INTEGRATION OF RENEWABLE ENERGY TECHNOLOGIES IN THE COMMUNITY OF THE AGRICULTURAL UNIVERSITY OF ATHENS

Christos Spyridon Karavas[a] and George Papadakis[a]*

[a]Agricultural University of Athens, Department of Natural Resources and Agricultural Engineering,
75 Iera Odos Street, Athens 11855, Greece,
*email: gpap@aua.gr

ABSTRACT: European Energy Union pursues for increased secure, sustainable, competitive, affordable and decarbonized energy. Increasing the share of renewable energy (RE) is an effective way to make energy supply more environmental friendly and energy sources more diverse. In this context, Iceland, Liechtenstein and Norway support energy efficiency programs in Greece. The programs aim to increase the share of RE and to meet EU targets on climate and energy. One of the ten projects which has been selected for funding is the project of the Agricultural University of Athens (AUA). The objective of this project is to demonstrate the application of RE at emblematic locations inside the AUA Campus. More specifically, four activities have been implemented; (a) An autonomous PV microgrid has been installed for the external lighting and also supply various electrical loads of AUA library, (b) Installation of efficient lighting systems in AUA's sports facilities powered by an autonomous PV microgrid, (c) A biomass boiler have be installed in AUA library in order to support the existing heating system and (d) an autonomous solar-driven charging station have be installed for supporting one electric mini-bus and ten electric bicycles. The project is expected to increase of RE consumption and to strengthen awareness and education in RE based solutions and to decrease the carbon footprint of AUA.
Keywords: Stand-alone PV Systems, Hybrid, Autonomous Microgrid

1 INTRODUCTION

The program of European Economic Area Financial Mechanism 2009-2014, (EEA grants of Iceland, Liechtenstein and Norway), provided funding to 16 EU countries in Central and Southern Europe. The Greek "GR03 – Renewable Energy" programme had a budget of €9,510,000. This program is co-funded by the Public Investment Program of Greece. The objective of this program is to increase the share of RE in energy production and to reduce the CO_2 emissions. The program also aims at mitigating social and economic disparities and strengthen bilateral cooperation between the donor countries and Greece. The ultimate target is the promotion and the effective implementation of a development framework which will create opportunities and prospects to the local economy and will familiarize the residents with sustainable energy technologies and improve the quality of their life. In particular, ten projects were selected for funding by this program in Greece. One of them, is the AUA's project.

The Agricultural University of Athens (AUA) has a long experience in developing and implementing Renewable Energy Systems (RES), as it has been active in research in the field of renewable energy and energy efficiency for the last 30 years [1-6]. Generally, Universities are recognized as ideal cases for demonstration and implementation of innovative interventions for RES internationally [7-12]. Therefore, AUA was selected as an appropriate site for RES installations due to its campus characteristics (25 ha of open space and 28 buildings at the centre of Athens), high visibility (over 5000 students and 500 staff members) and high research and educational impact.

The implementation of RES contributes to the University's carbon footprint mitigation in combination with lower energy consumption. On the other hand, the existence of such facilities will sensitize young researchers to be engaged with RE, academically and professionally, and increase research output of the university.

This project consists of four subprojects. Each subproject includes activities that have been implemented on the library building and the sport facilities of AUA. The library has been selected because it is the most visited building of AUA. Students from AUA and other universities of Athens visit its facilities for every day homework and studying. In addition, scientific events, conferences, seminars etc. are conducted very often. The sport facilities constitute a meeting point for students, employees, visitors etc. The four subprojects include the following installations:

(a) An autonomous PV microgrid for the external lighting and various electrical loads of AUA library.
(b) Lighting systems in AUA's sports facilities powered by an autonomous PV microgrid.
(c) A biomass boiler in AUA library.
(d) An autonomous solar-driven electric vehicle charging station and the purchase of one electric mini-bus and ten electric bicycles.

2 AUTONOMOUS MICROGRID

The library of AUA is a functional integral building while constitutes the heart of the University (Fig. 1).


Figure 1: AUA Library building

The objective of this subproject was to cover the lighting and various electrical loads of AUA library. An autonomous PV microgrid has been installed in order to secure the power supply. The microgrid includes energy resources and storage units. A PV array, rated at 100 kWp, has been installed on the library’s roof (see Fig. 1) and a typical deep discharge solar OPzV battery bank (600 kWh at least) will secure the autonomy of the system for three days as a minimum. The autonomous mode of the microgrid requires the regulation of the voltage and frequency and the maintenance of a power balance in order to secure a stable operation. The microgrid is able to operate in connection with the main grid and use it as backup. The inverters and the batteries of the system are shown in Figure 3.

Figure 2: The PV installation in the library’s roof

Figure 3: The inverters and the batteries of the autonomous microgrid of the AUA library

3 BIOMASS BOILER

This subproject aimed to assist the coverage of the library’s thermal needs and demonstrate a sustainable technology of thermal power production. A pellets’ boiler of nominal power of 30 kW has been installed and connected with the existing heating system of AUA library. The boiler features an automatic ignition and pellet delivery, with a robust burner. It works at high efficiency, up to 90%, and meets the European emissions standards. The biomass boiler is shown in Fig .4.

Figure 4: The biomass boiler

4 INTERCONNECTED AUTONOMOUS MICROGRID

The AUA provides sports facilities where both students and AUA’s staff can exercise and participate in various sports activities. Among others, AUA offers four open field sport courts; (a) one basketball court, (b) one volleyball court and (c) two tennis courts.

The objective of this subproject was to cover the lighting needs of the above mentioned four sport courts with the use of sustainable energy technologies (Fig. 5). The lighting has been based on LED technology and the required energy is producing by photovoltaics. As it is presented in Figure 6, twelve LED floodlight towers have be installed in the courts. The power supply is handled by an autonomous AC microgrid. The microgrid consists of (a) a photovoltaic (PV) array of typical polycrystalline silicon panels, rated at 5 kWp, (b) a Sunny Island inverter for grid forming, (c) a Sunny inverter for the PV array, and (d) a typical deep discharge solar OPzV battery bank. The battery bank consists of 48 batteries. Each battery has a nominal voltage of 2 V and the DC bus has been set at 48 V. For this reason, 2 battery arrays were connected in parallel where each array includes 24 batteries in series. The PV array has been installed on a specially designed shelter (Fig. 7) that acts as well as a rest area for the athletes. Furthermore, this microgrid have be interconnected with the library’s microgrid, in order to minimize the number of load shedding in the microgrid, providing an extra generation capacity (Fig. 8).

Figure 5: Lighting of the AUA’s sport courts

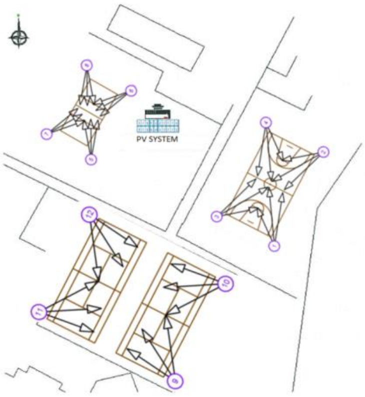

Figure 6: Installation scheme of the twelve floodlight towers

Figure 7: The PV shelter

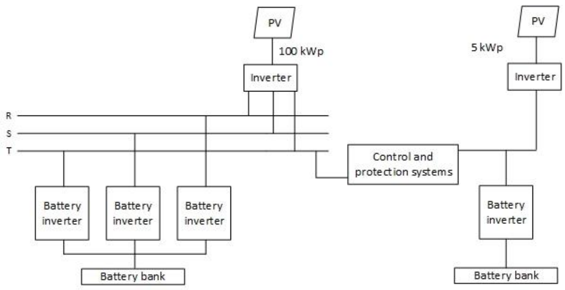

Figure 8: The interconnection of the two PV microgrids of 100 kWp and 5 kW.

5 ELECTRICAL VEHICLE CHARGING STATION

While the electric vehicles such as trains, trolleys and trams, are a safe and traditional mode of public transport in Greece, the penetration of the electric vehicles in the Greek market is very slow. AUA supports green projects on motion and the development of infrastructures in order to help students and staff to become familiar with electric vehicles.

This subproject refers to the study, the installation and the operation of an Autonomous Electric Vehicle Charging Station (EVCS). The EVCS aimed to cover the electrical needs of 10 electric bicycles and one electric vehicle (bus type) (Fig 9). Table I and Table II present the technical characteristics of the electric bicycles and electric vehicle, respectively.

Figure 9: The electrical bicycles and the electric vehicle

Table I: Technical characteristics of the electric bicycles

Type	
Battery Chemistry	Lithium-ion
Charge Time	6 hours (max)
Estimated Min Range	50 km
Top Speed	25 km/h

An autonomous microgrid power system based on SMA Sunny Island topology, was chosen for the power supply of the EVCS. The microgrid consists of: (a) a PV array of typical polycrystalline silicon panels, rated at 5 kWp, (b) three Sunny Island inverters for grid forming, (c) a Sunny inverter for the PV array, and (d) a typical deep discharge solar OPzV battery bank. The battery bank consists of 24 batteries, 2V each will be connected in series and the DC bus was set at 48 V. Furthermore, a photovoltaic parking shelter have been constructed (Fig. 10), for the parking of the electric vehicles.

Table II: Technical characteristics of the electric vehicle

Type	
Number of seats	16 plus driver
Motor Power	7.5 kW / AC
Motor Voltage	72 V / AC
Battery Chemistry	AGM
Number of Batteries	18 pieces at 8 V
Battery Capacity	160 Ah
Maximum Range	up to 120 km
Top Speed	45 km/h

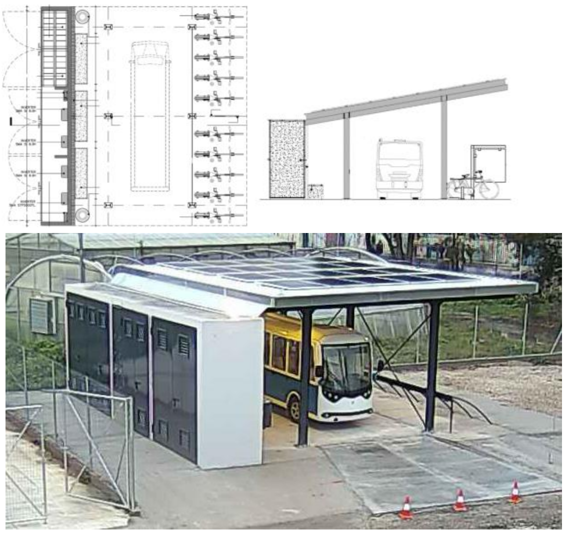

Figure 10: The photovoltaic parking shelter

6 DATA LOGGING SYSTEMS

Data recording systems have been installed, through which the production electricity data and any errors of the systems are recorded. Except of the safe operation of the systems, these data will be used for the implementation of future theses and systems' performance evaluation. Furthermore, three displays have been installed at each RES location in order to show the electric power, the produced energy and the avoided quantity of CO_2 emissions, on a daily basis.

7 CONCLUSIONS

The green character of the proposed activities in the community of AUA and the significant anticipated promotion of this project can act as an ideal developed environment in green utility. The transformation of the AUA community to "Green and Sustainable" will improve the quality of life at the campus. More in particular, the living conditions will be improved as the interventions in places where people work, will enhance the thermal comfort and upgrade the environmental sustainability performance of the university. The installation of PV systems will reduce the operation costs since 176 MWh/year will be produced and the biomass boiler will offer 14 MWh/year thermal produced energy. It is estimated that the exploitation of RES will reduce the AUA's carbon footprint at 1758 tnCO_2 per year. The electric vehicles will facilitate the access of students, staff and quests from the nearest metro station to AUA, with zero CO_2 emissions as the electric vehicles will be charged by solar energy. Finally, through the project activities, links between AUA and EU partners will be strengthened.

8 ACNOWLEDGMENT

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