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The Renewable Energy Sources as a Lever of Sustainable Development

Maria Tsiouni†[1], Dafni Petkou[2], Alexandra Pavloudi[1]

[1] Department of Agricultural Economics and Entrepreneurship, International Hellenic University, Greece
[2] Department of Early Childhood Education and Care, International Hellenic University, Greece

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ABSTRACT

Purpose:
The aim of this paper is to examine investors' economic and social profiles in renewable energy sources with the help of widely used investment rating indicators, such as Net Present Value, Internal Grade of Performance and Profitability Index.

Design/methodology/approach:
The study used an empirical research, gathering economic data from investments in renewable energy sources in the Regional Units of Thessaloniki, Imathia and Pella. Data was collected through a structured questionnaire, administered with personal interviews with investors, by applying a simple random sampling method through a population-total number of investors retrieved from the Ministry of Environment, Energy, and Climate Change records.

Findings:
The results demonstrate that investments in renewable energy projects are sustainable and highly efficient on a case-by-case basis. The main criterion for accepting an investment element in a specific renewable energy technology application is the calculation of the Internal Rate of Return. The optimal investment pertains to photovoltaic system installations. Among the investments, hydroelectric and wind investments are also enticing. Investments in wind energy have the highest net present value, followed by investments in photovoltaic and hydroelectric systems. Concerning the profitability index, it is observed that investments in photovoltaic systems have a higher profitability index, followed by investments in wind and hydroelectric systems. As far as social characteristics are concerned, the majority of investors, regardless of their profession, invest in photovoltaics. Freelancers predominantly invest in wind energy projects, while employees mainly invest in hydroelectric projects.

Research limitations/implications:
The main limitation of the survey is related to the sample, which consisted of investors from three regional areas of Greece. A future study may be conducted to a larger sample, from all Greek regional units and examine possible differences in the results related to geographical area and profile of the investors.

Originality/value:
From the literature review, it is found that there is a lack of a comprehensive scientific method for evaluating the optimal investment choice in the renewable energy sector, leaving potential investors without a reliable framework for assessment of investment proposals.
The current study can serve as a tool for investors in the renewable energy sector, assessing whether an investment yields financial gains compared to the capital allocated and therefore providing a tool to investors to know in advance the benefit of their potential investment.

1. Introduction

Renewable energy sources are derived from energy sources such as wind, solar power, hydropower, geothermal energy, biomass, and hydroelectric power (Andryeyeva et al., 2021). As we enter the 21st century, the world is facing an impending depletion of usable energy derived from fossil fuels, including oil, gas, coal, natural gas, and nuclear power. Unfortunately, renewable energies like wind and solar power have not yet reached a level of development that can fully replace traditional energy sources while providing flexibility. Consequently, humanity is now venturing towards greater reliance on renewable energy due to the finite nature of fossil fuel resources. Multiple estimates indicate that proven oil reserves will likely be insufficient to meet global demand, at least by the middle of the 21st century (Ucal & Xydis, 2020).

Many developing and developed countries are rapidly increasing their installed capacity, and one factor contributing to this is their rising standard of living. The energy sector serves as a driving force for development and relies predominantly on the use of fossil fuels, whose availability is constantly decreasing. The need to transition away from conventional energy sources and the restrictive measures implemented by the European Union (EU) in its energy policy align with the promotion of Renewable Energy Sources (RES).

The transition towards an energy system based on renewable sources will enable the achievement of sustainable development (Bao & Fang, 2013) and the mitigation of global warming. In fact, numerous scientists and experts worldwide have affirmed the crucial and significant role that renewable energy can play in economic growth (Alper & Oguz, 2016), greenhouse gas emissions reduction (Kardooni et al. 2018), and job creation.

The European Union (EU) intends to become a global leader in renewable energy (RE) development under the Energy Union established (EC, 2015). As a result of Directive 2009/28/EC, the extended implementation of RE investments is a requirement for the EU Member States to meet the national binding targets by 2030 (EC, 2015). Moreover, the European Commission has also established ambitious energy and climate goals for 2030, including an increase of 27% in renewable energy consumption at the EU level by 2030 (EC, 2016; European Council, 2014).

Despite the persisting issue of low electrification rates in developing countries, substantial investments are necessary to enhance electricity supply and accessibility on a global scale (Nock et al., 2020). The International Energy Agency (IEA) estimates that non-OECD countries will need to invest USD 10 trillion in the electricity sector by 2035 (Manju & Sagar, 2017). Simultaneously, there are concerns that a greater proportion of energy consumption will continue to rely on fossil fuels, potentially exacerbating climate change. In this context, it becomes crucial for countries to establish stable social economies and sustainable growth. Governments and international agencies should provide various forms of support to the energy sector in industrialized nations, including financial assistance, technical guidance, and counseling (Lyulyov et al., 2021).

Greece has been actively promoting the development of renewable energy sources. The primary contributors to the country's gross energy production from renewables are wind power, photovoltaic solar panels, hydroelectric power, geothermal energy, and localized biomass, albeit at smaller capacities. Wind and photovoltaic energy installations are the most significant contributors (Eurostat, 2015). According to the latest National Energy and Climate Plan, Greece plans to generate 28 GW of renewable energy by 2030, up from 19 GW under the previous plan, aiming for an 80% share of renewable energy in its energy mix by the year 2030. In addition, the country is working on its National Hydrogen Strategy and preparing for the development of offshore wind farms, which have the attention of energy heavyweights around the world. The sunny, Mediterranean climate in Greece makes solar energy another key source of power. However, the increasing share of renewable energy from a limited number of technologies presents certain challenges (EU, 2016).

2. Literature review

The renewable energy sector in Greece is considered one of the most dynamic industries, and as such, numerous research efforts have been conducted by both Greek and foreign scholars. In their study, Masini & Menichetti (2013) state that investments in renewable energy sources (RES) are seen as an effective means of recovering from the economic crisis. However, there is limited penetration observed in this sector due to a lack of financing and reluctance to invest in these technologies. This particular study examines the factors that influence investors' decisions and the relationship between RES investments and portfolio performance. Through the application of econometric techniques on primary data collected from a sample of European investors, the study investigates how investors' beliefs, preferences, and attitudes are affected when it comes to investing in RES projects. Additionally, the study explores how portfolio performance increases with the rise in the share of RES in the portfolio.

El-Karmi & Abu-Shikhah (2013), in a relevant study, examined the impact of introducing economic incentives to promote renewable energy projects in Jordan. The incentives investigated include tax reduction, grace period introduction, capital provision or reduced prepayment interest, reduced asset depreciation, as well as the use of accelerated depreciation methods. The results obtained indicate that the implementation of such tools leads to improvements that encourage private individuals to invest in renewable energy sources. Furthermore, in the present study, the conducted conclusions showed that the fluctuations in both the grace period and the tax rate had minimal effects on the internal rate of return and net present value. On the other hand, increasing the depreciation period makes electricity generated from renewable sources more attractive compared to the straight-line depreciation method.

Ming et al. (2014), in their study, examined the investment prospects in renewable energy sources, financing sources, and funding channels. They also conducted a comparative analysis of wind and photovoltaic electricity.

According to Delapedra-Silva et al. (2022), the literature on the financial evaluation of renewable energy sources (RES) projects has extensively explored various methods, but there have been changes over time, driven by different factors. This article aims to analyze publications on the financial evaluation of RES projects from 2011 to 2020 and provide a critical analysis of the literature. The evaluation methods were categorized into four groups: (i) traditional metrics such as net present value, internal rate of return, and payback period; (ii) levelized cost of electricity; (iii)

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return on investment approach; and (iv) real options analysis. A quantitative analysis considered author relevance, productivity by country and the most influential journals for each group. Additionally, a qualitative analysis of the five most cited articles in each group was conducted. The findings reveal that traditional methods continue to be widely used for financial evaluation in RES projects. However, approaches based on levelized cost and real options have gained importance in addressing the complexities of financial evaluation and comparison of RES projects.

According to Steffen (2020), in energy economics, numerous models are used to assess the costs of alternative power generation technologies. These models rely on well-calibrated assumptions, particularly regarding the cost of capital or discount rates, which are crucial for renewable energy due to the wide variation in capital costs across countries and technologies. This article provides a comprehensive review of estimation methods for the private cost of capital in renewable energy projects and discusses their appropriate use to ensure unbiased results. Furthermore, empirical evidence from 46 countries during the period 2009-2017 is evaluated. The findings reveal a consistent global ranking order among technologies, with the cost of capital being highest for offshore wind power, followed by onshore wind and solar PV. On average, developing countries have significantly higher costs of capital compared to industrialized countries, and there is also substantial heterogeneity within each group.

Anton et al. (2020) analyzed the impact of financial development on the utilization of renewable energy within a panel dataset of 28 European Union (EU) countries from 1990 to 2015. The study employed a panel fixed effects model, incorporating income, energy prices, financial development, and foreign direct investments as variables. The empirical analysis revealed that all three aspects of financial development (banking sector, bond market, and capital market) had a positive influence on the proportion of renewable energy consumption. Furthermore, the results indicated that the development of the capital market did not significantly affect renewable energy consumption in the new EU Member States. These findings offer valuable insights into the effective allocation of capital within the renewable energy sector, aiming to provide competitively priced options to customers and ultimately foster the expansion of higher value-added services.

Angelopoulos et al., (2017) in their paper provided a comprehensive assessment of the existing risks associated with RE investments in Greece concerning the respective policies and evaluated their impact on WACC. In order to verify the findings, important individuals involved in the Greek renewable energy market were also consulted. These individuals include policy makers, project developers, investors, equity providers, bankers, and energy analysts. The conclusion drawn from these consultations is that the risk associated with policy design has the most significant impact on the cost of capital and, consequently, the level of investment in renewable energy projects. Through the cost of capital valuation process, it was determined that the weighted average cost of capital (WACC) for onshore wind projects in Greece is estimated to be around 12%, while solar PV projects have slightly lower values.

To date, various studies have approached this problem by evaluating the dynamics of Renewable Energy Projects (REPs) by category and comparing them both quantitatively and qualitatively. This differs from the international reality where sufficient effort has not been made towards assessing the fundamental financial mechanisms. Consequently, there is a lack of a comprehensive scientific method for evaluating the optimal investment choice, leaving potential investors without a reliable framework for assessment. This study aims to fill the specific gap. The objective of this study is to serve as a tool for investors, assessing whether an investment yields financial gains for the entrepreneurial investor in relation to the capital allocated. The specific goals are to investigate the economic profile of the sample under examination, followed by the development of mechanisms for evaluating investment proposals, and finally, the presentation of financing methods for Renewable Energy Projects (REPs).

2. Methodology

For this research, economic data from investments in renewable energy sources in the Regional Units of Thessaloniki, Imathia, and Pella were utilized. In Central Macedonia, there is the highest installed capacity of RES units (Kablioni, 2020). The techno-economic data used in the study were collected through a well-structured questionnaire administered during personal interviews with investors, conducted during the period of 2022. The data regarding the number of investors initially originated from the Ministry of Environment, Energy, and Climate Change (YPEKA) records. The completion time for each questionnaire was estimated at 60 minutes per investor. The sampling method employed for sample selection was simple random sampling (Siardos, 2005). Ultimately, a total of 139 investments were included in the sample. The questionnaire consists of two parts. The first part serves as an introduction and initial approach to the investor's profile, containing general questions regarding individual characteristics such as age, education, profession, and household income. The second part involves recording the techno-economic data of the investment. It includes questions related to the financial data of the investment. Additionally, there are questions concerning financial incentives, whether they come from grants or bank loans.

In order to evaluate a project, it is essential to conduct its financial assessment, enabling the investor to make a critical decision on whether to invest in it or not. The financial assessment constitutes the first step in project evaluation, and if the project is deemed financially unviable based on the assessment results, it is rejected. The annual cash flows were calculated. To evaluate an investment project financially, the annual cash flows were computed. The net cash flows are the sum of cash flows from capital investments and disposals, cash flows from changes in working capital, and operational cash flows. To determine whether an investment is profitable or not, certain investment evaluation indicators were examined, namely: Net Present Value (NPV), Internal Rate of Return (IRR), and Profitability Index (PI). The techno-economic analysis is the result of processing data from 30 fixed photovoltaic projects, 65 mobile photovoltaic projects, 12 small-scale wind projects, and 32 hydroelectric projects. The results represent the average values within each project category.

3. Results

From the following table (Table 1), it is evident that for fixed photovoltaic installations, funding mainly comes from own capital (59,3%). Government subsidies account for 10% of the funding, while bank loans constitute approximately 31% of the total investment. In the case of mobile photovoltaic installations, funding primarily comes from own capital (53,4%). Government subsidies represent around 11% of the funding, while bank loans amount to approximately 36% of the total investment. For wind power projects, funding mainly comes from own capital at approximately 61%. Government subsidies make up 14,5% of the funding, while bank loans constitute 24,5%. Lastly, for hydropower projects funding is sourced from own capital at around 53%. Government subsidies account for approximately 10% of the funding, while bank loans amount to 36%.

Table 1: The financial structure of investments.

	Equity (%)	Government Grant (%)	Bank Loan (%)
Fixed Photovoltaic investments	59,3	10,0	30,6
Mobile Photovoltaic investments	53,4	10,7	35,7
Wind investments	60,8	14,5	24,5
Hydroelectric investments	53,4	10,1	36,4

Source: Author's construct, 2023

From Table 2 it is evident that mobile photovoltaics have a higher internal rate of return (38%) compared to other investments. They are followed by investments in fixed photovoltaics (30%), hydroelectric (26%), and wind energy (20%). The net present value is positive in all cases, with the highest value observed in wind energy. The profitability index is higher for fixed (15%) and mobile photovoltaics (14,5%), followed by wind energy (6%) and hydroelectric (5%).

Table 2: Calculation of financial indexes for renewable energy projects.

	Fixed Photovoltaic investments	Mobile Photovoltaic investments	Wind investments	Hydroelectric investments
Net Present Value (NPV) (€)	37.092,08	118.937,53	273.821,62	20.382,83
Internal Rate of Return (IRR)	30%	38%	20%	26%
Profitability Index (PI)	15%	14,5%	6%	5%

Source: Author's construct, 2023

From Table 3 it is evident that the majority of investors, regardless of their profession, invest in photovoltaics. Freelancers predominantly invest in wind energy projects, while employees mainly invest in hydroelectric projects.

Table 3: The profession of investors in renewable energy sources

	Employee (%)	Freelancer (%)	Farmer (%)	Retiree (%)	Household (%)	Student (%)
Fixed Photovoltaic investments	40	35	37	55	70	85
Mobile Photovoltaic investments	35	30	41	40	30	15
Wind investments	5	18	4	0	0	0
Hydroelectric investments	20	17	18	5	0	0

Source: Author's construct, 2023

From Table 4 it is evident that most investors in photovoltaic projects have an average income ranging from 1.001€ to 4.000€. In wind and hydroelectric projects, the majority of investors have a monthly income greater than 4.000€.

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Table 4: The average income of investors in renewable energy sources.

	0-1000 (%)	1001-2000 (%)	2001-3000 (%)	3001-4000(%)	>4000 (%)
Fixed Photovoltaic investments	32	65	45	20	5
Mobile Photovoltaic investments	60	25	32	35	10
Wind investments	5	0	15	20	45
Hydroelectric investments	3	10	8	25	40

Source: Author's construct, 2023

4. Discussion and Conclusions

In this paper, an evaluation of selected renewable energy investment projects was conducted. These specific investment projects were chosen to represent the entire spectrum of renewable energy technologies that an investor can choose from, covering both high and low investment capital. As the primary evaluation criterion for these investment projects, the internal rate of return (IRR), net present value (NPV) and profitability index (PI) were calculated.

The results demonstrate that investments in renewable energy projects are sustainable and highly efficient on a case-by-case basis. The main criterion for accepting an investment element in a specific renewable energy technology application is the calculation of the Internal Rate of Return (IRR). An investment plan is deemed acceptable when it presents a higher internal rate of return than the minimum required return defined by the investor. The optimal investment pertains to photovoltaic system installations. The expected reduction in equipment and installation costs is anticipated to make these investments even more attractive. Among the investments, hydroelectric and wind investments are also enticing. Furthermore, a criterion for evaluating and making investment decisions is the company's goal to maximize its net worth. This means that an investment proposal is favourable for the company when its contribution to the net value of the company exceeds the implementation cost. Investment decisions are made after a detailed and comprehensive evaluation of the relevant proposals, and their significance for the well-being and further development of the company is significant due to the magnitude of the required capital and the long-term implications that these decisions entail for the entire enterprise. According to the results presented in the previous section, at Table 2, investments in wind energy have the highest net present value, followed by investments in photovoltaic and hydroelectric systems. Finally, concerning the profitability index, it is observed that investments in photovoltaic systems have a higher profitability index, followed by investments in wind and hydroelectric systems. As it concerns social characteristics, in terms of their professional status, employees were predominant, followed by self-employed professionals. The average household income was in the range of 2501-3000 euros, which, for more than half of the respondents, came from their work.

Generally speaking, there are possibilities for improving the economic efficiency of investments in renewable energy projects to ensure their sustainability. Established support mechanisms for renewable energy sources (RES) are crucial for this purpose. Future frameworks for the remuneration of generated energy from RES should be designed with the primary objective of ensuring the economic viability of investments and further penetration of RES in a secure and stable environment. Numerous plans are being examined by the global scientific community and it is particularly interesting to explore the framework under which the RES energy market will operate in the future. Better economic results can be achieved through advancements in material technology, characterized by higher efficiency, and maximum utilization of natural resources, leading to a reduction in initial investment costs and operational expenses. These factors will contribute to reducing the economic risk associated with such investments.

The main limitation of the survey is related to the sample, which consisted of investors from three regional areas of Greece. A future study may be conducted on a larger sample, from all Greek regional units and examine possible differences in the results related to geographical area and profile of the investors.

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