EU-CONEXUS Plus

MS10 – Definition of case studies for green campuses best practices

FINAL VERSION, WP*16 Green Campus*

Delivery date*: 29th of September 2023*

WP leader: Frederick University

Contributors: LRUniv, AUA, UCV, KU, UNIZD, UTCB, SETU, UROS

Dissemination level : confidential

Executive summary/abstract:

The aim of this document is to define and map the best practices employed by Green Campuses across EU member states participating in the project ‘EU-CONEXUS+’. The document covers a plethora of thematic scopes across the different campuses, as different regions experience differences in approaches. Both top-down as well as bottom-up approaches have been considered whilst detailing the different decision-making procedures that are used at the campuses.

By highlighting the successful implementation of green practices at campuses, a framework can be then created to reflect the best possible way to approach the implementation of said green initiatives. Each university provided information on how they were successful in reaching their goals as well as any hiccoughs that may have arose during the decision-making processes as well as the implementation of the ideas. Subsequently, by having a thorough understanding of the issues that may arise prior to implementing these ideas, it increases the likelihood of having a successful implementation phase.

Description:

With the eminent problem of climate change and the ever-growing demand in actions in order to promote and achieve green practices there is a strong drive towards changes in national and international legislations. This change has resulted in large institutions changing their own practices in order to drive the change by leading via examples. Large institutions such as universities are the leaders in driving these changes as they are able to invest through research and innovation practices as well as implement their ideas via their own pilot studies at their campuses.

Sustainability is driven at universities through a range of practices, although priority is given to the actions that are most suitable and appropriate to the problem areas of each campus as well as the ethics and practices that the university board chooses to implement. 'Green campuses' is a term that has been used, in recent years, to describe a university that chooses to introduce environmentally friendly practices in order to limit its impact onto the environment. These practices may include but are not limited to the installation and upgrade of energy efficient equipment as well as driving the change for behavioural changes.

Green campuses can either be driven by the practices of students, in a bottom-up approach, or by the governing body of the organisation from a top-down approach. The differences in approach is primarily due to the resources available to the decision making bodies.

This study looks to investigate the different sustainability practices carried out at different campuses across member states, in order to map out an operational framework.

Discussion/content:
Table of Contents

1. Scope of the Document

This document looks to act as a guide in recording and analysing the existing good sustainability practices that are followed at the campuses by the project partners. This document will record good practices of green campuses by listing the main aspects and their key features by covering all key environmental aspects of the organisations. A non-exhaustive list of the aspects of the plan includes natural resource issues such as energy and water, waste management and general circular economy topics, transportation issues, on-site comfort practices, environmental aspects of organizations, as well as horizontal issues which are related, among other topics, to promotion and information.

2. Green Campus Case Studies:

2.1 Frederick University

2.1.1 Introduction:

This report delves into the compelling case studies conducted at Frederick University, situated in the city of Nicosia, Cyprus, with a specific focus on the pioneering implementation of Smart Energy Meters and the cutting-edge Digital Twins Network. Throughout these case studies, we aim to shed light on the transformative potential of these technologies in promoting sustainable practices and fostering energy efficiency within university's campuses. This infrastructure has been developed as part of the Green Campuses Best Practices initiative, a pivotal aspect of the EU Conexus project WP16. With a steadfast commitment to eco-consciousness and sustainability, this report has been meticulously prepared and is dedicated to milestone 10 of the project, contributing to the dissemination of invaluable insights into the realm of green campuses.

The infrastructure demonstrated in this report was meticulously developed under the auspices of the EU-funded project D2EPC (GA 892984). The integration of Smart Energy Meters and the Digital Twins Network represents a transformative step towards defining and optimizing the operational energy performance of the university's buildings.

By harnessing the potential of these state-of-the-art technologies, Frederick University aims to identify and capitalize on valuable opportunities for energy savings. The ultimate objective is to pave the way for a carbon-neutral future, aligning the institution's campuses with the global agenda of combating climate change and promoting sustainable development.

This report endeavours to elucidate the potential of these initiatives and inspire other educational institutions to embrace sustainable practices for a greener, more resilient tomorrow.

2.1.2 Campus Profile:

Frederick University operates from two campuses. The main campus is in Nicosia, the capital of Cyprus, and the other campus is in Limassol, the second largest city. Nicosia campus comprises several buildings, all within walking distance from each other. Nicosia Campus comprises of 14 buildings.

The network of smart sensors was initially installed in the new wing building (building number 2, Figure 1). The typology of new wing building pertains to a mixed-use university building situated at precise geographical coordinates of Latitude 35°10'46.20" N and Longitude 33°22'46.70" E. The building is prominently located in the Palouriotissa area of Nicosia, specifically situated on Gianni Frederikou Street.

The new wing building of Frederick University is a two-story building with an area of 1441 m2 and an approximate volume of 4350 m3, encompassing the basement floor and parking area. Constructed in 2007, the building stands independent. It is structured in a basement area, a ground floor and two floors.

Figure 1 New Wing BIM model

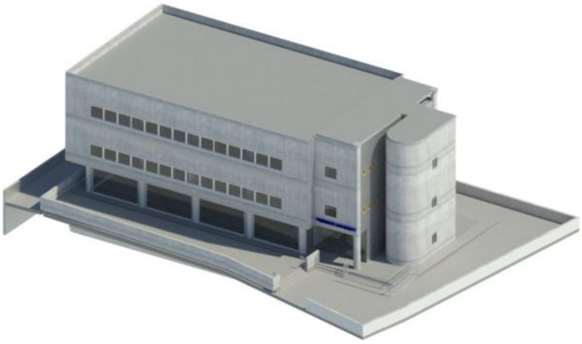


Figure 2 New Wing BIM model

Table 1 Occupancy, Surface area, and Volume per floor

Floor	Number of people	Surface area (m²)	Volume (m³)
Ground floor	35	467	1450
First floor	50	487	1450
Second floor	25	487	1450
Total	110	1441	4350

2.1.3 Best Practice Description:

The building is equipped with intelligent smart meters strategically installed throughout its premises. These devices enable real-time monitoring of electricity consumption and internal environmental conditions, including temperature, humidity, and carbon dioxide levels. Moreover, a dedicated platform facilitates the seamless acquisition, retrieval, and analysis of data generated by these smart systems, offering valuable insights for effective management and resource allocation.

Table 2 Monitoring equipment characteristics

Name	Accuracy	Qty	Picture
Hobo EG4115 Core Data Logger	0.5% revenue-grade accuracy compliance	3	
Hobo EG4130Pro Data Logger	0.5% revenue-grade accuracy compliance	1	

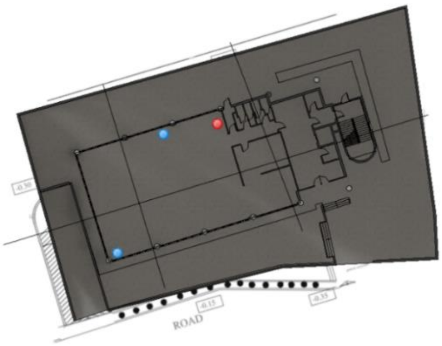
Hobo T-EG-0630-0100	Up to +/-1%	21	
Hobo T-EG-0940- 0100	Up to +/-1%	3	
Hobo T-EG-0940- 0200	Up to +/-1%	3	
Hobo T-EG-0390-0050	Up to +/-1%	30	
AM107-868M Milesight AM107 (LoRaWAN®)	Temperature sensing: -40°C - 85°C, ± 1°C accuracy Humidity sensing: 0% – 100% RH, ± 3% accuracy CO2 sensing: 400 – 5000 ppm, ±30 ppm or ±3 %	7	

Presented herewith in Figure 3 are the floor plans of the building along with the precise locations of the measuring devices.

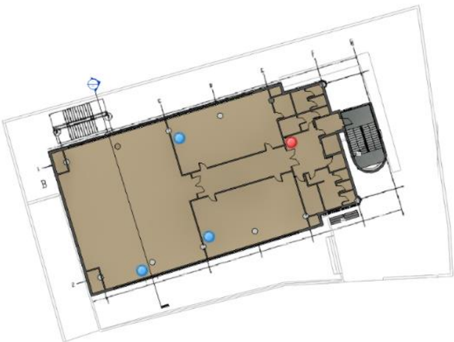
Power meters

Indoor Ambience Monitoring Sensor

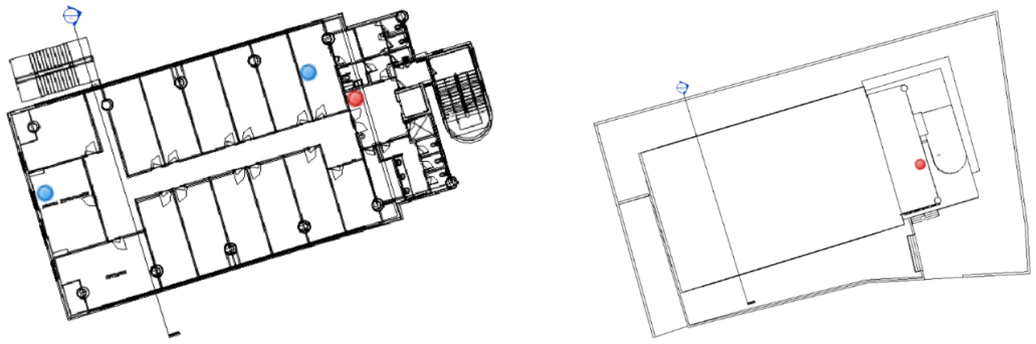
(Milesight AM107 LoRaWAN® with E-Ink Display) – Temperature, Humidity, and CO_2



Ground Floor



First Floor



Second Floor Roof

Figure 1 Floor plans of the building

2.1.4 Student and Community Engagement:

Frederick University is actively engaging its students in understanding and contributing to the performance of the Smart Energy Campus through various means. The university recognizes the transformative potential of the Smart Energy Meters and Digital Twins Network and aims to foster a culture of sustainability and energy efficiency among its students.

One of the key ways the university involves students is by presenting the performance of the smart energy system in relevant classes and courses. Professors and instructors incorporate real-time data from the smart sensors into their teachings, enabling students to gain practical insights into energy consumption and environmental conditions within the campus buildings. This approach not only enhances the students' theoretical knowledge but also instils a sense of responsibility towards sustainable practices.

Moreover, Frederick University encourages students to undertake final year projects and theses that utilize the measurements delivered by the smart energy system. By involving students in research and analysis using this valuable data, the university fosters a deeper understanding of energy optimization and resource management. This hands-on experience empowers students to develop innovative solutions for further enhancing the campus's energy efficiency and reducing its carbon footprint.

2.1.5 Performance Metrics and Achievements:

The implementation of real-time data in the formation of energy indicators has a considerable impact on boosting energy savings and realizing carbon reductions in buildings. The widespread use of building sensors and meters makes system-level data readily available, allowing us to effectively quantify and evaluate energy performance.

Utilizing real-time measurements from the building, the indicators documented related to:

- heating and cooling
- lighting
- electrical appliances
- total consumption

These indicators are calculated with respect to occupancy, surface area, and volume per floor within the building, shown in Table 3.

Table 3 Annual Indicators – June 2021-May 2022

Load	Annual Amount	Unit
Total for Heating and Cooling	25.22	(kWh/m^2)
	330.33	(kWh/Occupants)
	8.34	(kWh/m^3)
Total for Heating	7.31	(kWh/m^2)
	95.76	(kWh/Occupants)
	2.41	(kWh/m^3)
Total for Cooling	17.91	(kWh/m^2)
	234.57	(kWh/Occupants)
	5.93	(kWh/m^3)
Total for Lighting (1^{st} and 2^{nd} floor)	14.22	(kWh/m^2)
	184.57	(kWh/Occupants)

	4.76	(kWh/m³)
Total for Electrical Appliances (1st and 2nd floor)	19.18	(kWh/m²)
	249.10	(kWh/Occupants)
	6.43	(kWh/m³)
Total for the Ground floor (October 2021 – May 2022)	69.60	(kWh/m²)
	928.76	(kWh/Occupants)
	22.42	(kWh/m³)
Total Power of the building	128.22	(kWh/m²)
	1692.76	(kWh/Occupants)
	41.95	(kWh/m³)

The graphical representations of indicators are depicted in Figure 4

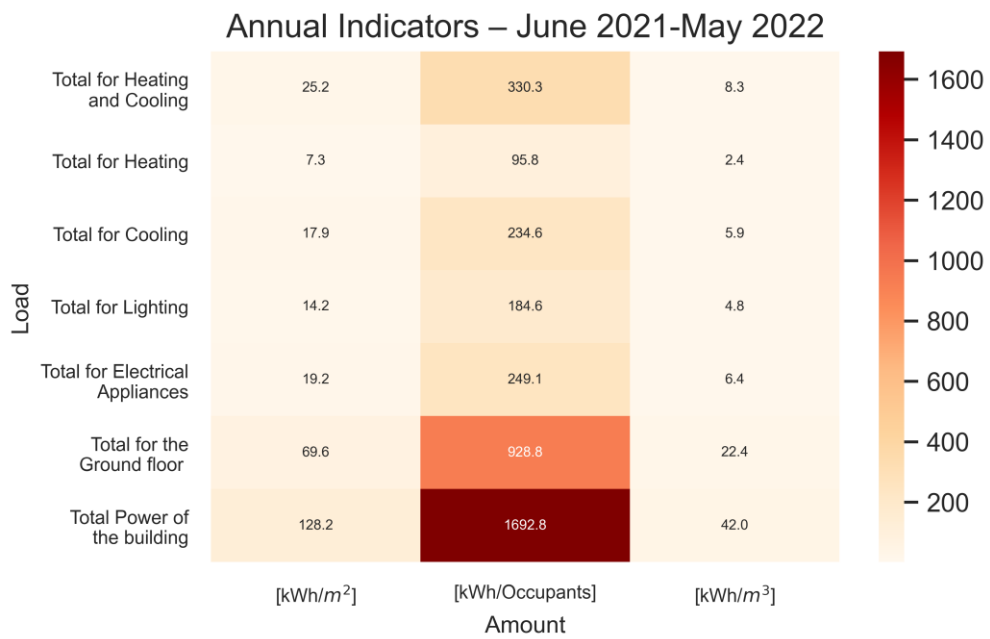


Figure 4 Annual Indicators – June 2021-May 2022

In Figure 5 and Figure 6, the representation of heating and cooling is presented, per each floor of the building, as well as the indoor temperature and per Degree Day.

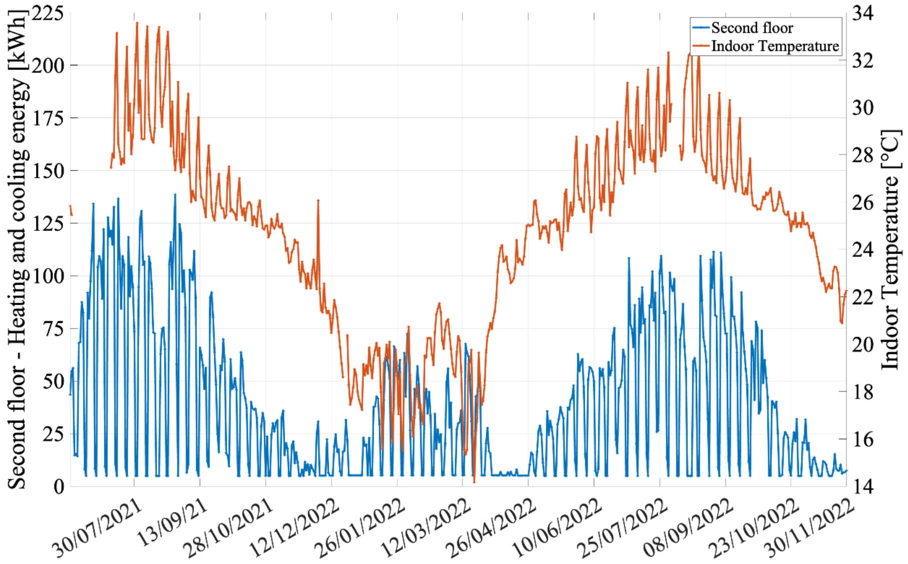


Figure 5 Second floor - Heating and cooling energy [kWh], Indoor temperature [°C]

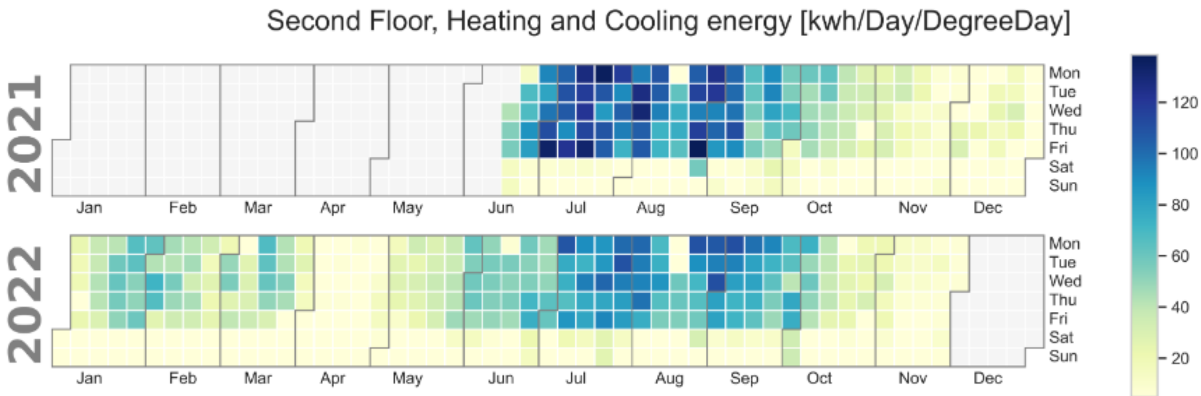


Figure 6 Second Floor, Heating and Cooling energy [kWh/Day/DegreeDay]

2.1.6 Challenges and Lessons Learned:

The implementation of Smart Energy Meters and the Digital Twins Network at Frederick University has resulted in valuable lessons for the entire university community. Most notably, this infrastructure has significantly enhanced the understanding of the operational energy performance of the buildings. Through real-time monitoring of electricity consumption and internal environmental conditions, students, faculty, and staff have gained insights into the patterns and dynamics of energy usage within the New Wing building.

The data collected from the smart sensors has proved instrumental in identifying opportunities and strategies for achieving energy savings. Armed with a comprehensive understanding of the building's energy performance, the university community can now take informed decisions on how to optimize energy consumption and proceed with energy upgrades for specific infrastructure within the building. This has opened up possibilities for implementing energy-efficient technologies and practices, ultimately contributing to the university's sustainability objectives.

Building on the success of this initiative, Frederick University is now in the process of certifying all operations conducted in the New Wing building with ISO 50001. This internationally recognized standard for energy management will facilitate a rationale and systematic approach to managing energy consumption. By setting specific future targets based on the insights gained from the smart energy system, the university aims to ultimately achieve a carbon-neutral status for the building.

Moreover, the operational data obtained from this infrastructure has also paved the way for the development of training seminars for personnel using the building. These training sessions will educate and empower staff and students to make conscious energy choices and adopt energy-efficient behaviours in their daily activities.

2.1.7 Related Sustainable Development Goals (SDGs):

The infrastructure of Smart Energy Meters and Digital Twins Network at Frederick University is related to several Sustainable Development Goals (SDGs) outlined by the United Nations. Some of the SDGs that this infrastructure aligns with include:

SDG 7 - Affordable and Clean Energy:

The implementation of Smart Energy Meters and Digital Twins Network enables real-time monitoring and optimization of energy consumption, contributing to the promotion of clean and sustainable energy practices.

SDG 9 - Industry, Innovation, and Infrastructure:

This infrastructure represents an innovative approach to energy management and efficiency, fostering sustainable infrastructure development within the university.

SDG 11 - Sustainable Cities and Communities:

By promoting energy efficiency and sustainable practices within the campus buildings, this infrastructure contributes to creating more sustainable and resilient communities.

SDG 12 - Responsible Consumption and Production:

The smart energy system facilitates better understanding of energy consumption patterns, encouraging responsible energy usage and promoting more sustainable production practices.

SDG 13 - Climate Action:

The reduction of energy consumption and the implementation of energy-efficient technologies align with efforts to combat climate change and reduce greenhouse gas emissions.

SDG 17 - Partnerships for the Goals:

The university's involvement in EU-funded projects like Conexus and D2EPC demonstrates a commitment to collaboration and partnerships to achieve sustainable development objectives.

2.1.8 Conclusion:

In conclusion, the implementation of Smart Energy Meters and the Digital Twins Network at Frederick University has proven to be a transformative endeavour in promoting sustainable practices and energy efficiency within the campus. Through compelling case studies, this report has illuminated the transformative potential of these innovative technologies in achieving the university's commitment to green campuses and a carbon-neutral future.

The invaluable lessons learned from this infrastructure have significantly enhanced the university community's understanding of operational energy performance, leading to the identification of opportunities for energy savings. This knowledge has empowered Frederick University to pursue ISO 50001 certification, ensuring a rationale and systematic approach to energy management, while setting ambitious future targets to zero the carbon footprint of the New Wing building.

Aligned with various Sustainable Development Goals, this infrastructure fosters responsible consumption, climate action, and sustainable infrastructure development. Furthermore, the data-driven approach has opened doors for energy upgrades and the development of training seminars, empowering the university community to actively contribute to a greener and more sustainable tomorrow.

Frederick University stands as a beacon of sustainable development and green initiatives in the educational sector, exemplifying how innovative technologies can propel universities toward a more sustainable and environmentally conscious future.

2.2 Universitaet Rostock

2.2.1 Introduction

According to the Paris Agreement [1], 193 countries worldwide committed to limit the increase in the global average temperature to well below 2°C above pre-industrial levels. A temperature increase of no more than 1.5°C was also aimed for, as this would significantly reduce the risks and impacts of climate change. In August 2021, following a judgment by the Federal Constitutional Court, in April 2021, the Climate Protection Act valid since December 2019 was tightened. Accordingly, emissions are to be reduced by 65% by 2030 and by 88% by 2040 compared to 1990 levels. Germany is to achieve net greenhouse gas (GHG) neutrality no later than 2045 [2].

To achieve this objective, a comprehensive transformation is required across all aspects of our lives and economy. This transformation impacts not only economic and private sectors but also the functioning of state institutions. Universities, in particular, play a crucial role in this regard. They must maintain their credibility through actions based on scientific knowledge. Moreover, due to their great economic importance in their regions, universities have a direct and indirect impact on the innovative development of climate-compatible goods and services.

In addition, it is to be expected that UROS (UROS) and the federal state of Mecklenburg-Vorpommern (MV) will also face considerable additional costs due to the constantly rising CO2 price. Already in the year 2022, one ton of CO2 produced by burning fossil fuels costs 30 euros [3]. The university already bears these costs. In fact, the Federal Environment Agency (UBA) estimates that damage worth 195 euros is caused by every emitted ton of CO2 [4]. For these reasons, the path to climate neutrality should already be envisaged now. A first step towards this is an analysis of the status quo, because only if we know how much CO2 we are emitting, we can determine effective reduction paths.

A working group of Scientists for Future (S4F) at UROS was voluntarily formed to determine the GHG emissions of UROS as best as possible. The working group was supported by the Academic Administration (ZUV) (including Dr. Jan Tamm, Peter Wickboldt, Brita Hamann, Astrid Lubinski and Gunnar Last) and the University's Sustainability Officer (Andreas Tesche). The GHG inventory (GHG emission report) of UROS for the years 2017 to 2020 was based on the GHG Protocol [5] and the manual "The Path to Greenhouse Gas Neutral Administration" of the UBA [6].

Our aim in preparing this report was to provide a transparent and scientifically sound assessment of the CO2 emissions of UROS. The results are presented, discussed, and evaluated, considering uncertainties and missing data. In accordance with the

UBA manual, the procedure, assumptions made, data sources used, and emission factors are documented in a comprehensible manner, allowing for review and further development at any time.

2.2.2 Campus Profile

UROS is a public university located in Rostock, MV, Germany. The campus buildings of UROS are located in several areas of the city. There are about 14000 students and 3000 staff members at UROS. Overall, the emission of climate-damaging GHG in CO2 equivalents (CO2(e)) in the reference year 2019 was about 5750 t, where business travel accounted for about 30%. This resulted in 3.2 t CO2(e) emissions per employee of the 1800 university employees (2019), which corresponds to one third of the average per capita emissions in all of Germany in 2019 (9.6 t CO2(e)).

2.2.3 Best Practice Description

3.1. Data sources

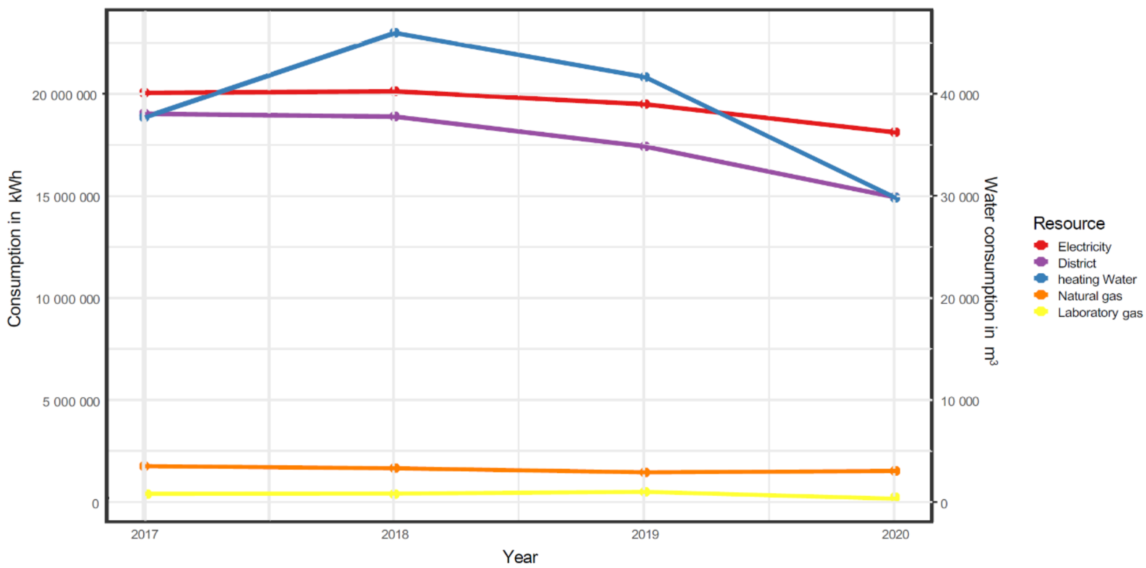


Figure 7 Consumption of electricity, district heat, natural gas and laboratory gas in kWh (y-axis) and of water in m3 (x-axis).

Our foundation for creating a CO2(e) balance primarily relies on the manual provided by the UBA in accordance with the GHG Protocol, titled "The Path to Greenhouse Gas Neutral Administration". We considered data from the following GHG emission sources: resource consumption (electricity, natural gas, district heat, laboratory gas and potable water) (Figure 7), waste generation (Table 4), business travel (Figure 8) and vehicle fleet (Figure 9). Data was provided by colleagues from ZUV in UROS.

Table 4 Waste generated by UROS in 2018 sorted by mass.

EWC Code	Type of waste according to European Waste Catalogue (EWC)*	Mass in t
15 01 01	Paper and cardboard packaging	451.6
20 03 01	Mixed municipal waste	360.1
15 01 06	Mixed packaging	81.31
20 03 07	Bulky waste	77.44
20 02 01	Biodegradable waste	62.11
17 01 07	Mixtures of concrete, bricks, tiles and ceramics	27.95
20 01 40	Metals	24.59
20 01 36	Discarded electrical and electronic equipment	21.26
20 01 35	Discarded electrical and electronic equipment containing hazardous components	15.785
15 02 02	Absorbents, filter materials, wiping cloths, protective clothing contaminated by dangerous substances	12.6
17 01 01	Concrete	8.96
17 09 04	Mixed construction and demolition wastes	6.12
07 01 03	Organic halogenated solvents, washing liquids and mother liquors	4.06
07 01 03	Organic halogenated solvents, washing liquids and mother liquors	2.395
15 01 10	Packaging containing residues of or contaminated by dangerous substances	2.105
13 02 05	Mineral-based non-chlorinated engine, gear and lubricating oils	0.95
16 07 08	Wastes containing oil	0.945
16 05 06	Laboratory chemicals consisting of or containing dangerous substances including mixtures of laboratory chemicals	0.93
17 02 01	Wood	0.85
16 05 07	Discarded inorganic chemicals consisting of or containing dangerous substances	0.43
08 01 11	Waste paint and varnish containing organic solvents or other dangerous substances	0.325
15 01 10	Packaging containing residues of or contaminated by dangerous substances	0.317
20 01 02	Glass	0.288
20 01 21	Fluorescent tubes and other mercury-containing waste	0.281
16 05 08	Discarded organic chemicals consisting of or containing dangerous substances	0.132
16 03 07	Metallic mercury	0.04
16 05 04	Gases in pressure containers (including halons) containing dangerous substance	0.025

The first four items are estimates. All other items are based on information in invoices

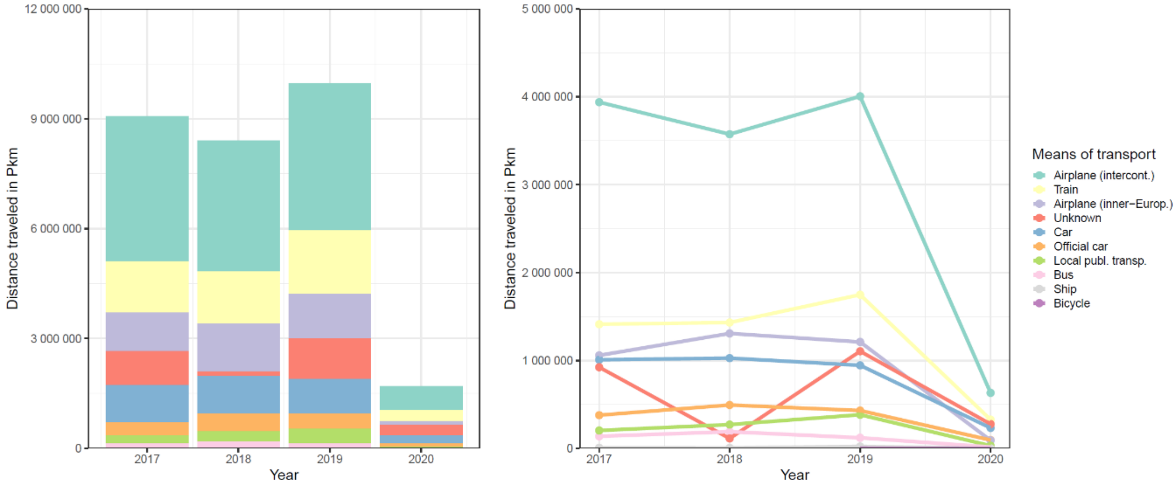


Figure 8 Distance travelled for business trips in person kilometres (Pkm).

The diagram on the left shows the data as a stacked bar chart so that the sum can be easily read. In the chart on the right, the data is presented as a line chart to show changes in distance travelled over time

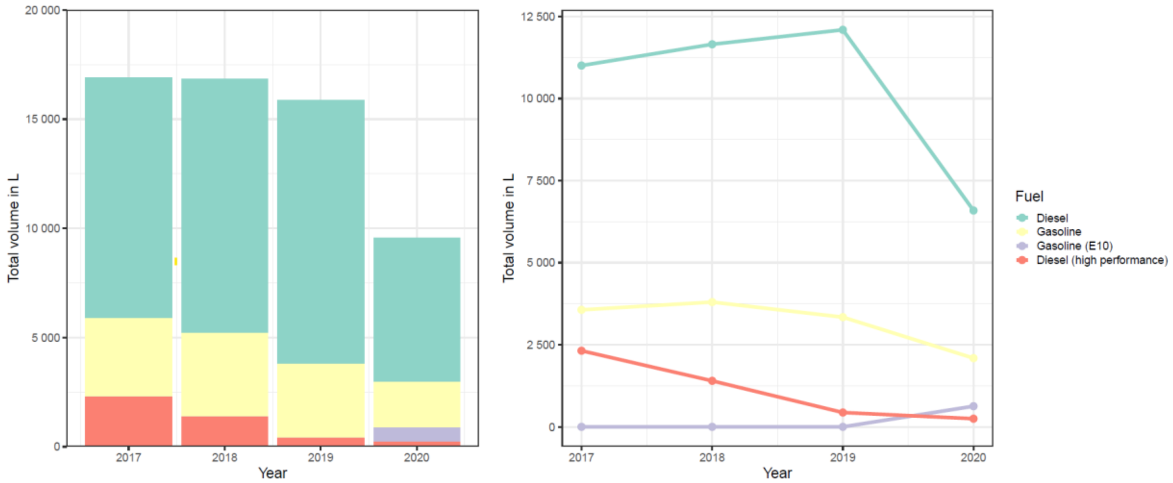


Figure 9 Total consumption of fuels used in the vehicle fleet taken from fuel card statements for the years 2017 to 2020.

In the left diagram, the data is shown as a stacked bar chart so that the sum can be easily read. In the chart on the right, the data is presented as a line chart to show the progression of fuel consumption over time

3.2. Emission factors

We consulted the following references as a basis for determining CO2 equivalents:

(I) UBA and Global Emission Model for Integrated Systems (Globales Emissions-Modell integrierter Systeme) (GEMIS) [7],

(II) UK Government Greenhouse gas reporting: Conversion factors 2021 [8],

(III) Municipal Utility Company Rostock (Stadtwerke Rostock AG) (SWRAG) (certificate),

(IV) MV State Property Office (Staatliche Bau- und Liegenschaftsverwaltung Mecklenburg-Vorpommern) (SBL).

The emission factors differ in some cases depending on the literature used. This deviation is because the primary energy sources are not always identical, and calculation methods can differ.

Electricity: Although UROS has been using green electricity since 2012 (supplier unknown), we do not take 0.0 g CO2(e)/kWh as the emission factor for electricity. In some cases, the federal mix is used for the GHG inventory since it indicates what is actually emitted per kilowatt hour consumed in the country and neglects any certificate trading. For the following three reasons, we decided to include upstream emissions. It should be noted that the value given by the SBL for green electricity is slightly higher than the one we calculated for the federal green electricity mix. We do not have the calculation basis of the SBL for this.

1. At 0 g CO2(e)/kWh, electricity disappears from the GHG inventory, and one does not see how the consumption changes.

2. Only 60% of the green electricity offered by SWRAG currently comes from renewable energies. The rest comes from the gas-fired power plant, and the resulting emissions are compensated.

3. Buildings (e.g., wind turbines) must also be erected to generate regenerative energy. This construction generates upstream CO2(e) emissions. We consider all upstream emissions of the German green electricity mix of 2020 and assume that the green electricity in Rostock would be composed like the federal mix (41.62% onshore wind energy, 19.53% photovoltaics, 12.72% biogas and biomethane, 10.96% offshore wind energy, 6.79% hydroelectric power, 4.51% solid biomass, 2.34% biodegradable waste and 1.53% other)

Table 5 Emission factors for different emission sources from the year 2021 unless otherwise stated.

Ressource	Emission in g CO_2(e)		
	UBA/GEMIS	UK	SBL
Electricity (renewable with upstream emissions)	41,66 /kW h	–	67 /kW h
Electricty (German/UK mix)	408,0 /kW h	212,33 /kW h	558 /kW h
District heat	258,415 /kW h	170,73 /kW h	132,8 /kW h$^{\diamond}$
Natural and laboratory gas (net calorific value)	201,234 /kW h	202,97 /kW h	240,0 /kW h*
Natural and laboratory gas (gross calorific value)	181,1 /kW h	183,16 /kW h	216,0 /kW h*
Water	–	149,0 /m^3	–
Waste disposal	–	21,3 /kg	–
Airplane (inner-European)	214,0 /P km*	153,53 /P km	230 /P km
Airplane (intercontinental)	–	193,09 /P km	192 /P km
Train (long distance)	29,0 /P km*	35,49 /P km	29 /P km
Local public transport	55 /P km*	28,13 /P km	55 /P km
Car (gasoline)	154,0 /P km*	174,31 /km	216 /km
Car (Diesel)	154,0 /P km*	168,43 /km	212 /km
Gasoline	2737,721 /L *	2339,69 /L	2692 /L
Gasoline (E10)	2703,514 /L *	2193,52 /L	–
Diesel	3015,239 /L *	2512,33 /L	3089 /L
Diesel (high performance)	3055,413 /L *	2705,53 /L	–
Photovoltaics (with upstream emissions)	56,144 /kW h	–	56,1 /kW h
Heat pump (with upstream emissions)	141,216 /kW h	–	67 /kW h

Emission factors always apply without upstream emissions unless explicitly stated or marked with an $*$. The factors we use are outlined in green. (Note that the average occupancy is 1.4 persons per car concerning car emission factors.) $\diamond$: This value is given by a 2017 certificate from SWRAG. The current data of the SWRAG are significantly lower and amount to up to 0 g CO2(e)/kWh

District heat: UROS is supplied at many locations via the district heat network of SWRAG. Therefore, we use the value calculated for SWRAG by the Institute for Power Engineering of Dresden University of Technology (Chair of Building Energy

Systems and Heat Supply) as the emission factor, available as a certificate from November 1, 2017.

Natural and laboratory gas: We have assumed that all UROS gas supply is natural gas and burned.

Water: The inquiry to the water supplier Nordwasser GmbH, whether a calculated emission factor for the potable water supply in Rostock is available, remained unanswered.

Waste: The UK emissions data gives the same emission factor for almost all waste types. This factor only includes the CO2(e) emissions from transport and processing. The GHG emissions resulting from energy generation (incineration) or material recovery (recycling) are attributed to the (new) user of this energy / material. This type of utilization and the associated avoidance of waste disposal in landfills saved about 27 × 106 t CO2(e) in Germany in 2015, compared to the emission of about 38 × 106 t CO2(e) in 1990 [9].

Business travel: Business travel consists of trips by car / bus, train, ship, and / or airplane. We subdivide flights into inner-European for distances less than 2500 km and intercontinental. For the calculation of CO2(e) emissions, emission factors are required for all means of transport.

Vehicle fleet: We use the corresponding emission factors for the fuels used to calculate the fleet's CO2(e) emissions.

Photovoltaics and heat pumps: Heat pumps use electrical energy and the earth's heat reservoir to generate heat efficiently. Therefore, we use the emission factor of green electricity for heat pumps. The electricity generated by photovoltaic systems is climate-neutral if we ignore the upstream chain.

3.3. GHG inventory

The total GHG inventory for the years 2017 to 2020 can be seen in Figure 10. It shows a decline in 2020, which can be linked to the COVID-19 pandemic and will be seen in some individual contributions to the GHG emissions shown next.

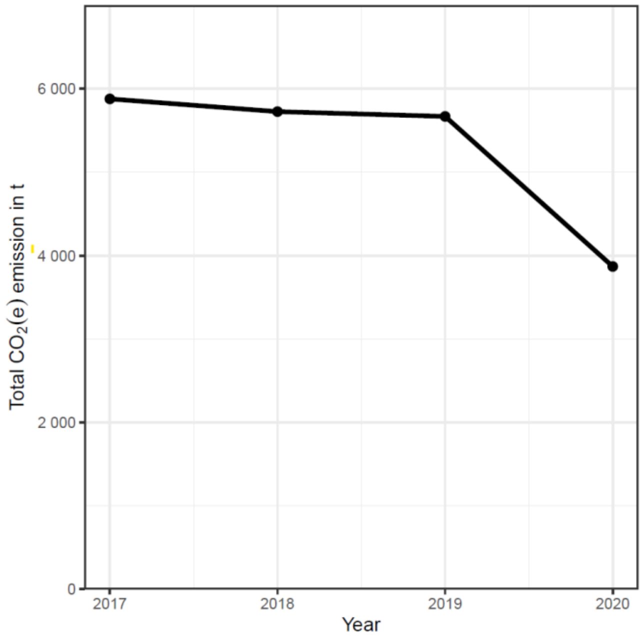


Figure 10 Total CO2(e) emissions from all GHG sources we considered

Emissions from resource consumption: The GHG emissions from resource consumption for 2017 to 2020 are shown in Figure 11. It can be seen that emissions from district heat use have steadily decreased from 2018 to 2020. Emissions from other resources have roughly stayed constant over the years.

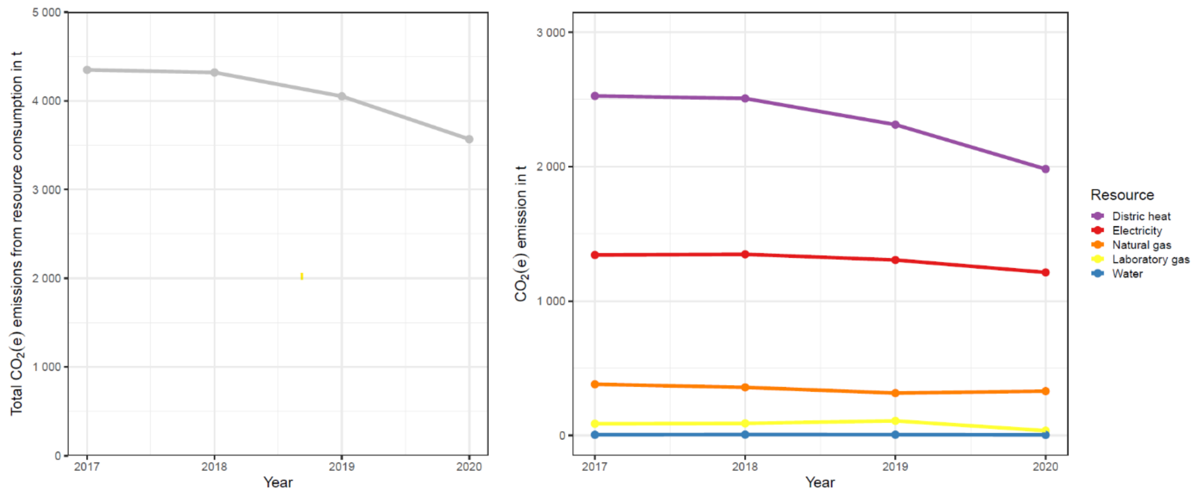


Figure 11 GHG emissions in t for the resources district heat, electricity, natural gas, laboratory gas, and potable water.

The summed data is plotted in the left diagram. The diagram on the right shows the data for the individual resources.

Emissions from waste disposal: Since we only consider the transport and minimal processing of the waste in the GHG inventory and, in addition, only an estimate for 2018 is available, we do not provide a graphical representation at this point and only disclose the final result. Accordingly, in 2018, the disposal of waste led to a CO2(e) emission of

1164 t × 21.3 × 103 g CO2(e) / t = 24.8 t CO2(e).

We do not include waste in our overall GHG inventory as no values are available for other years.

Emissions from business travel: The CO2(e) emissions from business trips are shown in Figure 12. It can be seen that the use of airplanes is responsible for at least two-thirds of the GHG emissions from the business travel sector. This use is mainly related to the participation of scientists in international conferences. For this reason, in the first COVID-19 year 2020, there was a very strong decrease in emissions from business travel.

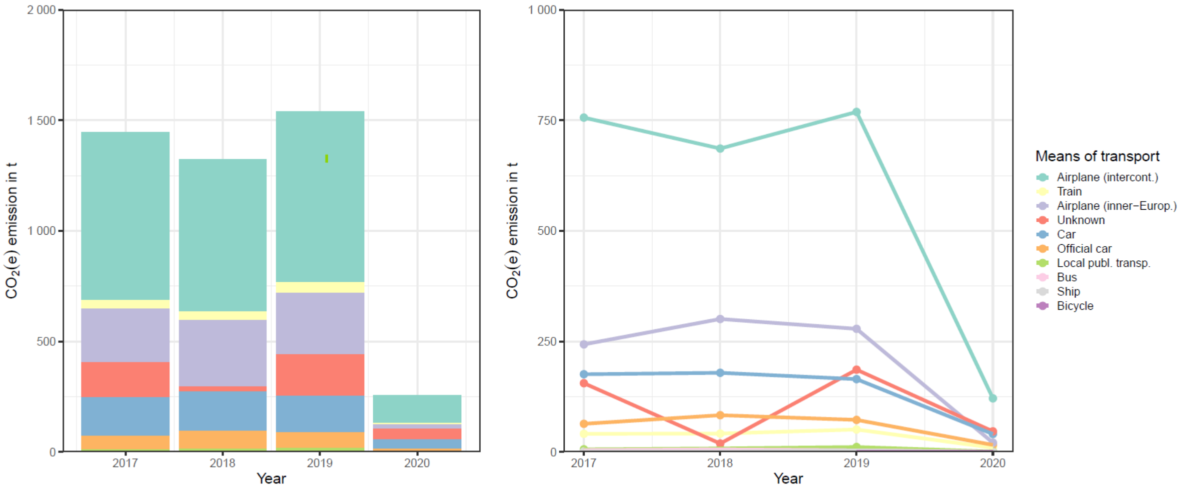


Figure 12 CO2(e) emissions in t from business travel

In the diagram on the left, the data is shown as a stacked bar chart so that the sum can be easily read. In the chart on the right, the data is presented as a line chart to show the time course of CO2(e) emissions

Emissions from the vehicle fleet (local business trips): The fuel consumption documented annually via fuel bills was converted into CO2 equivalents using emission factors from UBA. However, more vehicles are operated at UROS than is evident by fuel cards. Based on an inventory list of all vehicles in service from 2017 to mid-2021, it was possible to determine that approximately 42 vehicles were operated at the university during these years. The vehicle categories classified to be relevant were passenger cars, station wagons, mini-busses, vans, and multi-purpose vehicles. The GHG emission was extrapolated in two steps via the ratio of the total operated motor vehicles to the billed motor vehicles.

For some of the vehicles, the years of operation could be extracted from the list, although no fuel invoices were available. This situation applied to 4 to12 additional vehicles, depending on the year. In 2017, 21 out of 24 motor vehicles were included in the invoices. The situation was similar for the years 2018 (20 out of 26), 2019 (24 out of 31), and 2020 (20 out of 32). Thus, on average, there were about 26 to 32 motor vehicles in service whose operating times are known to us. In addition, about 14 other vehicles were listed in the above categories whose years of operation could not be determined but which, in principle, could be considered operational in all years 2017 to 2020. Therefore, the assumption was made that, in total, about twice as many vehicles were in use as were recorded by fuel cards.

Consequently, the CO2(e) emissions originally calculated were doubled to estimate the emissions of the entire university fleet (see Figure 14)). In addition to the uncertainty of the estimate, there is a risk of overlap in business trips outside of Rostock with university-owned vehicles. However, these possible double counts are unlikely in our view, as fuel costs of business trips usually are not paid by fuel cards but paid privately and reimbursed afterward.

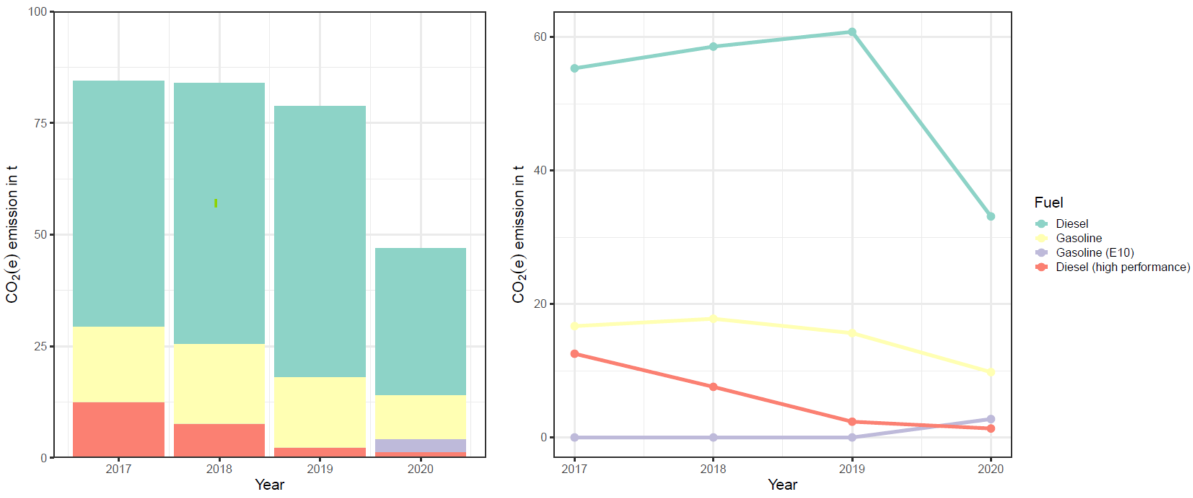


Figure 14 Extrapolated CO2(e) emissions in t emitted by official vehicles from 2017 to 2020.

This estimate includes the entire fleet of the university (including all relevant vehicle types and those motor vehicles whose fuel fillings were not paid by fuel cards). In the diagram on the left, the data is presented as a stacked bar chart so that the sum can be easily read. In the chart on the right, the data is presented as a line chart to show the time course of CO2(e) emissions.

3.4. Discussion

In our pilot project of a GHG inventory, we have found that a total of approx. 5750 t CO2(e) was emitted in the reference year 2019. Here, the consumption of district heat (approx. 2300 t CO2(e)), electricity (approx. 1300 t CO2(e)), and natural gas (approx. 300 t CO2(e)) as well as business trips by airplane (approx. 1100 t CO2(e)) represent the largest CO2(e) emitters at UROS. The CO2(e) emissions from the consumption of laboratory gas and water, the vehicle fleet, waste disposal, and business trips with other means of transport are significantly lower but cannot be neglected in total (see Figure 15). If the electricity consumption of UROS was multiplied by the emission factor of the federal mix, it would have the largest share of the university's GHG emissions with about 7000 t CO2(e) and the total emission would more than double to about 11 450 t CO2(e).

In the area of emissions from building operations, there was no noticeable decrease for the first COVID-19 year 2020 (see Figure 11). A significant decrease in emissions has occurred in business travel by 75% and in the vehicle fleet by approximately 40%. This decline was mainly due to the cancellation of almost all events and, thus, also business trips. In addition, the share of home office and online teaching has increased due to the pandemic. Currently, the share of renewable energy provided at the university (from photovoltaic systems and heat pumps) is negligible compared to purchased energy. In 2018, for example, 16 205 kWh of electricity was generated via the photovoltaic system in the new laboratory building of Faculty of Agricultural and Environmental Sciences. Approximately 20% of that roof area is covered with photovoltaic systems. In the same year, the heat pump at the main university library generated 106 826 kWh of heat. Compared to purchased electricity and heat, the share of regeneratively generated energy on site is less than 0.5%.

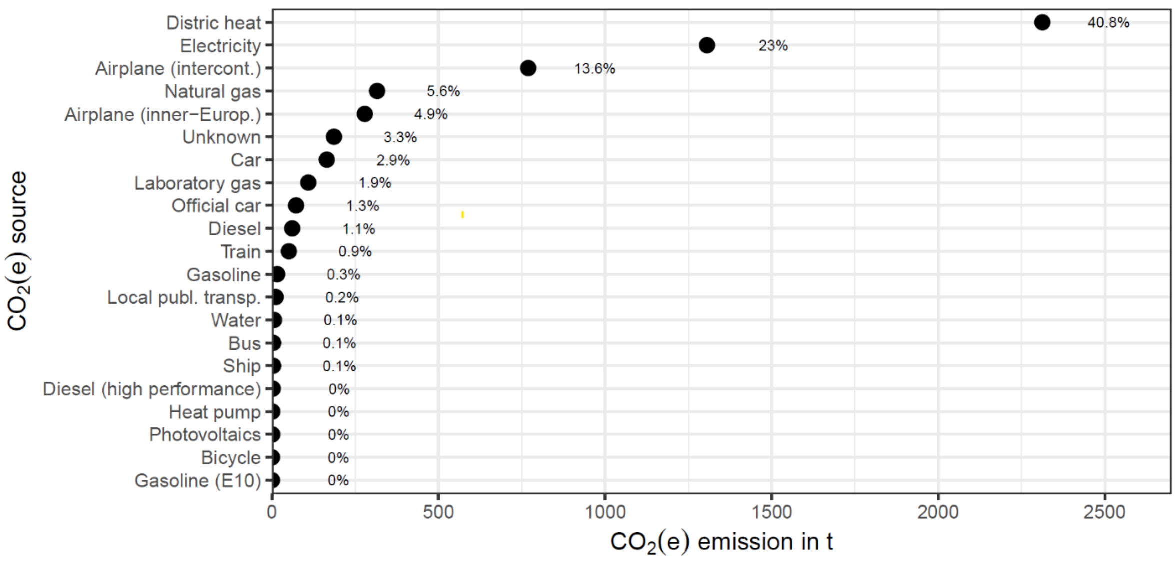


Figure 15 Comparison of $CO_2(e)$ emissions in 2019 for the sources we have considered.

2.2.4 Student and Community Engagement:

UROS has been proactively engaging both students and the broader community in various sustainability initiatives. In the context of this pilot study, students and researchers from diverse academic backgrounds and faculties came together voluntarily to form a research group. They dedicated time outside their regular schedules, meeting on a weekly basis to synchronize their efforts and engage in productive discussions regarding the ongoing research, as well as to review and discuss the latest findings. Furthermore, the university's administrative body has demonstrated a strong commitment to fostering sustainability endeavours led by students. The academic administration, in conjunction with the University's dedicated Sustainability Officer, played an active role in supporting and facilitating the study. This involvement underscores the institution's dedication to promoting sustainability initiatives initiated and driven by its students.

2.2.5 Performance Metrics and Achievements:

This pilot study investigated and estimated the emission of climate-damaging GHG in carbon dioxide equivalents ($CO_2(e)$) at UROS in the reference year 2019 was about 5750 t, of which business trips accounted for about 30%. This results in 3.2 t $CO_2(e)$ emissions per employee of the 1800 university employees (2019). The GHG inventory, if carried out regularly, can be used, for example, for steering processes or as a basis for a future climate neutrality certification and help the University of Rostock to reach its goal of climate neutrality by 2035.

2.2.6 Challenges and Lessons Learned:

The pilot project took much longer than we initially assumed. Overall, it took about a year from the establishment of the working group to the completion of the first draft of the report. A year and a half have passed before this detailed GHG inventory, which also more fully reflects the emissions from business travel, has been written. During the first year, the group met almost weekly for at least an hour outside working hours to coordinate joint work and discuss interim results. Particularly time-consuming were the communication with third parties, the data acquisition, the preparation of the business travel data, the utilization of data not available in digital form, and the compilation of the present report. The GHG accounting took relatively little time and could be carried out very time-efficiently with appropriately prepared data in the future. For this, an intensified collaboration of the respective offices of the academic administration with high data sovereignty would be necessary. The GHG accounting could then be performed using the R scripts, which are available in a private GitHub repository that we would make available at any time. The limiting factors of the pilot project were the limited time resources of the working group and the often insufficient data availability, which is strongly related to the degree of digitization and automation of data acquisition at the university and academic administration. Overall, we see potential for improving digital data availability.

Especially for accounting for the emissions of the official vehicle fleet, the time required to prepare the data was too long, and the insights were not relevant to our current estimation. However, with improved and reliable digital data on vehicle operation, potential savings could be estimated.

With regard to the business travel data, we were finally able to create a satisfactory data basis. We are optimistic that this will be possible in the future with less effort and with internal university data access.

2.2.7 Future Sustainability Goals:

UROS aims to reach the goal of climate neutrality by 2035. There are two options to reduce the amount of climate-damaging emissions directly. First, by reducing consumption, and second, by reducing emission factors.

Reducing energy consumption is possible through energetic refurbishment and prioritizing climate-friendly new buildings, replacing concrete with wood, for example. In the long term, upstream emissions should also be taken into account for new buildings/refurbishments and purchases. In addition, reducing the number of business trips and avoiding airplanes or lowering the room temperature during weekends or at night can lead to CO2(e). Introducing a job ticket or promoting bicycle use at the university and city-wide could lead to university members leaving their cars at home more often or not having one at all. Making employees aware of unnecessary power consumption, for example, because appliances are turned on unused, can also help to reduce power consumption. In purchasing, attention should be paid to the energy efficiency and required power of appliances.

The reduction of emission factors is possible by using alternative energy sources. Heating with district heat, for example, is lower in emissions than heating with natural gas. In particular, the heat plan for Rostock, which was developed in cooperation with UROS and provides for climate neutrality of the district heat network by 2035, could further reduce the emission factor of district heat.

Emissions from electricity and heat consumption could be reduced through the local provision and use of renewable energies (primarily photovoltaic systems and heat pumps) and the associated reduction in the proportion of purchased electricity or natural gas. In business travel, a rail trip generates significantly fewer emissions than an air trip due to the lower emission factor. An important step was taken here with the amendment to the MV Travel Costs Act (as amended on June 7, 2021), which favours the most environmentally friendly means of transport rather than the cheapest. Other universities already require in the business trip application that the CO2(e) emissions generated by the journey are reported. This step could increase awareness of environmental impacts and perhaps make alternatives more attractive.

In order to reduce emissions indirectly, there is also the possibility of offsetting them via compensation payments or the development of carbon sinks, for example, in university-owned ecosystems. This approach would require an analysis of the carbon cycle of the green spaces belonging to the university.

2.2.8 Conclusion:

This report documents the path and the result of a voluntary GHG accounting pilot project of the years 2017 to 2020. The basis for this was the GHG Protocol and the UBA manual “The Path to Greenhouse Gas Neutral Administration”. Through regular GHG accounting, UROS can be enabled to record and gradually reduce its climate-damaging emissions.

The aim of the pilot project and this final report was, in addition to calculating the emissions themselves, to describe how an emission report could be compiled in the future with little effort. In the course of this project, it became clear that data was often not available at all or not machine-readable. Improving data availability is essential for future GHG inventories. It can only be compiled quickly with digitally recorded, machine readable data, when reliable emission factors have already been determined. Consequently, the most time-consuming part of the GHG accounting process was obtaining and preparing data.

If all data required for GHG accounting were available in the future, regular GHG inventories would only require a few working hours per year. Annual GHG inventories can help identify significant emission sources first and enable a review of progress to a climate neutral university. A reduction in annual emissions can be achieved in particular through changes in business travel behaviour, efficient use of electricity and heat, a change in the heat supply, the use of renewable energies, energy-efficient building renovation, and climate-friendly new buildings. However, this also requires the support of the city of Rostock and the state of MV, since not all fields of action lie within the university’s area of responsibility.

2.3 La Rochelle Universite

2.3.1 Introduction:

The best sustainability practice at La Rochelle Université consist of calculating its carbon footprint in order to produce an action plan to help reduce its carbon emissions. Calculating the carbon footprint of an organization is useful in order to know the activities which have the most impact via carbon emissions in order to take measures to reduce them. For La Rochelle University, transportation has the highest impact, in terms of carbon emissions, followed by energy consumption.

Starting with this result, we have elaborated an action plan with the objectives of reducing the carbon footprint of La Rochelle Université. Also, we have created an exhibition with all the results, the action plan and some information about climate change, to raise awareness among our students and employees

This initiative structured a big part of the Sustainable Development policy of La Rochelle Université.

2.3.2 Campus Profile:

La Rochelle Université is located on one campus, close to the city centre with all 12 buildings, that make up the campus, being approximately a 10 minute walk between each one of them. The university consists of 1000 employees, stationed between all of the university buildings where 8000 students attend in total.

The whole campus has been included when calculating the carbon footprint.

2.2.3 Best Practice Description:

The carbon footprint of La Rochelle Université has been calculated at 11 902 ton of CO2 per year. This is equal to 1,23 ton of C02 per student per year at the university.

The carbon footprint is due to the following:

- Travel (commuting and business trips)

- Fixed assets

- Purchases

- Energy consumption

- Waste

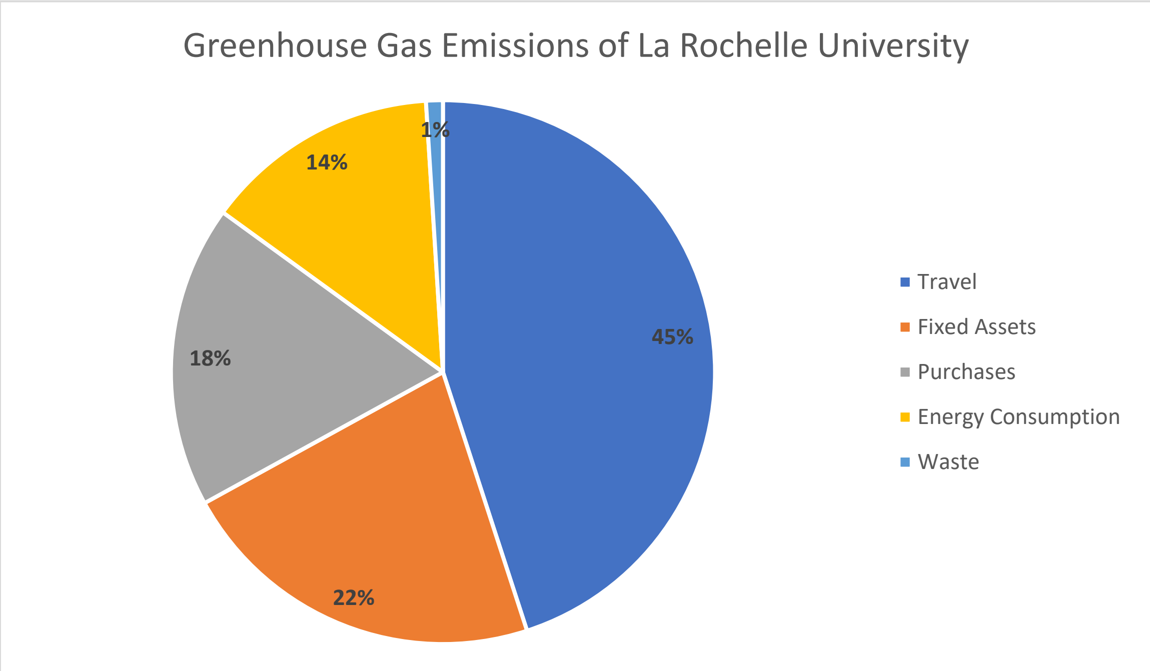


Figure 16: The carbon footprint of La Rochelle Université

By having an understanding of the accurate contributions of each different aspect that contributes to the university's carbon footprint, appropriate actions can be taken in order to reduce it effectively.

Measures to reduce the impact of:

Travel (commuting and business trip)

To reduce the impact of travel, we took measures in encouraging individuals to take the train instead of air travel. Also, we developed an app to calculate the travel carbon footprint of each business trip taken for the university. It is useful to raise awareness on the true impact of different means of transport and to encourage the less pollutant means such as taking the train.

Another initiative was to encourage sustainable transport means for daily commuting to our campus buildings. Riding bicycles is carbon neutral, making it extremely effective in tackling the carbon footprint due to commute associated emissions. As a way to help encourage both staff and students to use bikes, a partnership was drawn with an organization where it would offer free bike repairs. Other means are also being examined and tested through a research team at the university.

Purchases

The public purchases are a very important lever for the ecological transition. We decided to work with our purchase department to establish green criteria in the public order as office supplies, business trip, furniture, digital technology…

Energy:

Energy consumption was tackled by addressing both the human contributing aspect of this, as well as the actual machinery that consumed energy. Traditional lamps have been switched to LED ones, that are energy saving, and attempts have been made to change the behaviours of individuals using the university facilities by encouraging lights, computers and other machinery that my use electricity to be turned off when not in use/needed.

Each laboratory conducted their own carbon footprint analysis in order to measure the exact factors that highly influence it. Each laboratory team were instructed to take action in reducing their carbon footprint but without disturbing the efficiency or practices of the research taking place.

2.3.4 Student and Community Engagement:

We decided to use the carbon footprint analysis and the action plan to raise awareness among our community regarding climate change and the goals we have to achieve to reduce our impact.

An exhibition was created and was broadcasted on our social media as well as information was posted throughout our buildings. Workshops for team managers were also used to raise awareness on global warming and the importance of having an ecological transition throughout the university, as they are the ones taking the decisions about any changes that happen at the university. Both a bottom-up and top-down approach were used to raise awareness.

2.3.5 Performance Metrics and Achievements:

For this practice, performance metrics were used to calculate the university carbon footprint frequently, at intervals of 2-3 years, in order to have a good understanding of the impact that certain initiatives had. The university will calculate their carbon footprint next year, 2024, for the third time.

2.3.6 Challenges and Lessons Learnt:

The issues faced by the university, in order to implement changes catered to reducing carbon emissions, were primarily related to student and faculty engagement. Behavioural changes proved to be extremely difficult, yet the persistence from decision making actions resulted in the correct steps being taken. The inclusion of the general public – from the community surrounding the university campus- added pressure in order to drive change.

2.3.7 Related Sustainable Development Goals (SDGs):

This project is very transversal related to the Sustainable Development Goals. The mains SDGs covered by this project and actions which was implementing are:

SDG 13 - Climate Action

This project is naturally directed to achieve this goal, as it is tackling the carbon emissions of the university and thus the impact that it has onto the climate and the climate change phenomenon.

SDG 12 - Responsible Consumption and Production

This is addressed through responsible purchases on the campus as well as the implementation of green criteria.

SDG 11 - Sustainable Cities and Communities

This SDG is addressed by raising the awareness about climate change to our community, and to encourage energy savings as well as green transportation for commuting purposes.

2.3.8 Conclusion:

This initiative has been the backbone to the development of the university's sustainability action plan so that it can be used to support changes in the policies that the university chooses to enforce. It is an accurate way to paint a picture of the true carbon dioxide contributions, from the university, and thus appropriate actions can be used to tackle problem areas. This also allows for appropriate awareness to be raised among students and employees regarding climate change and their contributions towards it. Frequent measurements of the carbon footprint, allows for better understandings of how impactful certain actions may be and it can be used as an incentive for individuals to keep enforcing carbon neutral practices.

2.4 Funacion Univeridad Catolica de Valencia San Vincente Martir

2.4.1 Introduction:

Catholic University of Valencia San Vicente Mártir (UCV), founded in 2003, is a comprehensive private university of more than 11,000 students and 1,300 staff. UCV offers a wide range of interdisciplinary studies and research, that cover a plethora of fields such as experimental sciences - biotechnology and marine sciences-, education, social sciences, sports and health sciences. The main international studies and research expertise focuses on the following fields:

- smart urban and coastal sustainability and social awareness,
- e-learning technologies, and methodologies - especially on the topic of health care system
- European Union Strategy on human rights and security,
- pedagogies for early assistance to children with disabilities and inclusive education.

UCV has worked on its environmental policy, thus expressing its own commitment as well as transmitting to the entire educational community to employ the necessary economic, material and human resources to carry it out. UCV is a private university and is not supported by public grants, it strives to improve its environmental impact step by step.

The infrastructure of the campuses has been developed year by year towards defining and optimizing the operational energy and water consumption performance at the university's buildings. It is important to keep in mind that most of the UCV campuses are located in old buildings that have heritage value and it is more costly and difficult to make improvements to the facilities.

2.4.2 Campus Profile:

Catholic University of Valencia operates on 5 campuses:
Valencia – 6 buildings
Edetania – 4 buildings
Torrent – 1 building
Ribera – 1 building
Costera – 1 building

The majority of the buildings, used by the university have a historical and architectural significance based on their unique construction. Subsequently most of them have been rehabilitated, with special attention to the Valencia campus, where the buildings are located in a Properties of Cultural Interest Area and many of them have protected internal areas (Figure 17). This poses a difficulty when changes are needed to be made in order to modernize the infrastructure for the purpose of improving the energy certification, versatility of spaces, changes in degrees and changes in teaching needs. Nevertheless, this challenge has been overcome as there are currently improvements being made via the installation of photovoltaics (PV) at three different locations (Saint Ursula, S. Carlos, Padre Jofre), lighting has been replaced to more energy efficient LED ones and major upgrades have been introduced to the air conditioning systems via aerothermal energy. Electricity charging points for electric vehicles have been also been installed in the main parking lots of the campus. All upgrades and improvement objectives relating to energy efficiency are done so via the guidance of energy audits, where practices are quantitatively evaluated.

UCV is proud to have its own Veterinary Hospital that works around the clock, all year round, UCV Clinics, Virtual Hospital, Language Institute, Early Attention and Early Childhood Education Center, Institute for Research in Environment and Marine Science (IMEDMAR) and Campus Capacitas, that ensures the quality of life of people with disabilities. The UCV Campus Capacitas is one of the identity references of the Catholic University of Valencia and is configured to address areas around disability and social, cultural and educational inclusion. This campus is integrated in a transversal way in the set of lines, objectives and strategic actions of the university. These strategic lines are projected in the teaching, scientific, welfare and social fields, throughout the university.

Figure 17. (Buildings of UCV in the city centre)

2.4.3 Best Practice Description:

Due to the building classification of UCV centric buildings huge investments are required in order to improve the infrastructure in order to become more sustainable. This has not stopped the efforts of UCV to develop greener and more sustainable campuses as it continues to invest and make improvements on a yearly basis.

A notable building that has been upgraded over the past years, has been the one concerning the building of Santa Ursula. The building was originally constructed and used as a monastery. The 5000m2 property has now been converted into the university's central library, laboratories, multimedia classrooms, lecture hall, faculty offices and cafeteria. It also boasts a beautiful courtyard garden in the cloister. The building upgrades include solar panels, LED lighting as well as automation in classrooms and centralized climate control. These seemingly small changes have proven to be quite effective in reducing the electricity consumption as noted in Table 6:

Table 6: KWh Electricity consumption in the venue of Santa Ursula

Month	Energy Consumption 2022 (KWh)	Energy Consumption 2023 (KWh)
January	37.109	30.315
February	43.836	41.462
March	36.104	27.222
April	35.268	24.839
June	26.830	18.924
July	35.492	27.729

The locations of San Carlos, Santa Ursula, Brujas, San Juan and San Vicente have all had building management systems (BMS) in an attempt to decrease energy consumption and promote sustainability within the buildings. BMS is a control, monitoring and data acquisition system that automatically manages the services of a building. These include lighting, heating, ventilation and air conditioning systems (HVAC), security systems, fire protection systems (PCI) as well as water management.

2.4.4 Student and Community Engagement:

As sustainability is one of the core values of the United Nations 2030 Agenda for Sustainable Development plan of actions, the UCV actively participates in sustainable efforts on campus working towards utilizing community-engaged teaching, scholarships, faculty community services and student services in partnership with community organizations that utilize sustainable methods and practices. There is hope to both incorporate and strengthen problem-based learning approaches that focus on sustainability into academic coursework in order to work towards and achieve a more ecologically sound campus.

UCV students have shown a strong concern in regards to their impact on the planet and feel that UCV campuses should engage in sustainable practices. Taking the voice and opinions of the students into consideration has always been welcomed by the university as students offer diverse initiatives in achieving sustainability. Student led initiatives have been proven to be effective and widely accepted by the masses.

Moreover, university has the School of Volunteering and Social Action which contributes to building regional and local collaborations and partnerships with civil organisations, and with public and private organisations. Apart of the various actions and events on sustainability the areas of action of volunteering are especially focused on minors, hospitals, people at risk of social exclusion, people with functional diversity and the elderly.

2.4.5 Performance Metrics and Achievements:

The university's recent focus on collecting data related to Performance Metrics and Achievements associated with energy consumption marks a pivotal step towards a more sustainable and responsible future. Whilst the university is just embarking on this journey, several compelling reasons underscore the importance of this initiative.

Firstly, energy consumption plays a critical role in the institution's environmental footprint. As society becomes increasingly conscious of climate change and environmental sustainability, universities must lead by example. Gathering data on the energy consumption, areas that require improvements can be identify which will result in the reduction of the building’s carbon footprint as well as contribute to the global efforts to combat climate change.

Secondly, efficient energy management translates into substantial cost savings for the university. By tracking performance metrics and achievements in this domain, the university can pinpoint opportunities to optimize the energy usage which would translate into a reduction in utility bills as well as being able to allocate resources more efficiently. These savings can be reinvested into academic programs, infrastructure improvements, and student support services.

Moreover, data-driven insights into energy consumption empowers the ability to set and achieve ambitious sustainability goals. Establishing benchmarks and key performance indicators allows us progress to be tracked over time, establish accountability, and communicate the efforts transparently to the university community and the wider public.

Lastly, as the world grapples with a growing energy crisis and the need for cleaner, more sustainable energy sources, universities can play a pivotal role in research and innovation. The data collected can now serve as a valuable foundation for interdisciplinary research projects, collaborations with industry partners, and the development of innovative solutions for a more sustainable future.

In summary, the university's decision to start collecting data on Performance Metrics and Achievements related to energy consumption represents a crucial first step towards a more sustainable and responsible institution. It aligns with the commitment of environmental stewardship, cost-efficiency, and academic leadership in addressing pressing global challenges. Whilst this is still at the initial stages the potential benefits are both significant and far-reaching.

2.4.6 Challenges and Lessons Learned:

As aforementioned, the university uses its institutional resources to upgrade its infrastructure every year for the benefit of the environment. The implementation of solar panels, LED lighting has scientifically enhanced the understanding that the university not only can save energy in the long run but also contribute into making the environment more sustainable for future generations.

Notably, UCV has a certification of ISO 14001 which is part of a series of international standards that refer to the Environmental Management System, applicable to all types of organizations. It is the most widespread environmental management system standard in the world, based on the principles of a management system that includes planning, implementation, control and improvement action. UCV decided to implement and get certified in regards to the ISO 14001 standard to demonstrate a true commitment and sustainable management of it campuses, resources and energy consumption. Incorporating environmental issues when managing and organizing UCV throughout the chain of command, from top management to employees, greatly facilitates the successful achievement of the strategic objectives set by the UCV in terms of commitment to the environment.

In the last years UCV is seeking to proceed with other environmentally friendly and green campus oriented actions and has presented several project proposals in order to be awarded funds through national and European project calls.

2.4.7 Related Sustainable Development Goals (SDGs):

The Sustainable Development Goals (SDGs) provide a comprehensive framework for addressing global challenges across economic, social, and environmental domains. Universities, as centres of knowledge, innovation, and influence, play a crucial role in progressing and addressing the SDGs. In the environmental sphere, the Catholic University of Valencia plays a crucial role in understanding and mitigating the challenges posed by climate change, biodiversity loss, and resource depletion. Through research, education, and campus sustainability initiatives, UCV promotes environmental awareness, it has developed sustainable technologies, and has encouraged behavioural changes among students and staff. By incorporating sustainable practices into campus operations and influencing local communities, universities can drive environmental stewardship and contribute to the achievement of the SDGs.

SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

The university's innovative approach to incorporating sustainable practices into campus operations, offering tuition fee grants to one in every three students, serves as a beacon of progress in achieving Sustainable Development Goal 4 (Quality Education) while simultaneously addressing broader sustainability objectives. By breaking down financial barriers to education, this initiative ensures that a diverse range of individuals can access quality learning opportunities, contributing to a more inclusive and equitable society. Moreover, it promotes responsible consumption and environmental consciousness, aligning with SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) by reducing the economic burden on students and enabling them to make more environmentally friendly choices. This multifaceted approach exemplifies the university's commitment to fostering educational access, sustainability, and global citizenship. There are some emerging cooperation projects that look to enhance the exchanges of both teachers and students (i.e., Tanzania - training people and building the business fabric based on sustainability and excellence)

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Currently at UCV there are multiple projects that look to address the issue of affordable and clean energy. These project include the installation of photovoltaics, replacement of LED lighting, improvements in air conditioning systems with aerothermal energy as well as installation of electric charging points for electric vehicles. Energy audits of the buildings have been carried out and are being used to set and carry out improvement objectives oriented to energy efficiency

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation

Building Management Systems have been installed in multiple campus buildings to enhance the SDG 9 which looks to address the issues concerned with resilient infrastructure whilst still managing to promote inclusive and sustainable industrialisation whilst fostering innovation. A crucially important and difficult aspect due to the historical importance of the campus buildings at UCV.

SDG 10: Reduce inequality within and among countries

The Service for People with Disabilities (SAPD) is a service of the Catholic University of Valencia constituted by a multidisciplinary team formed by a multidisciplinary team, oriented to provide care, advice and support on disability and support in matters of disability to the entire university community. The SAPD was created with the aim of ensuring the principle of equal opportunities and non-discrimination of students with disabilities and non-discrimination of students with special educational needs, teaching and research staff and administration and services staff. The SAPD is part of the Campus Capacitas UCV.

SDG 12: Ensure sustainable consumption and production patterns

In order for UCV to ensure sustainable consumption throughout its campuses, it has enforced a variety of initiatives such as recycling programmes for plastic, packaging, and batteries, automated irrigation systems for the campus' gardens, controlled flow of flushing systems at faucets, urinals and showers as well as installation of LED lights at the venues of San Carlos, Santa Ursula, Padre Jofre, Brujas, vetenary clinic and Hospital Virtual.

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss.

The university' suppliers are required to ensure that all paper supplied at UCV comes from sustainable forests and with the "EColabel". Recycling containers for both paper/cardboard, plastic and batteries are available in all buildings.

SDG 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

UCV's involvement in EU-funded projects like EU Conexus - promotes interdisciplinary learning by creating joint programs and also encouraging students to take courses from different departments

2.4.8 Conclusion:

Sustainable development in UCV is largely about its people, their well-being, and equity in their relationships with each other, in a context where imbalances between the natural and anthropogenic environments can threaten economic and social stability. Initiatives to help create greener and more sustainable campuses look to eliminate inefficient and wasteful practices whilst replacing them with more sustainable ones. Many of these changes address the daily and practical aspects of campus life—correct disposal, handling, and storage of cleaning chemicals and materials associated with labs and automotive shops; purchases of environmentally friendly supplies; effective recycling programs. Other changes may require larger, big-picture investments, but changes don't have to happen all at once. Small steps are taken, on a yearly basis, to ensure a steady and achievable change into sustainable and greener practices. These changes are built into the institutional planning and budgeting processes, with an eye toward continually improving the campus and implementing responsible recommendations.

2.5 Universitatea Technica de Cinstructi Bucuresti

2.5.1 Introduction:

The purpose of this report is to emphasize the efforts undertaken by the Technical University of Civil Engineering Bucharest on its campus. These efforts are aimed at safeguarding and enhancing biodiversity, as well as revitalizing green spaces to fully realize their potential as biodiversity reservoirs within urban settings. To achieve this goal, we will delve into the OPEN Garden project, a communal garden situated on the UTCB campus.

The objectives are straightforward: to establish a replicable shared garden and develop a methodology that simplifies the execution of similar projects in the future. The central concept involves transforming this green area into a living laboratory and a dynamic showcase of environmental transition. This endeavour is driven by the aspiration to bolster biodiversity in both short and long term, while also setting an example for environmental education among garden users.

The garden's design encompasses various aspects of sustainability, judicious resource management, climate adaptability, and citizen collaboration. Beyond formulating a user-friendly methodology applicable to analogous initiatives, the sustainable and reproducible OPEN project is accompanied by an evaluation of its influence on the garden's planning. Initial environmental assessments were conducted on-site before the project commenced. These assessments were then translated into maps. Subsequent measurements following the project's completion will allow us to quantify the effects on public health and comfort within the garden's vicinity. Consequently, we can communicate the positive outcomes of such undertakings in an urban context prone to a spectrum of challenges stemming from environmental disruption.

In short, it's a question of responding to, if not preventing, the effects of these disruptions in the city, to ensure that it is ready to meet the new challenges it will face in the years and decades to come.

2.5.2 Campus Profile

The UTCB campus is fairly sparse, with the main building located in the north-east of the city. But a number of buildings make up this university. In this case study, we'll be looking at the C7 student residence, located a few minutes' walk south-west of the university's main building. The site of the OPEN experiment was chosen for its strong impact on the community. The area is characterized by the presence of a young community from all over the country (especially those living on campus), but also by a marked ethnic mix (Roma, Chinese and Turkish communities, for example). It should also be noted that the Technical University of Bucharest (UTCB) has welcomed a number of Ukrainians since the beginning of the conflicts in their country. Added to this is the presence of a dynamic working community in the nearby Pipera business park. All in all, this zone represents a surface area of almost 2,400m2 of green space, which will be landscaped and offered to this community as a meeting place. The greatest challenge in creating this garden is that of sustainability, and with it comes its greatest opportunity: citizen participation. Indeed, the greatest challenge of this project is to maintain the garden in the future, and at the UTCB we are sure that this will require the community's attachment to the project. That's why we're looking to involve as many people as possible from the beginning to the end of the garden's development. This allows us to create a network of close-knit participants specializing in different and complementary fields, and to unite them around a project based on the idea of sustainable development. As for the other challenges, they are obvious: Bucharest, like other European cities, faces numerous problems linked to environmental and noise pollution, as well as urban heat islands, not to mention the lack of interest among citizens in these issues, which has less to do with Romania's history than with reduced access to nature in the city. With this garden, we'd like to show that while humans can have a deleterious impact on their direct environment, they can also contribute significantly to making it more liveable and pleasant. At the same time, this project aims to raise awareness through local education, based on visual and tangible elements, made possible by the creation of the garden.

2.5.3 Best Practice Description:

The garden will be divided into three interconnected sections, each with its own function, although these may be more diffuse than they appear. In the first part, to the west of the residence, there will be a relaxation area featuring a number of urban furnishings and 2 "work cabins" equipped with Internet routers, enabling people to work outdoors or relax in the shade of a tree. Like the rest of the garden, this area will be structured by a meadow of tall, dense, impassable vegetation, to give nature its rightful place on the site. The idea is also to share this space with other species.

Figure 18

Figure 19

Figure 20

Figures 18-20: Expected results of garden once completed

The second part of the park, to the east, will be dedicated to cultivation. Four planters will be installed, allowing local residents to come and cultivate freely according to the seasons, and at the same time to reconnect with them. The planters are tailor-made to suit the physical characteristics of the land, and will be freely accessible under the supervision of the residence's students. The planters will have a hybrid function, first and foremost cultivation, but also benches for relaxing among the plantings or chatting with other gardeners.

Figure 21: Compost bin already installed

Lastly, the third zone is at the rear of the building, linked to the cultivation area by a small passageway that facilitates the exchange of matter between the two zones. This is an important point, and for good reason: the third zone is where the compost is installed to enrich the planters, and in the other direction, the waste from cultivation enriches the compost, creating a virtuous circle. That's the broad outline of the garden, but every detail has been thought out to reduce or even eliminate the negative impacts of the garden's construction, making it sustainable and having a positive impact on the environment and on people's consciences.

As part of this project, the garden has been designed to integrate the whole community and unite them around a project that responds to the issues of sustainable development. First and foremost, the project was designed to make maximum use of second-hand raw materials. The furniture, for example, has been made from recycled pallets, and a sunshade will be installed and designed from advertising tarpaulin, collected in the city and recycled. But the project has also been designed to reduce the use of resources, so most of the raw materials are sourced in Bucharest or in the immediate vicinity to reduce the impact of transporting materials.

Water was also central to the project. For the plant cover, for example, in cooperation with the project's landscape designer, we chose species that require little water and are adapted to Bucharest's particular climate. In addition, the plants were chosen for their air purification potential, the impact of which we'll be able to measure thanks to data such as PM2.5 and PM10, as well as CO2 and HCHO content in the field. These indicators were chosen because the impact of private mobility, and cars in particular, is significant in the Romanian capital and represents a real public health issue. Fine particles (Particulate Matter) can have various origins, depending on the context, but in the context of our project it seemed obvious that the main source was road traffic and its direct and indirect effects. (combustion, tire wear, etc.). However, as the area is highly residential, these indicators were also of interest as they could be derived from energy consumption.

What's more, since the aim of the garden is to be open to all, it seemed important to adapt all the facilities. Thus, most of the planters are adapted for people with reduced mobility, but also for the elderly. By raising them, the planters are made accessible to all, thus avoiding the stigmatization of a segment of the population that would otherwise be excluded from the right to action.

Firstly, we opted for a meadow-type garden, with dense, high plant cover, providing insects, small mammals etc. with a safe, connected habitat, which is quite rare in an urban environment. Added to this is the desire to install insect and bird houses in the garden. As far as birds are concerned, the revitalization of the space will be completed by the installation of a bird fountain and, in time, a watering point*[1] to further enrich the potential for biodiversity by creating a balanced "natural" eco-system with a rich flora attractive to a range of living organisms struggling to sustain their population in the city.

One of Bucharest's other problems is waste management: despite the law on the management of non-hazardous compostable waste promulgated on February 20, 2021, the city is still woefully lacking in ambition when it comes to the selective sorting of waste, so in the garden we set up composters to enable local residents to sort their waste. Composters have been set up and are managed by the students of the residence, and will eventually enrich the crops grown in the grounds and the garden in general.

Beyond all these good practices implemented in the field, the main aim of the garden is to develop good practices in general. The site also has an educational value, with information panels installed on the composters and near the trees to inform people about their ecological value, and so on. It also reconnects people with nature, its needs and its contribution to their daily health and comfort. In this way, the garden becomes a sensory museum of environmental transition, where the air is cooler and more breathable*[2]. What's more, on-site activities such as gardening have a positive impact on self-esteem, anxiety and reduce the risk of depression (Carly J. Wood, 2016), an impact that is combined with the creation of social ties. In fact, the aim of gardening is to make people think about space, about lived space and about how to interact with their environment by rethinking the way they consume and produce. By reconnecting them with nature, which is increasingly absent from cities. In short, by showing them that action is at hand.

*[1] To avoid the health risks associated with stagnant water, the pond should be fitted with a solar-powered pump to create a current, and why not be inhabited by indigenous predatory species such as amphibians or dragonfly larvae.

*[2] An airly air quality measuring device has been installed on campus, enabling individuals to use the eponymous application to check air quality in the garden in real time

2.5.4 Student and Community Engagement:

As far as student and civic commitment in general is concerned, it really is at the heart of the project's concerns. Indeed, the garden has been designed to be sustainable, but how can it be sustained without the active participation of individuals?

So right from the start, a group of students living in the residence were involved in the project, in response to two issues. First, the idea was to increase the project's acceptability. Since the garden is now shared, it previously belonged only to the students, and it would have been unthinkable to impose a sharing arrangement on them that they didn't want. So we thought about a garden that would please them, that would preserve their privacy while benefiting as many people as possible, and without creating friction between the different users. The second objective was to create a core group that would create a sense of attachment to the garden - an attachment that would be essential if the garden was to be maintained and kept in its original state, or even improved by the students themselves in the future. But also to have a group that could facilitate communication with other students and local residents on good practices, good citizenship and environmental protection in general. The students took part in setting up the project, from the initial idea to the final layout, investing in the creation and design of the furniture. They also found the materials used in the design by contacting suppliers in the surrounding area or in Bucharest. In short, if the garden was the objective of the project, the students involved were the driving force behind it. Other people got involved in the project. The neighbourhood civic group contributed its knowledge of neighbourhood life, of the uses required by local residents, and of the project's incompatibility with local lifestyles. But above all, they facilitated dialogue with local residents and stakeholders.

All these actors came together for one-off events organized in the field. A workshop to raise awareness of composting was held for project stakeholders and local residents. Workshops to build furniture, plant planters and create ecological paint with very low environmental impact, as well as brainstorming sessions punctuated the project.

All in all, we're convinced that the garden will only be a success if local participants invest in it and pass on their experience to others, so that this wonderful project can be sustained over the long term, awakening more and more people to the need to respect the environment, and then, why not, propagate this kind of initiative elsewhere in Bucharest.

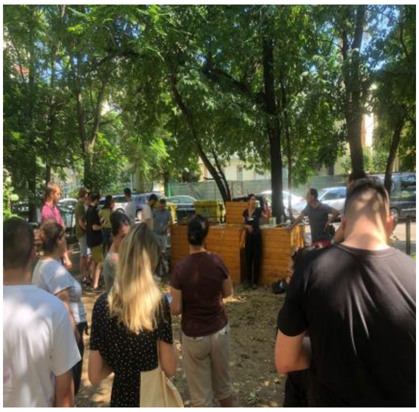


Figure 22: Compost workshop

Figure 23: Students cleaning the garden before the beginning of the project

2.5.5 Performance Metrics and Achievements:

It's rather difficult at the moment to talk about performance, and especially to present it in figures, given that the project is still in progress. However, expectations in terms of environmental gains are high, and theoretical considerations lead us to draw up a list of objectives in terms of results.

In this way, we hope to considerably increase the biodiversity of what is currently an almost unattractive area in ecological terms. The introduction of native plant species will certainly lead to a revitalization of Bucharest's own fauna, as can be observed in other revitalized or protected areas of Bucharest. The addition of watering holes, insect houses and bird nests will also, we hope, contribute to the rewilding of the area. From the point of view of air purification, the selection of resistant species adapted to the weather conditions and to the context of Bucharest in general will optimize air purification through vegetation. Plant associations are also designed to have a positive effect on those around them. Several measurements were performed in order to evaluate the environmental quality.

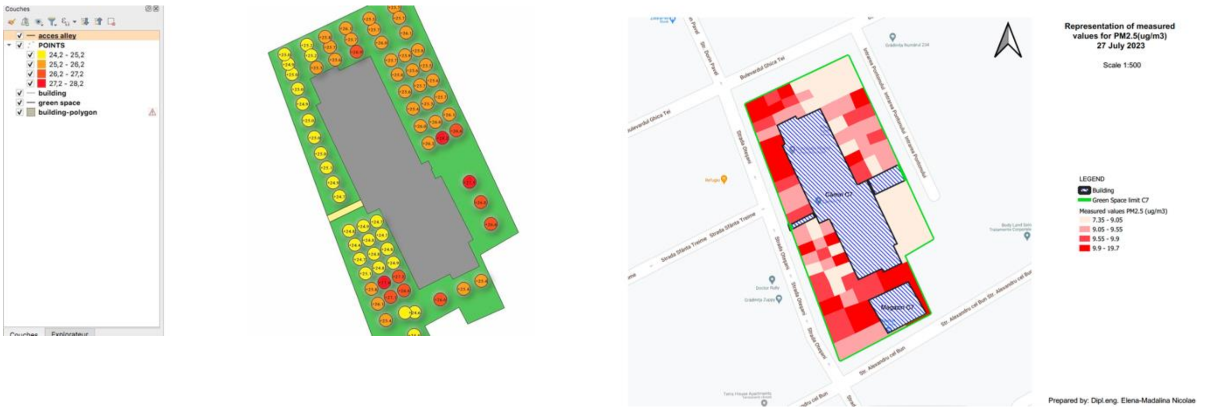


Figure 24 : Measurements in the demonstration area (temperature and PM 2.5)

Obviously, in addition to purifying the air, the increased plant cover will also cool it, limiting heat islands in the area and making the space much more pleasant for humans and other species. The last two points can be illustrated after the garden has been laid out, by taking measurements in addition to those taken before the project began. This will make it possible to create simple before-and-after comparison maps, showing whether or not the project has been a success in these two aspects.

In terms of waste management, the simple fact of having composters in the garden has reduced the amount of waste which, unfortunately, under normal circumstances would have been collected indiscriminately and ended up in a landfill or cremated.

Now it's recycled and redistributed in the garden, breaking out of the usual dysfunctional circle of Bucharest waste processing.

The aim of the garden is also to raise awareness, and in this regard we are already seeing results. A garden clean-up session was organized spontaneously following the compost workshop, and new students have signed up to build the furniture.

Socially, then, the creation of the garden itself already has an impact even before it is "in use". So the education part of the project is already underway, and will develop more and more as time goes on, since it relies on the group effect and exemplarity. What's more, the events that have already taken place, as well as those that are planned and others that will take place in the future, create a sense of belonging to a community in which the garden will be the focal point, the meeting point. A shared living space focused on sustainable development, which can only have a positive impact on ecological awareness and give users the desire, taste and power to act. Ecologically, time and the outcome of the project will tell whether the ecological and health impact is greater or lesser. As far as biodiversity is concerned, it's obvious that the garden's layout will have a positive impact.

2.5.6 Challenges and Lessons Learned:

As for the challenges, the main one has been and will remain the durability of the garden. The aim is to create something that will last for years to come, not to create a garden that will be left to decay year after year. The main challenge is therefore to continue to create an ever-growing group of people committed to helping maintain the garden.

The second challenge was to stay within the budget allocated for the project. Unfortunately, in the first phase of the project, only some of the ideas were retained and put into practice. The challenge for the months and years to come will be to obtain funds to improve and maintain the garden, following through on the ideas that have already been put forward.

It's also important to point out that during the project we faced challenges such as acceptability, as the environment isn't exactly a priority in Bucharest. However, we noted that on a local scale, with communication and local investment, it was easy to make people understand the direct consequences of inaction. The challenge is to extend the movement started around the residence. A concrete example is that of compost, which was much talked about for reasons of comfort, particularly olfactory, and maintenance, but in the end, following training on compost with a group of individuals, some of whom were opposed to it, we observed acceptance. Therefore the main challenge remains education and prevention, to limit the impact of misunderstandings and fears linked to certain practices.

Even today, we're still thinking about sovereignty over the garden, as all the facilities are currently available to the public. We sincerely believe that if communication is done in an appropriate manner - and this is the case at the moment, thanks to the creation of a "community animator" - good practices can develop, and the experience represented by this garden will show us whether this is true in the short and long term.

Finally, one of the remaining objectives for the OPEN garden is to get the authorities to recognize the positive impact of this project and to work with us to legitimize our action, expand the scheme and, why not, extend it to other areas of the city. What's more, the garden's ideology has been subjected to pressure from outside the project. For example, when it comes to waste sorting, even though the campus is equipped with waste sorting garbage cans, there is no differentiation in terms of waste collection. As a result, the efforts made in waste sorting are only rewarded by a lack of consideration from the authorities.

Finally, it's safe to say that the most important lesson learned from this project is a very positive one, and can be summed up as follows: if you listen to all the parties involved, you can create something that is well thought-out, coherent, acceptable, inclusive, ethical and very clearly positive for the environment, and it seems that if the project is driven by people who believe in it, then success will be proportional to their involvement. We believe that when it comes to the environment, the multiplicity of stakeholders and respect for their needs can be a strength in bringing it to fruition.

2.5.7 Related Sustainable Development Goals (SDGs):

It's clear that our objectives will be to respond to the challenges that have arisen in the course of the project.

To make the project sustainable, we need people who are committed and determined to help it evolve, not only for its direct impact on the environment and the comfort and health of its inhabitants, but also to democratize the symbolism of this garden, which presents itself as a site for learning and transmitting values shared by those of sustainable development. For us, it's obvious that change also comes through the younger generation, and given the presence of a number of schools in the vicinity of the garden, we'd like to involve the teaching staff in the project and build with them an educational framework enabling children to learn to live with nature and take care of it, not out of obligation but out of recognition of the benefits it provides.

The aim will also be to complete the garden, which in its current form is no more than a preliminary sketch of all that the various participants in the project had to offer. We'll need to find the funding to complete the project.

The garden is intended to be reproduced easily, quickly and cheaply, so we hope to see other initiatives of this kind develop on our UTCB campus of course, but also elsewhere in the city, to create a network of shared gardens guided by environmental protection and increased urban biodiversity, promoting the values of sustainable development and creating links between communities and within communities. To do this, we need to show that we've succeeded in doing something that has a real impact. We'll need to use our measurements, we'll need to create a simple methodology to enable the easy development of this type of project, and finally we'll need to communicate the results of our work to as many people as possible (authorities, civil society, companies, citizens...) to show that the garden is having a real impact and to justify potential further action.

2.5.8 Conclusion:

The OPEN project aims to stimulate sustainable urban development in Bucharest through sustainable communities and to provide examples of best practices for a sustainable greening of the city. The concept of community in the urban environment does not have strong roots in the culture of Bucharest, especially when it comes to the general population. Moreover, due to economic problems, social disparities, lack of education and awareness, civic initiatives have taken timid steps and have been mainly based on administrative needs rather than common goals. We saw with this project that with a core group motivated to act it's easy at a little scale to involved more and more people.

As a demonstration project for an urban garden, the overall idea is to create an example of sustainable community best practice, followed by extensive awareness-raising campaigns among target groups (neighbourhood citizens, authorities, dormitory residents, etc.) for a process of transformation of the whole society. Key activities for the implementation of the urban lab are envisaged for the future, together with awareness raising and education campaigns. The implementation of community gardens could be beneficial for such a large and mixed city, not only for environmental reasons, but also for social reasons, such as reducing social inequalities, harmonising neighbours or planning educational programmes for the younger generation.

Our project raises the question of sustainability. We know that there have been and always will be gardens, a symbol of man's desire to connect with nature again and again. We want more: the idea is to pass on this garden to future generations, and with it the values it promotes. Values of sharing, questioning, discussion and give-and-take, all with the common goal of preserving the environment. In short, participation is a driving force and a challenge, and we know that the success of this project will depend on our ability to unite people around it.

In short, our garden is a small urban ecosystem experimenting with a new way of sharing space. It's a concrete experiment in putting collective intelligence into practice in the service of sustainable development, one that's set to evolve further and further, and is driven by a real desire to create a positive movement designed to serve the environment in a human-nature relationship that's beneficial to both parties. Of course, the challenges are many, and this solution cannot claim to be the answer to all the environmental problems facing our societies, but it is the first representative of them in the values it defends and the ambitions it has set itself.

2.6 Geoponiko Panepistimio Athinon

2.6.1 Introduction:

The Agricultural University of Athens (AUA) offers high-level undergraduate and postgraduate levels of education and research in agricultural science. Its vision is to achieve educational and research excellence and occupy a dynamic position in the international academic environment.

AUA is the third oldest university in Greece, established in 1920. It consists of 6 schools (Plant Sciences, Animal BioSciences, Environmental and Agricultural Engineering, Food and Nutritional Sciences, Applied Biology and Biotechnology, Applied Economics and Social Sciences) and 13 departments. Its campuses can be found in 4 cities alongside the 3 farms of the university that are situated in agricultural regions.

AUA operates as a leader in the scientific fields it operates in where it contributes to the development of geotechnical, agri-food and related sciences, both nationally and internationally. It is a pioneer in academic research and innovation for the development of methods and practices that contribute to tackling and adapting to climate change, as well as other sustainability issues. These methods include digital agriculture, precision agriculture with the use of artificial intelligence, biotechnology, modern approaches via forecasting models, robotic agriculture, application of environmentally friendly new chemical agents, energy balances to reduce footprint, flower entrepreneurship with a given emphasis to the "from farm to fork" principle.

Research in the AUA promotes multiple sustainable development goals (SDGs) and particularly goals 2, 3, 4, 6, 7, 12, 13, 14, 15, 17.

AUA extends to 4 cities and maintains farms in three others. The campus in Athens normally hosts thousands of students and hundreds of employees and researchers daily. It is a vibrant urban node with facilities that include a vineyard, a plantation, valuable collections of plant material, a museum, experimental facilities for plants, livestock and aquatic organisms, a model dairy and winery , 13 greenhouses, agricultural machinery, a sericulture and beekeeping unit, a composting unit as well as a library and an information centre. Therefore, AUA is a small city within the city and the need for environmental management and reduction of its carbon footprint is a concern.

AUA realizes its role as an important factor in the pursuit for sustainable development for the city as well as its students and employees. The university's strategic objective is to improve the well-being of the AUA community and visitors as well as to highlight the AUA campus as a metropolitan park by:

• reducing the university's ecological footprint

• promoting sustainable mobility

• promoting circular economy

• increasing engagement of students and staff

• increasing cooperation with social partners

•highlighting dynamics and added value through synergies and networking for sustainability.

The target is to link AUAs operations to the UN SDGs and the agenda of 2030.

The AUA Environmental Management Office's actions fall within the scope of environmental, national and EU policies. Indicative:

- The European Strategy for the Prevention of Waste Generation (e.g. ban on the use of single-use plastics) for waste management and circular economy, which place precise emphasis on waste prevention, material reuse, recycling by sorting at source and recovery of organic waste.

- The European Green Deal (2020) which seeks to accelerate the procedures of EU member states for the adoption of policies that revolve around the axes of: circular economy, zero pollution, research and innovation, clean, affordable and secure energy, sustainable and smart mobility, optimal nutrition, conservation and restoration of ecosystems and biodiversity, building renovation and finally the reduction of pollutants produced for a climate neutral Europe.

- The new ‘National Waste Management Plan’ (2020) as well as the ‘National Prevention Plan’ (concerns the period 2021 – 2030). Both are based on the above European strategies and priorities.

- The National Strategy for the Circular Economy (2018).

- The national legislative framework for recycling as it derives from the laws:

• Law 2939/2001 "Packaging and alternative management of packaging and other products Establishment of a National Organization for the Alternative Management of Packaging and Other Products and other provisions" (as amended by Law 4496/2017 and in force),

• Law 4685/2020 "Modernization of environmental legislation, incorporation into Greek legislation of Directives 2018/844 and 2019/692 of the European Parliament and of the Council and other provisions".

• 4736/2020 "Incorporation of Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment and other provisions".

- The "Strategy for Education for Sustainable Development" adopted by the 56 countries of the United Nations Economic Commission for Europe (UNECE) in 2005, in Vilnius, Lithuania, which requires governments and all relevant bodies to promote ESD at all levels and asks universities to "contribute significantly through the development of appropriate knowledge and skills" as well as the general reform of the paradigm they exude through their teaching, operation and governance.

- The "Agenda 21" of the International Conference in Rio de Janeiro in 1992. Chapter 36 recognizes the role of Education at all levels and calls on Universities to play a leading role. [The admonition was repeated in 1996 by the UNCSD (UN Commission on Sustainable Development) in its International Programme of Work on Education, Public Awareness and Training. Subsequently, the historic Thessaloniki International Conference (1997) "For the Environment and Society" definitively paved the way for Education for Sustainable Development (ESD) at all levels].

- The UNESCO Roadmap for Education 2030 "Framework for Action".

- The actions also take into account the UN Sustainable Development Goals (2015) (3-Good Health & Well-being, 4-Quality Education, 5-Clean Water, 11-Sustainable

Cities & Towns, 12-Responsible Consumption and Production, 14-Life on Water, 15-Life on Land, 17-Cooperation for the Goals).

2.6.2 Campus Profile:

The Agricultural University of Athens is located in the Prefecture of Attica in the center of the basin in the Municipality of Athens on the 'Iera Odos' in the area of Eleonas. The area of Eleonas coincides with the Sacred Olive Grove of the ancient Athenians which was an additional area of recreation and country walks. 'Iera Odos' was the sacred road that crossed it from east to west reaching the ancient port of Elefsina city.

Today, the area presents a generally unfavorable and environmentally incoherent picture, which contributes to the formation and continuous deterioration of the negative environmental cordon of the capital. Combination of polluting units, luxurious offices next to the scrap yards, and illegally disposed waste to streams next to the experimental crops of the Agricultural University of Athens, form an image of urban and environmental anarchy that has no parallel either in the central districts of the capital or in other urban centers.

Today, due to its location next to the historic center of Athens, its administrative fragmentation, its multiple historical physiognomy, as well as the regressions of the state in matters of industrial, environmental and urban policy, Eleonas constitutes a multifaceted, fragmented and internally contradictory reality.

The only green areas found in the area are the Botanical Garden, within the boundaries of the university, as well as the vineyards on Agios Polycarpou Street, which also fall under the property of the university. In the wider area there are no organized or natural green areas.

The area occupied by AUA, according to the concession of the Ministry of Agriculture (17/12/1951) amounts to 247,000 m2. The campus includes 28 building complexes, 44 well-organized and equipped laboratories for education and research, 55 modern auditoriums and many classrooms. The possibilities of studying at the foundation are expanded by the vineyard, the plantation, the valuable collections of plant material, the museum, the experimental facilities of plants, productive animals and aquatic organisms, the model dairy and winery, the 13 greenhouses, the agricultural machinery, the sericulture and beekeeping unit, the composting unit and the Library and Information Center. The restaurant, the canteen, the sports halls and the recreation areas create conditions for gathering and creative interaction of members of the academic community within the University premises.

The distribution of the coverage of the university premises by use of coverage are:

Type of coverage	Area m2
Exhibit halls	465
Classrooms	5,799.50
Archive – Multipurpose Halls	474
Offices	6,576
Parking surface	3,916
Road Network Surface	11,615
Pavement Surface	3,353
Laboratory Rooms	7,812
Laboratory Space Vineyard	90
Common areas	6,045
Garages	808
Library area, reading room and auditorium	2,620
Total coverage	49,573.50

Concerning human resources, the AUA hosts more than 6000 students, almost 1000 postgraduate students and more than 400 people as personnel.

2.6.3 Best Practice Description:

Based on energy saving actions AUA tried to diminish operation costs as well as to reduce its environmental and carbon footprint. These actions included:

- Participation in GR-Energy project with an act entitled "Application of innovative green technologies in an emblematic building and facilities of the AUA" concerning the energy upgrade of buildings (in progress).

- Replacement of old windows in the main building and in other areas, with new top energy efficiency ones.

- Replacement of energy-consuming luminaires and lamps to energy saving ones (LED technology of more than 2000 luminaires).
- Supply of electric passenger vehicles for the University’s needs.
- Photovoltaic (PV) electricity supply charging stations for the University owned electric mini-bus along with university owned electric e-bikes.
- At least 110 kw of PV systems are established to cover the needs of the “passive” architecture building which houses the university’s library, as well as the lighting of outdoors sports facilities (2 tennis fields, a basketball court, a volley court and a gym).
- A complete change from diesel to the use of natural gas for heating.

2.6.4 Student and Community Engagement:

Web announcements on the main page of the university’s website, and targeted e-mail messages towards the community via “all users” are used to inform and involve the university’s community, as well as to disseminate results from the activities. These fall under the following categories:

- Informative on new activities and results.
- Motivational on ways to get involved or helpful.
- Reminders when asking for more attention or in poor results.
- Critical on indifferent groups or in poor implementation.

It is also common a door to door informing in affected areas or/and an in situ “queries solving”. Information on activities can also be found in the Environmental Management Office webpage: https://aua2020.wixsite.com/recycle

Other means of engagement include articles in the university’s electronic magazine and the development of an awareness video, titled, “The Green University: innovating in education and the environment", aiming to inform about the environmental profile of the university. https://www.youtube.com/watch?v=_ddly7VP7h8&t=6s (in Greek, subtitled in English).

Cooperation with labs (e.g. GIS lab in AUA) is also a choice to produce free and widely available to the community web based informative applications for PCs and mobiles like http://recyclemap.aua.gr/

2.6.5 Performance Metrics and Achievements:

Suitable monitoring could help a realistic evaluation of actions and systems implementation. Moreover, this could assist prioritization of targeting, which is important especially under circumstances of restricted resources.

Based on energy consumption data, mitigation actions are calculated to save at least 150 tones of CO_2 equivalents.

2.6.6 Challenges and Lessons Learned:

The past years were quite particular due to the special conditions created by the pandemic, resulting in the reversal of plans and the suspension of actions, especially in the field of awareness and information. However, there were other challenges that govern all functions at the university and are constantly presented.

Inclusion of environmentally friendly objectives should be included in the university's strategic plan and design in a sound and clear manner. All related actions should serve this strategy in a holistic approach to produce added value to the achievements.

Location and timely absorption of funding is crucial to avoid inadequate in volume and targeting financing.

Lack of coordination and cooperation can severely affect the effectiveness of actions. Broader partnerships are needed.

Community involvement is sometimes incomplete due to negative attitude towards changes.

Energy saving and efficiency is a part of the overall energy strategy the university could implement including provision for energy production (e.g. through the creation or participation in Energy Community).

2.6.7 Related Sustainable Development Goals:

The following SDGs are directly linked with the actions carried out by the university at its campuses:

SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 13: The urgent action to combat climate change and its impacts

2.6.8 Conclusion:

Reducing the Environmental Footprint of the University is a major objective in the University's strategy. Energy consumption is a crucial factor that significantly contributes to the environmental footprint. Building upgrade, replacement of consumptive elements and incorporation of renewable energy systems are applied in the university's operation and seem to provide valuable environmental benefits. Nevertheless, smart energy meters per building, strengthening of PV systems, implementation of proper monitoring in relation to a holistic approach design seem necessary as further steps towards energy saving and benefits maximization.

2.7 Sveuciliste u Zadru

2.7.1 Introduction:

According to the Sustainable Waste Management Law (Official Gazette of Croatia 94/19, in force since 1 January 2020), "waste producer" means any person whose activity generates waste [...], "waste collection" means the collection of waste, including the prior sorting of waste and the storage of waste for the purpose of transportation for processing; "waste prevention" means measures taken before a substance, material or product becomes waste that (a) reduce the amount of waste, including the reuse of the product or the extension of the life of the product, (b) reduce the harmful effects of waste on the environment and human health […]“

According to Article 11 of the Law, "the disposal of waste into the environment is prohibited. [...] Wastes whose valuable properties can be used shall be collected and stored separately in order to enable the management of these wastes. The Republic of Croatia promotes high quality recycling with measures to achieve the required quality standards in individual recycling sectors, and waste should be collected separately when appropriate and feasible, taking into account technical, environmental and economic conditions."

The vision of the Ministry of Environmental Protection and Energy of the Republic of Croatia is to promote Croatia as a promoter and advocate of sustainable development in the European Union. The University of Zadar, as a public higher education institution, considers sustainable development and the introduction of sustainable waste management as one of the forms of social responsibility.

According to the development strategy of the University of Zadar, several activities are planned for the establishment of the University ECO. These activities are manifested in the following goals:

- Establishment of a system for separate collection, recycling and reuse of waste in cooperation with Čistoća d.o.o.

- Raising awareness among employees and students about the importance of separate waste collection, protection and preservation of the environment

- Establishment of a bike-sharing system between remote components and locations of the university

- Introduction of a green library - refers to library programmes and services aimed at developing green literacy, i.e., increasing awareness and information about sustainable society and environmental protection, developing the ability to think critically about environmental issues, and acquiring knowledge and skills necessary to improve the quality of one's life as well as the life of the entire community.

2.7.2 Campus Profile:

Today, the University of Zadar is the largest fully integrated university in the Republic of Croatia with a total of 27 university departments, five scientific and research centers and two centers for teaching activities, the University Library, the Center for Student Standards, the Center for Student Counseling, the University Laboratory, the Business Center, the Agency for Student Standards and offices and services organized for the fulfillment of the corresponding financial, administrative and technical tasks.

The University of Zadar has a total of 659 employees, including 443 teaching and 216 non-teaching staff. The ratio between the number of employees in the University Library, administrative, technical and support staff and teaching staff is 1:2. The ratio between the number of teaching staff (scientific-teaching, artistic-teaching, teaching and associated staff) and the number of students is 1:12. The ratio between administrative, technical and support staff and students is 1:25. The departments, as components of an integrated higher education institution, each have an administrative staff member, i.e. a department secretariat.

As independent organizational units, the University of Zadar has established five scientific research centers for the organization and promotion of scientific research (Center for Adriatic Onomastics and Ethnolinguistics, Stjepan Matičević Center, Center for Karst and Coastal Research, Center for Interdisciplinary Marine and Maritime Research, and Center for Glagolitic Research) and two centers for teaching activities (Center for Physical Education and Student Sports and Center for Foreign Languages).

The University of Zadar uses a total of 21,800 m2 of green space at several locations in Zadar and in Lika-Senj County for conducting teaching and scientific research activities. Faculty members of the University of Zadar hold their lectures at a dozen locations in Zadar and Gospić. For teaching, the University of Zadar uses a total of 65 lecture halls equipped with basic and necessary equipment IT and six cabinets IT.

For conducting teaching and research activities, as well as student internships, the University of Zadar has established and equipped the University Laboratory and leased 16 hectares of agricultural land in the locality of Baštica. Production and experimental plantations for the study of applied ecology in agriculture were established on the territory of the locality Baštica.

The university library has a total area of 840 m2 in three locations.

2.7.3 Best Practice Description:

Environmental awareness and attitudes affect consumption and waste management, bringing environmental benefits through optimization of materials, reduction of energy consumption, reuse of natural resources, and conscious and responsible practises.

One of the plausible measures accepted by students, staff, and the community is the introduction of larger bins that can collect many different categories such as plastics, metals, glasses, and others.

By encouraging the use of community bins where the full range of recycling options are available, we aim to improve recycling. This will be an ongoing process over the life of the University Strategy, involving at least three buildings per year (sometimes as part of a project).

The most significant change, however, is the waste recycling initiative.

Previously, almost all general waste was sent to landfills, including empty plastic bottles, paper packaging, office waste, etc., which is no longer acceptable for a professional organisation. As part of the sustainability initiative, a recycling initiative was launched across campus, and now we sort our waste and recycle our paper and cardboard together. People were educated, and there was some resistance at first, but eventually everyone embraced the idea.

The goal is to reach 40% recycling in the dorms by 2025. This is a challenging goal because it requires the participation of about 2,500 students per year, about two-thirds of whom are new to campus. We need to find ways to improve communication and engagement

2.7.4 Student and Community Engagement:

Sustainable UNIZD becomes an important aspect of the social responsibility of the University of Zadar. The aims of these activities look to include the following actions, within the structure of the university:

- Promote social responsibility for all stakeholders at the University of Zadar
- Raise awareness of employees and students about the importance of separate waste collection, protection, and preservation of the environment
- Establish a system of separate waste collection, recycling, and reuse of waste in cooperation with Čistoća d.o.o. (in accordance with legal regulations on sustainable waste management)
- Implement socially responsible activities such as cleaning, reforestation, collection of certain types of waste
- Cooperation with ecological and humanitarian associations (collection of corks, food, clothing and other types of waste)
- Obtaining a ECO certificate (ECO school, ECO campus, Green University) or ISO
- Develop and strengthen the culture of quality and social responsibility.

2.7.5 Performance Metrics and Achievements:

The implementation of the measure was started just before the crisis COVID and the measurements that should lead to the evaluation of all impacts have not yet been carried out. In addition to the activities, changes were made to the lighting system that should lead to a reduction in energy consumption. Together with other measures, this should lead to a reduction in energy consumption, i.e., obtaining energy certificates at higher levels.

With the implementation of all planned activities, future measures should contribute to the improvement of environmental efficiency and lead to the development of a modern green campus.

Considering that most buildings are relatively old, there are many challenges to overcome to ensure energy efficiency. The best results will be seen when, after some time, an analysis of the energy efficiency of the new renovation of the technical school building or the new dormitory is carried out

2.7.6 Challenges and Lessons Learned:

The following plans have been introduced for the successful implementation of additional activities although they were all associated with challenges of their own:

- Introduce mandatory user education on energy-conscious behaviour (workshops on the harmfulness of waste and the time it takes different types of waste to decompose, as well as energy savings)

- Teachers: reducing paper use, submitting seminars and other documents electronically, using document review tools (tracking changes), printing documents on both sides or printing multiple pages on one sheet, etc., reducing energy use (turning off computers and lights, using the stairs instead of the elevator, etc.)

- Office space and services: Reducing paper and energy consumption (turning off computers and lights, using the stairs instead of the elevator, etc.)

- Student meals: Eliminate single-use plastic packaging at all campuses and facilities.

- Laboratories: Need for separate waste collection to save paper and energy

- Improve the university's internal mail system to reduce the use of envelopes and paper, digitise the mailing of various forms and documents within the University;

- Use of recycled paper for printing, reusable pens, etc. (Purchasing service - procurement of recycled materials (toilet paper, paper towels, printer paper, energy saving light bulbs, bio-detergent, etc.)

2.7.7 Future Sustainability Goals:

The university has set out the following goals in the hopes of becoming green and sustainable:

- Installation of containers for waste separation and establishment of green islands
- Promotional materials and marketing activities
- Keeping records of the amount of waste collected
- Implementation of socially responsible environmental protection activities
    - annual actions (cleaning of a specific area and reforestation).
    - this includes cleaning of the university's surroundings (park, waterfront, New Campus) and other public spaces
    - reforestation/planting of flowers/herbs
- Cooperation with ecological and humanitarian associations

- Advanced initiatives such as the use of solar panels, further installation of solar panels in locations other than the solar tree installed so far; installation of solar benches and solar panels to cover parking lots

All of which are directly linked to the following SDGs :

SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

SDG 6: Ensure availability and sustainable management of water and sanitation for all

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

SDG 12: Ensure sustainable consumption and production patterns

SDG 13: Take urgent action to combat climate change and its impacts

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss

2.7.8 Conclusion :

To execute all these goals and ambitions, a study of the different types of waste generated at the University of Zadar (depending on the activities) was planned and partially carried out. As expected, it turned out that the components, offices, services, and students produce the largest amount of waste in the form of paper (photocopies, handouts, office supplies) and plastic (plastic bottles, plastic packaging - foils, nylon, packaging, plastic caps), while the student restaurant has a different type of waste (paper packaging, plastic packaging, glass packaging, cooking oil, organic waste, etc.).

Therefore, the installation of an adequate number of garbage cans for separate waste collection ("paper garbage cans", plastic bins, glass bins (canteen), toner bins, battery bins, organic waste compost) and their locations will be systematically planned.

In order to strengthen the activities, it is necessary to adopt a policy of environmental awareness and social responsibility, as well as a set of regulations that prescribe waste separation (not in the form of a recommendation, but in the form of a standard) and provide sanctions for non-compliance. The regulation should state that in the 21st century it is no longer acceptable to talk about waste separation, but that it is necessary to introduce waste separation before disposal.

In order to implement all the planned activities, the procurement of containers for the separate collection of other types of waste has begun, with part of the activities taking place within the framework of individual projects that are currently being implemented and through which awareness of the need for waste separation will be further raised.

2.8 Klaipedos Universitetas

2.8.1 Introduction:

This report contains information on the implementation of innovative solutions for the use of renewable energy sources such as solar and geothermal energy, as well as the building management system of the one of the research institute (Marine Research Institute-MRI) situated in the Klaipeda University (KU) campus. These solutions were adopted and implemented on the basis of studying the specific conditions of the current situation in the campus of KU, located in the city of Klaipeda, Lithuania. The decisions made would be interesting in that they are implemented in the university campus, where historical buildings under the protection of historical heritage are situated, and at the same time, new educational corpora and buildings intended for scientific research are taking place. At present, the implemented energy efficiency and smart building management technologies of the university campus are being developed and constantly improved. Such infrastructure has been developed as part of local and regional initiatives/projects. KU follows its renewed strategy, where the commitments to sustainable development (sustainable development goals) takes pride of place. Therefore, the contribution of KU to the "Green Campus Best Practices" and campus development is one of the indicators of sustainability and an intention to create a complete green infrastructure based on international cooperation. The report also mentions other green initiatives that optimize the use of resources, restore the surrounding environment biodiversity, and thus positively affect the environmental consciousness of students, teachers and visitors.

2.8.2 Campus Profile:

KU campus is located in three areas of Klaipėda city and has organized educational activities in 10 buildings that covers a total area of 23.4 ha. In 2010, the detailed plan of the extent of the campus was approved. There are 6 historical buildings on the territory of the KU campus, the total area of which is 10,616 m2. These buildings were constructed in the beginning of the 20th century and are in need of a renovation. However, traditional renovation methods regarding walls and windows are not applicable due to the historical and cultural values of the buildings.

The Marine Research Institute (MRI) building was put into operation in 2018 where smart, real-time BMS were installed along with PV panels. BMS allowed for the monitoring and managing the temperature and humidity in all working and relaxation spaces as well as for the laboratories housed in the building. The consumption of water, heating and cooling energy, electricity and ventilation are also possible to control and regulated through the systems that are currently installed

Figure 25. The historical heritage buildings of KU Campus

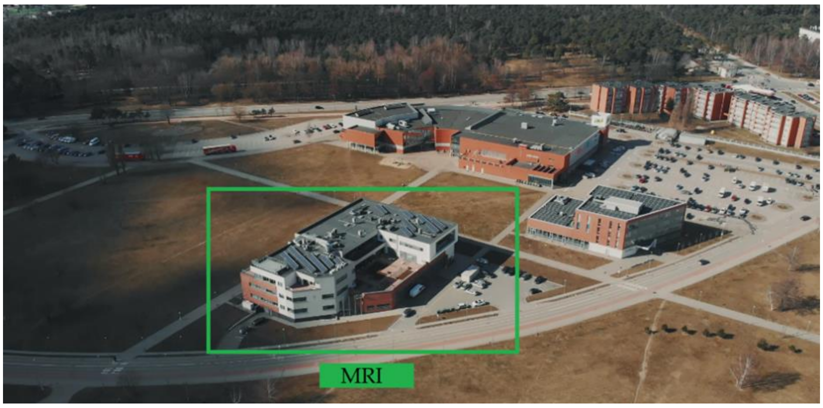


Figure 26. The modern part of the KU campus with Marine Research Institute (MRI)

2.8.3 Best Practice Description:

Renewable Energy Network and Smart Building Management System

1. Renewable Energy Network (Geothermal and solar energy application)

Considering the peculiarities of the KU campus' architectural composition and following the sustainability principles, a decision was taken to use suitable, renewable energy sources where appropriate. All historical buildings are being heated with geothermal energy. The geothermal boiler room prepares the heat carrier (ethylene glycol) up to a temperature of 50° C. When the outside temperature is lower than -15° C, the gas boiler automatically turns on, which allows for the temperature of the heat carrier to rise up to 65° C. Since the external temperature rarely falls below -15° C in Klaipėda, this rarely happens and the geothermal power plant is the main source of heating of campus's historical buildings. The principle scheme of the geothermal power plant is presented on the Figure 3.

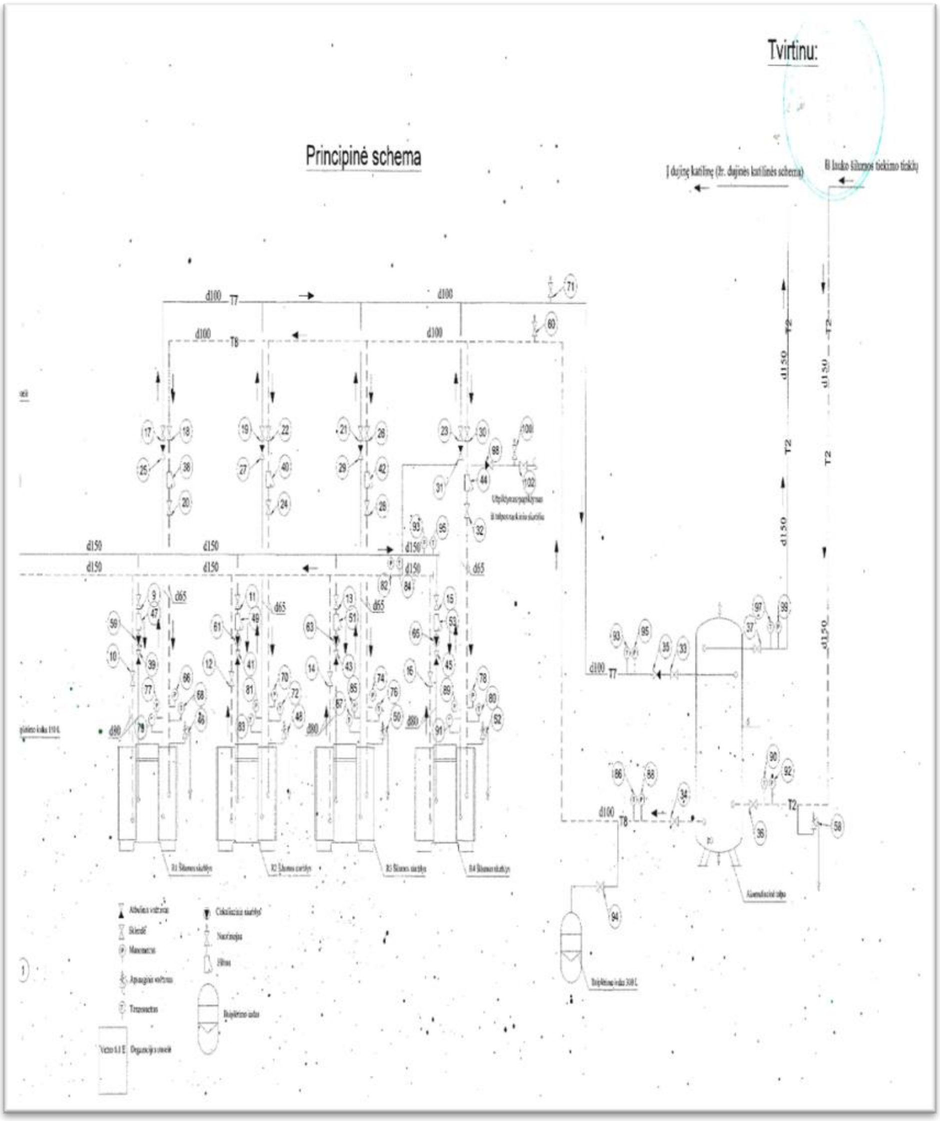


Figure 27. The fragment of a geothermal power plant's scheme

2. Smart Building Management System (BMS)

Building Management System were installed in 2018 at the MRI building – the only building to have this at the campus of KU.

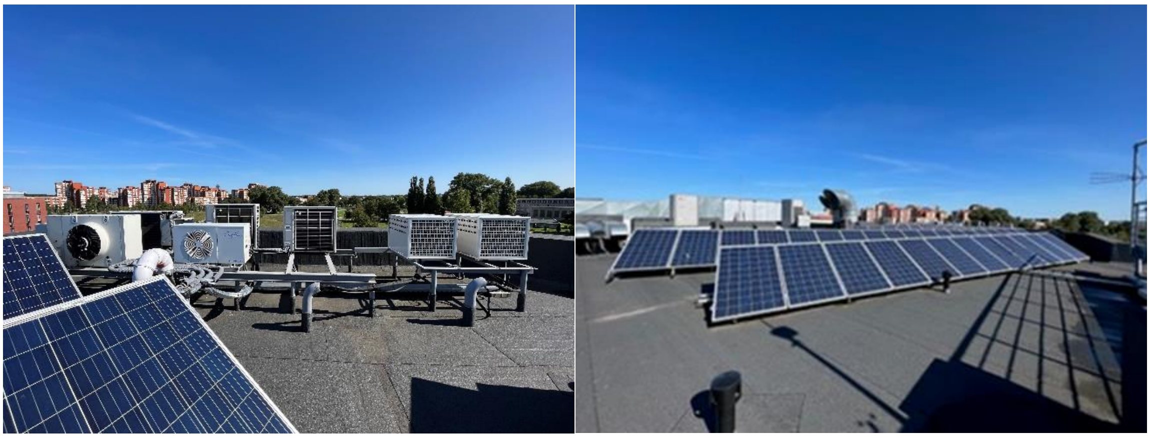


Figure 28. The roof of the MRI building with solar panels and BMS equipment

Table 7. MRI building parameters and the number of employees

Floor	Number of people	Surface area (m2)	Volume (m3)
Ground Floor	0	524	1572
First Floor	25	2245	13470
Second Floor	25	1704	6816
Third Floor	70	1450	5800
Total	120	5923	27659

The different floors of the building, are all heated via different methods. The ground floor is heated via a single recuperation unit, whereas the first floor is heated using thermoregulated natural convection radiators and three heat recovery units with central heating system heat exchangers. The second floor is heated using thermoregulated natural convection radiators, four heat recovery units with central heating system heat exchangers, and air-to-air split heat pump equipment during the seasonal change. The third floor is heated using thermoregulated natural convection radiators and six heat recovery units. All ventilation systems in the building are equipped with heat recovery units

2.8.4 Student and Community Engagement:

In accordance with the KU strategy, university teachers and staff support creativity and develop conditions for KU students to contribute to the smart and renewable energy development and management in the university campus. The students of KU are engaged in the research and education activities regarding energy efficient consumption and implementation of innovative decisions related to rational use of resources.

The most popular ways to introduce students to sustainable practices and promote behavioural changes whilst developing their environmental conscience are via presentations of innovation technologies through traditional teaching methods as well as hands on experience of working on projects made up of international scientists. Such an approach fosters students' innovative insight into environmental solutions and the use of their potential, not only for the university campus's sustainability but also for increasing their responsibility for actions affecting climate change.

2.8.5 Performance Metrics and Achievements:

1. Renewable Energy Network (Geothermal and solar energy application)

The KU campus boiler room consists of 4 boilers at 62.6 kW each, a total of 240 kW.

44 boreholes were drilled at a depth of 102 m where one borehole consists of a ring of 200 meters. Figure 5 represents the equipment (heating pumps) of the geothermal plant situated in the underground of the KU campus parking area.

Figure 29. The geothermal power plant's equipment (heating pumps)

As shown in Figure 6, there are also sealed equipment where GHG emissions are contained so as to reduce the amount of emissions and thus the impact to the climate and to the global warming effect.

Figure 30. The greenhouse gas containment equipment

A new auditorium building with two modern auditoriums with 240 seats and a 70-seat conference hall was built in cooperation with the private sector. In 2016, a new A-energy efficiency class dormitory with 170 beds was constructed in the KU campus. Currently, a new dormitory of A++ energy efficiency class for 240 individuals has been designed and a construction permit has been obtained, where on its roof an 80 kW solar power plant will be installed. The construction is yet to begin.

2. Smart Building Management System (BMS)

The MRI building is equipped with nine 35 kW air-to-air heat pumps and three 12 kW heat pump, It also has an additional 102 solar panels installed on the roof, with a total power of 28.05 kW (102 pieces x 275 W = 28.05 kW) . The building has its own AC/AC transformer (10 kV/0.4 kV) and cannot supply electricity to other users, as there are no other electricity users connected to the 0.4 kV network.

The building has obtained a B energy efficiency certificate, due to the multiple windows on the second and third floor. The national regulations regarding energy efficiency are more stringent compared to other EU countries. All windows in the building have three glass layers and two internal chambers. LED lighting is installed throughout the building, and automatic movement switches are present in the corridors. The BMS also allows the control and management of the recuperation/ventilation units and the split air-to-air heating conditioning system.

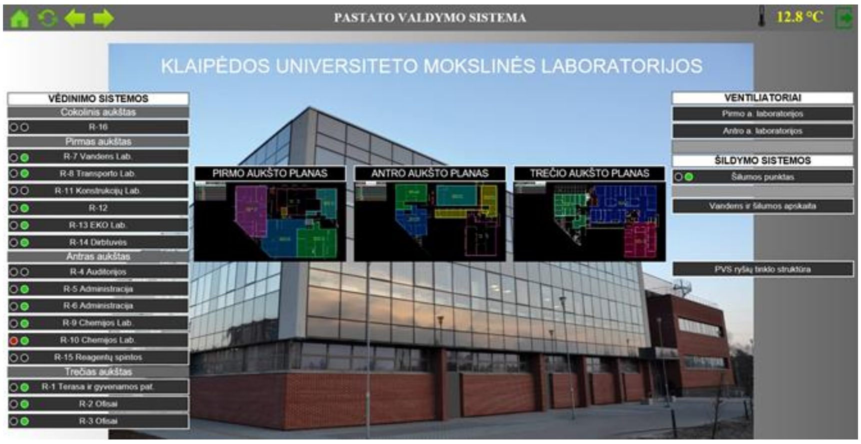


Figure 31. MRI building management system

Figure 32. The zoning plan of the ventilation-recuperation system of the third floor of MRI

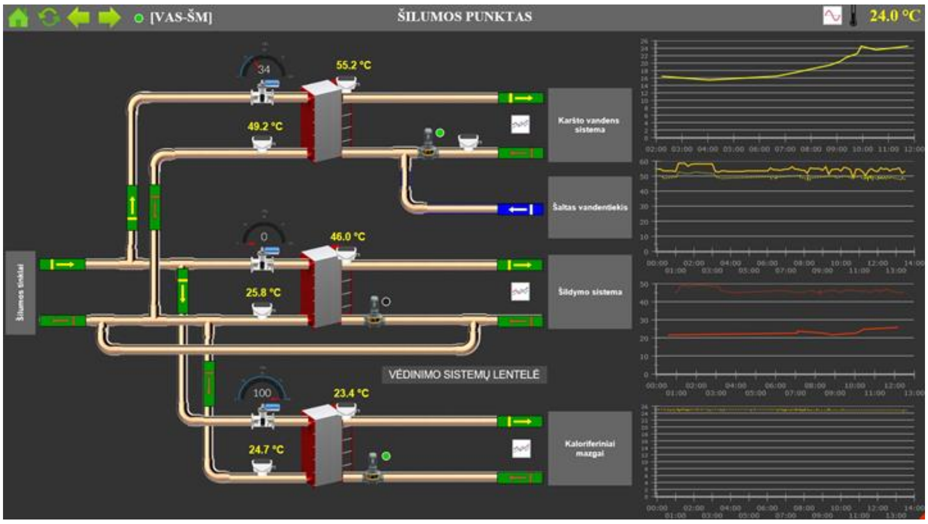


Figure 33. The heating system of the MRI building (hot and cold water consumption, heating system and calorifiers' unit)

VANDENS IR ŠILUMOS APSKAITA

Pirmas aukštas				
Vartotojai	Projekto Nr.	Apskaitos duomenys	Srautas	Darbo laikas
Vartotojai	ŠV.1-1	115.6 m³	0.0 m³/h	2427.0 d
Vartotojai	KV.1-1	115.6 m³	0.0 m³/h	2427.0 d
Vartotojai	ŠS.1-1	37088.6 kWh	n/d	3097.0 d
Vartotojai	ŠV.1-2	115.6 m³	0.0 m³/h	2427.0 d
Vartotojai	KV.1-2	0.0 m³	0.0 m³/h	2432.0 d
Vartotojai	ŠS.1-2	33300 kWh	n/d	3097.0 d
Vartotojai	ŠV.1-3	24.1 m³	0.0 m³/h	2429.0 d
Vartotojai	KV.1-3	31.6 m³	0.0 m³/h	2433.0 d
Vartotojai	ŠS.1-3	168940 kWh	n/d	3608.4 d
Vartotojai	ŠV.1-4	1.5 m³	0.0 m³/h	2428.0 d
Vartotojai	KV.1-4	1.2 m³	0.0 m³/h	2410.0 d
Vartotojai	ŠS.1-4	57675.1 kWh	n/d	3252.3 d
Vartotojai	ŠV.1-5	4.0 m³	0.0 m³/h	2435.0 d
Vartotojai	KV.1-5	2.4 m³	0.0 m³/h	2412.0 d
Vartotojai	ŠS.1-5	116352 kWh	n/d	3097.0 d
Vartotojai	ŠS.1-6	61858.3 kWh	n/d	3097.0 d
Vartotojai	ŠS.1-7	76498.2 kWh	n/d	3097.0 d

Antras aukštas				
Vartotojai	Projekto Nr.	Apskaitos duomenys	Srautas	Darbo laikas
Vartotojai	ŠV.2-1	35.3 m³	0.0 m³/h	2181.0 d
Vartotojai	KV.2-1	8.2 m³	0.0 m³/h	2179.0 d
Vartotojai	ŠS.2-1	42341.8 kWh	n/d	3608.3 d
Vartotojai	ŠS.2-2	62037.5 kWh	n/d	3608.4 d
Vartotojai	ŠS.2-3	102448 kWh	n/d	3608.4 d
Vartotojai	ŠS.2-4	56174.8 kWh	n/d	3608.4 d
Vartotojai	ŠS.2-5	57488.4 kWh	n/d	3252.4 d
Vartotojai	ŠS.2-6	63953 kWh	n/d	3608.3 d
Trečias aukštas				
Vartotojai	ŠS.3-1	33011 kWh	n/d	3608.4 d
Vartotojai	ŠS.3-2	67084.2 kWh	n/d	3608.4 d
Vartotojai	ŠS.3-3	69492.4 kWh	n/d	3608.4 d
Vartotojai	ŠS.3-4	66164.3 kWh	n/d	3608.5 d
Vartotojai	ŠS.3-5	62621.1 kWh	n/d	3608.5 d
Vartotojai	ŠS.3-6	91088.5 kWh	n/d	3608.3 d
Vartotojai	ŠS.3-7	57536.7 kWh	n/d	3608.2 d

Figure 34. Estimation of the water and heating energy consumption of each building room.

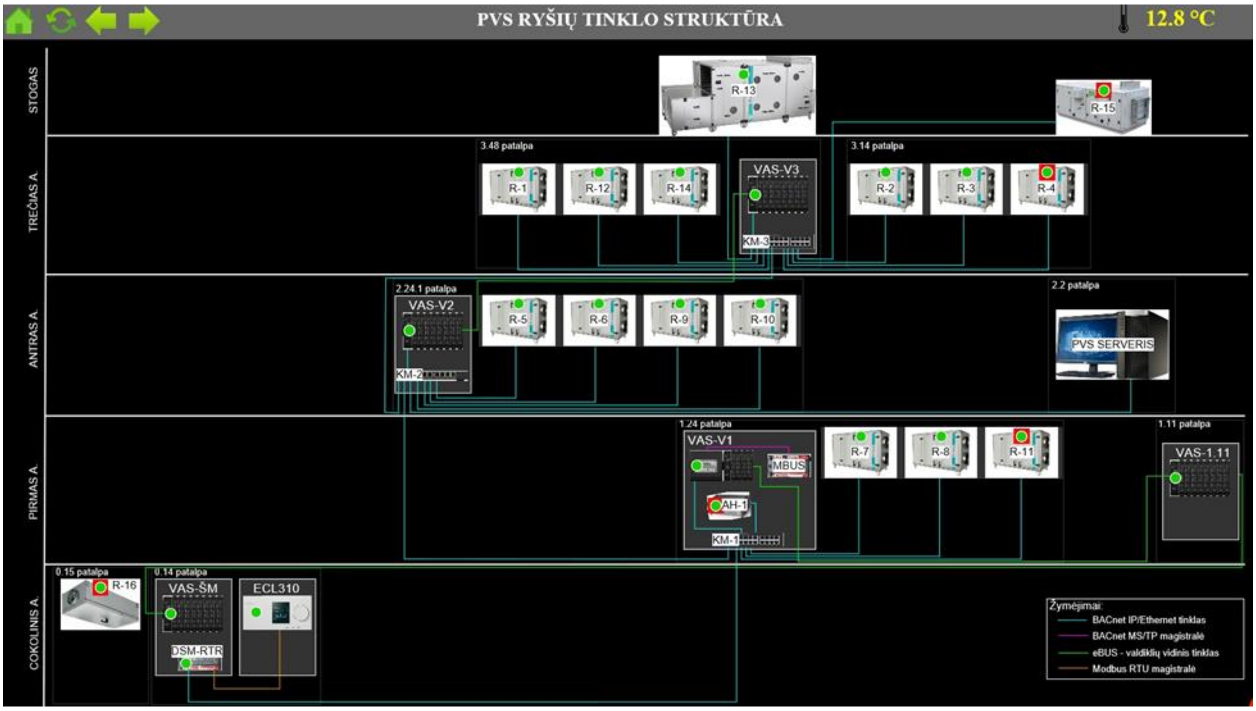


Figure 35. BMS Network connectivity structure

The use of smart building management systems provides the university with reliable data regarding heating, electricity and water consumption.

Table 8. Monthly indicators of the Marine Research Institute building

(January- December 2022)

January - December, 2022	Electricity	Heating	Water
	KWh	KWh	m^3
January	39 920,00	71 110,00	70,00
February	37 700,00	65 050,00	34,00
March	41 761,00	57 840,00	71,00
April	38 809,00	40 560,00	85,00
May	45 074,00	16 820,00	78,00
June	46 107,00	7 450,00	101,00
July	47 392,00	7 950,00	69,00
August	49 885,00	3 410,00	23,00
September	44 752,00	6 050,00	87,00
October	46 142,00	8 971,00	68,00
November	43 700,00	40 677,00	49,00
December	37 547,00	91 023,00	62,00
Total:	**518 789,00**	**416 911,00**	**797,00**

2.8.6 Challenges and Lessons Learned:

The installation of the geothermic power plant in the old part of the university campus and the real-time energy management system in the newer buildings, have been significant measures of the innovative solutions implemented regarding economic and environmental aspects of energy consumption. These decisions also had a social impact on the students’ education process, academic and industrial society in the Klaipeda city and its region. The environmentally friendly infrastructure of Klaipeda University helps students and faculty as well as other city organizations to understand the "Responsible Consumption and Production" goal of sustainable development and act towards reducing carbon emissions from buildings.

The KU community also recognizes that data obtained from the energy consumption and economic analysis could be improved. The smart sensor and meter reading system is not sufficiently leveraged to meet new perspectives for achieving energy savings. Better energy metering and analysis will provide valuable data on energy consumption from one perspective and working conditions from another. Therefore, the optimization measures between appropriate working conditions and the economy can help the academic community to make decisions regarding the purchasing and exploitation of specific infrastructure and equipment taking into consideration indicators of energy performance.

2.8.7 Related Sustainable Development Goals (SDGs):

The installation of the BMS in the MRI building as well as renewable energy sources exploitation for historical buildings as well as the MRI building at the campus of Klaipeda University are directly related to particular UN SDGs. The developed infrastructure supports the following SDGs implementation:

SDG4 – Quality Education

Environmentally friendly solutions regarding energy savings will provide theoretical and practical knowledge to students as well as encourage them to go deeper into technical aspects of energy consumption solutions and increase their opportunities to develop new ones.

SDG 7 - Affordable and Clean Energy

The implementation of the Building Management System and employment of the green energy sources, such as geothermal and solar power allows consumers to control and optimize the energy consumption in real time and contribute to the climate change reduction by application of the sustainable energy producing methods.

SDG 9 - Industry, Innovation, and Infrastructure

The described practice characterises an innovative approach to energy consumption management, to reduction of natural and fossil fuel resources usage and efficiency, encourage other KU departments to develop sustainable infrastructure at all parts of the university.

SDG 11 - Sustainable Cities and Communities

The positive experience of Klaipeda University will contribute to the city and region's well-being and state as a good practical example for other community's movement toward sustainability.

SDG 12 - Responsible Consumption and Production

The use of renewable energy sources and smart building management systems are important and reliable evidence of sustainable energy and its resources' consumption and responsible attitude to the environment and human beings.

SDG 13 - Climate Action

Rational and responsible energy consumption based on innovative technologies positively affects the quality of the biosphere due to a reduction of greenhouse gas emissions and a decrease in fossil fuel mining and consumption.

SDG 17 - Partnerships for the Goals

The Klaipeda University via participation in EU-funded projects has the opportunity for cross-border cooperation in order to achieve university commitment to reach sustainable development goals provided by the KU strategy

2.8.8 Conclusion:

The installation and operation of a geothermal power plant, a real-time building management system and solar panels for more efficient and rational use of resources and energy are reliable proof that Klaipeda University has implemented and is promoting sustainable solutions in the KU campus. It was also found that the potential of the installed infrastructure can be used more effectively through a more profound analysis of real-time meters. This report highlights the importance of implementing case studies as a first step towards achieving particular UN Sustainable Development Goals and reaffirms the university community's commitment to contribute to green/sustainable campus development.

2.9 South East Technological University

2.9.1 Introduction:

The Pathfinder programme is co-funded by the Department of Further and Higher Education, Research, Innovation and Science and the Department of the Environment, Climate and Communications under Project Ireland 2040, and administered through the Sustainable Energy Authority of Ireland (SEAI) and Higher Education Authority (HEA).

This is a key climate action measure which will support higher education institutions in making progress towards 2030 targets of a 50% improvement in energy efficiency and 51% reduction in greenhouse gas emissions. The Pathfinder programme will continue to test a range of building retrofit approaches to build evidence and capability in the sector, and to inform decisions as larger scale programmes are rolled out in the future.

SETU applied for Deep Fabric Retrofit of Business School and were successful in securing funding in 2021. After a detailed design stage and tendering the project commenced on site on 15th May 2023.

2.9.2 Campus Profile:

As of 1st May 2022, the South East Technological University (SETU) was established, making it the newest university in Ireland. SETU is a multi-regional university with campuses in Carlow, Waterford, Wexford and Wicklow with over 18,000 students and 2,000 staff across all campuses. The University is expected to have over 6,000 students graduate each year.

SETU operating at the south east region which is experiencing an exciting period of significant change through a rapid population increase of over 35% compared to the population of 1991. Its economy is diversifying in the light of shifting national, European and global environments, and a changing socio-cultural landscape marked by increased diversity, new patterns of population distribution and a changing demographic profile.

SETU will provide leadership and act as a centre of knowledge as well as a research and innovation centre in the region. Additionally, it will look into helping the region in capitalising on the broader economic drivers, both nationally and internationally. It will educate and nurture future generations of active and engaged citizens across the south east region and will be a driver of social inclusion, social justice and of technological, cultural and artistic activity in the coming decades.

2.9.3 Best Practice Description:

The Business School building was built in 1977 and has cavity wall construction. The building is home to School of Business undergraduate and post graduate courses. The building comprises of offices, lecture rooms, computer laboratories, The Growth Hub, and the ‘Student Life and Learning’ centre .

The Pathfinder Project included a deep fabric retrofit of the Business School.

The works included:

- Replacement of external windows and doors and associated air tightness details.

- New internal and external doors and screens.

- Replacement of existing ventilation ductwork and removal of standalone HVAC.

- Removal of the existing air handling units (AHU) and installation of 7 new AHU's, including new structural steel supports.

- Addition of external insulated render system,

- Replacement of luminaries and sensor controls.

Figure 36: Deep Fabric Retrofit of Business School with installation of new external render in progress

Photo 37: New AHU plant installed as part of the Deep Fabric Retrofit

Figure 38: During a previous project the Business School already had 160 PV panels installed

2.9.4 Student and Community Engagement:

This project involved extensive consultation with staff and students including presentations, meetings, emails and external engagement to inform the wider community and the public about the project. There are currently efforts being made to set up a web story to catalogue the project and inform the wider community.

Figure 39: Banner outside Cork Road Campus about decarbonisation of Campus

2.9.5 Performance Metrics and Achievements:

The aim of the project is to reduce the thermal energy consumption as much as possible, with a minimum requirement of 50% total emissions reduction and a heat demand of <55W/m2.   The Business School building should also achieve a Building Energy Rating (BER) of B.

An air tightness test will be completed in ordr to verify the carbon emissions reductions on 29th September 2023.

2.9.6 Challenges and Lessons Learned:

- Limited number of contractors with adequate experience and expertise to complete the project.

- Very tight timeframe to complete the works leading to resource challenges for contractor

- Project based on modelled data and parameters

- Disruption to staff and students although minimised during summer months as large numbers of staff work throughout the summer months.

2.9.7 Related Sustainable Development Goals (SDGs):

Deep Fabric Retrofit of the Business School contributed to the following SDGs:

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable.

SDG 13: Tak urgent action to combat climate change and its impacts

A drastic fossil fuel dependency reduction is an important part of the goals set out by SEDU in regards to the energy sources used for the heating of the buildings. The project will be used as an exemplar practice for the Irish Government. In addition, the Business School building previously had PV panels installed to carry the baseload. These measures will play a significant role in reducing SETU carbon emissions.

2.9.8 Conclusion:

This was a very exciting project to be involved in. It is an exemplar project for the Government of Ireland and the learnings can then be replicated in future publicly funded projects.

3. Conclusion:

Based off the green campus examples presented by the consortium members, a plethora of green and sustainable practices have been used throughout different university campuses to achieve the goal of reducing carbon emissions with the aim of one day becoming carbon neutral.

Different university campuses used different approaches in enforcing green practices. The different approaches focused on both different decision-making procedures as well as different thematic groups that the green procedures addressed. Both bottom up approaches as well as top down approaches were deemed acceptable and successful in introducing change; said changes were both focused on structural and infrastructural changes as well as behaviour driven changes. Through the analysis of the data that was provided by the consortium members, it was evident that a combination of both bottom-up and top-down approaches were beneficial at driving change throughout the campus.

As stated, change can be driven by both top-down as well as bottom-up approaches where the level of impact varies drastically as the level of influence of the two approaches is different in regards to decision-making processes at the university level.

As expected, top-down approaches have a better/stronger ability in making changes to university campus infrastructures and building mechanisms. This is considered a tough decision-making process, as the majority of these changes have a high initial cost that might take years to attenuate in order to see the true benefit of said changes, in monetary values. Apart from the initial high cost of these changes, issues arise through the protection of the buildings that host the universities. The majority of the university campus' buildings, at the universities participating in this study, are of cultural and architectural importance resulting in limitations in what changes can be made. Buildings that are of cultural and architectural importance must maintain their original character as well as their original features so as to keep the original aesthetic of the building. Subsequently, the changes that can be made are rather limiting, when addressing the structural aspect and the envelope of the building. Said buildings have also been constructed using different regulations and in combination with the age of the buildings, the structural integrity of buildings is not at the same standard of newer built buildings. Subsequently, when new installations of PVs as well as other mechanisms on the roof of the building, structural stress is increased which may cause further damage to the building. Thus, when changes to the envelope as well as when changes are made via the addition of more energy efficient equipment, the structural load must be taken into account as well.

All nine (9) green cases studies, in this study, have all included changes in regards to energy efficiency and renewable energy. As the EU strives for carbon neutrality by 2050, all industries are expected to reduce their GHG emissions, although some more polluting industries have more strict goals compared to others, such as universities. It is important to note the significant contributions that universities have in their surrounding communities. Universities have the ability to drive change by leading by example as well as invest money in research and development and promote eco-friendly and green practices that are attainable by most individuals. This results in bottom-up approaches and initiatives by local communities, based off the good examples and knowledge provide by the universities.

Bottom up approaches have proven to be successful in the universities themselves as student lead initiatives are ones that are thought to be most easily achievable by the general student body and staff members. This bridges the gap between the issues that arise when the decision-making personnel are not aware of the needs, concerns and abilities of the student body. Subsequently, when ideas arise from the students themselves, they are more likely to be embraced and implemented at a faster rate than if the decisions were taken without the consultation of students. Such initiatives are usually more successful in the long-run as well. This in turn, adds pressure to the director's team and the decision-making individuals when they see that students are actively making changes for a better and greener future. The students will demand to see true change being led by the governing bodies as they are the ones in the position to drive changes at a larger scale, where large sums of money are usually required for the changes to be made.

Three out of the nine universities participating in the study, have included measures in making changes towards green buildings and infrastructures as well as waste management whereas two of the nine universities have included initiatives such as sustainable transportation as well as biodiversity and green spaces. All campuses showed an enthusiasm in implementing green practices it is evident that the level of successful implementation varies between the universities.

Some universities have had extremely positive results from their initiatives and have followed through with further expansions in order to become greener than ever. These successful initiatives are exemplary in driving the change in campuses across the EU in order to achieve the goal of reduced carbon emission and subsequently becoming green campuses. The successful cases will act as fuel to the campuses yet to initiate changes as well as help drive the change at campuses at the initial stages that may be struggling.

Consistent monitoring of the work being implemented is crucial for the campuses to be truly green, this will also aid in a more universal definition of green campuses, based off their good practices. At large institutes, it is not enough to pledge to make change and not follow through with it or not be consistent with the monitoring of the changes being implemented. The green house gas emissions being emitted in the atmosphere are a reliable way to monitor the changes being implemented at each campus, but also within different departments of the university. University campuses are extremely dynamic as digital infrastructure may change based off the needs of both the academic staff – in terms of teaching – as well as the research facilities of the campus. Universities are at the foreground of research and innovation, thus new technologies are constantly being implemented in order to stay on top of all research. This being said, it should be noted that different departments have different needs in their energy use, raw material consumption and these factors can be rather constricting in terms of the amount of change that can be made in each department.

Therefore, universities have acknowledged the need to not only track their green house gas emissions as a whole (including all university buildings, infrastructure and different departments) but rather look at the green house gas emissions of each department that may be a high contributor to the green house gas emissions. Some universities have mentioned that this is a tactic that they are implementing within their campuses – measuring their green house gas emissions prior to making any changes, after the initial changes have been implemented and after that they will be measuring said emissions in order to ensure that they are stay at low levels.

All of these aspects will be taken into account in order to define what it means to be a green campus based off the good green and sustainable practices that are being implemented by partner universities. As the universities that are being investigated are situated in different climatic zones, have different infrastructure and different profiles they are capable of adding different insights that may be raised in different regions within the European Union. Thus, by taking into account all of the concerns raised by the different campuses as well as the good practices being implemented a green campus can be defined based off the real life practices and struggles faced.