Energy Supply of a Conference Center Towards Nearly Zero-Energy Building in Accordance with the Standards of the European Green Deal

SOUKOULI A.[1], KALOGERAKIS A.[2,3], ANGELIS-DIMAKIS A.[4], and ARAMPATZIS G.[1*]

[1]School of Production Engineering and Management, Technical University of Crete, Chania, Greece
[2]Institute of Theology and Ecology, Department of the Orthodox Academy of Crete, 73006 Kolympari, Greece
[3]Department of Science Natural Resources and Outdoor Studies, University of Cumbria, Cumbria LA22 9BB, UK
[4]School of Applied Sciences, University of Huddersfield, Queensgate, HD1 3DH, Huddersfield, UK
[5]School of Production Engineering and Management, Technical University of Crete, Chania, Greece

*corresponding author:
e-mail: garampatzis@pem.tuc.gr

Abstract. In December 2019, the European Commission proposed the European Green Deal, a set of policy initiatives that aim to transform the European Union into a low carbon economy and achieve climate neutrality by 2050. Building renovation is a core element of the European Green Deal, promoting the decarbonization of heating and cooling and enforcing stricter building performance standards. The purpose of this paper is to implement principles of the Renovation Wave in an international conference and research center: "The Orthodox Academy of Crete". More specifically, the paper focuses on how to cover annual energy demands of the conference center and examines the installation of PV panels, wind turbines and hybrid solar wind system. All the alternatives cover the energy demands of the building. The most economic feasible alternative in each scenario is chosen based on financial criteria of Net Present Value and Internal Rate of Return. According to the results, the installation of PV solar system is the most economic feasible solution that covers completely the energy demands of the conference center.

Keywords: European Green Deal, Renovation Wave, Energy Supply, Renewable Energy Sources, Conference Center, Orthodox Academy of Crete.

1. Introduction

Climate change is considered one of the greatest threats modern humans have to face worldwide. Human activities, such as fossil fuel extraction, unsustainable agricultural activities and natural environment degradation, emit huge amount of greenhouse gases to the atmosphere. European Union aims to meet the climate challenge by transforming the EU's economy to a clean and circular economy.

European Green Deal [1] is a set of policy initiatives, which promotes a sustainable transformation of all the sectors of the economy, including buildings, food production, transportation, industries etc. Regarding building sector, the EU presented the "Renovation Wave, a strategy that aims to boost building energy renovation rates, promote the use of renewable energy sources in buildings and enforce stricter building performance standards.

Within this context, this paper will examine energy supply scenarios using renewable energy sources for the conference and research center of the Orthodox Academy of Crete which is located in Kolympari, Greece [2].

2. Renovation Wave Strategy

The "Renovation Wave" strategy aims to boost the renovation rates of commercial and household buildings. Energy refurnished building stock can contribute significantly to a decarbonized and clean EU energy system. With 75% of the Europe's building stock being energy insufficient, the "Renovation Wave" targets to increase annual renovation rates to 2% and reduce the greenhouse gas emissions produced from the building sector up to 55% until 2030. Fundamental principles of the Renovation Wave strategy are the following [3]:

- Energy efficiency is set as priority.
- Decarbonization of the building sector and gradual integration of renewable energy sources [4].
- Implementation of circular economy principles to reduce buildings carbon footprint and promote green infrastructure and use of organic materials from sustainable sources.
- Energy efficient and sustainable buildings have to be affordable to everyone, especially to low or middle income households.
- Strict health and environmental standards, including improved air quality, water management etc.

3. Method

In this paper, the energy refurbishment scenarios that will be examined refer to the installation of PV panels (Scenario 1), wind turbines (Scenario 2) and hybrid solar-wind systems (Scenario 3). Each scenario consists of different alternatives that cover the annual energy demands of the conference center. For each scenario the most economic feasible alternative is chosen based on the criteria of Net Present Value and Internal Rate of Return [5]. If the Net Present Value is positive then the investment is approved. Otherwise, the investment is rejected. On the other hand, regarding the Internal Rate of Return, if the IRR is higher than the discount rate then the investment is approved. In case that the criteria give different results for the same investment, then only the criteria of the NPV has to be used to determine the most profitable investment.

Regarding the calculation of the annual production of the above scenarios, two software were used for design and simulation purposes; PVsyst and Homer Pro. PVsyst designs the PV system and calculates the annual production according to the orientation and the solar radiation of the region. Homer Pro designs, simulates and optimizes energy systems (including wind turbines, PV panels, fuel cells, biomass) and in this case it is used for the wind turbines and the hybrid solar wind system.

4. Results

The first scenario refers to the installation of photovoltaic panels, to cover the annual energy demands of the conference center. In this scenario, 4 alternative PV panels will be examined [6]. The first alternative considers the installation of 135kW photovoltaic tiles [7], which are one of the latest technologies in the field of the photovoltaic systems. The second alternative refers to the installation of PV panels of 125kW nominal power, on the roof of the building. The color of PV panels is the same as the color of the tiled roof. This alternative was chosen to avoid aesthetic disruption of the roof and ensure that the PV panels are in harmony with the building. The third option is the installation of a solar-PV system with 118kW nominal power, similar to the existing installation in the conference center. Lastly, the fourth alternative is the installation of 118kW PV solar system, which according to the manufacturer has constant efficiency throughout its life-time. The other alternatives are assumed to have linear reduction in their efficiency every year. The efficiency for the first alternative is reduced 0.8% per year and for the other two 0.6% respectively.

The second scenario examines the installation of wind turbines. This scenario consists of two parts. Due to the current legislation the upper nominal power limit of wind turbine installation is 5kW in the island of Crete. So, in the first part the installation of a 5kW vertical wind turbine is examined [8]. After 2023, it is expected that the upper nominal power limit will rise to 60kW for Crete due to the underwater power supply interconnection between Crete and the mainland of Greece. In the second part, future additions are examined including the installation of wind turbines with 30kW and 60kW nominal power.

The third scenario has two alternatives based on the current and future Greek legislation and studies the installation of a hybrid solar-wind system. The first alternative is the installation of 5kW wind turbine and solar PV system with 113kW nominal power, based on current legislation. The second alternative suggests the installation of 30kW wind turbine and 57kW of solar PV system, based on expected future changes in the legislation.

After calculating the annual production of each alternative, the criteria of Net Present Value (NPV) and Internal Rate of Return (IRR) are used to determine the most economically feasible solution for each scenario (Tables 1-3).

Table 1. Energy and financial results for Scenario 1

Scenario 1	Annual Production	NPV (i=6%)	IRR	Payback Period
PV 136 kW	181.111kwh	13.39 €	7%	12 yr
PV 127 kW	181.147kwh	10.064€	6%	11 yr
PV 118 kW	182.341kwh	123.322€	17%	6 yr
PV 118 kW	183.712kwh	127.959€	16%	7 yr

Table 2. Energy and financial results for Scenario 2

Scenario 2	Annual Production	NPV	IRR	Payback Period
WT 5kW	12.714 kWh	-1.203€	5%	14 yr
WT 30kW	92.849 kWh	54.135 €	14%	7 yr
WT 60kW	153.876 kWh	51.827 €	10%	10 yr
WT 30kW + 30kW	185.698 kWh	108.271€	14%	7 yr

Table 3. Energy and financial results for Scenario 3

Scenario 3	Annual Production	NPV	IRR	Payback Period
PV 113kW + WT 5kW	182.664kwh	115.928€	14%	7 yr
PV 57 kW + WT 30kW	183.743kwh	113.239 €	15%	7 yr

The most economically feasible solution for the 1st scenario is the fourth alternative, due to the highest NPV value. Generally, in mutually exclusive projects, in case

the criteria of NPV and IRR give different results, the acceptable alternative is the one with the highest NPV. So, although the third alternative has the highest IRR and the shortest payback period it is not the most economically feasible alternative. In the second scenario, the alternative with the highest NPV and IRR value is fourth option with the installation of two wind turbines of nominal capacity of 30kW. However, this option cannot be applied with the existing legislation. Lastly, in the case of the hybrid solar-wind system, the first alternative that refers to the current legislation is the most economically feasible solution.

According to the existing legislation, only the 1st and the 3rd scenario can be compared with each other. In the 2nd scenario, the most profitable investment can be applied only after the electrical interconnection between Crete and the mainland of Greece. So, in case the conference center proceeds with the energy refurbishment during the existing legislation, the most profitable scenario is the installation of 118kW PV system, because it has higher NPV and IRR values. Comparing all the scenarios, the installation of PV panels to cover the energy demands of the conference center is still the most profitable and feasible solution.

Table 4. Results comparison according to existing legislation

Scenario	Annual Production	NPV	IRR	Payback Period
Scenario 1	183.712kWh	127.959€	16%	7 yr
Scenario 3	182.644kWh	115.928€	14%	7 yr

Table 4. Results comparison according to future legislation

Scenario	Annual Production	NPV	IRR	Payback Period
Scenario 1	183.712kWh	127.959€	16%	7 yr
Scenario 2	185.698kWh	108.271€	14%	7 yr
Scenario 3	182.644kWh	115.928€	14%	7 yr

5. Conclusion

The scope of this paper was to examine energy alternative energy supply solutions for a conference center, using renewable energy sources. Three scenarios were examined including the installation of photovoltaic panels, wind turbines and hybrid solar-wind systems. Among the three examined scenarios, the installation of photovoltaic panels proved to be the most feasible solution since their annual efficiency remains constant and have the highest NPV value with the lowest cost. Constant efficiency means constant annual cash flows, while with the rest of the alternatives the annual cash flows are reducing every year. Another advantage of this scenario, is that it can be implemented even without the electrical interconnection of Crete with Greece's mainland. On the other hand, the 2nd and the 3rd scenario could be applied only after the interconnection of Crete with country's mainland.

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