by over 50 teams in the university.
- The university provides bicycle loans, cycle training and a bike repair facility to encourage green travel for staffs. Furthermore, it funds the cycle maps produced by Cyclox.
- WARPit (Waste Action Reuse Portal) is a website that the university departments use to reuse and recycle unwanted items including furniture, equipment, stationery, accessories, plants and anything you can name.
- Around 30 Oxford Colleges are currently competing in the Student Switch Off energy saving competition run by the National Union of Students, which promotes economical use of electricity and utilities.5. Several courses highlighting the impact, need and techniques of a sustainable mindset and actions are offered by the university.

8. SUSTAINABLE DEVELOPMENT STRATEGY

Sustainability at TU Delft is currently dealt by bottom-up initiatives from students, employees and other stake holders. The year 2019 has seen lot of progress in terms of the commitments towards climate action, with various initiatives supporting it. Starting from the CO_2 roadmap by Prof Andy van den Dobbelsteen [4], campus strategy by Campus Real Estate (CRE) and various operational and social initiatives by GreenTU Delft. Despite the progress made, the bigger ambitions surrounding sustainability cannot be achieved in the required time frame with just bottom-up initiatives. There is a strong need for policies and to streamline the process of reaching the goals.

Presently, there are multiple activities being undertaken by various stakeholders within the university which are definitely contributing to TU Delft's progress towards sustainability. The current report shows the various initiatives that are contributing to sustainability to the best knowledge of the authors. But there could be lot more educational & research activities and other teams within the CRE, Facility management and Finance who are already looking at sustainability within their own portfolio. But there is no common entity to keep track of these activities and to monitor the progress. Hence the authors recognise the need for an organizational structure within the university which can oversee the progress and develop policies which can accelerate the transition towards a sustainable campus.

The necessity of a new organizational structure, need for policies, further research & feasibility studies and ideas to realise the targets are the main focus points of this chapter on sustainable development strategy. GreenTU Delft has been an active participant in pushing bottom-up initiatives for sustainability, one of which is the current report. Based on the evaluation of TU Delft and research on the best performing universities around the world, the authors present possible strategies to realise the commitments made by the university. Some of these ideas depend on the new technologies, some demand financial strength, some need time, specific ideas need more detailed feasibility studies and almost all of them need strong policies set by the university. But in addition to this, every strategy needs commitment to the society and to the planet.

The current report is much more than defining a vision and presenting feasible solutions to build a sustainable campus. It is a beginning that engages the TU Delft community. The students, teachers, employees and the alumni of TU Delft are its true legacy. Only when all these stakeholders understand the value of protecting the

planet and contribute in their own way to build a sustainable world, the university is truly sustainable.
As quoted by Robert Swan, “The greatest threat to our planet is the belief that someone else will save it.” Achieving sustainability is a shared responsibility and the authors believe that the university has a great role of educating the students with these values, scientific facts and with means to achieve it.

In this chapter, the authors Based on the possible strategies mentioned in this report, the authors suggest that these ideas need further feasibility studies to know in detail how it can fit into the TU’s ecosystem and the next phase would be planning and executing these ideas. There are various factors effecting this process and not all ideas can be effectively executed. These factors include:

- Knowledge about the technology
- Infrastructure
- Budget constraints
- National policies
- Social acceptance
- Cultural and behavioural change

Few of the ideas proposed in this report may Not make it past the phase of feasibility study, due to one of the above factors. But with some commitments and cooperation, most of them can be implemented and the results can be observed. The authors would like to give a multi-dimensional approach based on socio-technical solutions to build a sustainable campus. The ideas are supported by scientific references or practical applications elsewhere. As mentioned earlier, this strategy is GreenTU’s perspective to show various possibilities for transitioning to a sustainable university. This report does not imply that TU Delft or any of its departments have committed to implement or take these ideas forward. The further studies and execution of the ideas will be evaluated after the publication of the report by relevant departments of the university and GreenTU Delf

8.1 ORGANIZATIONAL STRATEGY

This section will discuss the organizational changes that are needed to improve the governance of sustainable activities in TU Delft. Currently, the topic of sustainability receives special interest from the Executive Board with Vice Rector as the primary point of contact. Until the year 2019, sustainability was addressed with many bottom-up initiatives, which are being executed in a decentralised manner. The university is lacking a strong governing body that can make decisions, develop policies and coordinate all the aspects of sustainability. A major shift in this was the appointment of Mr Gerrit Kahlman as the Sustainability Coordinator of TU Delft in 2019. Mr kahlman is also in charge of the GreenTU Delft which is the first structured organization working towards sustainability focusing on various portfolios.

During various projects and discussions in the year 2019, it was realised that there are many people working on sustainability within the TU without a common point of reference. For example, CRE started with designing a vison and developing strategies, researches like Prof Andy van den Dobbelsteen has developed the CO2 roadmap and there are many other initiatives taken up by facility management. All the work being done is to promote TU Delft's ambitions towards being a sustainable campus, but the lack of coordination and collective decision making is resulting in loss of information and slow progress of projects. Mr Kahlman has been acting as the common point of reference who brought together different departments under operations and also interacted with the researchers to support the sustainable initiatives. With the momentum in the current projects, the scope of sustainability is going to rise in the coming years. This demands better governance, policies and collective decision making. The four pillars for sustainability Education, Research, Operations and Social Engagement need to be equally represented and should be involved in bringing out the best outcome. This will also improve the efforts towards building a living lab and promoting sustainability in education.

The current report tries to bring together various initiatives and departments within the TU that are working towards sustainability. GreenTU Delft has been an active in initiating sustainability related projects and the members see the need for a better organizational structure from the top down. The authors call for setting up an official Department Of Sustainability (DOS) which will be the responsible party within the TU to address any issue pertaining this topic. This department will be the point of reference to connect the different portfolios and departments and steer the sustainability initiatives. The authors define five main objectives for the Department Of Sustainability:

1. Policy making
2. Feasibility studies and assessments

3. Planning
4. Execution
5. Reporting

Considering the various parties within the TU who are working on this topic, the following governing body could help in structuring the projects and achieving the goals within the timeline.

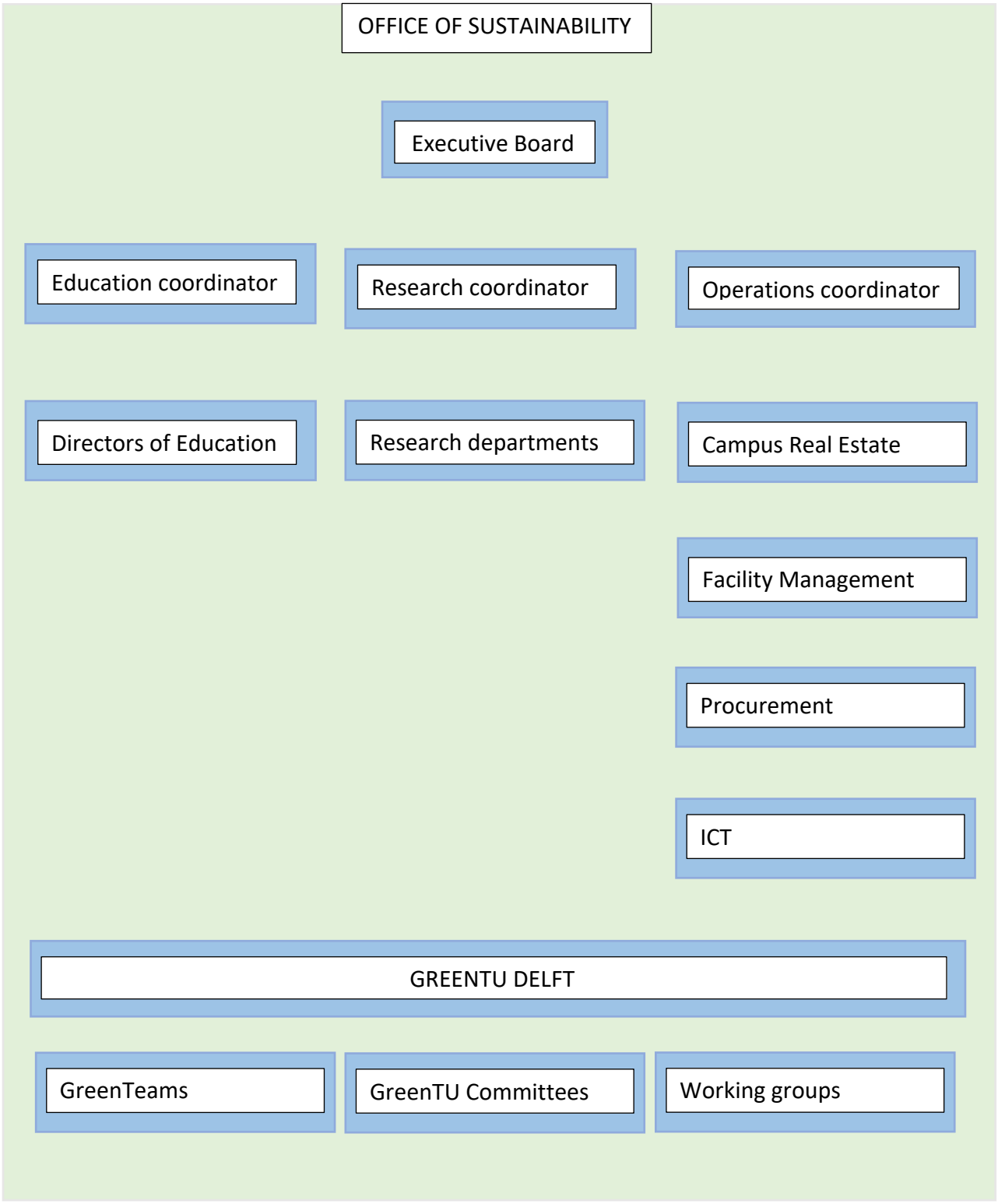
With the Executive Board as the promoter and prime decision maker, the DOS comprises of three sustainability coordinators responsible for sustainability in education, research and operations.

The education coordinator will represent the Directors of Education with in the TU and will focus on incorporating sustainable development related topics in the curriculum. The coordinator can be assisted by GreenTeams which are set up at different faculties in the TU.

The research coordinator will represent the various research initiatives and research departments within the TU who are working on this topic. The prime responsibility would be to harness the research potential of TU delft in every possible SDG and contribute to the impact for a better society. The research coordinator can also be the point of contact for Valorisation within sustainability. The GreenTU and GreenTeams can assist the coordinator with their activities.

Finally, the Operations Coordinator would be a representative for CRE, Facility Management, Procurement and ICT. The main responsibility would be to coordinate between these different departments and oversee the planning and execution of the projects. The Operations coordinator can be assisted by the GreenTU and its projects committee.

This organizational setup aims for better coordination and collective decision making to accelerate the projects. To perform feasibility studies or for some research on a particular project, the authors suggest forming working groups for each project. The working groups can be groups of students supervised by the employees. The GreenTU and other sustainability related student organisation within the TU can help in setting up these working groups.


OFFICE OF SUSTAINABILITY
Executive Board
Education coordinator
Research coordinator
Operations coordinator
Directors of Education
Research departments
Campus Real Estate
Facility Management
Procurement
ICT
GREENTU DELFT
GreenTeams
GreenTU Committees
Working groups

8.2 STRATEGY FOR EDUCATION:

TU Delft is home to 25000 young people who are getting equipped to be the change makers of tomorrow. It is important that they are well aware of the action required towards climate change and they should acquire responsibility towards sustainable development. Hence it is the moral and social responsibility of the university to offer enough opportunities to explore sustainability related topics within and outside the student's study of interest. Though GreenTU is not an expert in determining the best solution for this, the authors would like to share their ideas based on the experience, interactions and feedback from various stakeholders within the university.

The threefold vision for Education:

- All students should have (roughly) the same basic knowledge concerning sustainability
- Students should be given the opportunity to explore sustainability if they have a specific interest
- Provide opportunities to become an expert on sustainability

With this vision, the authors define the following goals to be achieved in the next ten years:

- TU Delft should provide every student with an opportunity to study sustainability irrespective of their program
- Encourage the inclusion of sustainability related concepts into projects or thesis. And make sustainability one of the learning objective
- Promote the various sustainability related educational activities that are offered by the university and create awareness among students
- Create interdisciplinary courses on sustainable development
- Create an online portal for various sustainability related educational and research activities across all the faculties
- Encourage career prospects in the field of sustainability through career fairs and workshops
- Create a platform for teachers to learn from each other and through workshops
- Offer extracurricular educational opportunities in sustainability through MOOCs, Lunch Lectures, Workshops, Excursions, DreamTeams, etc
- Create new honours program or minors to explore sustainability
- Try to integrate the topics of sustainable development into bachelor studies

Strategy:

Basic knowledge on sustainability:

1. Create a separate course focused on sustainability.

This could be a course with the same basis for everyone and 'add on modules' to make it specific for the field of study, or the specific part could be integrated into other (already existing) courses, so students can see the direct use and implementation of knowledge.

2. Create a separate course in which ethics and sustainability are (partially) integrated.

This could be a "Societal Impact" course where students are triggered to think about the impact of the actions they take as an engineer on society and our planet.

3. Integrate sustainability in the bachelor end project and master thesis.

Use the BEP and thesis to make sure everyone indeed has the same basic knowledge.

4. Integrate sustainability in other regular education.

For example by adding design criteria, using 'sustainable' examples (e.g. calculate the profit of a windmill instead of a mine), changing the goal of a calculation, etc.

Risk: By making (only) a sperate course and not doing anything else with sustainability within education, it could become just another box students have to check. Therefore GreenTU would recommend not picking just one of these options, but implementing different ways of integration.

Potential content could be (either integrated or as separate courses or both):

- An overview of the present climate scenario.
- UN sustainable development goals with technologies and policies that aid in achieving them.
- Course on topics such as health, food, mobility, energy, climate, and communication derived from reports produced by the United Nations and the World Bank.
- Faculty or master specific course which can add value in terms of sustainability (Example: Green electronics course for electrical engineering).

- Design or engineering related course on how to make products more sustainable.

Ideally the basic knowledge level should be offered in bachelors. One way to approach this for master students could be to create a common course during the beginning of the course.

Exploring sustainability:

Promoting the existing possibilities is the most important step to take. The GreenTeams can help with the inventory and promotion of the opportunities. Updating the Study Guide and webpage with sustainability courses is a good start. GreenTU can play a role in promoting these courses among students.

In addition to the existing offer, options for exploration are:

- A honours program on sustainability.
- More minors related to sustainability (especially since 15 EC minors offer more flexibility).
- Offering (virtual) exchange programs with other universities.
- More project assignments related to sustainability.
- A 'project annotation' or something similar in which students have the opportunity to do something extra on their project related to sustainability.
- Some courses also have the opportunity to pick from several projects. When that is the case, having a sustainability option should ideally be provided.

Becoming an expert in sustainability

With a motto of "Impact for a better society", TU Delft must offer the best possible engineers to fight the biggest challenge of sustainability and climate action facing the world today. Its engineers must have a holistic approach in dealing with technology and environment.

As of now there are only two full time masters' courses, MSc Sustainable Energy Technology and MSc Industrial Ecology concentrating on this. Other programs like Architecture and Material Science have courses that go relatively deep into sustainability, but still focus on the engineering aspects.

It is also suggested to look into international programs like InnoEnergy (program supported by European Union) which brings together premier institutes in Europe to offer master courses related to sustainable energy.

Master Thesis

The thesis is another important aspect where sustainability can be included in education and help students in gaining expertise. It gives an opportunity for learning by doing. Supporting projects contributing to climate action and encouraging to include sustainability in technology related projects could add a lot of value.

- Quoting an example from universities like KU Leuven, Gent and Uppsala University, they have set up special bodies which specifically oversee sustainability related projects connecting students to companies and professors.
- Another suggestion is to collaborate with Green Village for masters' thesis. This could give students an opportunity to work on real time problems.

Suggestions for improvements in master programs:

Based on the research on different master courses and tracks together with an interaction with the respective Directors of Education, the authors would like to suggest the following tips to improve sustainability in these master programs. More detailed information on this can be found in the GreenTeam inventory reports.

Faculty of Aerospace:

Track	Current state	Improvement
Aerodynamics & Wind Energy	In the profile of Aerodynamics, only the course of Aircraft Aerodynamics touches upon the tip of sustainability. As for the Wind Energy profile, it is pretty well integrated with sustainability given the fact that wind energy, and the various aspects of design of wind turbines and applications of this renewable source, is well taught in the courses.	The concentration on the topic can be increased further by exploring ways to integrate sustainability in the design aspects.
Control & Simulation	Integration of sustainability in visible in the profile: Aircraft Noise & Climate Effects. The Aircraft Emissions and Climate Effects course provides a profound understanding of the fuel consumption, effects of the emissions in the environment and the importance of finding alternative technology to reduce the climate change.	The concentration can be increased in the courses of Automatic Flight Control System Designs, Avionics & Operations and Operations Optimisation.

	For the profile of Air Transport Operations, the course of Airline Planning & Optimisation touches upon the concept of sustainability. The course, Aircraft Noise and Emissions, also explores the influence of airlines in aspects of noise pollution and detrimental emissions in the environment.	
Space Engineering	No focus	Needs improvement (tbd)
Aerospace Structures & Materials	The Materials profile explore the topic of sustainability via the course of Design of lightweight structures: Composites & metals, Designing Materials with Aerospace Specific Properties, Manufacturing of Aerospace Structures & Materials, Polymer Science etc. The profile of Structures only focuses on the topic via the Design & Analysis of Composite Structures I course. Manufacturing profile does not have much focus on sustainability as of now. The track also has a profile dedicated to Durability, whereby courses like Smart Materials & Sensors, Stability & Analysis of Structures I, Design & Analysis of Composite Structures I and Polymer	Integrated There is possibility of exploring the topic more via the Polymer Composites Manufacturing course in the profile. In the profile of Manufacturing, the concentration can be increased via the course: Manufacturing of Aerospace Structures & Materials.

	Composites Manufacturing are taught, touching on the concept of sustainability.	
Flight Performance & Propulsion	The concept of sustainability can be well explored via the courses of Aero Engine Technology, Advanced Aircraft Design I, MDO for Aerospace Applications and Aero Engine Technology. Advanced Heat Transfer and Combustion for propulsion and power technologies are already existing courses which put a focus on incorporating sustainability in the course domain.	Integrated

Faculty of Applied Science:

Track	Current state	Improvement
Masters in Life Science & Technology	The courses of Fermentation Technology & Environmental Biotechnology and Green Chemistry & Sustainable Technology, put an enormous focus on sustainability and green practices. The course Microbial Community Engineering focusses on anthropogenic disruptions of ecological element cycles. Also the course Bioprocess Engineering focusses a bit on sustainability through water and energy integration in factories and through a lecture on Life Cycle Analyses.	Well integrated with recent additions in terms of projects.
Masters of Chemical Engineering	The profile of Process Engineering has integration of sustainability via the courses Process Dynamics and Control, Applied Transport Phenomena, Reactors and Kinetics and related electives. However, there is always room for further integration by elevating the space for sustainability	Courses like Product & Process Design and Design Project have the ability to provide more room for exploring sustainable concepts, encouraging students to think further on making

	amidst the technical knowledge provided.	the design process more sustainable. The course on Structure/Property Relations of Advanced Chemical Products have the ability to incorporate the topic by discussing more on the effects of chemicals on the environment, exploring advanced products and encouraging students to think more on the subject.
Masters in Nanobiology		Does not directly discuss the practice of sustainability or strongly focus on the concept, nanotechnology and sustainability are able to walk hand in hand in many applications, which can be discussed and brought out through the various courses in the track.

<u>Faculty of Civil Engineering and Geosciences:</u>

Track	Current state	Improvement
Transport & Planning		3 courses under the Transport Networks profile- Resilient Transport Systems, Urban Regions, Transport & Economics and Assessment of Transport Infrastructure &

		Systems room for integration of sustainability in them. The profile of Road traffic systems, Intelligent Vehicles for Safe and Efficient Traffic: Design and Assessment and Traffic Safety can have integration of the concept of sustainability in them. More integration also in the profile of Public transport and Railway system.
Masters of Geoscience & Remote Sensing	Sustainability integration is visible in the courses- Cryosphere: Remote Sensing and Modelling, Ocean topography and sea-level change, Gravity, Geodynamics and Climate Change, 3D Surveying of Civil and Offshore Infrastructure, Journal club on climate change and geoscience, Geographical Information Systems (GIS) and Cartography.	Well Integrated
Geo-Engineering	The courses that firmly spark the interest and thoughts on sustainability for students include Geo-Energy Engineering Challenge, Energy Transition, Geo-Energy Engineering Project, Petroleum Exploration and Production, Subsurface Storage, Effects of Subsurface Engineering and Production Science and Technology.	Well Integrated

European Mining Course	Provided in collaboration with Aalto University and RWTH Aachen University, also substantially integrate sustainability in the domain or course plan. With courses like Fundamentals of minerals engineering and recycling, Economic geology and mineral economics, Feasibility studies of mining projects, Mine Wastes, Financial engineering and investment scenarios and Project execution/mine start-up planning, the students are motivated to explore various sustainable concepts.	Well Integrated
Applied Geo-Physics		Sustainability only in the course of Geothermal Energy, Application of Geophysical Prospecting in Earth and Environmental Science, Portfolio Management, Evaluation and Energy resource Management and Mineral Exploration, all of which are provided outside TU Delft.
Building Engineering Hydraulic Engineering	Strongly focus on sustainability with almost half of the courses that are offered.	
Environmental Engineering		Well Integrated

Faculty of Electrical Engineering, Mathematics and Computer Science

Track	Current state	Improvement
Masters of Computer Engineering	Almost none of the courses in the modules give a profound attention to sustainability.	Need to be analysed

Master of Applied Mathematics	Almost none of the courses in the modules give a profound attention to sustainability.	Need to be analysed
Master of Computer Science	Almost none of the courses in the modules give a profound attention to sustainability.	Need to be analysed
Master of Microelectronics and Wireless Communications & Sensing	Almost none of the courses in the modules give a profound attention to sustainability.	Need to be analysed
Electrical Power Engineering	Concept of sustainability into consideration for some of the courses such as in Systems Engineering, Transients in Power Systems, Electrical Energy Conversion, FEM for Electrical Energy Systems, Co-simulation of Energy Systems. Elective options from MSc Sustainable Energy technology like PV Technologies, PV Lab Course, Wind Turbine Design and Introduction to Wind Turbines etc give a scope to explore sustainability.	Well integrated

Faculty of Mechanical, Maritime and Materials Engineering

Track	Current state	Improvement
Master Biomedical Engineering	Courses like Bioelectricity focus on sustainability.	Electives and projects concentrating on sustainable use of materials in medicine can widely promote the need and practice of sustainability.
Masters of Marine Technology	Promoting the technology and applications of Tidal and Ocean Energy.	

Masters of Material Science & Engineering	Various courses like Society's Needs: Case Studies and Materials Challenges, Processing of Materials, Design & Analysis of Composites, Materials and Sustainable Development, Economics and Regulations of Sustainable Energy Systems, Materials and Ecological Engineering and Materials for Clean Energy Technology discuss the importance and applications of sustainability within the study. Specializations like Materials for Sustainable Development provide courses like Photovoltaic Basics, Recycling Engineering Materials and Renewable Energy provide a sound background of energy transition and sustainability.	Integrated
Masters of Mechanical Engineering	One of the tracks that focus on sustainability is the track on Energy and Process Technology. The courses of the study including World of Energy and Process Technology, Thermochemistry of Biomass Conversion, Electrochemical Energy Storage and Bio-Inspired Design revolve around the aspects of sustainability.	Integrated
Masters of Offshore & Dredging Engineering	Various courses explore the concept of energy and sustainability. Some to name are Ocean Waves, Introduction to Offshore Engineering, Introduction to Dredging Engineering, Offshore Geotechnical Engineering, Offshore Wind Farms Design, Offshore Wind Support Structures and Drive & Energy Systems.	Well Integrated

Masters of Technical Medicine	The course of Biomaterials and Issue Biomechanics is the only course that touches upon the concept of sustainability.	tbd
Masters of Systems and control	No focus	tbd

Faculty of Industrial Engineering

The Faculty of Industrial Design already has a profound integration of sustainability within the curriculum via Studio work, projects and assignments revolving around green practices. The Masters courses like Design Theory and Methodology, IDE Academy, Product Understanding, use and Experience, Context and Conceptualisation, Interactive Technology Design, Project Exploring Interaction, Project Usability and User Experience Assessment in Design and various sustainability related graduation projects. Further integration of sustainability is possible in the Sustainable product design courses, whereby the various new technology, methods and sustainable aspects can be explored.

Faculty of Technology, Policy & Management

Track	Current state	Improvement
Masters of Complex Systems Engineering & Management	Four of the courses concentrating on Energy like Engineering Optimization and Integrating Renewables in Electricity Markets, Electricity and Gas: Market Design and Policy Issues, Design of Integrated Energy Systems and Socio-technology of Future Energy Systems, widely touch upon and discuss the need, applications and progress of energy transition, and thereby sustainability in the curriculum.	Integrated
Masters of Engineering & Policy Analysis	Consist of various courses underlining the importance of sustainability and discussing various energy policies. Some of such courses taught are the Understanding International Grand Challenges, Policy Analysis of Multi-	Further exploration of energy policies can be increased in the track via introduction of more interactive projects and lectures regarding the

	actor Systems, Introduction to TPM Modelling, Actor and Strategy Models, Advanced System Dynamics, Advanced Discrete Simulation, Macro-economics for Policy Analysis, Model-based Decision-making and Societal Challenge Project	current state of energy agreements among various nations around the globe.
Masters of Management of Technology	Courses like Social and Scientific Values, Inter, - and intra-organisational decision making, Responsible innovation, Sustainable Innovation and Transitions, Infrastructure and Environmental Governance and Decision making in multimodal transport systems.	Integrated

Faculty of Architecture & Built Environment

Track	Current state	Improvement
Track of Architecture	Four of the courses concentrating on courses like Delft Lectures on Architectural Design and Research Methods, Fundamentals of Housing Design, Design Studio: Architecture and Urbanism Beyond Oil, Solar Decathlon, Infrastructure and Environment Design, Sustainability project – design and elaboration, Design for a resilient Rotterdam, MSc2 Studio: Urban (Re)Development Game, The Delta Shelter etc, touch on the topics of sustainability, exploring the different domains where applications can take place.	Integrated
Building Technology	Courses like Innovation and Sustainability, Bucky Lab Design – Design, Bucky Lab Seminars - Material Science, Bridge Design, Zero-Energy Design, Technoledge Structural Design, Technoledge Climate Design and 1:1 Interactive Architecture	Further exploration of Energy policies can be increased in the track via introduction of more interactive projects and lectures regarding the current state of Energy

	Prototypes Workshop are the fundamental courses that tip on sustainability.	agreements among various nations around the globe.
Management in Built Environment	Courses like Urban (re)development game: Integrating Planning, Design and Property Development and Re-design: complex redevelopment projects put a good focus in the subject of the sustainable development.	Integrated
Landscape Architecture	Courses such as the Architecture and Landscape: Design Studio, Urban Landscape: Design Studio and Dutch Landscape: Design Studio, revolve around sustainability.	Integrated
Urbanism	With courses like R&D Studio: Designing Urban Environments, Sustainable Urban Engineering of Territory, R&D Studio: Spatial Strategies for the Global Metropolis and Research & Design Methodology for Urbanism, the topic of sustainability is strongly underlined in the track.	Integrated
Building Engineering	Tbd	Tbd

Online sustainability portal:

There are many courses, projects and interesting extra-curriculars that are offered by TU Delft on Sustainability. Though the students who study subjects related to these topics are aware of it, the rest who do core computational or technical programs are not familiar with these options. The current online study guide (studiegids) also does not provide all the information on these courses. The current sustainability webpage also has this information but not fully complete.

To bridge this gap and to start a dialogue on sustainability within the education portfolio, the GreenTU and Lijst Béta (Central Student Council) have come up with the idea of developing an online portal focusing on sustainability. The main focus of

this would be to show the current possibilities for students and to encourage teachers to publish open material on sustainability related topics. This portal would be a destination for information on:

- Courses
- Minors
- Honours programs
- Annotations
- Projects
- Career opportunities
- Events
- News
- Information exchange (blogs)

Though the idea was well discussed and got support from various parties within the students and employees, it never went into execution. Considering the fact that many students are lacking the information of their possibilities to work on sustainability and compromising their interests, the authors recommend taking this up as an immediate project and ensure the information is accessible for everyone. With GreenTU and Lijst Béta as the primary partners, developing this portal can be a great start to improve sustainability in education.

8.3 STRATEGY FOR RESEARCH:

As seen in the research overview, most of the TU's research initiatives are linked to the SDGs. The research departments are always in the frontier of their fields publishing great content every year. This can be seen from the Elsevier's ranking based on SDGs [8]. TU Delft is ranked first in the Netherlands for research contribution towards the SDG 6,9 and 11 [8]. In addition to the work by the researchers, the student teams at TU Delft are also working on exciting projects like Hyperloop, Solar vehicles, Hydrogen-powered vehicles, Sustainable buildings, etc which also aim towards the topics related to sustainability.

Despite these achievements, there are still few areas where the ranking is not as expected or the full potential is not harnessed. Considering the fact that this report is on behalf of a student organization, the authors want to clarify that any advice that is mentioned in this report is based on the data from the rankings, inspirations taken from the best universities around the world and based on our experience in facilitating sustainability-related activities.

The threefold vision for Research:

- Explore new and interdisciplinary research areas related to sustainability and encourage researchers towards contributing to them
- Create a common platform to facilitate sustainability related research for all the stakeholders of the university
- Promote the concept of campus as a living lab connecting researcher, operations team and students

With this vision, the authors define the following goals to be achieved in the next ten years:

- Perform a comprehensive study on areas of research and TU's ranking. Identify the areas of improvement
- Encourage and support new research projects contributing to sustainable development
- Review and act on TU Delft's commitment to contribute towards climate action research
- Establish a channel for communication between the TU Delft operations team and the researchers
- Create a Centre for Sustainability which can act as a platform for sustainability related research connecting students, researchers and external parties
- Encourage students to work on practical living lab projects for these thesis
- Provide knowledge and financial support to student teams who come up with ideas for sustainable development

- Encourage clean tech academic spin offs through Yes! Delft.

To achieve these goals and to be a front runner in research towards sustainable development, the authors suggest the following:

- Perform a comprehensive study on TU Delfts research potential and current progress
- Set up a Centre For Sustainability
- Define a vision for Living lab

1. Perform a comprehensive study on TU Delfts research potential and current progress

With the call for decade of action, the concept of sustainable development has gained lot of importance over the past two years. The trusted ranking institutions like Times Higher Education have started University Impact Rankings where the university's contribution to the SDGs is evaluated. TU Delft has submitted data for this ranking for 2020 and the results are still awaited. During this procedure, the evaluation of TU's research on SDGs has given some interesting insights. TU Delft is ranked as one of the best on the research on clean water, energy, infrastructure and sustainable cities being in the top 2 in the Netherlands and top 10 in Europe. But coming to SDG 13, which is climate action, the TU ranks 4th in Netherlands and 41st in Europe. And the world ranking for climate action research is greater than 100.

The result on climate action is surprising, as the TU's contribution to this is quite significant. But when analysed a bit more, it was observed that the key words play an important role in this ranking. Though TU Delft has multiple research contributions towards climate action, the results are not directed to it because of less usage of the important key words. To keep up the brand value of TU Delft and to promote the TU's research towards sustainable development, it is important to make a comprehensive study on the research contributions and provide directions to improve the rankings.

Additionally, there are many more areas within sustainable development that TU Delft can contribute to. Especially with interdisciplinary research between the faculties. As a step towards SDG 17, which is partnerships for the goals, TU Delft should bring all the resources together to support this cause. In addition to this, collaboration with fellow universities around the world and joining the network of organisations working towards these goals is also an important step to pursue.

2. Set up a Centre For Sustainability

TU Delft has multiple research departments and a large number of researchers who work on various dimensions of sustainability. But there is still room for collaborations

with the departments to explore new possibilities and enhance the outcome. In addition to this, the number of students who are interested in working on this topic is growing every day. From a student perspective, it is quite difficult to look out for these opportunities and tune their interests. Hence the authors call for setting up a Centre For Sustainability which acts like a platform to facilitate research for sustainability. It will be a place for collaborations, opportunities and finding new possibilities. This platforms needs to bring together the researchers, students, TU Delft operations team, industry partners and other academic partners. This network of people can be a great asset for the TU to improve its contributions towards climate action. This project can be taken up by Green Village and GreenTU who have already been active in connecting and networking with various stakeholders working on sustainability.

3. Vision for Living Lab

The Green Village at TU Delft has been serving as the Living Lab with many exciting projects related to sustainable development. From energy to architecture, Green Village has become a test bed for many innovations in TU Delft. Inspite of the success, there is much more potential that can be explored.

One of the directions that was not explored until now is student contributions to the Green Village. With lot of bright minds graduating every year, many students are interested in working on practical projects which can include sustainability. Providing a direct channel between the Green Village and students could be a great push. To encourage innovation and promoting student interests, offering innovation funds through competitions or grant applications for students would greatly motivate the students to work towards sustainable innovations. Also, providing opportunities through Green Village to pursue theses or internships could add a great value to students.

Another important aspect that needs attention is establishing collaborations between the Green Village, TU Delft operations team and researchers. TU Delft has great resources to test the various innovations happening on campus. For example TU Delft owns its own power grid and power plant. This could be a great asset in testing new innovations for future power systems. Establishing these connections could accelerate the feasibility, testing and scalability of the projects.

Hence expanding the Green Village by extending its reach to all the stakeholders of the university could further promote the research contributions of TU Delft towards sustainable development. The means to implement this could be the setting up of Centre For Sustainability.

8.4 STRATEGY FOR OPERATIONS:

Methodology:

The strategies are based on the investment need for a particular initiative and the impact created by it. The ideas are divided under three categories;

1. No or low investment (<500,000 EUR)
2. Medium Investment (> 500,000 and <5,000,000 EUR)
3. High investment (>5,000,000 EUR)

The inspiration behind choosing this kind of a strategy is to show that a huge impact can be created even without much investments and just with certain policies and small changes in the thinking of the individuals. On the other hand, to also show the importance of investment in large scale projects to achieve the targets by the year 2030.

To show the impact of each of these ideas, the simulation model that is introduced in chapter 5 is used. The authors intend to show the amount of emissions these initiatives can decrease based on the conversion factor obtained from scientific studies.

The coming sections will discuss the strategies for six areas within operations;

- Energy
- Food
- Mobility
- Waste
- Water
- Procurement

8.4.1 Energy transition strategy:

TU Delft has one of the best expertise for sustainable energy and future energy systems, and it is recognized around world for its contributions. Thus the university has the potential to be a pioneer in energy transition inspiring various organisation and individuals. The TU's campus operations also need to reflect this expertise. While contributing to the final goal of being carbon neutral by 2030, the energy transition must also focus on building a future proof and reliable energy system which can withstand the growth of the university and can evolve with developing technologies.

The threefold vision for energy transition;

- Reflect TU Delft's expertise in the campus operations
- Build a sustainable, reliable, affordable and future proof energy system
- Develop a system to monitor, evaluate and track the progress

With this vision, the authors define the following goals to be achieved in the next ten years;

- Organise expert sessions involving the professors, researchers and the campus energy team to brainstorm and develop ideas/strategies for energy transition
- Establish collaborations between the academic and operational teams who work on energy related topics. Achieve mutual gains by sharing the common vision and contributing to each other's work
- The TU Delft campus needs to fully develop as a living lab with professors and researchers making it a test bed for energy transition
- Lead student engagement in the campus energy transition through projects, internships, thesis or as volunteer work based on student interests
- Promote research on exploring possibilities for producing energy on campus. This includes solar, small wind turbines, biomass and geothermal
- In addition to top down initiatives by the energy team, push for energy saving measures and encourage bottom up action from students, employees and other stakeholders
- Define energy standards and guide lines for;
    - Commissioning of new buildings
    - Renovation of old buildings
    - Energy saving guides for various facilities on campus
    - Efficiency standards during procuring electrical equipment (for operations, academics and research)

- Develop a centralized integrated control system to monitor and control energy use
- Setting up of a centre/hub for data collection, monitoring, analysis and reporting
- Defining bench marking standards, annual evaluation of the progress and re-define strategies based on the developments

To achieve a carbon neutral energy system, the Sustainability team of CRE has developed a set of KPIs [23] to evaluate the progress and has set targets for 2030. The main target is to achieve zero scope 1 and scope 2 carbon emissions by 2030.

Source: CRE [23]

	KPI	Target
CO 2- neutral, scope 1 and 2	Total CO 2- emissions	0 in 2030

KPIs for existing electricity and heating system [23]:

	KPI	Target	Reference
Efficient use of Warmth	Final heat demand per m 2	50 kWh / m 2 in 2030, decreasing linearly 6 from 2018	100 kWh / m 2 in 2018, halving compared to 2018
Efficient consumption of electricity	Final electricity demand per m 2	50 kWh / m 2 in 2030, decreasing linearly 5 from 2018	100 kWh / m 2 in 2018
production of heat	Part of the final heat consumption that net itself becomes sustainable cheerful	100% in 2030	0% in 2018
production from electricity	Part of the final electricity consumption that net itself is generated sustainably	By 2030 50%, increasing linearly 5 from 2018	1-2% in 2018
Life cycle emissions	Total CO 2- emissions about the life cycle per m 2	to be completed (2020) to be	n / a
Scope 3 CRE Sharing targets		completed (2020)	n / a

In order to reach these targets and measure the KPIs, the CO2 roadmap has already provided few possible measures. The new campus strategy being developed by CRE is also concentrating on these initiatives. To get an updated and overall overview of which measure will be feasible per building, energy audits will be conducted in the end of 2020 and beginning of 2021. The feasible solutions will be shown in the maintenance plans of CRE. The results of these energy audits will be also the basis for meeting the requirements for the energy legislation. Furthermore, number of studies are currently in progress like a PV potential scan for the complete campus, not only on the roofs, but also facades and open areas. Several projects and pilots on sustainability are already performed, e.g. the transition to LED lighting and the combination of energy monitoring data and BMS data.

As an organization responsible to promote sustainability, GreenTU takes an initiative to engage all the stakeholders in building a sustainable campus. Hence in the present document, the authors would like to show every possible solution concentrating on small bottom-up initiatives for energy saving to high investment projects like Geothermal. This report will explain the ideas along with an impact assessment based on a behavioural model developed to predict the future emissions. An effort has been made to show every possible idea that can be quantified using a behavioural model. These solutions/ideas are examples and the (practical) feasibility of these solutions/ideas for the TUD Campus aren't discussed or confirmed by TU Delft CRE.

According to the model, with the increasing population, by 2030 the energy usage would increase as population rises to the peak of 36000 which is set as a limit. This energy usage would result in carbon emissions of nearly 33000 t CO_2-eq. But to achieve carbon neutrality, these emissions need to be made zero by 2030. This can be realised by reducing the energy use along with using more amount of renewable energy. Hence this strategy explains both of them with various ideas.

Based on 2018 data, the current electricity usage in the TU is 67908 MWh annually (excluding third party buildings). Of this 56% is used for academic and office purposes and 44% is used for research use. This data is used as a base to show the impact of different scenarios.

The below strategy can be understood as follows;
EX.Y.Z
EX – Investment level
Y – Energy saving or renewable energy
Z – Initiative

	1. Energy savings	2. Renewable energy
Basic – No or low cost E1	1. Winter closure 2. Summer closure 3. Energy standards for procurement of electrical equipment for operations and research 4. Guidelines for usage of IT equipment 5. Green roofs	1. Contributing to biomass based energy indirectly by out sourcing waste treatment to energy from waste companies

Medium investment E2	1. Lab airflow management 2. Lighting upgrades 3. Home automation 4. Replacement of old and high energy consuming equipment	1. Phasing out CHP plants or selling the electricity to outside parties. 2. Focus on procuring 100% wind energy 3. Explore options for solar roofs and facades 4. Invest in recommissioning and developing new energy storage systems. Underground storage and batteries
High Investment E3	1. Define energy standards for new buildings and aim for energy neutrality 2. Insulating old buildings 3. Develop an integrated energy control system to efficiently manage the energy use	1. Geothermal site on campus for heating 2. District heating facilities operating at low temperatures 3. Electric heating options

E1.1.1 Winter closure:

According to the available data from 2018, TU Delft consumes around 6276 MWh of electricity in the month of December alone [24]. As per records the consumption in December is higher than the rest of the months. This can be attributed to the fact that more lighting is used. But for nearly two weeks in December, the university is shut down for the winter break. Though the exact occupation of the campus is not known, there is definitely a decline in the number of facilities used and all learning centres being completely on halt.

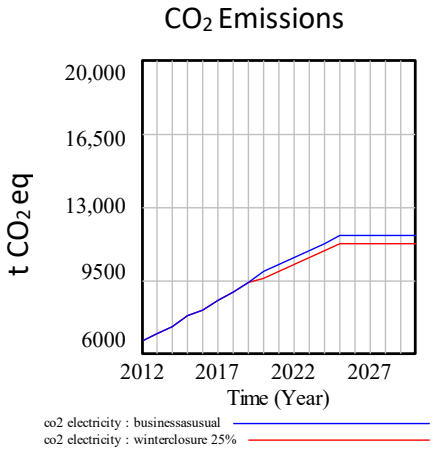
If there is a little effort into identifying what facilities need to be functioning all days of the year and identifying specific users based on an annual survey, providing electricity/heat only to these entities can already make a huge difference our energy usage and emission count. Another approach to this is to encourage the participation from stakeholders to engage in energy saving measures by volunteering themselves or their departments by turning off for two weeks. A similar initiative already in existence in Stanford University and is being implemented successfully every year because of its fruitful results.

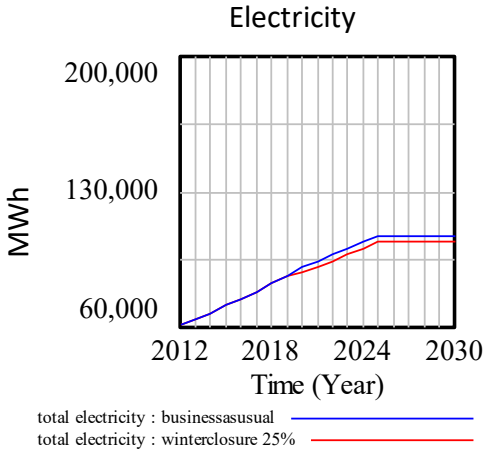
Impact assessment:

- Only 25% of the energy being used for 14 days of every December
- Zero energy usage for academic use

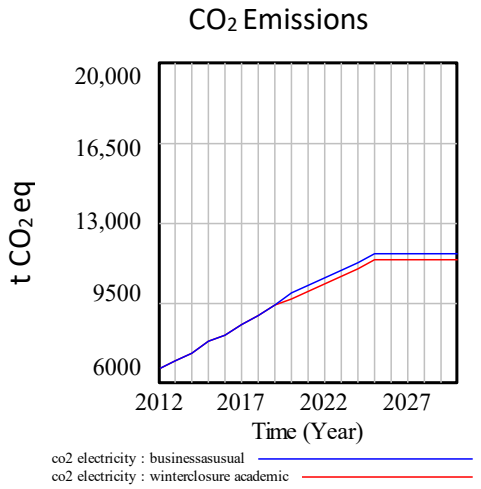
If only 25% of the electricity is used, it leads to an annual saving of 3.24% and reducing only the academic usage would reduce 2.42% of annual electricity use. The emissions would also reduce because of the energy saved.

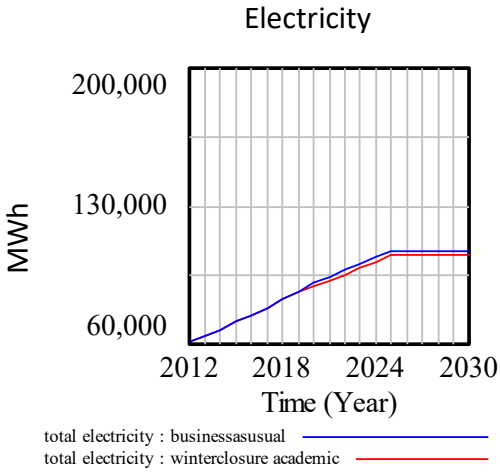
25% usage





Zero academic usage





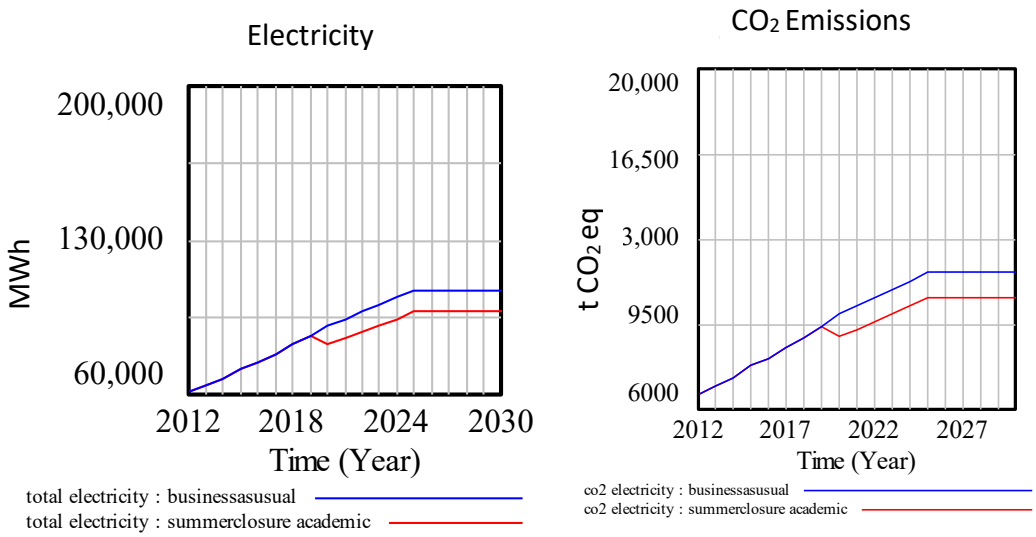
E1.1.2 Summer closure:

As discussed in the above case, a similar situation is observed even during the summer months of July and August. Based on the 2018 statistics, the consumption is 5716 and 5585 MWh in July and August respectively [24]. This consumption is almost similar to rest of the year despite the low occupancy due to no classroom usage and less research activity. Even if we consider the fact that the vacation days vary individually, it can be assumed that the occupancy is not more than 50% in both the months (considering the time for grading exams in July and introductory programs in August). Controlling the energy usage in these two months can have a dramatic impact on the emissions from energy. Considering the uncertainties in the vacation dates of individuals, this can be addressed by a voluntary participation from individuals and various research departments by specifying their closure time.

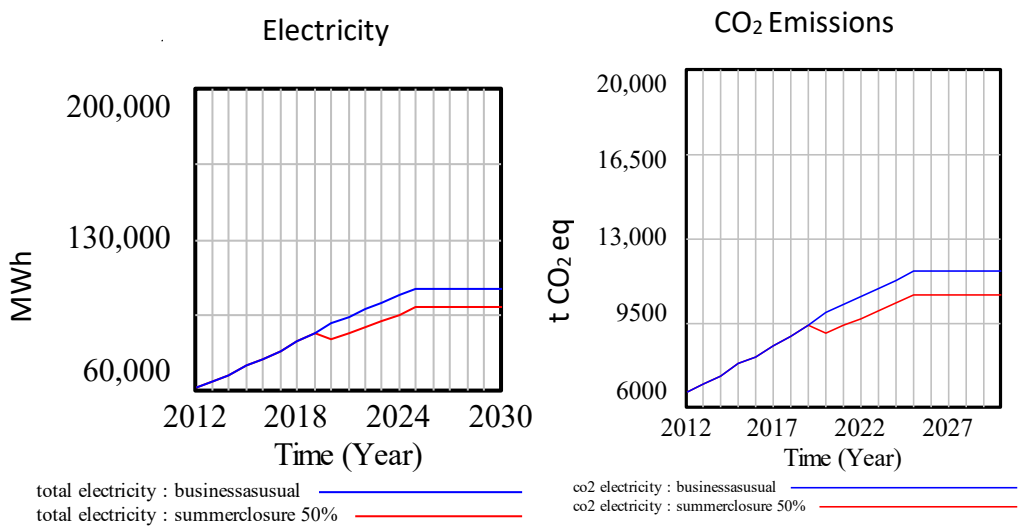
Impact assessment:

- 50% energy usage in both months – saves electricity of around 8.32%
- Shut down academic usage – annual savings of 9.32%

Zero academic usage:



50% usage



Considering the above initiatives, if just the academic use is shut down during the vacation period, there would be savings of at least 10% annually. But considering the worst case scenario of just saving 5% of the electricity.

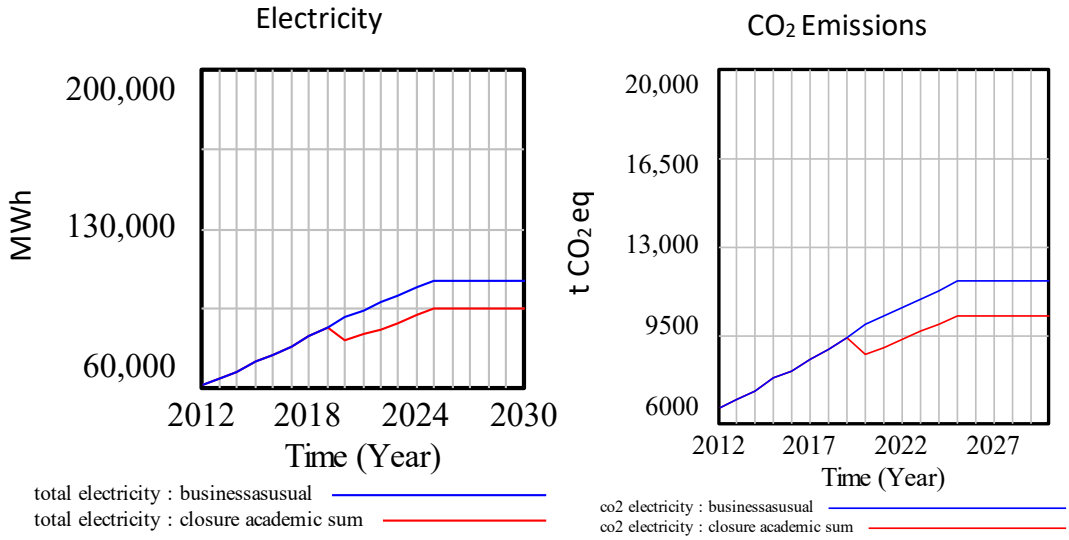
Energy saved = (5% of 67908MWh) = 3395 MWh = 3,395,000 kWh

Assuming the price to be around 0.205 euro cents per kWh [25]

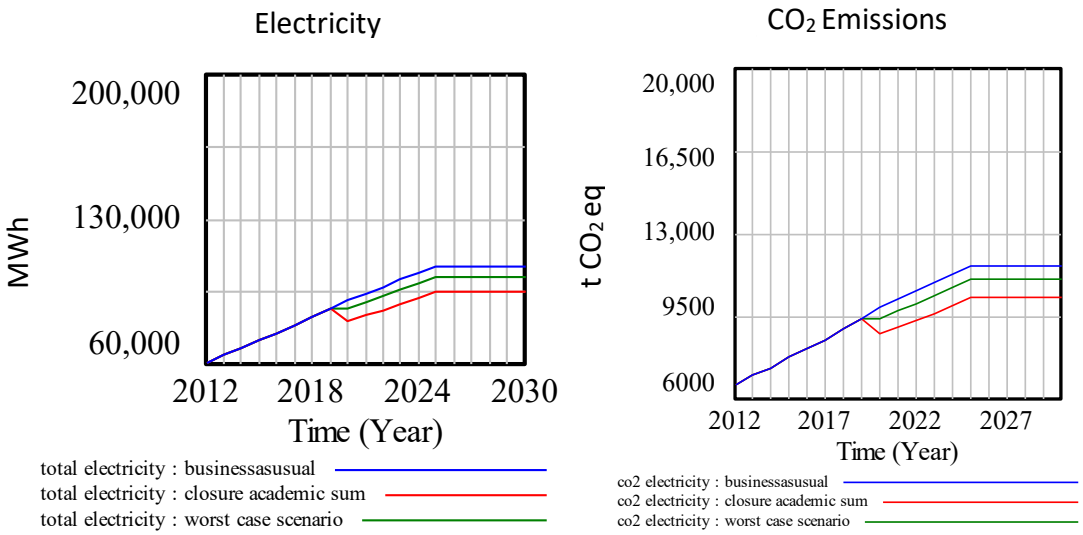
Cost saving of around = 679,000 EUR

Even if central automated monitoring system is not in place, the above savings can be used to hire a temporary employee who can manually ensure the shutdown of unused spaces.

Academic closure during vacation:



Worst case scenario with 5% saving



E1.1.3 Energy standards:

The Government of Netherlands recommends to follow the energy standards defined and accepted by the European Union for various electrical appliances [26]. Though most of the new buildings in TU Delft are developed considering these standards, it is important that any new equipment purchased is adhering to them. This includes research equipment, servers, workstations and any operational electrical equipment. The procurement team must ensure that these standards are maintained by all the departments even if the cost of the equipment is a bit expensive. The additional expense can be recovered easily on the long term in the form of energy savings.

E1.1.4 Guide lines for usage of IT equipment:

TU Delft is home for hundreds of workstations and high end computational equipment. In addition to this, appliances like printers, projectors and many more power consuming devices are always ready for operation for everyday use. Based on their consumption and the number, the IT equipment contributes to about 15% of energy use [4]. Hence it is important that these resources are used efficiently and we try to reduce the wastage where ever possible. Starting with the procurement, operation and until discarding, it is advised to set some guidelines to make their lifecycle more sustainable and circular.

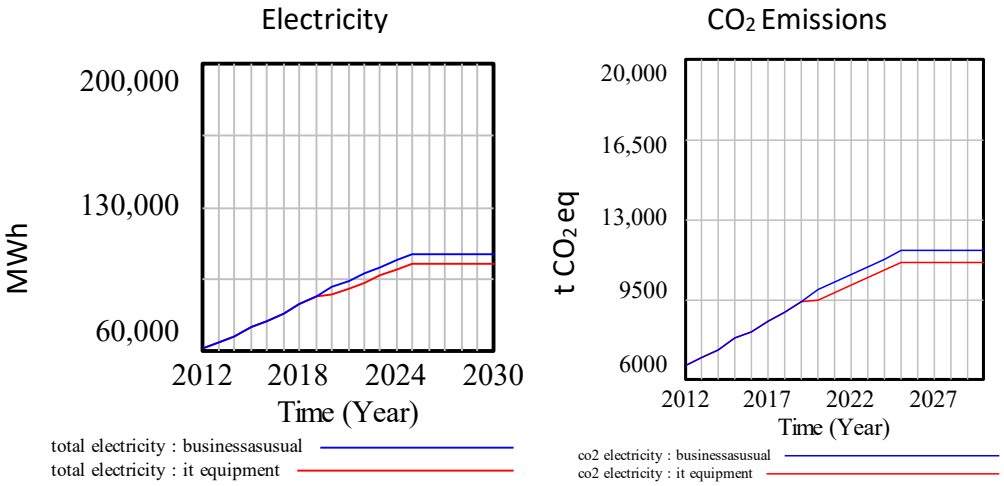
Few recommendations are as follows;

- Procurement of equipment with Energy star label or greater than A+ standard of the EU
- Use of smart power strips which are equipped with load sensing [27]
- Use of technologies like Cisco energy manager
- Setting timers for printers to avoid energy consumption when the building is closed

Impact assessment:

Activity monitor smart power strips control the power usage of computers and the peripheral devices connected to it. Each of these strips cost range from 50$ to 99$ and can save the energy use on average up to 27% depending on the devices connected. Connecting more devices will make it more advantageous and the ROI would be within 2 to 3 years [28].

Around 15% of the total electricity is used for different kinds of equipment including computers for educational and research purposes. If these smart standards and power strips are installed, it may be able to save around 27% of the electricity used for this equipment. This will result in an annual saving of 4.3%.



E1.1.5 Green roofs

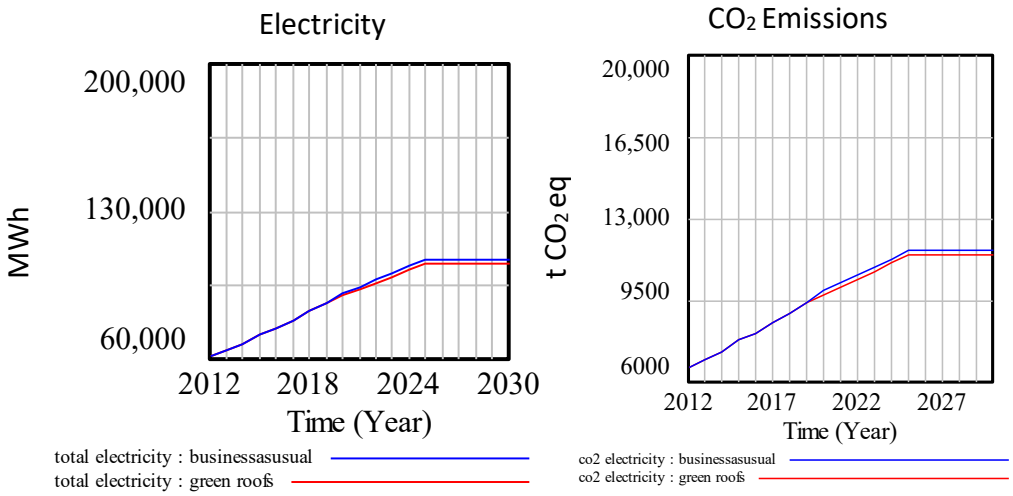
In this context, green roofs refer to rooftop gardens which can contribute to the biodiversity of the university. In addition to this, green roofs have proven record to reduce the temperatures of the building by a significant amount which reduces the energy used for cooling during summer months. The TU uses 11% of its electricity for cooling purposes [4].
A study was conducted on the current green roof on the CiTg building by a research group [info based on a conversation] and it was observed that the roof with the green side was 12 degrees cooler than the side without during the summer month of July.

This difference can significantly reduce the amount of energy used for running the air conditions in the buildings. These green roofs are a very viable options for buildings with large surface areas. Starting with buildings of Civil engineering and Geosciences, 3ME, Applied science, TPM, Drebbelweg and others.

Scientific results have shown that a one degree change in the operation of air conditions already contribute to energy savings of around 3-4% per one degree decrease [29].

Impact assessment:

As a worst case scenarios, Green roofs can reduce the room temperature by 5 degrees and each degree would reduce the electricity consumption by 3%, this would reduce the electricity used for air conditioning by 15% and the overall annual electricity by 1.7%.



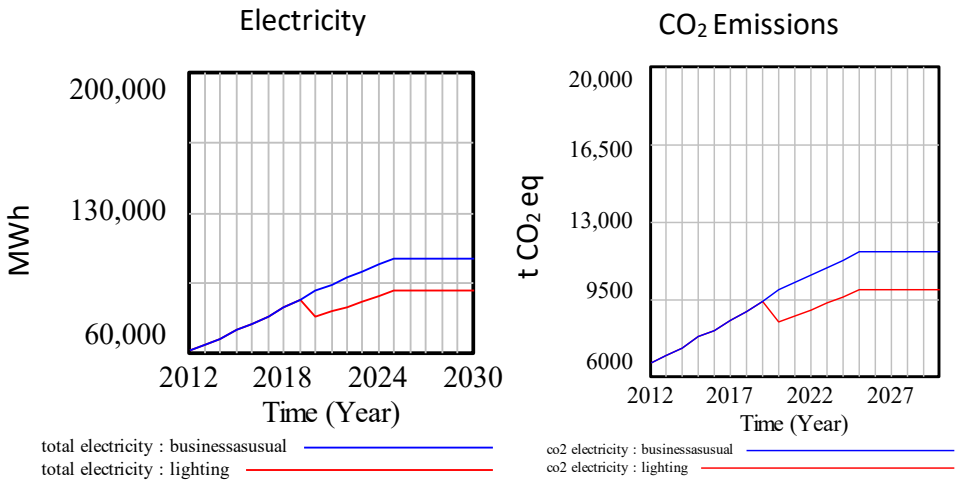
E2.1.1 Lighting upgrades [4]

Based on the available data, about 30% of the electricity used in the TU is accounted for lighting purpose. Except for the newly built buildings like Pulse, only the building of Architecture has been fitted with LED lightings. In 2018, around 9379 LED luminaries were installed and were found to save almost 49% of the electricity consumed for lighting [4].

If this is implemented across all the buildings in the university, it would already reduce 14.7% of the total electricity usage.

Impact assessment:

- Reduction of 14.7 percent in annual electricity consumption. This step alone would reduce the CO_2 emissions by about 1500 t CO2 eq.



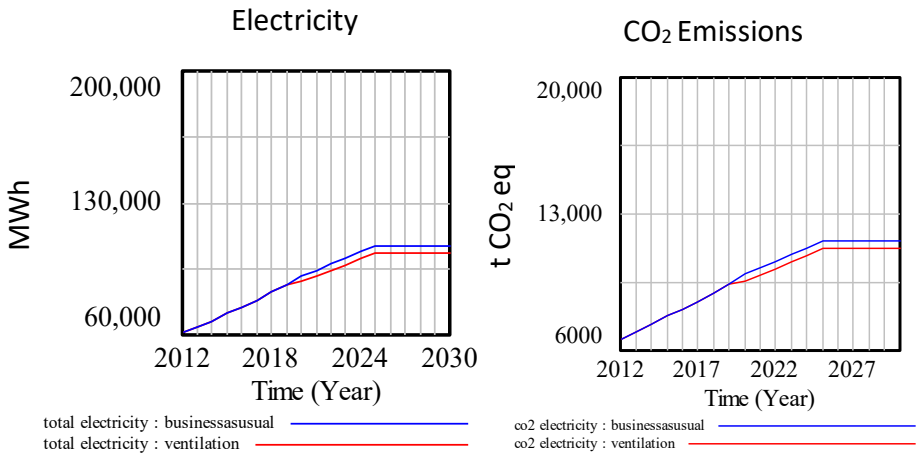
E2.1.2 Home automation:

Implementation of building control systems with multiple sensors can play a major role in energy savings. For example:

- Electricity use for ventilation can be reduced by using smart air circulation sensors which work based on sensing the number of people occupying the area and the schedule of the usage (mainly for classrooms). Pilot project in 3ME resulted in energy saving of 50% for ventilation [4]
- Use of occupancy sensors (integrated in power strips) in labs and spaces with workstations can ensure that the IT equipment is turned off when not in use [30]
- Smart lighting
- Timers for devices which are active in scheduled time. This ensures turning off these devices when the building is closed and during night times. It can be applied to Printers, coffee machines, kitchen equipment, etcetera [31]

Impact assessment:

- 50 percent reduction in ventilation for academic use (mainly classrooms). Using smart ways to control ventilation would reduce the annual consumption by 3.6%



E2.1.3 Replacing the old and high energy intensive equipment

TU Delft has been a home for great research with diverse labs and best in class infrastructure. But there are still research facilities and also operations related equipment which are old and energy intensive. These equipment which are not certified with the energy standards need to be assessed and changed in the next ten years. To ensure sustainable discarding of these equipment, they are be sent for refurbishing or recycling to ensure they have a better life ahead.

E2.1.4 Lab airflow management

TU Delft is a home for cutting edge research in various fields and is equipped with world class labs to facilitate the research activities. On a broader level, every research activity is aimed towards improving the quality of life. So, it is important to ensure that these research activities are carried out as sustainable and responsible as possible.

The amount of energy used by these research lab contributes to very high amounts. In addition to the equipment being used, the use of HVAC (Heating, Ventilation & Air Conditioning) systems consumes high energy which can be saved with proper measures and renovations. According to a research by NREL, the use of HVAC systems and fume hoods in the labs consume about 45 – 85% of the energy depending on their age and the location [32]. And it is estimated that 50% of this energy is wasted due to excess air flow which is not controlled efficiently, especially in old laboratories.

Currently, there has been no assessment on the laboratory operations and hence no data to evaluate the present state. Hence, it is recommended to perform an assessment on high energy consuming laboratories and undertake measures to improve the airflow management systems.

E3.1.1 Defining energy standards for new buildings and renovations

TU Delft's population in the past years has been growing at the rate of... and will only be able to accommodate more only with the expansion of the campus and construction of new buildings. This has already began with the construction of the PULSE building and the ongoing construction of ECHO. These buildings are constructed with standards to be energy neutral and are sustainable according to the BREEAM standards. The CRE has committed to use the BREEAM standard as an important KPI for future constructions and for renovations [23].

KPIs CO_2 new construction / midlife renovation

	KPI	Target	Reference
Efficient use of Warmth	Current final heat demand per m_2	15 kWh / m_2	Reference Pulse based on EPC calculation: heat demand 12 kWh / m2 0 m^3 / m^2 (gas) 0 GJ / m^2 (heat)
Efficient use of electricity	Current final electricity demand per m_2	30 kWh / m_2	Reference from Pulse based on EPC: Building related energy usage: 24 kWh / m2 GFA User-bound energy according to NEN 7120 for education: 17.5 kWh / m2 GFA
Production of electricity	Production of durable electricity on / on or directly at the Total CO	50 kWh / m_2 until 2020, increasing linearly to 70 kWh / m_2 in 2030	Echo 50 kWh / m2 Pulse (from EPC): 23 kWh / m2 GFA
Indirect CO_2-footprint	building $_2$- emissions in the construction chain	0.3 tons of CO_2 / m_2 until 2020, decreasing linearly to 0 in 2030 (provisionally, to be finalized in 2020)	/
New construction	BREEAM	Excellent or higher [7]	Quickscans TNW (good), Pulse (excellent), Echo (excellent)

E3.1.2 Insulating old buildings

The energy used for heating old buildings is an important factor for high fuel usage and emissions from heating. Due to their aging and the old construction techniques the following four buildings need special attention to reduce the energy used for heating.

- Applied physics (building 22)
- Civil engineering (building 23)
- 3ME (34)
- EWI (36)

As mentioned in the CO_2 Roadmap [4], decommissioning of these building would not be an efficient idea but a mid-life renovation can definitely improve the performance of the building.

Use of modern insulation methods for traditional and old buildings could improve the performance of the building. Simple low cost measures like draught proofing windows and doors and upgrading the boilers if not connected to the district heating network can already save a lot of energy [33].

Methods for insulating old buildings [33]:

Upgrading Option	Estimated Payback Period	Cost Bracket
Insulation: Hot water tank	6 months	Low
Insulation: Lagging to hot water pipework	1 year	Low
Draught proofing windows and doors	1 year	Low
Insulation: Loft	2 years on average but dependent on materials used	Medium
Upgrading to high-efficiency boiler with correct controls	Less than 8 years	Medium (changing from a 70% to a 90% efficiency boiler would result in typical savings of approximately €300 per year)
Insulation: Suspended timber floors	2 years	Medium
Adding front porch	30 years	High
Installing double glazed windows	40 years	High

Cost and Payback Periods

The energy efficiency improvements indicated above include simple actions such as installing a hot water cylinder jacket and draught proofing windows. The price and effectiveness of various upgrading measures will vary for any given building. Available options are discussed in more detail in Chapter 3. This chart gives a rough indication of typical cost and payback periods for different interventions. These are a guide only and will vary with individual properties, and will reflect, to a certain extent, the quality of materials and workmanship employed (Source: SEAI)

E3.1.3 Integrated energy monitoring and control system

In line with the vision for energy transition, another important goal to be achieved is to develop an integrated and intelligent energy monitoring system. Today most of the

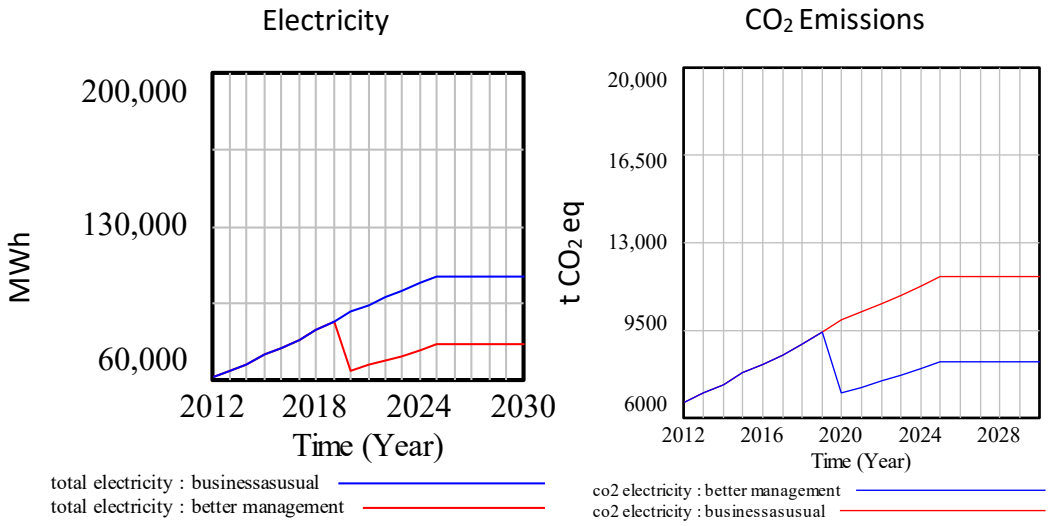
control systems are manual. This could be an important factor effecting the implementation of energy saving measures like winter or summer closure.

Thanks to its vast energy system, TU Delft owns the energy distribution grid providing a great opportunity to efficiently operate its energy usage and avoid any wastage. Hence developing an intelligent, integrated system to control the energy usage could be a great advantage for TU Delft's energy transition. Use of a similar Integrated control and analytics system has led to a saving of 40% of energy from 2018 in Stanford [34].

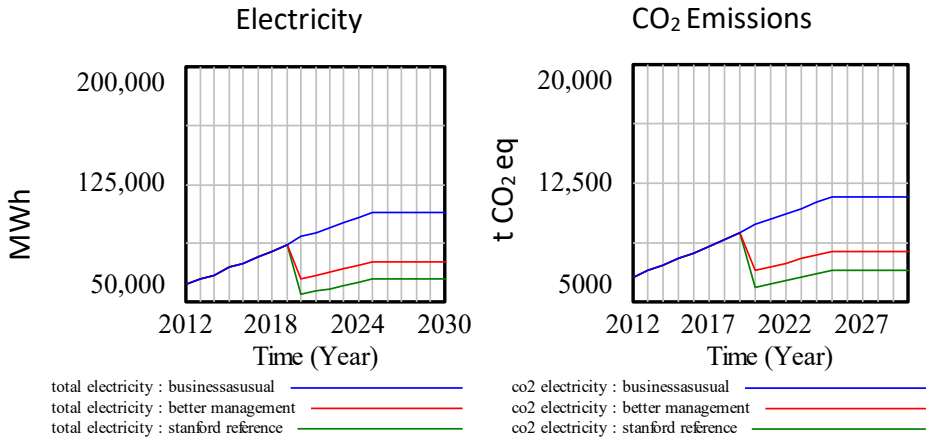
Also, it is important to keep track of the usage and the impact on the environment regularly and take necessary actions towards our final targets. Currently TU Delft is also lacking standard certifications for energy monitoring. It is recommended to further develop the system in accordance with the ISO 50001 standard for Energy Management System which provides a framework to [35]:

- Develop a policy for more efficient use of energy
- Fix targets and objectives to meet the policy
- Use data to better understand and make decisions about energy use
- Measure the results
- Review how well the policy works, and
- Continually improve energy management.

Impact of all above mentioned strategies:



Based on Stanford data – 40% savings with better control system[60]



Renewable energy:

E1.2.1 Indirect contribution to renewable energy

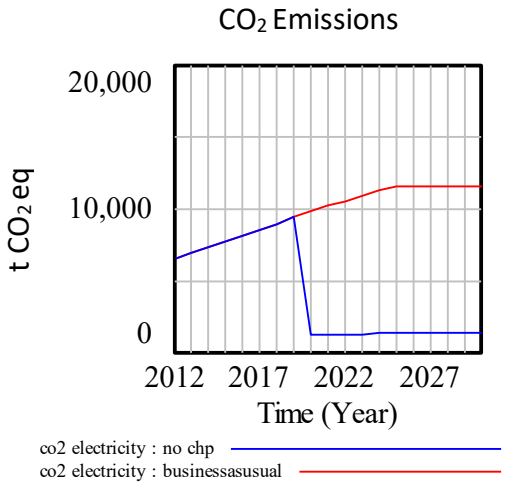
Currently around 20% of the waste generated by TU Delft is used to generate energy by third parties [5]. Though 42% percent is recycled [5] , there is still a lot of residual waste which is going either to landfills or being used for other organic purposes.

TU Delft needs to make an effort in ensuring that all the waste is reused or recycled in one or the other form. This can be done by improving the waste separation and outsource it to third parties who use it to generate energy. This will also help in achieving the goal of Circularity.

E2.2.1 Phasing out CHP plants or selling the electricity to outside parties

The CHP plant on the TU campus is a major source for both heating and electricity. And it accounts for about 7705 t CO_2-eq of emissions [4]. Hence there is a need to phase out these plants as we approach 2030. While various other possibilities are being explored for heating purposes, until then the foot print from the plants can be reduced or compensated by selling the electricity to outside parties. And the procurement of wind energy can be increased to meet the demand of the TU.

If the buildings are renovated in the coming years and the temperature of operating the boilers can be reduced, then the use of CHP can be reduced dramatically. But to avoid the economic burden of decommission the plant, exploring the option to sell the energy to third parties or the city of Delft is a very viable option. Considering the intermittent nature of the renewable sources, CHP plants can also act as a stable backup to the energy system when needed.



E2.2.2 Procurement of 100% wind energy.

Currently around 78% of the electricity consumed in the TU is produced from wind and is procured from ENECO. Though the current contracts are restricted to this, in the coming years this needs to be extended to nearly 100%. This can reduce the emission count from the electricity use and will also be a cheaper option in the coming years when carbon taxes are imposed on fossil fuel based energy sources. To account for the intermittency, the CHP plants can act as a stable back up. Also with the development of energy storage technologies, it could be a very viable option. Implementing these practices by TU Delft would inspire many other organisation across the Netherlands and the world.

E2.2.3 Solar roofs and facades

Though all new buildings are now being installed with rooftop PV, it is recommended to exploit the potential on all the roofs. Earlier research on the PV assessment stated that it is difficult to exploit all the roofs because of the obstacles present. But in those cases, green roofs can be applied. In addition to this, there is unused space in the south of campus and in parking spaces where PV can be used.

To further increase the self-generation on campus, solar facades is another option to explore, especially on taller buildings. With the recent advancements in this technology, there are facades which also act as very good insulators for the buildings. For example, Solar Activated Facades [36] can act as insulators reducing the energy needed for heating and cooling. This option can be explored for future renovations of old buildings. It would solve the problems of insulation and also contribute to generating energy.

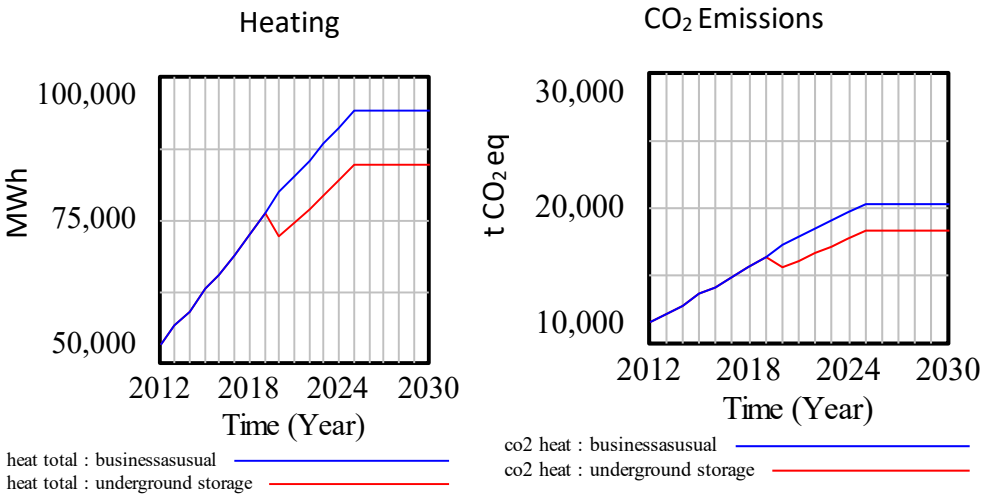
E2.2.4 Energy Storage

Underground storage:

TU Delft currently has 13 ATES systems (Aquifer Thermal Energy Storage). Two of these are newly commissioned with the PULSE and the ECHO buildings. The 11 ATES systems have been in use since few years and the oldest one ages back to 1998 in the EEMCS building. These old systems are equipped with heat exchangers but not heat pumps. Hence they are not fully efficient. In spite of this, the ATES system in EWI reduces the gas usage for heating by 20% [37]. Though the replacement of the system or adjusting the existing system could be expensive, it would be a worthwhile investment on long term.

There are around 24 underground wells identified on the TU campus and exploring all of them in the coming years would be a great addition to achieve a sustainable heating system [37]. According to the 2017 data, the ATES systems excluding PULSE and ECHO have contributed to about 6.8 GWh of heat and 8.4 GWh of cooling [4]. This reduces gas usage by almost 15% in total. If all 24 sites are explored, this could be doubled and can reduce the emissions by a significant amount.

Impact assessment: 30% reduction in gas usage



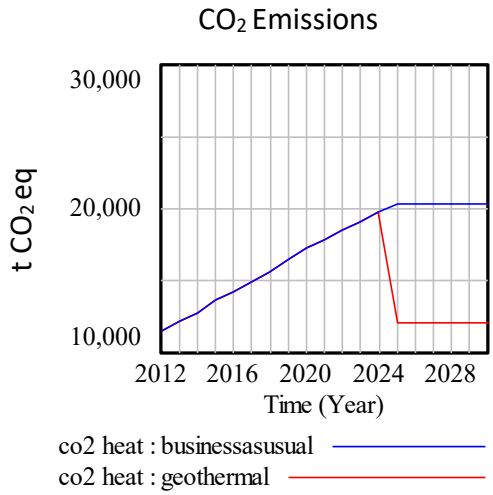
Batteries:

In the development of sustainable and future proof energy system, storage plays an important role. With the growing use of intermittent renewable energy sources, use

of large batteries could provide a strong support to the stability of the system. Last few years has seen a steady decrease in the cost of battery systems and is expected to decrease further. In the next five year, with the increased self-generation capacity, use of Li-ion battery storage systems could be a viable and sustainable option. Deploying of these systems in TU Delft would also be inspiring for various organisation in the Netherlands.

3.2.1 Geothermal site on campus for heating

Implementation of a geothermal system on the campus will make a major shift in the energy transition. The CO_2 roadmap suggests that the geothermal source can meet 60% of the heat demand on campus [4]. With the present momentum among the stakeholders and the discussions with the city of Delft, the project is most likely to see the light within the next 10 years. This will significantly reduce the use of gas and thus the emissions from heating on the campus.



E3.2.2 Advanced District heating facilities

Low temperature operation:

Renovation of old buildings, use of thermal storage systems or geothermal can greatly influence the operating temperature of the gas boilers. They can save the fuel consumed by operating at low temperatures. This will reduce the use of CHP plants and thus the emissions from them.

Use of heat recovery systems:

Inspired from the recently developed Central Energy Facility in Stanford University. The initiative seems to be promisingly transform the heating system on the campus. Stanford Energy System Innovations (SESI) project seems is an ambitious project

which was commissioned to modernize the heating system. The system is built with three large water storage tanks used for chilling and a heat recovery system. The project also changed the heat supply in the form of steam to that of hot water. With 70% overlap in the use of heating and cooling systems, SESI was found to be an efficient and economical solution despite its high investment. The project has the lowest life cycle cost and will pay back many times during its tenure of operation.

E3.2.3 Electric heating options

The use of electric heating systems is gaining attention all around the world with concentrated PV and other sources. This could also be a viable option to explore for the heating needs of the TU. Though this might need drastic increase in the network capacity and new infrastructure to make is possible, it is considerable option to reach 100% sustainable heating which is quite difficult to attain just by using geothermal energy. Also, having a mixture of resources and forming hybrid systems would offer more reliability to the energy system. As the world is fully shifting to being all electric from machinery to vehicles, it might be a good opportunity for TU Delft to take a step towards electric heating facilities and to lead by example.

Personal Interview of Gilbert De Nijs, Energy transition coordinator, TU Delft

As scope 1 and 2 emissions play an important role in achieving carbon neutrality and they mainly deal with carbon emissions from energy use. The authors had a personal interview with the current energy transition coordinator of TU Delft, Mr Nijs to understand an expert perspective on TU's energy transition. The things mentioned below are solely personal views of Mr Nijs and what he envisions in achieving a carbon neutral campus.

Energy transition plays an important role in building a carbon neutral campus by 2030. How do you envision this?

TU Delft has an extensive ecosystem with wide knowledge base on energy from the research perspective, companies, start-ups and scale-ups and also an unique energy system for the campus. I envision that this combination is a great asset which can make TU Delft one of the best;

"Energy transition lab of the Netherlands and the World"

What are the opportunities you see to promote or accelerate energy transition?

The unique energy ecosystem of TU Delft itself is a great opportunity to accelerate energy transition. With institutions like the Delft energy initiative, Electrical Sustainable PowerWeb lab, Energy Transition Lab and many more, TU Delft is already leading in the research on various aspects of energy transition. From sustainable energy sources to future smart power grids, TU Delft is in the frontline for research in these areas. On the other hand, the energy system in the TU Delft is quite diverse with wind energy, solar, CHP plants, gas boilers and upcoming geothermal project. TU Delft's energy system comprises of diverse energy sources and the university is also the owner of the energy networks (heating, cooling, electricity, gas). This makes decision making about innovation on for example smart grids easier than in the public domain. It is a unique selling point for the researchers to test their innovations on the campus and make them well equipped for the societal use. Thus, this paves way for TU Delft to be a perfect living lab for energy transition.

Living lab is therefore an important tool that can support a transition to new phase.

This kind of a system gives an opportunity to accelerate the market readiness of new innovations by the researchers at TU Delft by testing it on the campus network from theory to prototype to real operational tests. ,

What are your immediate steps towards these goals?

Currently exploring opportunities to connect with the various experts and researchers in the university and start setting up the framework of the living lab.

Working on making inventories on different aspects of making the buildings sustainable. This includes assessments on PV panels on the roofs, inventory on lighting upgrades and may more.

Each building is quite unique and asks for a different approach to make it energy efficient. Hence currently we are focusing on assessing each building exclusively but also in the campus context and tailor the strategies to make them better.

Also, all new constructions on the campus will be energy neutral or even energy producing to meet the goal of producing 50% of the energy on campus.

What do you think are the main hurdles to achieve the energy transition targets?

The alignment of technology, finance and the organizational readiness is an important factor in progressing energy transition. Though the technology is growing at a very high rate, it also requires financial strength and change in the peoples mindset to push for the change. So aligning these three aspects to an equilibrium is a major challenge.

While the problem electricity is being addressed already, how is the heating part being dealt with?

The hopefully upcoming geothermal project will be a great asset which will contribute to sustainable heating system. The system is expected to meet 60% of the needs and reduce the gas use significantly.

Also, new ATES systems are being explored and will be used effectively in the south part of the campus for any future constructions.

But the availability of sustainable heating isn't that much a problem, cooling is an more important problem that needs to be addressed in the coming years. We need to explore options like improving the insulation, solar based cooling or use of surface water. This particular issues needs further investigation.

Is electric heating a viable option for the TU Delft network?

Though electric heating is an interesting option, it would need many adaptations in the network. The electricity procurement needs to be increased, the grid capacity will need to increase and a lot of new infrastructure needs to be installed. This is very expensive. And because sustainable heating can be produced efficient in many other ways, I think it's wise to reserve electricity as energy source for other purposes A transition of our current multi-commodity grids to a smart multicommodity grid will improve the reliability of the system and will it also be more economically efficient and sustainable.

What are your final thoughts on making TU Delft a sustainable campus?

As mentioned before, a living lab could be an important tool in building a sustainable campus. I call upon for more collaborations between research and us and ideas from the research community in the university to explore and use the diverse energy system TU Delft can offer. By collaboration we can accelerate the transition to a future proof energy system.

8.4.2 Food:

Carbon neutrality according to the standards or government specifications only focuses on emissions from scope 1 and 2, but scope 3 emissions also play an important role especially at an individual level to know the impact and make changes in the lifestyle. TU Delft is home for around 25000 young students who are soon going to be professionals, policy makers, social workers or hold any other office of responsibility. And as a university and an organization with huge resources, TU Delft can definitely play a role in moulding the cultural and behavioural aspects of all the stakeholders towards responsible consumption and reducing the negative impact on the environment.

The CO_2 roadmap has shown that according to the standard Dutch diet and several other assumptions, TU Delft is currently responsible for 13,800 tCO2 equivalent of emissions from food consumption. This is the highest amount of emissions compared to other operations related activities. Most of these emissions are attributed to the consumption of meat on campus. Though the number of vegetarian options are increasing in all the cafeterias across the campus there has been no reduction in the consumption of meat. Also there has been no proper evaluation of the impact of food based on data from Cirfood (the caterer of TU Delft) and other restaurants. To take successful measures for reduction and to track the progress of the university, it is important to know the base case scenario as close to reality as possible.

Vision for sustainable catering and food consumption:

- Define healthy and sustainable food standards for the all the restaurants
- Reduce scope 3 emissions from meat, dairy, packaging, cutlery and food waste
- Create awareness among the consumers for alternative options

With this vision, the authors define the following goals to be achieved in the next ten years;

- Perform a study on the impact of food on carbon emissions based on accurate data from the caterers and restaurants
- In addition to the environmental impact, focus on personal wellbeing and healthy life style
- Define healthy and sustainable standards for caterers and restaurants for procurement, menus, preparation and waste disposal
- Study business cases focusing on sustainable food options to support the restaurant owners and assure that it is economically feasible and profitable

- Take measures towards reducing the meat consumption
- Increase vegetarian and vegetarian meat options
- Reduce the use of disposable cutlery and plastic packaging
- Expand the current pilots like no meat week to all the faculty cafeterias and make it an annual or biannual tradition
- Create awareness among the stakeholders about the emissions from food through using net presenters
- Define guidelines for catering large meetings or events focusing on sustainable menus, reducing food wastage and avoiding disposable cutlery

Strategy:

Reduction of emissions from food is a critical task as it needs lot of encouragement and collective participation from all the stake holders. It is important that top down initiatives come to light from the university and the caterers. But it is also important that everyone understands the motive behind it and gradually make changes to their habits and lifestyles. Achieving sustainability in food mainly depends on the commitments, policies and social responsibility than investments. It demands lot of commitments and compromises from various stakeholders but it is definitely achievable.

In the current strategy, we approach sustainability in food based on various initiatives that are possible and presenting what each stakeholder can contribute to. This includes the TU Delft campus operations, Caterers, Restaurants & food truck owners, student organisations and consumers.

The student organisation here include GreenTU, Food and More and Foodsharing Delft who have been actively pushing for a sustainable campus. Organisationally, it is also recommended to designate an team to work on various aspects mentioned in this strategy. This includes helping with research, implementation of strategies and to actively track the progress being made.

Strategy	Initiative	Involved stakeholders
F1. Emission reduction	1. No meat week 2. Meatless Monday 3. Meat alternative menus 4. Reusable cutlery 5. Packaging	TU Delft campus operations, Caterers, Restaurants & food truck owners, student organisation and consumers.
F2. Standards for caterers and Restaurants	1. Procurement 2. Healthy menus 3. Waste and excess disposal	TU Delft campus operations, Caterers, Restaurants & food truck owners
F3. Guidelines for events	Food menu Reusable cutlery Managing excess food	Caterers & Student organisation
F4. Creating awareness	1. Study based on data from caterers 2. Business cases to support caterers and restaurants 3. Awareness through net presenters 4. Recognized student team to work on sustainable food options	TU Delft campus operations & student organisation

F1.1 No meat week

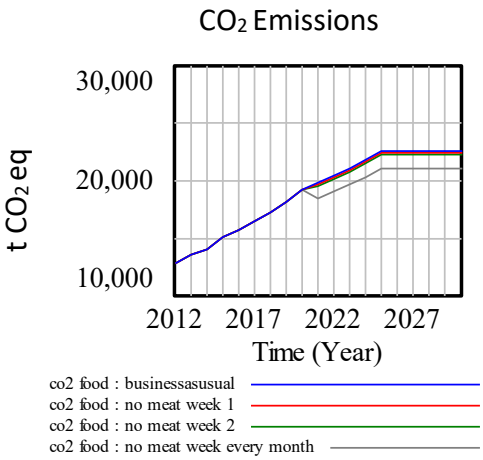
In March 2020, GreenTU in collaboration with Cirfood and Food&more organized a no meat week in the Ketelhuis cafeteria of the Faculty of architecture. The impact of this imitative on emission reduction was analysed using the data from Cirfood. Based on this data on the consumption and the emissions from different items on the menu, it was estimated that having no meat in this cafeteria for one week saved around 630 kg of CO_2 and around 350000 litres of water. The no meat week was a

great success being well received by the customers and was also a profitable venture for the caterers.

If this initiative is expanded to all the faculty cafeterias as an annual or biannual tradition, it contributes a lot to the emission reduction and initiates the idea of looking for alternatives among the consumers. This initiative also helps restaurants to experiment with their menus and know how to make this initiative a profitable venture.

Impact assessment:

Annual no meat week
Biannual no meat week
No meat week once a month

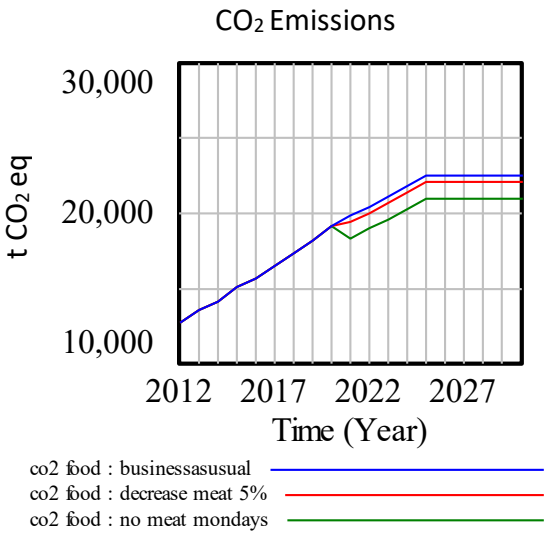


F1.2 Meat less Monday

Based on the feedback from the no meat week and the growing interest among people to reduce meat consumption, it is quite feasible to move towards having cafeterias serving only vegetarian options one day in a week. With a positive response from the no meat week, it would also be a profitable venture for the caterers and restaurants. Meatless Mondays is a popular concept being followed in many organisation and universities even in Netherlands. Implementing the tradition of Meatless Mondays would significantly contribute the emission reduction and changing the behavioural patterns of everyone.

Impact assessment:

42 weeks of no meat Mondays



F1.3 Menus with meat alternatives

Innovation in food is growing every day and encouraging this innovation towards sustainable alternatives could contribute a lot to reduce the meat consumption. Today the number of vegetarian options in the menus across different cafeterias and restaurants in TU Delft is very less and vegetarian meat options is still quite far from implementation. But the interest towards these options are growing among the people and could be both feasible and profitable. Hence it is recommended to push for offering more vegetarian and meat replicant alternatives in all the restaurants.

F1.4 Reusable cutlery

Currently almost all the cafeterias and restaurant in TU Delft use plastic cutlery. Though there is no data on the amount of usage, it definitely has a significant negative impact on the environment. Though it might be expensive to facilitate ceramic cutlery to meet the demand of the TU, other alternatives like commodities which are eco-friendly and biodegradable need to be explored. Few of these possibilities include;

- Plant based
- Edible cutlery
- Wood
- Bamboo

During the brainstorm session for sustainable food, one of the idea that was decided to be implemented as a pilot of to provide reusable cutlery for students. A customized cutlery set made of bamboo will be procured to be tested in one of the cafeteria. This would cost around 1 EUR and the users receive a discount of 10 EUR cents every time they dine in with this cutlery.

It is recommended to implement this across the campus and encourage the initiative by free giveaways of this cutlery. This can be taken up by organisation like GreenTU and Food and More. The master and bachelor introduction programs every year provide some goodies to incoming students, giving these cutlery through this would be a great to get things started by the new comers to the university.

F1.5 Packaging:

Sustainable packaging is another important aspect that needs attention. Though there has been a recent changes like the use of wood and paper based packaging product, the use of plastic is still a lot. Reducing the use slowly and further completely restricting the single use plastic is the way to go to achieve fully sustainable catering. This is an important policy decision that needs to be taken up by the TU and push for this idea among all the caterers and restaurants.

F2.1 Standards for procurement

The food that is consumed today is produced using various artificial chemicals and formulas. This is causing a great impact on the soil and thus making agriculture a unsustainable practice. Despite various political views on this, as a responsible organization TU Delft can contribute to sustainable agriculture by encouraging the caterers and restaurants to procure from organic sources. Though this might slightly impact the prices, collaborating with local suppliers and long term contracts with them can reduce the costs.

A shared and common standards needs to be defined for all the involved parties for procuring the food supplies. Few of these include;

- Organic food
- Local suppliers and farmers
- Future contracts with vendors who supply commodities with sustainability indicators

F2.2 Healthy Menus

The health and well-being of the people defines the university's progress. It is a due responsibility to strive and ensure supply of healthy food which improves the productivity and life style of the students, faculty and all other staff members. So it important that the food menus include healthy options which meet the daily body requirements and offered at reasonable prices especially for students. Most of the students go for cheaper options without focusing on meeting the nutritional requirements. Hence offering healthy food options at reasonable prices would

greatly boost the reviews on the catering/restaurants and improve the well-being of all the stakeholders making them more productive.

It is recommended for the working team to research on sustainable and healthy food standards which can improve the wellbeing of people. It is important that the TU commits to the wellbeing of its people and takes required action to push for good and healthy food options. The caterers and restaurants can start this as an pilot by testing their experimental products until they get the pulse of the customers. Implementing this could be a great addition for TU's focus on the welfare of its people.

F2.3 Waste and excess disposal

Disposing the organic waste from food preparation and discarding the leftovers by caterers and restaurants is also an important aspect that needs to be taken care. Though there are no specific details on how the current waste or excess is dealt with, it is advised to have a common policy on how this issue needs to be attended.

Food Sharing Delft, a student initiative formed to reduce the food wastage from various restaurants and grocery stores has been very active in the year 2019-20. The leftover food which is good condition is collected and is open for everyone to pick it up from their freezers located in Ichange, Delft. The organization also has an idea to develop a mobile application to expand the initiative. The application will be focused on identifying the locations where there are leftovers and will allow them to collect the food. Later the available food data will be shared on the app for public to collect for free of cost.

Recognizing this organization and implementing their initiative in a TU wide scale would definitely add a great value and save lot of food from ending into the garbage. This can further be extended to collaborate with NGOs which work on food security and offer food to the needy.

Coming to the organic waste from the food preparation, it should be ensured that the waste separated from other dry waste and is treated accordingly. The TU needs to support this by providing separate bins for wet and dry waste within the kitchens also. The Facility Management can take up this extend it to use the waste as compost for maintaining the greenery on campus. The campus already holds a compost facility, so it would be a very viable option to explore.

F3 Guidelines for sustainable events

Events, meetings and other gatherings with lunch or dinner are another major contributors to food wastage and unsustainable practices. Starting with the use of

disposable cutlery and glasses, comparatively less vegetarian options to unattended leftover food, many gatherings can be organized more responsibly. For the year 2019-20, GreenTU has taken the initiative to consult and support (with ideas and financially) various organisation in organizing their events in a sustainable manner. One of the ideas was to procure reusable glasses which can be used by other student and study associations for their events.

To reduce the environmental impact from events especially from catering, it is recommended to provide specific guidelines to make the events sustainable. Starting from providing sample menus, guidelines for use of cutlery & glasses to offering suggestions on how to deal with leftovers and waste. The guidelines can be developed based by student organisation like GreenTU, Food and More and Food sharing Delft. But for successful implementation and to ensure all events organized by the TU also are an integral part of this, it is important that the facility management considers and approves this after required discussions.

To begin with, the current report gives a direction to this cause with the following tips for attaining sustainable catering for events;

- Encourage menus with plant based food and vegetarian meat options
- Reduce meat consumption
- Serve healthy salads and fruit
- Place the orders based on RSVP or registration and avoid wastage
- Avoid using bottled water, instead provide pitchers of tap water
- Purchase reusable party glasses for shared use by all the student and study organisation
- Avoid the use of disposable plates and cutlery. If needed opt for biodegradable materials.
- Ensure waste separation at the event location
- If there are any leftovers, make sure they are well attended either through organisation like Food sharing Delft or by free giveaways at prime locations on the campus

F4.1 Study based on real data from the caterers

The present emission data that is report is a great way to start the sustainability initiatives in the TU but there are lot of assumptions behind these calculations. To know the true impact of the university it is important to analyse based on the real data from the caterers. There needs to be a comprehensive study based on the kind and the number of items sold and their respective carbon impact. The study needs to put together information from all the food joints on the campus to bring it close to

the reality. This study could be a very good bench mark and would help in tracking the progress while implementing the different strategies.

The study can be taken up by a working group dedicated to deal with sustainable food on campus. The working group could be one of the present student organisation like GreenTU, Food and More and Food sharing Delft, a collaboration between them or a separate entity which will focus on implementing various ideas mentioned in the current report.

F4.2 Business cases to support caterers and restaurants

As an extension to the F4.1, it is also important to investigate and show that the implementation of various ideas like no meat, healthy menus etc are profitable and viable options for caterers and the restaurant owners. While various initiatives are implemented, it should be ensured that the business of the restaurant or the people related to them are affected in any way. Hence it is recommended to perform case studies on making sustainable catering a cost effective initiative.

F4.3 Awareness through net presenters

Though there are reports and data being published on the carbon impact of the university, it is not reached to all the stake holders. It is a due responsibility to create awareness among everyone about this and lead the way towards a behavioural change. The use of net presenters which are placed almost in every building of the TU could be a very good initiative. The information being displayed could include;

- The current carbon emission from food
- Amount of food wastage
- Information on various initiatives being taken
- Report on the emissions saved and avoided wastage
- Tracking the progress monthly and yearly

F4.4 Recognized student team to work on sustainable food options

For the successful ideation and implementation on an initiative it is important to have a dedicated team working towards the goal. Operational activities like energy have dedicated top down team working towards the transition. Whereas food, a major contributor to the emission count does not yet have a specific team to work towards making it sustainable. During the year 2019-20, with the support from the Facility Management and the Sustainability Coordinator, GreenTU made a start by organizing a brainstorm session to discuss sustainability in food. The other collaborators who joined this include student organisation like Food & More and BKGreen.

But in order to perform an after math for the present report or to push for other ideas for sustainable food in TU, it is important to have a dedicated team working on it. This can begin with forming a student working group who can start with some research and feasibility studies. The ideas like use of net presenters, organizing no meat days, analysis and tracking the progress can be taken up by this team. GreenTU Delft can be responsible for setting up this team and collaborate with it whenever needed.

8.4.3 Mobility:

The impact of mobility on the carbon emissions also takes a significant proportion in the total emission. In spite of most commuters use bikes as their primary transport, the high emissions are attributed to the business trips by air travel. As per the research done for the CO2 roadmap, the air travel by the various stake holders of the TU accounted for around 33 million kms. This is almost equal to 6667 t CO_2-eq. In addition to this the daily commute by employees and students contributes to 4963 t CO_2-eq [4]. The total carbon emissions from travelling is around 11630 t co2 eq.

Currently around 27000 people travel to the TU campus every day [6]. This number is going to increase further in the coming days. To tackle the issues of expanding the facilities and promote sustainable mobility, CRE and the HR department have made an extensive research and published a report with a vision for mobility and campus accessibility [6]. This report gives a great idea on the amount of work that needs to be and can be done.

With the increasing use of cars, the parking spaces are already filled up to 82% during the peak times [6]. This stresses the need for building new parking facilities to accommodate the future demand. This will further make the travel unsustainable. Also with the growing globalization and increasing capabilities of the TU, the air travel is also expected to grow if no control steps are taken. Hence, it is the need of the hour to develop a Sustainable Travel Policy which focuses on daily commute to & from the campus and also on business trips.

With this vision, the authors define the following goals to be achieved in the next ten years;

- Create awareness and encourage sustainable transportation
- Develop schemes and subsidies to support employees to choose sustainable alternatives
- Improve the public transport facilities and infrastructure to and from the campus
- Avoid air travel unless it is mandatory
- Promote clean transport by encouraging e-bikes and build infrastructure for e-charging stations
- Limit the building of parking spaces
- Improve facilities for meeting future bike traffic and parking
- Encourage and promote research on clean transportation
- Purchase only electric vehicles for the TU fleet

In this report the authors would like to mention few initiatives that can help in transition towards sustainable travel by the TU stakeholders.

The strategies are based on the investment need for a particular initiative and the impact created by it. The ideas are divided under three categories;

- No or low investment (<500,000 EUR)
- Medium Investment (> 500,000 and <5,000,000 EUR)
- High investment (>5,000,000 EUR)

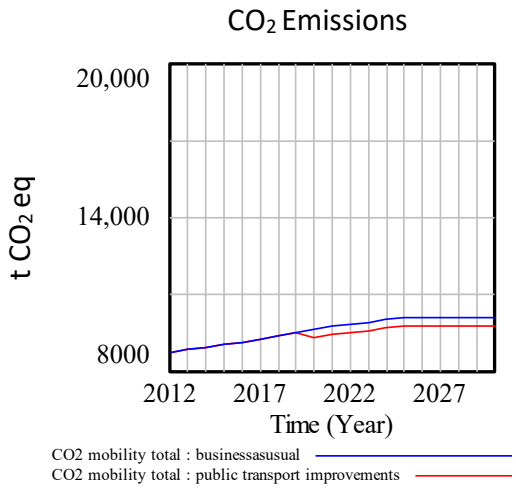
Strategy	Initiative
M1. No or low investment	1. NS business cards to employees 2. No car day 3. Ride sharing/car pooling 4. Restricting air travel 5. Encourage video conferencing 6. Implementing nominal parking fee 7. Travel portal
M2. Medium investment	1. Subsidies for purchasing e-bikes 2. Facilities for virtual conferencing 3. Improving biking facilities 4. E-charging stations 5. Travel fund 6. Mandate Compensation
M3. High investment	1. TU fleet to be all-electric 2. Connectivity between Delft station and the campus

M1.1 NS business cards to employees

Currently there are no schemes offered by TU Delft to promote the use of public transport. The university pays all employees a monthly sum of 47 EUR to spend on travel and this need not be a sustainable mode of transport. This scheme currently cost around 2.8 million EUR for the TU [6]. In addition, the connectivity between the TU and the Delft Central Station also needs improvement. Nevertheless, the tram lane to the TU will be completed in the coming years and would greatly encourage the use of public transport. It is estimated to increase the use of public transport by 10% [6].

It is becoming a common practice by various organisation and universities across the Netherlands to offer NS business cards to the employees. This is not practiced in the TU yet. Encouraging the employees with NS business cards would further increase the travellers using public transport. Based on the feedback from a sustainable mobility pilot [39], 22% of the participants claimed to use public transport more often. Hence providing means like the NS card would definitely encourage employees to think in these terms.

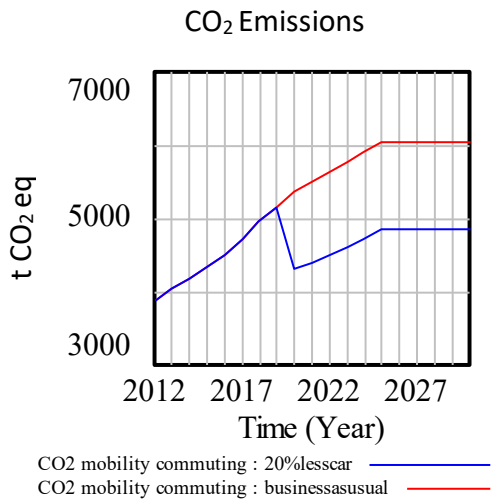
Impact assessment: 10 % increase in public transport



M1.2 No car day

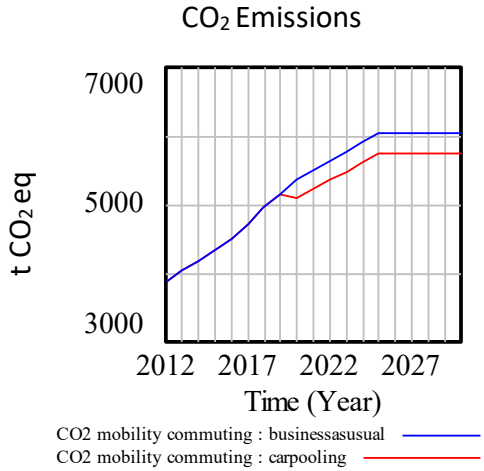
An initiative being practiced in many organisation across the world, a no car day can make a lot of difference in reducing the emissions and inculcating sustainable practices among people. If one day in a week can be declared to be a no car day, this could already reduce the emissions from daily commute by 1/5th. This will also encourage people to explore various public transport options and might eventually use it more often.

Impact assessment: 1/5th decrease in emissions from cars



M1.3 Ride sharing/Car pooling

According to the mobility report, only 2% of the TU staff use carpooling to commute for work [6]. Though it might be logistically difficult to organise, studying the possibilities of offering carpooling or ride sharing facilities by the TU itself might give new nuances into people's opinion on exploring this option. A research by Mobycon found that atleast 21% employees live in distances that cannot be reached by a bike but can be covered by an e-bike [6]. Providing ride sharing facilities from prime locations around Delft for this 21%might decrease the car use atleast by 5%.
Impact assessment: Decrease car use by 5%



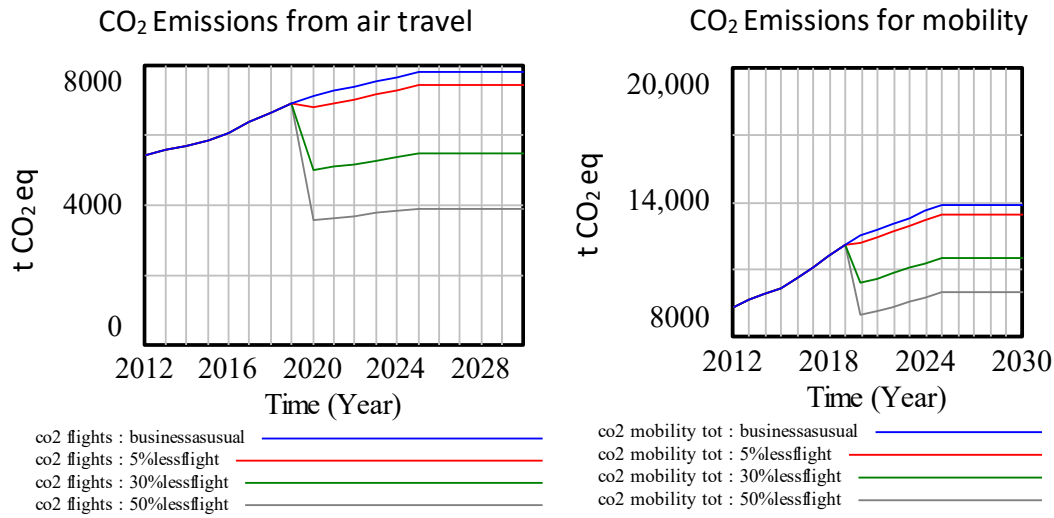
M1.4 Restricting air travel

The carbon roadmap has proposed an initiative to travel by train within the radius of 700kms around Delft unless and until it is necessary [4]. The distance of 700 kms around Delft covers many major cities that usually people from the TU travel using flights. Travelling by train instead takes almost the same amount of time as the flights considering the time to reach the airport, waiting, baggage, etc. In addition it offers the comfort to work during the commute. Hence if TU Delft can mandate this initiative

with proper set of guidelines, it will significantly reduce the emissions from the using air travel. This might initially increase the expenses but over the years it will definitely save the amount that needs to be paid as tax or compensation.

If the journey is to a place farther than 700kms, the flights can be used but it is recommended to implement a policy to compensate for the emissions. The TU can collaborate with organisation which facilitate this compensation activities to ease the process. But if such a travel is being undertaken to attend a meeting of an hour, it is advised to check for alternatives like video conferencing.

Impact assessment:



M1.5 Encourage video conferencing

As mentioned in M1.4, limiting the travel to large distances can be avoided by promoting virtual meetings and video conferencing. Unless it is a must, the TU needs to encourage people to use video conferencing for their meetings if they are for short duration but are in far off places. At the time of writing this report, the COVID 19 crises has pushed the whole world in to a virtual work space. Most meetings, conferences and events have shifted to online platforms in many creative ways. The business travel has almost dropped to zero but still things are working and people are participating in various activities through online modes. Though the format is missing human interaction, it is still saving lot of time and resources along with saving the environment.

The COVID scenario could be taken as an inspirational case study to explore alternative options to reduce business travel. A great start has been already made and many people are getting used to this norm. This provides the right opportunity to bring in policies on encouraging video conferencing and virtual meetings.

M1.6 Implement nominal parking fee

TU Delft has around 3800 parking spaces approximately and they are 82% filled during peak times [6]. This shows the demand for the use of parking facilities. Currently there is no charge for using the parking spaces and this encourages people to make use of the facilities. Also, between 4-10% of these parking spaces are being used by people not related to the TU but use them because they are free [6]. In the coming years the demand for parking spaces is expected to increase and will need new facilities to be built to accommodate them. This would be another huge investment and also unnecessary land and resource use.

To avoid outsiders using the resources of the TU and to encourage people to use sustainable modes of transport, it could be nice to offer access cards with minimum monthly charge for using the parking spaces. Putting a price on using the parking space can provide an incentive for the people to use e-bikes or public transport. The amount collected from the fee can be used for funding other sustainable mobility projects.

M1.7 Travel portal

With new initiatives coming up and the growing awareness among people about sustainable modes of transport, it is important to communicate all the information that is available. Hence it is suggested to have an online portal linked to the TU Delft website for dealing with the mobility related issues. This could include subscribing for ideas mentioned in this report like NS business cards, parking access cards, to know about compensating for flights, etc.

Currently there is a mobility page which are mainly designed for the mobility pilot project conducted in 2019 [39]. This is good opportunity to expand this site to be a portal with all the information about accessibility to and from TU and the various sustainable initiatives.

M2.1 Subsidies for purchasing e-bikes

A survey by Mobycon revealed that 21% of the TU employees live in a distance around the TU that is not reachable by a bike but can be easily done by an e-bike. But currently only 1% of the employees use these e-bikes. Based on the mobility pilot project which was conducted in 2019 use of e-bikes was the prime focus. After the pilot concluded, of the 517 employees who participated, 22% of the participants have bought an e-bike and another 32% were planning to buy one in the near future.

This shows that many if all the employees realise the use of e-bikes and have some push from the TU towards purchasing it, there would be a great transition towards sustainable mobility. The university can offer this in the form of a subsidy. The funds for this can be diverted from the 2.8 million EUR which currently pays around 50 EUR for each employee towards travel. The same money spent over 2-3 years can already pay for a good e-bike.

M2.2 Facilities for virtual conferencing

As proposed in this report, virtual meetings and conferences needs to be encouraged to avoid air travel to long distances. From the COVID 19 scenario, it is clear that it is viable and a practical solution. To facilitate this effectively, the TU needs to develop the required infrastructure for virtual meetings and conferences. A similar initiative has been taken up by the ETH Zurich in Switzerland and a conference was organized to promote virtual academic exchange [18]. Though human interaction is definitely important, if a long flight trip is only to spend one or two business hours, the idea needs to be rethought.

M2.3 Improving biking facilities

The use of bikes by the students and the staff is already quite high and is expected to grow over the years. To meet the increasing demand, there is a need for adding more bicycle racks on campus. Currently there are 14000 racks and they are 80% occupied most times of the year [6]. Few buildings like the Aula, EWI and TN are already facing shortage of the bicycle racks resulting in mis-parking. To avoid discouraging the bikers in the future, it is important to expand these facilities.

In addition to this, the coming years will see an increase in the use of e-bikes on the campus. Considering the cost of the bikes and the maintenance it demands, it is important to facilitate separate parking spaces for them. Also need to ensure that the area is theft proof to assure the safety concerns of the users.

M2.4 E-Charging stations on campus

In the recent years, the use of electric cars had a sharp rise and is expected to increase further in the coming years. To encourage and support the EV users, the infrastructure for charging the cars must be put in place. Presently, few parking spaces have these ports but it needs more expansion. It is suggested to have at least one charging spot in each parking area and more than one in prime locations. Care should be taken to see that the chargers use sustainable energy like solar of wind.

M2.5 Travel fund

To support various initiatives mentioned in this report, the financial aspects also needs to be looked into. Creating a separate travel fund with different kinds of incomes on travel could be an option. This includes the amount allocated by the HR department, parking fee, flight emission compensation fee and others. This fund can be used to implement ideas like subsidies for e-bikes, issuing NS business cards and paying for train trips instead of flights. Though is an initial idea, studying the case further can definitely yield good results on the longer term.

M2.6 Mandate compensation

Currently, the university provides assistance to many stakeholders for their business trips. But these flight trips are not compensated for the carbon footprint. It is only being done with a personal interest from the individual but there is no policy from the TU on this. Hence it is important to promote the concept and bring out ways to facilitate this compensation. It also needs to be decided if TU Delft will pay for the compensation or will it be the responsibility of the individual. It is suggested to push the responsibility towards people know the impact being created and discourage them from using flights unless it is mandatory. Therefore compensation needs to be mandated to bring behavioural change and to indulge in alternative good practices like afforestation which is a widely practiced activity using the compensated amount.

M3.1 All TU fleet to be electric

As an part of procuring sustainable products, TU Delft also needs to invest in buying only electric vehicles. The current vehicles which are fuel based needs to be replaced to sustainable means.

M3.2 Connectivity between Delft station and the campus

The lack of proper connectivity between the Delft central station and the campus is a major factor for less public transport use. Current journey for people who travel from the central station would take atleast 20-25 minutes by walk or by taking a bus (including the waiting time). TU Delft and the Delft municipality have already approved a plan to have a HOV tram line connecting the campus to the station [6]. This would be a great way to reduce the travel time and also the cost. This line is estimated to increase the public transport use by atleast 10%. But to ensure the project is on time and can support the sustainability efforts, TU Delft need to be active in pushing for realization of this project.

8.4.4 Waste:

With a population of around 30000 people, TU Delft has a huge amount of waste outcome. The total waste generated is around 2.8 million kg per year and is expected to grow even higher with the present growth rate. The main waste streams are residual waste, GFT, paper & card board and debris from construction/demolition [4]. Currently, the waste management in the TU is done by Renewi and despite the various waste treatment initiatives the university still accounts for about 908 t CO_2-eq [4]. Though this number is quite small compared to the emissions from other sources, managing the waste streams is also an important part in achieving circular economy. Therefore, to reach the goal of being Circular by 2030, it is the need of the hour to take concreate steps in managing the waste streams and push for sustainable procurement.

According to the 2019 statistics by Renewi, about 42% of the waste generated is recycled and raw materials are extracted [5]. This is a great initiative that is paving towards circular economy. For example, the coffee cups are being used to make toilet paper. Initiatives like these are encouraging and provide a great scope for improvement in the next ten years. But what about the remaining 58%?

Of the waste that is not recycled, about 20 % is used to produce energy (waste to energy), 23 % is being reused organically and the remaining 15% is being dumped in landfills [4]. Though use if waste for generating energy cause small amount of emissions (about 370 t CO_2-eq [4]), it is an efficient way of treating waste. It is also commendable that all of the GFT waste which is from catering and landscaping (of about 468,100 kg) is being treated in one or the other ways mentioned above.

The 15% waste which is sent to landfills accounts for 415 tonnes per year. Better ways of treating the waste can be explored if it can be separated efficiently at the source and this is still not fully implemented all across the campus. Along with the initiatives taken by the university to improve waste treatment, we also need awareness among the people to practice them. The amount of waste generated per person in Netherlands is 7^{th} highest in the EU with 8.2 tonnes per year in 2016 [40]. A behavioural change towards reducing the wastage and reusing things needs to be inculcated.

With this vision, the authors define the following goals to be achieved in the next ten years;

- Create awareness among stakeholders on waste reduction measures
- Taking concreate steps to avoid single use plastic usage and waste on campus
- Improve waste separation facilities across the TU campus, both inside and outside the buildings
- Reduce the amount of waste being dumped in the landfills to 5%
- Explore new and sustainable ways of treating waste
- Evaluate and explore ways to treat hazardous waste
- Promote composting practices on campus
- Reduce the waste generated from events (disposable cups & cutlery, food, etc)

The current report will focus on ways to improve the waste treatment and ways to reduce the waste generated. The strategies are based on the investment need for a particular initiative and the impact created by it. For waste treatment, the ideas mostly No or low investment (<500,000 EUR)

	1. Waste treatment	2. Waste reduction
W1. No or low investment	1. Data collection and performing MFA 2. Waste separation bins 3. Special bins for hazardous waste 4. Waste separating guidelines for caterers 5. Avoid single use plastic 6. Reutilization or selling old furniture 7. Online market place for TU stake holders to buy/sell old items 8. Composting on campus	1. Organizing recycling events 2. Avoid food waste through Foodsharing Delft 3. Mandate two side printing 4. Bring your own cup

W1.1.1 Data collection and performing MFA

The Circularity road map made by CRE in 2018 has performed a Material Flow Analysis (MFA) based on the financial data of procurement activities. But to get a real

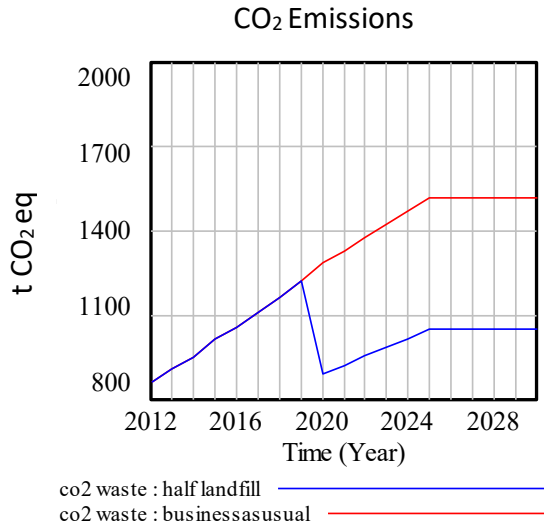
grasp of the scenario and to track the progress, it is important to make an overview of all procurement and disposal activities. Hence collecting this data at least for an year and performing a MFA would give a much realistic idea about the circularity and the steps to be taken to improve waste treatment. Authors suggest that this can be taken up by CRE but can also be a very interesting project for students especially in Industrial ecology studies.

W1.1.2 Waste separation bins

A pilot project was started in 2019-20 in collaboration with Renewi where recycling islands were set up in Aula and Faculty of Architecture. These islands had separate bins for paper, PCD and other waste. In addition to this, the catering facilities also had a separate bin for food. With this initiative, users will find one of these islands for every 30 seconds walk. This would be a great opportunity to expand the waste separation on campus. Expanding this to all the buildings and cafeterias will improve the recycling of paper and other residual waste which comprises of around 300 tons of waste which is sent to landfills.

In addition to this, there needs to be an improvement in separate bins for glass, wood and metals being placed one per building. Today we rarely find bins for glass on campus. It is also recommended to have bins for e-waste on prime locations on the campus.

Impact assessment: Atleast 50% decrease in landfills



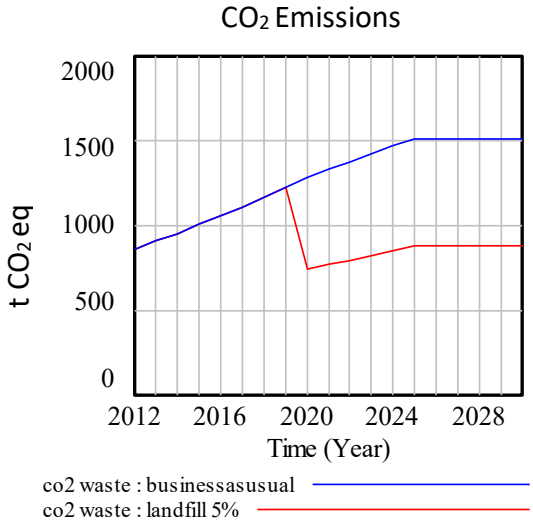
W1.1.3 Special bins for hazardous waste

Currently all the hazardous waste from TU Delft is about 100 tons and they are either sent to landfills or its outflow is unknown. It is important that these materials treated

appropriately. The waste from landfills releases harmful gases and the presence of these hazardous materials or chemicals might make it even more harmful.

So it is suggested to ensure that these wastes, especially from the labs should be collected separately and the contractors should ensure that they are taken care responsibly. Thermal, chemical or biological methods needs to be investigated to see that these hazardous wastes are treated in a sustainable manner. Managing this waste stream will save around 100 tons of waste from entering the landfill.

Impact assessment: 100 tonnes of hazardous wasted treated in an alternative way and avoid sending to landfills. This reduced the waste sent to landfills by 5%.



W.1.1.4 Waste separating guidelines for caterers

Currently there are 19 cafeterias/ restaurants and other food trucks in TU Delft that use the facilities and generate waste. It is important that the waste generated during their processes and the access food waste that is generated is well separated and managed. To ensure common practices among all the caterers, a set of guidelines needs to be adapted. To make a start on these tips/guidelines, the authors suggest the following;

- Use of separate bins for organic waste
- Avoid disposing used oil in the garbage but use separate containers
- Avoid the use of plastic cutlery or plates
- No use of plastics for packaging
- Give away the access food for sell for discounted price instead of discarding it

To support these guidelines, the TU and the waste management contractors should facilitate required infrastructure and also explore ways to treat things like oils.

W.1.1.5 Avoid use of single use plastic

A popular opinion from students and many organisation within the TU is the ban of single use plastic in all the activities. This includes plastic bottles in vending machines, cutlery, packaging, etc. A decisive step needs to be taken to address this issue and minimize the use of plastic within the university.

W.1.1.6 Reutilization or selling old furniture

In promoting circular economy, the university needs to take steps towards reutilizing its property. TU Delft has some of the best in class infrastructure when it comes to furniture, teaching equipment, computers, etc. After the maximum lifetime or in renovation stage, these items can be utilized for other purposes or can be give away to students or can be resold if in good condition. It is suggested that the concerned people will look at these possibilities before discarding the materials. A live example is the new Sustainability hub that is ready for inauguration in the Fellowship. The furniture being used is something that was discarded from the old buildings. So there are many more possibilities like this which if explored can make a lot of difference.

W.1.1.7 Online market place for TU stake holders to buy/sell old items

Online market places is becoming quite popular for buying and selling old products. With various platforms like MarketPlats and Facebook groups, this is already a popular initiative among students. Considering the population of the TU, having its own platform would be a great advantage to even sell old items from the TU. This platform could also be used for organizing recycling events and providing information about sustainable materials and waste management initiatives. This could also be executed as a student project in collaboration with organisation like GreenTU.

W.1.1.8 Composting on campus

There is lot of biodegradable waste that is generated on the TU campus, especially from landscaping and food waste. This can be treated efficiently by having compost facilities on campus. This in be again used in the landscaping procedures and to improve the campus greenery.

W.1.2.1 Organizing recycling events

Encouraging the organization of annual or bi annual recycling events at the TU would be a great initiative to collecting waste form work and house. This can focus on collection of rare waste items like electronics and furniture. A similar initiative was conducted in 2019 to collect old mobile phones and received a decent response. Student organisation should come up with such interesting events and the TU also needs to be an integral part in contributing within the university.

W.1.2.2 Avoid food wastage

As discussed in the strategy for sustainable food, care should be taken to avoid food waste or use the access food in a meaningful way. The authors suggest recognizing food sharing Delft to be viable partner in this by expanding their reach.

W.1.2.3 Mandate two side printing

An initiative that is coming up in various big organisation is to reduce their paper use and encouraging digital way of doing things. Currently, there are no such initiatives and it is observed that one side printing is a common practice being followed. Unless it is really required, everyone should rethink on using the resources. Mandating two side printing can be a great way of reducing the use of paper. This will save the money being invested in procurement and also reduce the waste generated.

W.1.2.4. Bring your own cup

The initiative of bringing their own cup needs to be popularized. Not many people across the TU know that bring their own cup gives them a discount on their coffee. This needs to be expanded to all coffee places with small rewards for people who bring their own cups. This will reduce the thousands of coffee cups being disposed every year.

8.4.5 Water:

Supply of clean drinking water and responsible consumption of water are two main aspects of water management with regards to SDGs. Currently the emissions from water in the TU is quite negligible and cannot be addressed any further. Despite the fact that there is water scarcity in the TU or in the surroundings, it is important to imbibe the practices of saving the recourse and consume in a responsible way. This can be done as follows;

- Collection of rain water and using them for internal use in toilets
- Use of sensor based taps across the campus
- Reuse of waste water in WCs or other purposes
- Setting up of drinking water taps and encourage people to carry water bottles. This also avoids the use of single use plastic on campus

8.4.6 Procurement:

The procurement of various items for direct use or for selling on campus play an important role in TU Delft's environmental impact. The scope 3 emissions coming from these procurement activities are not yet calculated or accounted for in the university's CO2 emissions. The purchasing action also has a direct impact on the circularity of university. The Circularity roadmap determined that TU Delft is currently 5-15% circular based on the MFA [5]. This may not be completely certain due the lack of data.

To be carbon neutral and circular by 2030, it is very important to take decisive actions on various procurement activities. TU Delft needs to include sustainability as an important criteria for decision making during any tenders or contracts. A comprehensive Procurement Policy needs to be developed with selection criteria's for different commodities. As a pre-requisite to the Procurement Policy, the authors would like to highlight few Sustainable Purchasing Guidelines;

- Research on sustainable alternatives and vendors offering them
- Collection of procurement data, analysis and reporting
- Incorporate sustainability into contracts and tenders
- Cost decisions should value the long term impact and ROI created by sustainable procurement
- Preference to purchase reusable commodities
- Review the sustainability value of the products by metrics and certificates
    - Energy: Purchasing electronics with A+ (or better) or Energy star rated
    - Water: Discourage plastic bottles in vending machines and facilitate water filters more widely
    - Chemicals/pollutants: Products should not contain lead or mercury unless mandatory or if there is no other alternative
    - Packaging: Gradually ban single use plastic and invest in reusable and long lasting items. Or use recyclable or compostable alternatives
    - Paper: purchase recycled paper and ensure used/waste paper is almost completely recycled

8.5 STRATEGY FOR SOCIAL ENGAGEMENT

Achieving sustainable development is a collective effort. Despite of the various initiatives taken up by the university management and the organisation like GreenTU, it is important that people believe in the cause and make their individual contributions to it. To encourage this culture, the current report identifies social engagement to be an important tool for sustainable development. This includes both internal and external interactions of the university with regards to sustainability. And this social engagement can pave way for addressing the SDGS of 'Partnerships for the goals' and 'Gender equality'. The authors suggest that social engagement can be evaluated and addressed with respect to four areas where improvements can be made;

- Communication (internal and external)
- Stakeholder engagement
- Events
- Inclusion

1. Communication:

As seen in the current report, there are various ongoing sustainability related activities in TU Delft. But this report marks the first time that they are being brought together and shown to the world. Communicating what is happening and what is intended to be done is very important with the extreme movements rooting for climate action, happening around the world. Currently, except for the commitment given towards the climate action, no policy or official information has been released by the university. This is causing serious problems for the university rankings and effecting the brand value. In addition to this, even within the TU, there are many students who are interested in starting or following sustainable initiatives but are not aware what is already happening and whom to contact. To address these problems, the authors suggest the following;

- Framing policies
- Sustainability website
- Annual sustainability reports & Feasibility studies
- Internal communication

<u>Framing policies:</u>

As mentioned before, there are no official policies released by TU Delft regarding its action towards sustainability. This is resulting in many people and departments within the university who are working towards this topic without a defined vision and no

further direction. Though bottom-up initiatives give a great scope for innovation and diversity, it is important that these ideas are streamlined and executed in an effective way. Today the number of these decentral projects have been increasing and it is the need of the hour to make official policies which can guide various initiatives on the campus.

In addition to this, the 2020 SustainaBul ranking which is known for ranking universities across Netherlands for sustainability has ranked TU Delft at 23rd position in Netherlands. One of the main reason for this was the unavailability of official polices and information about the various initiatives on the TU Delft webpages. Despite of the data submitted, the lack of any official information or reports on sustainability has resulted in poor rankings.

Therefore it is important that the policies are developed with consultation from experts and the various works done on this topic until now are recognized and made official by the TU. This includes documents like CO2 roadmap, Circularity roadmap, mobility assessment etc.

Sustainability website:

The TU Delft webpage has a tab for sustainability which gives an idea of various initiatives on a macro level. The website is redesigned with updated information and new page for GreenTU and GreenTeams. Before, the website lacked updates and held very old information. GreenTU has taken the responsibility to improve the content on this website and constantly update it with new projects and information. But it is important that this page is highlighted and can be reached easily. As practice by various organisation, GreenTU also suggests that the sustainability tab should be included on the main home page of the TU Delft webpage.

With more expansion and frequent updates, this page needs recurring promotion to improve the communication towards sustainability. Showing major projects on the university home page could be a great way of doing this. The TU Delft official social medias need to keep track of the new updates and share them more often. This will improve the visibility of the webpage for external parties and also for the university stakeholders.

Annual sustainability reports & feasibility studies:

The Sustainable Development Strategy 2020-30 is the first report reviewing the sustainability in TU Delft and suggesting measures towards sustainable development. However, implementation of these measures need further feasibility studies and reports with plans of action. The first step as an aftermath of the current report is to

get expert advice on the ideas and to work out the possibilities for implementation. These reports can be taken up by the TU employees, GreenTU and its committees. Otherwise, recruiting - voluntary or paid-working groups who can spare time and perform a detailed study. It is also important that these studies are published on the TU website and social media channels to show the progress being made.

Next, sustainability reports can play a great role to keep track of the developments made and to show various initiatives that have been started in the TU. Sustainability reports have now become a custom is various organisation. From 2020, the GreenTU has taken the responsibility to make the annual report on sustainability. This should become a custom and should evolve with the years to come. To improve the report further, the authors advice further research on the Global Reporting Initiative and the standards mentioned in it for sustainability reporting. It is also advised make a Green House Gas inventory based on the standards of the GRI which is being followed by many institutions.

Internal communication:

Another important aspect about communication that needs improvement is the on campus awareness using the various media channels. As an example, coffee cups recycling bins exist on campus but using a small infographic showing the impact of collecting the cups efficiently would create more awareness among people. Also showing the information like food wastage or emissions saved due to no-meat could be a great way of encouraging people to participate. Another aspect is sharing about initiatives and achievements about sustainability with students. Use of net presenters for communicating this information could be very effective as it is already done with solar panels energy production.

Presently, GreenTU and various other organisation are ensuring that the sustainability related initiatives reach students through their social medias. But it is also important that the university employees are aware of this information. Hence, we suggest circulating internal newsletters for the employees at least on quarterly basis and update them about the progress being made. This might also trigger their interests and bring out new opportunities.

2. Stakeholder engagement

There are many organisation within the TU who are promoting sustainability and engaging the students in their activities. To name a few, the Energy Club, Centre For Sustainability, Students4Sustainability, Foodsharing Delft and Lijst Béta are already quite popular and are doing a great job for this purpose. All these organisation are working hard and each have a specific audience with varied interests. However, these

groups and associations are often not working together, thus splitting potential audience and active members interested in the topic of sustainability.

To increase the reach of these organisation and various activities they do, it is important to improve the collaborations between them. These organisation can join forces to be a strong group of people with common goals and vision which will increase the effectiveness of the initiatives taken. This can engage more people, create more awareness and create more audience for their communication channels and events. These collaborations will also improve the effectiveness of social media channels where the information can reach more people.

As an official sustainability department of the university, GreenTU Delft can take up the responsibility in bringing these organisation on to the same stage. This is already happening with the organization of the Day Of Sustainability since the last two years but can be improved further. In 2019-20, GreenTU has started the Student Sustainability Council (SSC) which is aimed at connecting with various study associations within the TU to collaborate, advise and support them in becoming sustainable. The SSC is planned to meet every quarter to discuss the progress made, network with fellow organisations and collaborate. This SSC can be extended further to include all the sustainability related organisation in TU Delft, thus enabling more collaborations and bigger community.

The GreenTeams also play an important role in engaging students and teachers on the topic of sustainability. The inventory reports that were prepared by them to make the faculty sustainable include lot of recommendations based on the suggestions from students and the professors. The summary of the reports than be found in Appendix A.

3. Events

Events are an important way of bringing people together and encouraging them to participate in sustainability. The Day Of Sustainability an important event that is organized by GreenTU in collaborations with various other organisation. The event includes workshops, lectures, games and lot of networking. The DOS 2019 has been a great success with wider audience and interesting programs. This particular initiative needs to get better every year to continue the dialogue on sustainability. Also, the Sustainability Career event by IESA Swift which was planned but cancelled due to COVID measures is another great initiative to show new opportunities to people.

In addition to this, there need to be more events which can help people to change their lifestyle towards a sustainable one. One such example is the Secret Santa 2019,

organized by GreenTU, Centre For Sustainability and ISA. The event was aimed to promote reusing the given products and reducing the waste from festivals. Also the Zero waste challenge organized last year has received great response from the participants.

All in all, it is advised to organize more events focusing on developing the interest among students and employees on the topic of sustainability. Also, collective organization of these events needs to be encouraged to reach a bigger audience and have a bigger impact.

4. Inclusion

Inclusion is something that happens on all levels of TU Delft. As an institution, TU Delft has the responsibility to create an inclusive atmosphere, where personal differences are celebrated and minority voices are lifted up. The responsibility to make sure its students and staff feel welcomed. As stated, this is something TU Delft is actively working on and has made significant progress in recent years. However, there is still a long road ahead. Based on experiences, conversations or available knowledge, the authors would like to suggest the following ideas to bring everyone together.

Gender Equality:

Open days and informational campaigns can also be targeted to improve the gender diversity of incoming students.

Encouraging women participation in science and technology by employing more women scientists.

More women speakers and inspiring personalities during events.

Offer scholarships for women from underdeveloped or developing countries to recognise and flourish their talent.

Global and Diverse

To promote an inclusive atmosphere among students, many study associations and student societies have their own committees and events to promote issues such as gender equality, international integration, or community building for such minority groups. However, this is often not sufficiently integrated in the association or society, resulting in many students still being left out. The Diversity & Inclusion Office of TU Delft could work with these groups to further improve their openness. Such issues

are often framed in terms of what language should (or more frequently, should not) be used. However, it also extends to the what these organisations build their identity around.

Affordable housing with a priority for those who need the most financial assistance.

To provide a space for people who pray/meditate throughout the day, a contemplation room has been opened at X. However, it is suggested that this comes at the cost of closing comparable spaces at EEMCS and AE, which should only be done in agreement with the community of those faculties.

9. Conclusion

The main aim of this report is to study and present GreenTU's vision on sustainability at TU Delft from a broader perspective focusing on the UN Sustainable developments Goals. An effort has been made to understand the current state of sustainability at TU Delft in the four portfolios of education, research, operations and social engagement.

It is observed that the university is performing quite well in the education and research aspects considering the fact that most studies are core technical programs. The master programs and tracks offer a wide range of subjects focusing on sustainable energy, circular economy, sustainable architecture and so on. This can be further improved by more multidisciplinary programs focusing on sustainability. Considering the student opinion and from the case studies on reputed universities, the smaller programs like minors, honours and elective courses can provide a great opportunity to improve education related to sustainable development. Though there are multiple minors related to this field, most of them are offered by partner universities. The authors believe that TU Delft has much more potential to offer more programs within the university either as minors or honours. One of the main concern is to create awareness on the sustainability related programs and courses offered by TU Delft and making it accessible to all the students. As suggested in section 8.3, the authors encourage establishing an online platform for facilitating this. This platform could also be a great source for exchange of knowledge between students and teachers and to share interesting project opportunities. The current report also made an effort in identifying how sustainability can be improved in each master program based on interview with directors of education and to the best knowledge of the authors. More detailed information on this can be found in the inventory reports by the GreenTeams.

Coming to the sustainability in research, TU Delft is already leading its away in SDGs like 'Industry, innovation and infrastructure', 'Sustainable cities and communities' , 'Affordable and clear energy' and others. As seen in section 3.2, all the four Delft Research-based Initiatives (health, energy, global and infrastructure) focus on more than one SDGs thus making an impact for a better society. In addition to this, TU Delft also has multiple student teams working on most exciting projects related to sustainability. Most of these teams are acclaimed internationally and rest are gearing up to make their mark in varied fields like mobility, energy and architecture.

But there are still few areas where the full potential is not explored. The current report shows such topics based on rankings and recommends a further research into identifying potential research areas. Also, in order to promote and engage in research related to sustainable development, the authors call for setting up a Centre For Sustainability. This platform would act as a point of reference to

connect students, researchers, TU Delft operations team and the external parties who are interested to work on topics related to sustainability. This report also highlights the importance of establishing TU Delft as a living lab and being a test bed for new innovations. Currently, Green Village has been quite successful as a living lab. But there is still lot of possibilities for expanding it especially by engaging students. This could be either through projects, master theses, internships or other volunteer work.

The next and the most important part discussed in this report is the TU Delft operations and to make it a carbon neutral and circular campus. The university currently accounts for emissions of 47957 tCO_2-eq based on the CO2 Roadmap. This is the first base to analyse the university and to make concrete plans for future. The section 3.3 of this report gives an overview of various sustainable operational activities being undertaken in the university. Starting from procuring wind energy for meeting 78% of the demand, solar panels on the roofs, use of ATES systems for heating to building energy neutral buildings like PULSE, TU Delft is performing very well in addressing the emissions from electricity. The emissions coming from the heating still needs lot of improvement and it is exciting to see the energy transition team working towards it very actively through projects like geothermal energy.

During the course of this report, it was observed that the emissions from scope 1 and 2 are been taken quite seriously and various possibilities are being explored to achieve the carbon neutrality. Whereas, the scope 3 emissions which includes food, mobility, waste management and procurement are still not taken seriously. Though the CO2 Roadmap gives a good base for these scope 3 emissions, there is a need to study them further based on more accurate and comprehensive data. Also, the emissions from procurement are not accounted for yet. Procurement is expected to be a major contributor to the emissions and also in deciding the circularity of the campus. Hence there is an immediate need for a detailed study on the various procurement activities undertaken by TU Delft.

The year 2019-20 saw a great progress towards addressing the scope 3 emissions. Together with collaborators from campus operations and student organisations, GreenTU Delft has started various initiatives in the areas of food, waste and mobility. Few of these initiatives are, No-meat week, new waste separation pilot in architecture and a brainstorm session with experts for policies on mobility. In addition to this, there are many more projects and ideas which are being geared up for implementation in the year 2020-21.

In this report, the authors suggest a number of strategies to make the TU Delft operations more sustainable. These ideas range from small initiatives which need more commitment and social responsibility to economically intensive ideas like sustainable buildings and geothermal energy. The authors have shown various possibilities based their knowledge in this area, case studies, interviews, feedbacks

and literature research. In order to show the impact of these ideas, the authors developed a behavioural model using Vensim software. This software has been used to predict the future emissions of the university based on the population growth. The prediction was limited by the TU Delft's current resources which can only accommodate 36000 people and this is expected to be reached by 2024-25. At that moment in time, under the current business as usual scenario, the emissions are expected to be around 70000 tCO_2-eq. Some of the strategies that authors propose and which can be quantified approximately are represented using this Vensim model to show the effect of the future emissions.

Combining the various initiatives, the authors present a scenarios with the following strategies being implemented and the decline in future emissions can be seen as follows; The graphs below show the business as usual scenario for each case along with the total and individual impact of the ideas. This below scenario includes the implementation of following strategies:

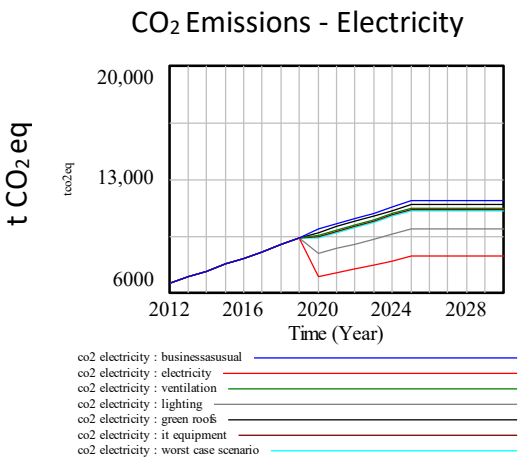
Electricity:
- 5% energy saving using winter/summer closure (Worst case scenario)
- Energy savings from IT equipment (IT equipment)
- Developing green roofs
- Improving the lightings
- Home automation (ventilation)

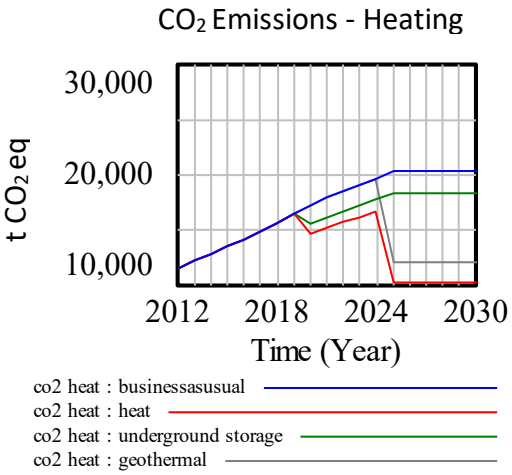
Heating:
- Geothermal
- Underground storage

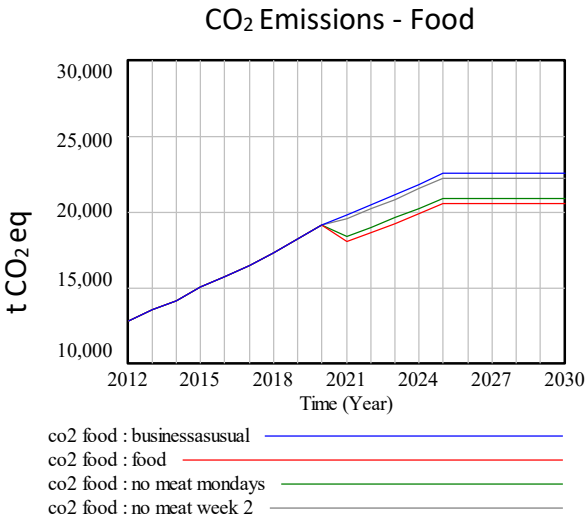
Food:
- Two no meat weeks per year
- No meat Monday

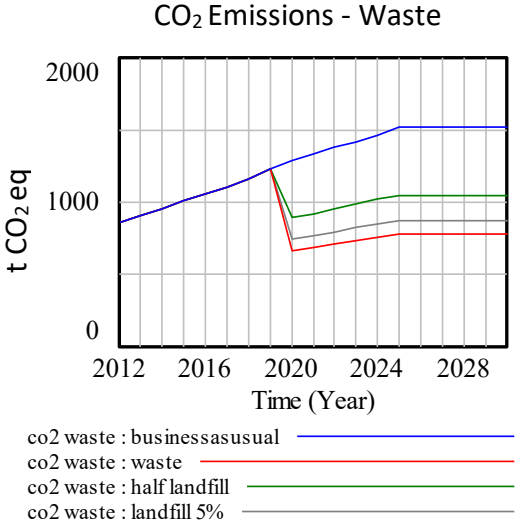
Waste:
- Better treatment of hazardous waste (5% less waste to landfills)
- Reducing the waste sent to landfills by half by improving the recycling (half landfill)

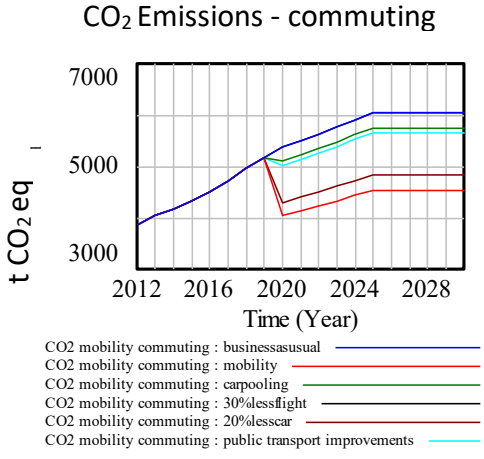
Mobility:
- One no car day per week (20% less car use)
- Carpooling or ride sharing
- 30% less air travel
- Improvements in public transport

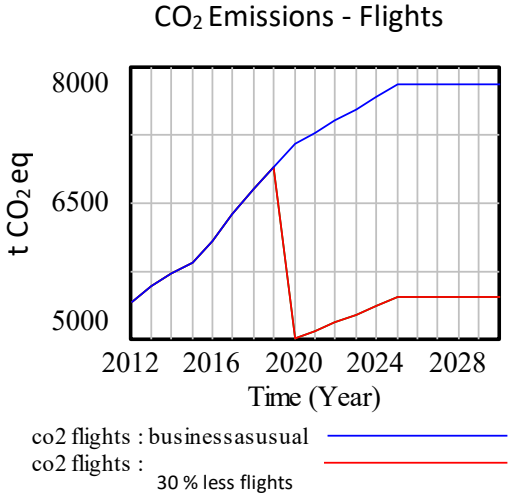










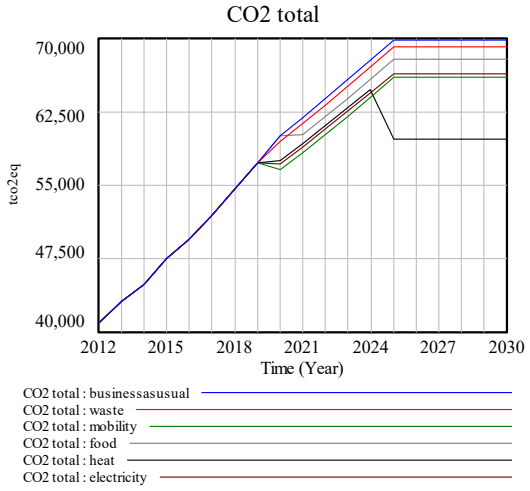


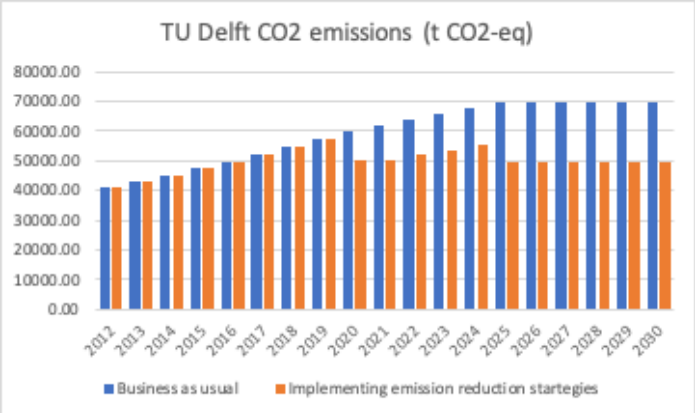
The above scenario shows the impact of implementing few of the strategies mentioned in the current report. Tough it is limited to few ideas which could be quantified with limited data, if is evident that small steps taken towards sustainable

alternatives also have a major impact on the emissions. It can be seen that by implementing energy saving measures, the electricity use and the corresponding emissions can come down by 30 percent. In the year 2024, when the population is expected to be in the peak, these measures can reduce the emissions to nearly 8000 tCO_2-eq form 11200 tCO_2-eq. Similarly the emissions from heat would be reduced to 10200 tCO_2-eq from 20000 tCO_2-eq in 2025 when the geothermal project would be running. If this can be further extended by the decommissioning of the CHP plants, the scope 1 and scope 2 emissions would be dropped significantly close to zero. These measures would thus help TU Delft in achieving carbon neutrality with responsible production and consumption activities.

Coming to the scope 3 emissions, the ideas mentioned in the report to reduce emissions from food, waste, mobility and water need further qualitative and quantitative analysis to see their feasibility and the impact. The reduction of scope 3 emissions need more social commitment and awareness among the stake holders towards responsible consumption. Hence it is quite difficult to define the amount of reduction in these emissions based on the ideas mentioned in the current report. But the authors have tried to depict this by using some simple but effective steps. These include no meat Mondays, no meat weeks, improving the waste treatment by recycling and better treatment of hazardous waste, reducing the flight use, no car for one day a week (20% less car use) and few others. These simple steps with minimal implementation could reduce the emissions by almost 8000 tCO_2-eq. If the response is better and the implementation is more effective, then the strategies mentioned in this report can significantly reduce the scope 3 emissions from TU Delft.

The implementation of the above mentioned scenario with small initiatives can reduce the emissions to 50000 tCO_2-eq from 70000 tCO_2-eq by 2030. If the phase out of CHP plants is implemented with sourcing renewable electricity and using sustainable heating systems, then there would be an additional decline of another 18000 tCO_2-eq.





An important aspect to focus currently is to engage more people and explore the possibilities of reducing the scope 3 emissions. Of the ideas are implemented effectively, for example having a monthly no meat week would reduce the emissions from food by 25%. And encouraging virtual meetings similar to the COVID 19 scenario would reduce the emissions from flying by more than 50%.

If the measures are not implemented to control the emissions, TU Delft will have to pay an annual carbon tax of about 2 million EUR for scope 1 and scope 2 emissions in 2024. This is based on the projected carbon tax of 55 EUR per t CO_2-eq by the EU [13]. If the scope 3 emissions are also included, then the tax amount would be as high as 4 million EUR. In the contrary, if the university takes steps to reduce the carbon emissions, it will not only save all the tax amount but would also reduce the social costs. On the other hand, use of strategies mentioned in the report could reduce the energy use by 30% if better control mechanisms are implemented. This would further save 2-3 million EUR depending on the extent of implementing the measures.

It is evident that most of the topics discussed or suggested in this report need lot of commitment from the stakeholders. Hence the report highlights the need for social engagement in achieving sustainability. Currently, there are many organisations and initiatives that are working towards increasing the awareness on sustainability. But there is a further room for improvement. GreenTU is now growing as an umbrella organisation to bring together all the organisations working on sustainability. Along with this, the TU also needs to take steps towards communicating about the various sustainability initiatives to the internal stakeholders and to the outside world. There should be further studies, assessments, fact sheets, guidelines and policies to show the commitment of the university and its stakeholders towards building a sustainable campus.

Finally, this report is a first attempt to bring the various sustainability related activities taken up TU Delft and to show various possibilities to achieve its sustainability targets

by 2030. With immense confidence, the authors predict that with better commitment, more awareness and more social engagement, TU Delft can definitely achieve its goals of contributing to the Sustainable Development Goals and become carbon neutral campus by 2030. And GreenTU Delft will strive for making this a reality in the coming decade.

Appendix:

A. Summary of GreenTeam inventories:

GreenTeam EEMCS

The inventory report was separated into four portfolios: education, operational, communication and research. In order to research these fields of interest, several methods of investigation were used: staff (both academic and operational) were interviewed, a survey among the student populace was conducted and online research was carried out. Additionally, the GreenTeam spent time promoting sustainability on campus through social media.

Education

Inspired by the feedback from the students and the educational staff the GreenTeam promoted the idea of horizontally integrating sustainability in the education of EEMCS. This entails that there shouldn't necessarily be one dedicated course for sustainability but rather that sustainability is an overarching theme which teachers can comment on when relevant in existing courses. Additionally, in project-based courses, sustainability could become a secondary learning goal (e.g. designing and programming a carbon footprint tracker instead of a game).

Operational

In the research of the operational portfolio, it was found that currently a lot of single-use plastics and promotional materials are being used in the EEMCS faculty, whilst a majority of the students indicated to be against this. An example of how this could be reduced is by introducing a small fee for the use of plastic cutlery, hence stimulating people to bring their own cutlery.

Communications

Currently, the topic of sustainability is not prominently featured on the website of the faculty. A specific page highlighting all the courses, research, co-operative partners and operations regarding sustainability could be created. Similarly, a brightspace page could be made such that interested students could subscribe to this page and get updates on the different sustainable activities on campus.

Research

Currently, the EEMCS faculty already has a focus on sustainability, namely the Electrical Sustainable Engineering research department which focuses on the sustainable energy transition.

GreenTeam CEG

The report was structured in a systematic way such that 4 most important pillar within the faculty were targeted: Education, Operations, Research and Communications. A brief summary of the findings of each of the category is explained below:

Education

Both Bachelors and Master tracks were targeted. It was observed that a lot of focus has already been given in the bachelor program of Applied Earth Sciences and few courses have been following it in Civil Engineering. In addition, as there no record of a document listing the possibilities of selecting minors related to sustainability, therefore an exclusive list was made by the team which includes the options from other universities as well.

Operations

For operations, 4 main fields were researched- energy usage, waste management, renovation activities and food management. Energy usage targeted the areas of Solar panels, energy consumption, heating and gas consumption within the faculty. Data regarding these aspects were gathered and analysed. Also, the usage of printers and its relevant costs within the faculty was investigated. In addition, the energy consumption before the pandemic was analysed and important conclusions were made with respect to energy consumption in CEG.

Research

It came to our notice that the Faculty of Civil Engineering Geosciences has a sound perspective and attention towards sustainability. The motivation and ethic of the researchers involved promise to create more sustainable projects for the upcoming future.

Communications

Since this is the first year of the GreenTeam of Faculty CEG, the team decided to make itself known via various social media channels. In order to fully comprehend the opinion and position of the different staff members, faculty members and students in CEG, the team decided to reach out to various groups of audience through a survey related to sustainability within the Faculty.

GreenTeam AS

As was recommended by the GreenTU board, the GreenTeam of Applied Sciences divided their analysis of the faculty into four portfolios: Education, Operational, Research and Communication.

Education

The courses are organised into four categories: courses that did not in any way relate to sustainability, such as calculus courses; courses that could include examples or indirect mention of sustainable topics; courses that could integrate sustainability in a more fundamental way into the course and finally, courses that have already integrated the topic of sustainability into the course.
The courses under each of these criteria are identified and it is suggested to forn small groups of students (TA's, members of the GreenTeam and other enthusiastic students) to research topics relating the course to sustainability is a strategy that seems promising for next year.

Operational

Up till now, it seems that energy is used wastefully in several ways that could be solved by maintaining effective rules for staff. Also, a closer look should be taken at the plans for the new building replacing Building 22, since it is the reason that sustainable renovations of Building 22 have stagnated.

Research

The relation between research department and sustainability can be placed, roughly, into two categories: the research field is not directly related to sustainability in any way and the research field is very relevant to sustainability and the topic is already being integrated substantially. Therefore, it did not seem that there was much for the GreenTeam to do.

Communication

The available communication tools are excellent for spreading information and awareness about sustainability. Yet from the survey done among students the conclusion can be drawn that not many students are aware, on the topic of sustainability, of the status of the faculty, the progress that needs to be made and the progress that is being made. There is a great opportunity for the GreenTeam to stimulate this.

GreenTeam AE:

The inventory is made across four portfolios: education, operations, research, and communication.

Education:

Master education already integrates sustainability in many courses, but there is room for improvement in offering a solid foundation on this subject to all students. This solid foundation is also lacking in bachelor education: the DSE offers a lot of potential for students to investigate sustainability themselves, but they could be better prepared for this task earlier in their education. Moving forward, course coordinators, especially those of projects, will be approached to discuss what can be made possible. Programmes offered at the Faculty of Aerospace Engineering already bring a heavy workload, so the addition of sustainability in a course will most likely have to be at the expense of other material.

Operations:

In terms of the operations surrounding the Faculty of Aerospace Engineering, many points of improvement could be identified to reduce the amount of waste or energy used. Take, for example, single-use plastics at the canteen and at events, or awareness surrounding waste separation. This also includes events organised by the study association VSV 'Leonardo da Vinci', who are currently already working on waste reduction. Other changes will need to be brought up to a variety of responsible parties, some of which would best be coordinated centrally by GreenTU.

Research:

The Faculty of Aerospace Engineering is already quite invested in sustainability-related research. However, this is seemingly not the case across all departments. It was also found that mindsets at the faculty and of stakeholders are not always sufficiently sustainability oriented. GreenTeam AE could work on spreading awareness, while discussions with the faculty's sustainability committee could result in further change. Additionally, interdisciplinary communication was investigated and found to be lacking. However, researchers generally don't experience this as hindering.

Communication:

Sustainability is already a hot topic at the faculty, so communication surrounding it isn't hard to find. However, several small points of improvement have been identified. These often relate to how sustainability is framed to (prospective) students, who could have difficulty finding what subject or track bests suits them if sustainability is something they want to pursue. GreenTeam AE could take it upon itself to create new material for students to orient themselves on this topic.

Appendix B:

Model description

The food model is constructed with some small differences with respect to the others. In fact, it does not take into account potential rates variation of average consumption per person. Instead, days of meat-diet and no-meat diet are taken into account, and the proportion between them leads the evolution of the model. This choice has been made to make it possible to visualize consequences of possibly implemented policies (like the no-meat Mondays or no-meat weeks). For meat-days, the EF of average Dutch lunch diet (taken from Andy van Den Dobbelsteen paper) is multiplied by number of week days and by population of campus. For the no-meat days a different EF has been computed. What is possible to notice when a decrease of 5% in meat (no-meat days/meat days) is implemented is a slight change. This is because the EF of a vegetarian diet is smaller than EF for average Dutch diet, but not close to zero, thus the results of such a small difference in habits cannot be seen. However, when potentially implementing one no-meat week (5 days of no-meat diet at all canteens), or two no-meat weeks (10 days), or even no-meat Mondays every week (54 days) a more important decrease can be seen.

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