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University of Genoa best practices in managing Energy and Climate Change

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Abstract. Since 2011, the University of Genoa (UniGe), Italy, focused on sustainable management of its campuses. In one of them, the Savona Campus, research and projects are specifically focused on Sustainable Energy and Smart City topics. Great efforts were made to reduce the carbon footprint by the creation of two large Research Infrastructures (a Smart Microgrid and an energy self-sufficient building) integrating different renewable energy sources and system automation. These infrastructures allowed to improve the energy performance of the Campus. Several actions have been then carried out also in the Genova Campus, including the implementation of a system for the real-time monitoring of the consumption of electricity for the most energy-intensive buildings. Results permitted to reduce energy consumption and provided significative and practical guidelines for energy saving. In 2015, the UniGe Commission on Environmental Sustainability was created and since then UniGe joined several international sustainability networks, such as ISCN (International Sustainable Campus Network) and UNICA GREEN (Network of Universities from the Capitals of Europe), sharing its best practices with other universities. UniGe is also active member of the Italian Universities' Network for Sustainable Development (RUS). In 2022 UniGe made a strong and explicit pledge against climate change, defining its Climate Neutrality Strategy 2022-2030. The strategy, starting from its latest UniGe greenhouse gases (GHG) inventory, outlines a path that the university must follow to reduce both direct and indirect emissions and defines the actions to do for the offsetting of residual emissions. This is the last step of the strong and continuous commitment towards the spreading of the sustainability culture in all the Campus activities.

1. Introduction

In 2015, the UN Member States adopted the 2030 Agenda for Sustainable Development, pursuing the commitment to tackle worldwide climate change by 2030 through the 17 Sustainable Development Goals (SDGs). These goals aim to strengthen public awareness to act against the planet degradation, guarantee economic growth and reduce social inequalities. In particular, the reduction of greenhouse gases (GHG) emissions into the atmosphere is a very urgent issue to be faced to reduce the global warming. Now more than ever, the energy transition towards sustainable systems is considered one of the main drivers to implement important climate actions [1, 2]. This awareness has been strengthened also by the European Green Deal, with the ambitious plan to achieve a Carbon Neutral EU by 2050 [3].

Universities can play an active role in facilitating this important process because of their "cross-sectoral" research, their international approach and their partnerships with public–private institutions [4]. In addition to education and research, the so-called "third mission" encourages academic staff to work toward the improvement of people's lives, contributing to the growth of a sustainable society and the development of economic systems. Universities can test at the campus level new facilities and methods through Living Labs and open-innovation environments used as pilot sites for urban applications [5].

UniGe, beyond offering high education and scientific consultancy services, plays the fundamental role of cultural hub between local reality and global society. UniGe recognizes, in its Charter, the Sustainability as one of the main pillars for its future evolution, in strict connection with the development lines of the surrounding territory (Northwest Italian district). The university joined several international sustainability networks, such as ISCN (International Sustainable Campus Network) and UNICA GREEN (Network of Universities from the Capitals of Europe) and participates every year to the UI Greenmetric ranking. Moreover, since 2015, the UniGe Commission on Environmental Sustainability manages all the activities related to sustainability, in strict connection with the university governance. Particularly, concerning energy management and policies against Climate Change, UniGe has a Campus specifically focused on Sustainability and Smart City topics, (the Savona Campus), a University Energy Saving Working Group, which study and implement energy saving measures at the Genova Campus, perform annual greenhouse gas (GHG) inventory and has recently defined its Climate Neutrality Strategy 2022-2030.

2. The Savona Campus Energy infrastructures

The Savona Campus of the University of Genoa is a compound of about 55,000 sqm, two kilometers from the Savona city center. Since the most relevant city features are represented, the area can be compared to a small city district. For this reason, UniGe decided to focus the research inside this Campus on Sustainability and Smart City topics [6]. In 2011, thanks to full public financing, the "Energia 2020" project was developed at the Savona Campus [7,8]. The project was conceived to install innovative energy systems aimed at reducing pollutant emissions and costs, creating at the same time a comfortable working environment for Campus users. The project consists of two main subprojects: the Smart Polygeneration Microgrid (SPM) and the Smart Energy Building (SEB).

2.1. The Smart Polygeneration Microgrid (SPM)

The SPM is a three-phase low-voltage "intelligent" distribution system, coupled with a thermal network composed by electrical/thermal loads and generation units [7]. The electrical energy is produced by two cogeneration microturbines and two photovoltaic fields. There are also storage systems, which are used to store surplus production coming from both the PV plants and the cogeneration units. The heating demand of the Campus is satisfied by the aforementioned microturbines and by two boilers, all fed by natural gas. To cover the cooling needs, most of the buildings are equipped with dedicated compression chillers, and only two buildings are cooled by two absorption chillers, thermally fed by the two microturbines. As far as electric mobility is concerned, there are three charging stations connected to the SPM: two are quick AC charging stations and one is vehicle-to-grid (V2G) type [9]. The grid is controlled and managed by a three-level system composed of smart meters and local automation devices,

a SCADA (Supervisory Control And Data Acquisition) system and an Energy Management System (EMS). The EMS is based on a model aimed to determine the daily optimal scheduling of cogeneration units, boilers and storage systems, with the goal of minimizing operating costs and emissions.

2.2. The Smart Energy Building (SEB)

The SEB is a zero-emission building connected to the SPM as a "prosumer", equipped with renewable power plants and characterized by high energy efficiency measures (high-performance thermal insulation materials and ventilated facades). The heating and cooling system is based on the exploitation of the geothermal source by a heat pump coupled with eight borehole heat exchangers [8]. The building is also equipped with an air source heat pump and two vacuum tube solar collectors for the production of domestic hot water, while an air-handling unit controls the air quality in each room of the building. As far as electrical production is concerned, a photovoltaic field is installed on the roof of the building, which can also exchange power with the SPM. The main electrical loads of the SEB are represented by LED lamps, office workstations, auxiliary systems of electrical/thermal power plants and fitness equipment in the gym located at the ground floor of the building. In the gym, there are also elliptical machines and bikes that convert human energy into electricity. A vehicle-to-building (V2B) station for electric vehicles is installed inside the building [9]. The SEB is managed by a Building Management System (BMS) that interacts with the EMS of the SPM; therefore, thermal/electrical generation units and loads of the building are monitored and managed in real time to reduce the whole energy expense and the carbon footprint of the Campus. Furthermore, different indoor comfort levels can be set by the BMS to control energy demand of the building.

2.3. Energy performance of Savona Campus

The Energia 2020 actions allowed to reduce the energy bill (electricity and thermal energy) of the Campus of about the 30%. Moreover, different companies, public entities and universities are developing Research and Development activities in collaboration with UniGe researchers with the goal of creating innovative hardware and software products for smart microgrids and smart buildings. The implementation and the study of the SPM and SEB infrastructures at the Savona Campus allowed to define several sustainability best practices to be reproduced at the city level designing residential, tertiary and industrial districts characterized by distributed generation units and efficient buildings.

3. UniGe Energy actions at Genova Campus

The Genoa Campus is spread in different areas of the city, both in the old town and in the harbour area and in the rest of the city. It is organized in several buildings spread in the urban settlement and characterized by a variety of buildings ranging from historical and protected ones (UNESCO Heritage) to modern buildings. Many facilities for research and education are present in all the sites (laboratories, classrooms, etc.) and all the main services for students are presents and distributed in different locations (libraries, canteens, student desks, study halls, guest houses, sports facilities, etc.).

UniGe has for years set up an internal University Energy Saving Working Group. The group is made up of structured personnel (Professors, Technicians and Researchers) and of unstructured personnel (PhD students and Research Assistants) to promote and carry out the necessary energy management activities of the Genova Campus.

UniGe is also part of the Italian Universities' Network for Sustainable Development (RUS). In particular, in the RUS Energy Working Group UniGe actively collaborates in sharing projects and good practices for the use of energy, in the preparation of documentation reference, such as the green paper "Sustainable energy Management" with the aim of promoting energy management in universities and in the study of energy needs of the structures university, the shares for their reduction e satisfaction with renewable energies, in compliance with the standard of comfort of the services provided.

UniGe receives electricity from 97 delivery points (POD), of which 20 in Medium Voltage (MV), located throughout the city. The main activities relating to energy management and energy efficiency operated at the Genova Campus include:

- installation of an energy consumption monitoring system
- implementation of a microgrid at the Department of Economics
- the use of incentives relating to thermal energy consumptions (Thermal Energy Account) and other projects relating to energy efficiency and events to raise awareness of the energy issue.

3.1. Energy Monitoring System

Since 2011, UniGe Genova Campus has been equipped with a real-time monitoring system for energy consumption. The consumption measurements of the medium voltage substations and of the main energy-intensive users of the various departments are acquired by the instrumentation and sent every 15 minutes to the central server. The system is provided through a web service that allows the visualization and analysis of the data through a pre-established reporting or allows the definition of customized views [10]. The system is also equipped with an invoice verification module. In 2012, the university's energy consumption was 22 GWh per year. The use of the monitoring system to identify inefficiencies and carry out interventions to improve energy performance, has made it possible to significantly reduce annual consumption, up to reaching 18 GWh per year in 2020, also considering the increase in the number of buildings related to the university. Using the monitoring system, it was possible to identify both technological interventions, such as the replacement of lighting or other energy-intensive users, and "zero cost" interventions, such as the modification of the operating times of certain users or the verification of their shutdown when not needed. The following figure shows an example of a graph of the monitoring system where it is possible to identify the moment in which the interventions to modify the operating hours were carried out and the consequent benefits in terms of reduction in consumption.

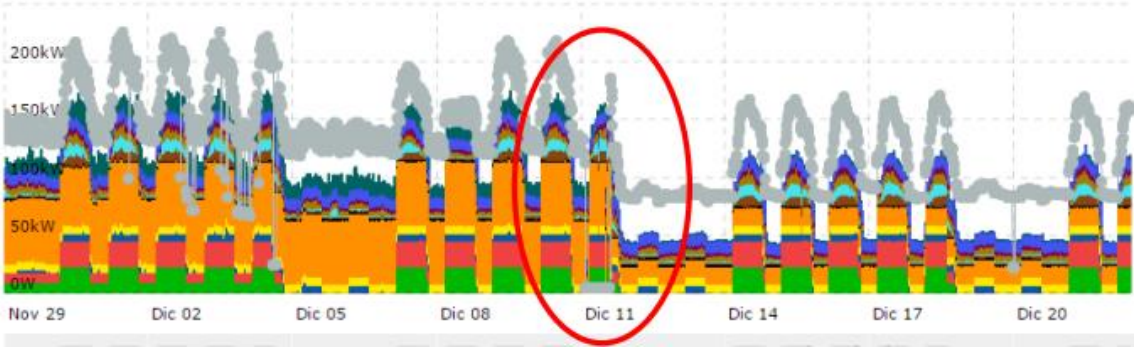

Figure 1. Monitoring system chart example

3.2. Microgrid of the Department of Economics

UniGe has realized a Low Voltage (LV) microgrid located in the School of Economics of the Genova Campus. The test facility is composed of: a set of 20 kWp PV panels installed on the building roof and connected to the ac busbar through two 10-kW inverters; a 10-kW–12-kWh ion-lithium storage system located at ground level, in the local medium voltage (MV)/low voltage (LV) substation, with auxiliary services loads; the monitored local load which collects the energy consumption of the building. The system has an advanced functionality that manages and controls a storage system coupled with renewables production. In particular, the implemented control strategy is based on a mixed-integer linear optimization algorithm [11]. The forecasting algorithm (based on Artificial Neural Networks) is also used in the Education Science Department (DISFOR) to control the air conditioning system [12].

A weather station, located on the roof, provides the meteorological measures necessary for the renewable generation forecast algorithm. All the mentioned devices are connected with a local Distribution Management System (DMS) through specific converters that allow MODBUS communication protocol via TCP/IP with a sampling rate of 0.1 s. The DMS is equipped with several advanced functionalities as the algorithm for generation forecast (AGF), which provides the expected production of the mentioned PV system, and an estimate of the battery State of Charge (SoC).

3.3. Incentives relating to thermal energy consumptions (Thermal Energy Account) and other projects

The incentive encourages interventions to increase energy efficiency and the production of thermal energy from renewable sources. The beneficiaries are Public Administrations, Companies and individuals who will be able to access funds for 900 million euros per year, of which 200 for the Public Administrations. The person responsible for managing the mechanism and providing incentives is the Energy Services Manager - GSE, the public company that promotes the development of renewable sources and energy efficiency in Italy. UniGe used the incentives to finance various energy efficiency interventions concerning the replacement of existing winter air conditioning systems with winter air conditioning systems using condensing heat generators in several buildings of the Genova Campus.

UniGe is also involved in various funded energy projects, such as the VIRTUS project (virtual management of distributed energy resources), which aims to carry out the prototype construction of a VPP (Virtual Power Plant) in an industrial or in a tertiary context. The demonstration phase will have a significant role and will be also performed using UniGe as a case test. A part of the demonstration phase will also make use of simulation tools to have clusters of customers / DERs of different types available and to broaden the demonstration context. The energy services will allow the end customer access to the energy market, improving energy efficiency locally and globally and the security of energy supply. The project intends to create a prototype VPP that also allows the integration of the conventional generation of electricity and heat with the network infrastructures and with the supply systems along the entire value chain: the organization of the energy portfolio , the use of forecasting systems, the management of customer relations (Customer Relationship Management-CRM), the adoption of geographic localization systems (Geographic Information System-GIS) and measurement and billing activities [13].

4. UniGe Climate Neutrality Strategy 2022-2030

Since 2013, UniGe has decided to proceed with the accounting of its greenhouse gas (GHG) emissions through the creation of the GHG inventory within the framework of the standard UNI ISO 14064 part 1. The calculation of GHG emissions is functional to the objective of evaluating its impact both through measures to reduce emissions and through the adoption of offsetting instruments for emissions that cannot be avoided. According to the ISO standard, the definition of organizational boundaries followed the control criterion, and therefore the classification of emissions reported considers only those under the direct control of the university as emissions of Scope 1 and Scope 2; emissions attributable to contracting entities are considered within Scope 3. UniGe has both owned offices and rented buildings, which following the control criterion have been included in the inventory.

Accordingly to the standard and the boundaries: Scope 1 includes direct GHG emissions and indirect energy emissions directly attributable to the activity of UniGe, i.e. emissions deriving from natural gas and diesel oil, leakage of refrigerant gases, and the vehicle fleet; Scope 2 includes the indirect GHG emissions from electricity consumption; and Scope 3 includes other indirect emissions, such as GHG emissions related to water supply and consumption, waste treatment processes and emissions generated by business trips and daily mobility of staffs and students. Such boundaries apply to all the years, except for 2013 and 2014 when Scope 3 was not assessed. Figure 2 shows the trend of UniGe GHG emissions from 2013 to 2019, divided in Scope 1, Scope 2 and Scope 3.

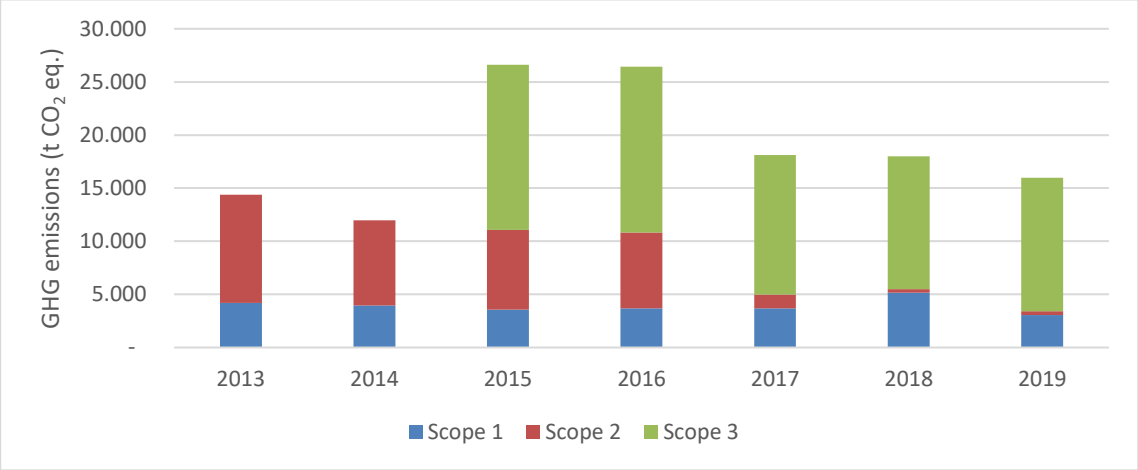

Figure 2. GHG emissions by UniGe in years 2013-2019

Energy saving actions implemented by UniGe in the past years allowed a reduction in electricity consumption that, coupled with the purchase of renewable energies through Guarantees of Origin (GOs), resulted in an above 95% reduction in Scope 2 emissions. Moreover, the UniGe Climate Neutrality Strategy 2022-2030 forecasts a further 30% reduction in electricity (Scope 2) and heat (Scope 1) consumption by 2024 with respect to 2019.

On the other side, as the main contributor to Scope 3 and to the overall GHG emissions is represented by daily mobility, the following actions will take place in the next years in order to reduce its impact:

1. Incentives for the use of public transport/sharing for UniGe students thanks to PRINCE project
2. Free/discounted public transport travelcards for UniGe Students
3. Creation of University cycle paths on Ministerial Fund and installation of UniGe bike racks
4. Green Deal Mobility Scheme, agreement between Ulysseus partner universities, provided for incentives for the mobility of Erasmus students
5. Car sharing facilities for UniGe students.

The overall impact of such measures is reported in Table 1, showing the target of a 20% emission reduction in 2024 with respect to 2019. It must be noted that Scope 2 does not decrease as a worst-case scenario is considered for the renewable energy mix offered by GOs.

Table 1. Expected GHG emission reduction by UniGe in years 2022-2024

	GHG emissions [t CO_2 eq]			
	2019	**2022**	**2023**	**2024**
Scope 1	3,060	2,756	2,452	2,149
Scope 2	354	1,560	1,420	1,279
Scope 3	12,572	10,845	10,603	9,384
Total	15,985	15,161	14,475	12,811

5. Conclusions

In the past years UniGe has declared and demonstrated with facts its strong commitment towards the increase in sustainability culture in its community and networking represents a key part of its plan. Participating in several national and international networks - and the application to GM - are helping UniGe to find the right pathway.

A continuous effort has been devoted to include sustainability in education and research activities. Moreover, considering UniGe campuses as living labs allowed to increase the awareness of academic

community and external stakeholders on sustainability topics. Recently, UniGe has defined its Climate Neutrality Strategy 2022-2030 confirming its commitment toward climate neutrality within 2030.

Concerning energy, UniGe, aware of the need to optimize energy consumption and pollutant emissions, gives serious attention to energy performances of its buildings. For this reason, various measures have been taken over the years to optimize consumption and various efficiency measures have been carried out, both technological and behavioral: a smart grid and a smart building were created in a campus allowing to produce and consume energy from renewable sources and a real time monitoring system has been installed and made available to users through a web service. Furthermore, the synergy with the world of research and participation in various projects allowed to develop intelligent algorithms for the energy consumption optimization and for the integration between energy production through renewable sources and storage systems. All these measures, together with the use of national incentives for the efficiency of technological systems, led to a significant reduction in energy consumption and GHG emissions, while increasing the quality of life of university staff and students.

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