


**ENHANCING THE BANKABILITY OF GREEN ENERGY PROJECTS IN KUWAIT**

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ARTICLE INFO	ABSTRACT
<p><b>Article history:</b>  <b>Received:</b> Feb, 21<sup>st</sup> 2025  <b>Accepted:</b> Apr, 23<sup>th</sup> 2025</p>	<p><b>Objective:</b> The purpose of this research paper is to empirically analyse how conventional economic and financial metrics influence investment in solar energy projects in the state of Kuwait. The empirical analysis is based on 13 years of data covering the period from 2010 to 2023.</p>
<p><b>Keywords:</b>  Renewable Energy;  Solar Investment;  Multiple Linear Regression;  Kuwait.</p>	<p><b>Theoretical Framework:</b> This literature review examines the factors influencing bankability and explores strategies to enhance financial viability. The authors of the research designed a financial model to produce some necessary financial metrics.</p>
	<p><b>Method:</b> A multiple linear regression model is used to study the relationship of total solar investment in MWh and six independent variables, such as Weighted average capacity factor, WAAC weighted average cost of capital internal rate of return (IRR), Payback period, and PVOOUT. Along with statistical tests such as ANOVA and OLS regression, used to evaluate the strength and significance of the relationship between the dependent and independent variables.</p>
	<p><b>Results and Discussion:</b> The result of the analysis identifies only LCOE as the only marginally significant factor influencing investment in solar energy projects in Kuwait, with a negative coefficient (-454.79) and a p-value of 0.0822. Other independent variables, including the weighted-average capacity factor, WACC, payback period, and IRR, are shown to be statistically insignificant, indicating limited influence on investment decisions.</p>
	<p><b>Research Implications:</b> This study has limitations that should be acknowledged. First, these findings show that investment in solar energy relies especially on conventional economic and financial investment metrics which are not enough to rapidly advance renewable energy development in Kuwait. Proactive public policy with attractive tools that stimulate investor confidence and promote a sustainable energy transition is not included.</p>
	<p><b>Originality/Value:</b> This study provides original empirical evidence on the economic and financial factors influencing investment in solar energy projects in the State of Kuwait. As a relatively underexplored topic in the renewable energy finance literature, particularly within the context of Kuwait.</p>
<p>Doi: <a href="https://doi.org/10.26668/businessreview/2025.v10i5.5511">https://doi.org/10.26668/businessreview/2025.v10i5.5511</a></p>	

**AUMENTANDO A BANCABILIDADE DE PROJETOS DE ENERGIA VERDE NO KUWAIT**

**RESUMO**

**Objetivo:** O objetivo deste trabalho de pesquisa é analisar empiricamente como a métrica econômica e financeira convencional influencia o investimento em projetos de energia solar no estado do Kuwait. A análise empírica baseia-se em 13 anos de dados relativos ao período de 2010 a 2023.

**Theoretical Framework:** Esta revisão de literatura examina os fatores que influenciam a banca e explora estratégias para melhorar a viabilidade financeira. Os autores da pesquisa projetaram um modelo financeiro para produzir algumas métricas financeiras necessárias.

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**Método:** Um modelo de regressão linear múltipla é usado para estudar a relação do investimento solar total em MWh e seis variáveis independentes, tais como Fator de capacidade média ponderada, custo médio ponderado WAAC da taxa interna de retorno do capital (IRR), período de retorno e PVOU. Juntamente com testes estatísticos como a regressão ANOVA e OLS, usados para avaliar a força e a significância da relação entre as variáveis dependentes e independentes.

**Resultados e Discussão:** O resultado da análise identifica apenas LCOE como o único fator marginalmente significativo que influencia o investimento em projetos de energia solar no Kuwait, com um coeficiente negativo (-454,79) e um p-valor de 0,0822. Outras variáveis independentes, incluindo o fator de capacidade média ponderada, o CMPC, o período de retorno e a TIR, mostraram-se estatisticamente insignificantes, indicando influência limitada nas decisões de investimento.

**Implicações da Pesquisa:** Este estudo tem limitações que devem ser reconhecidas. Em primeiro lugar, essas descobertas mostram que o investimento em energia solar depende especialmente de métricas de investimento econômico e financeiro convencionais que não são suficientes para avançar rapidamente o desenvolvimento de energia renovável no Kuwait. Não estão incluídas políticas públicas pró-ativas com instrumentos atrativos que estimulem a confiança dos investidores e promovam uma transição energética sustentável.

**Originalidade/Valor:** Este estudo fornece evidências empíricas originais sobre os fatores econômicos e financeiros que influenciam o investimento em projetos de energia solar no Estado do Kuwait. Tópico relativamente subexplorado na literatura sobre financiamento de energia renovável, particularmente no contexto do Kuwait.

**Keywords:** Energia Renovável, Investimento Solar, Regressão Linear Múltipla, Kuwait.

## MEJORAR LA BANCARILIDAD DE LOS PROYECTOS DE ENERGÍA VERDE EN KUWAIT

### RESUMEN

**Objetivo:** El propósito de este trabajo de investigación es analizar empíricamente cómo los indicadores económicos y financieros convencionales influyen en la inversión en proyectos de energía solar en el estado de Kuwait. El análisis empírico se basa en 13 años de datos que abarcan el período comprendido entre 2010 y 2023.

**Marco Teórico:** Esta revisión de la literatura examina los factores que influyen en la bancarabilidad y explora estrategias para mejorar la viabilidad financiera. Los autores de la investigación diseñaron un modelo financiero para producir algunas métricas financieras necesarias.

**Método:** Se utiliza un modelo de regresión lineal múltiple para estudiar la relación de la inversión solar total en MWh y seis variables independientes, como el factor de capacidad media ponderada, el coste medio ponderado del capital, la tasa interna de rendimiento (TIR), el período de recuperación de la inversión y el PVOU. Junto con pruebas estadísticas como la regresión de ANOVA y OLS, se utiliza para evaluar la fuerza y la significación de la relación entre las variables dependientes e independientes.

**Resultados y Discusión:** El resultado del análisis identifica solo a la LCOE como el único factor marginalmente significativo que influye en la inversión en proyectos de energía solar en Kuwait, con un coeficiente negativo (-454,79) y un valor p de 0,0822. Otras variables independientes, incluyendo el factor de capacidad media ponderada, WACC, período de recuperación de la inversión y TIR, muestran ser estadísticamente insignificantes, lo que indica una influencia limitada en las decisiones de inversión.

**Implicaciones de la Investigación:** Este estudio tiene limitaciones que deben ser reconocidas. En primer lugar, estas conclusiones muestran que la inversión en energía solar se basa especialmente en indicadores económicos y financieros convencionales que no son suficientes para impulsar rápidamente el desarrollo de la energía renovable en Kuwait. No se incluye una política pública proactiva con herramientas atractivas que estimulen la confianza de los inversores y promuevan una transición energética sostenible.

**Originalidad/Valor:** Este estudio proporciona pruebas empíricas originales sobre los factores económicos y financieros que influyen en la inversión en proyectos de energía solar en el Estado de Kuwait. Como un tema relativamente poco explorado en la literatura financiera de energía renovable, particularmente en el contexto de Kuwait.

**Palabras clave:** Energía Renovable, Inversión Solar, Regresión Lineal Múltiple, Kuwait.

## 1 INTRODUCTION

The transition to green energy is critical for sustainable development globally. In the Gulf Cooperation Council (GCC) countries, the push toward renewable energy projects is bigger now due to international climate commitments. However, ensuring the bankability of green energy projects remains a significant challenge in this region. Due to their large supplies of gas and oil, these nations have become increasingly dependent on hydrocarbons for economic growth. In fact, a sizable amount of the GDP in this region comes from the export of gas and oil (Minić and Filipović, 2024). More than 40% of the GDP of Kuwait comes from oil and government initiatives that are mostly financed by oil profits (Tagliapietra, 2017). In the GCC macroeconomic framework, oil constitutes a key distinction between oil exporters and oil importers, as demonstrated by the compositions of GDP, fiscal revenues, and exports. However, oil also affects other macroeconomic factors like labor productivity and employment.

The green transition as a roadmap to a more suitable future represents one of the main initiatives for a more secure, reliable, and robust growth model that is backed and secured with a knowledge-based foundation. As the nations and economies are seriously challenged with climate issues and global warming, a transition from conventional-based economies to green transition commitment has become the priority for most of the country, including Kuwait.

Solar energy projects have been developed and have gained attention in the last decade as an indication of ideas of sustainable solutions. This trend has become a main priority for the private and public sectors as initiatives for a clean, secure, and sustainable future. The favourable radiation conditions and continuous decreases in the cost of solar energy technology, supported by public policy, are among factors that make the solar energy sector attractive to investors.

The investment in renewable energy projects is an important signpost and commitment toward reform in the energy sector and economic diversification. As the world economies significantly move towards sustainable energy solutions, the state of Kuwait faces a trade-off between huge radiation potential in solar energy and important decisions about its future. The country's energy sector has long been characterized by heavy reliance on fossil fuels, supported by a policy environment that aims to maintain low energy prices for domestic consumption (El-Katiri and Laura, 2014). However, this reliance is increasingly scrutinized due to its implications for long-term economic viability and environmental sustainability. The rapid energy sector transformations in various countries indicate the necessity for Kuwait to reform its pricing mechanisms and attract foreign investment in renewable technologies (IRENA,

2019). Thus, understanding the notes and challenges of solar energy investment is crucial for Kuwait to navigate both its energy needs and its objectives for sustainable development.

Reviewing the traditional economic and financial metrics and other types of risks associated with total investment in solar projects is essential to identifying the barriers that hinder greater investment in this sector. Kuwait's transition to green energy is aligned with its Vision 2035 development plan, which seeks to position the country as a regional hub for economic, financial, and business activities. A key objective of Vision 2035 is economic diversification, primarily by reducing dependence on fossil fuels and adopting sustainable energy and economic diversifications. As part of this initiative, Kuwait has set an ambitious target to generate 15% of its total electricity from renewable energy sources by 2030 (IRENA, 2019).

The first steps in a large-scale renewable energy project investment date in 2016 with the establishment of the SIDRA 500 plant in Umm Gudair with a 10 MW photovoltaic capacity (GEM.VIKI). Following this, the Al-Shagaya project, as the second renewable energy park with 70 MWh Installed capacity, combined wind, photovoltaic, and concentrated solar power CSP technologies, became operational in 2017 (IRENA, 2019). These developments are shown as crucial milestones in establishing Kuwait's renewable energy sector and open the door for the private and public sectors to invest. Despite these developments, the overall contributions of renewable energy sources in total electricity production remain minimal, with less than 3% of the country's electricity production (IRENA,2023).

In recent years, there have been no significant increases in Kuwait's renewable energy capacity. This inactivity underlines the need for more aggressive policies, financial incentives, and strategic investments to achieve the 2035 target. The data from the International Renewable Energy Agency (IRENA, 2023) indicate a steady decline in LCOE from \$0.46/kWh in 2010 to \$0.044/kWh in 2023, highlighting significant cost reductions in solar energy projects. This sharp cost reduction, combined with improvements in capacity factors and reasonable financing mechanisms in the GCC region RES project, is the motivation for domestic and foreign investors to reach unarticulated RES project markets in Kuwait.

Despite favourable data which indicates the decline of LCOE and reductions of Capex in solar energy projects, the conventional economic and financial factors do not show a strong prediction in the solar project investment cycle. The regression analysis conducted suggests that LCOE has a statistically negative relationship with installed capacity, implying that lower generation costs are a strong determinant of increased investment in solar energy. While other

variables such as IRR and WACC have shown less statistical significance, indicating the need for further policy support and financial incentives to enhance investor confidence.

The State of Kuwait, with its high solar potential, is progressing toward the development of a strong solar energy sector. However, investment in renewable energy projects remains limited due to financial, regulatory, and policy-related challenges. This research paper aims to evaluate the investment landscape in Kuwait, considering the economic and financial factors as well as the impact of existing policies.

This research aims to assess the economic feasibility of renewable energy projects in Kuwait, with a focus on solar energy investments. The research will also evaluate government policies, financing mechanisms, and international investment opportunities that could support the sustainable transition toward a renewable energy-based economy. Ultimately, the study will provide strategic insights for policymakers, investors, and stakeholders to optimize renewable energy investments and foster economic diversification in Kuwait. The study will analyse the initial capital costs, operational and maintenance expenses, and long-term financial benefits of transitioning to renewable energy compared to conventional fossil fuel-based power generation.

The research aims to answer the following questions:

1. What lies behind the limited role of economic and financial indicators in driving solar energy investment in Kuwait, and how can policy tools be structured to bridge this gap?
2. How much progress has Kuwait made toward its target of generating 15% of electricity from renewables by 2030 and how does Kuwait's renewable energy strategy align with the broader Vision 2035 development plan?

Furthermore, this research will explore various financing mechanisms, including public-private partnerships (PPPs), green bonds, international funding, and government incentives, to determine the most effective financial strategies for supporting large-scale renewable energy projects in Kuwait. By providing data-driven insights and strategic recommendations, this study aims to assist policymakers, investors, and financial institutions in making informed decisions to optimize renewable energy investments, enhance energy security, and support Kuwait's long-term economic diversification efforts.

In addition to financial aspects, this study will investigate the environmental impact and sustainability benefits of renewable energy in Kuwait, particularly in terms of carbon emissions reduction, climate resilience, and energy security. It will also assess the policy and regulatory frameworks required to mitigate financial and environmental risks, ensuring a smooth transition toward a sustainable energy future in 2035.

## 2 THEORETICAL FRAMEWORK

This research examines the factors influencing bankability and explores strategies to enhance financial viability. The goal established by the Kuwaiti government is to raise the proportion of renewable energy sources to 10% by 2020 and 15% by 2030. There are currently only a few tiny demonstration projects among Kuwait's active renewable energy facilities. Shagaya project, Kuwait's premier renewable energy project, was introduced in 2019 and produced in collaboration with the Ministry of Water and Electricity and the Kuwait Institute for Scientific Research (KISR).

Shagaya Renewable Energy Project, which constitutes the first phase (Phase I) of an ambitious Master Plan to generate approximately 3.2GW at the Shagaya Renewable Energy Park. Phase I sets the basis for future renewable energy developments in Kuwait through the installation of a 50 mega-watt (MW) Concentrated Solar Power (CSP) plant that was commissioned in December 2018, a 10 MW Wind Farm that was commissioned in May 2017, and a 10 MW Photovoltaic (PV) plant. With a 1.5 GW capacity, the project's second phase, Shagaya Phase II, is anticipated to rank among Kuwait's biggest solar projects. The Kuwait National Petroleum Company, the project's owner, anticipates that it will provide 15% of the electricity required by the oil industry (Al-Sarihi and Mansouri, 2022). The project took on an EPC contract with a consortium consisting of the Spanish company TSK and Kuwait's Kharafi National in 2015. Shagaya CSP Plant will produce 180 GWh/year with a total area of 250 hectares and reduce emissions by more than 81,000 tons of CO<sub>2</sub>/year.

Bankability refers to the ability of a project to attract financing due to its perceived risk and return profiles. Critical factors include regulatory frameworks, market structures, and access to long-term financing. In the GCC, regulatory uncertainty has been a persistent barrier, despite recent reforms aimed at liberalizing energy markets (Atalay et al., 2006; Tagliapietra, 2017).

Although in all the Gulf states, Saudi Arabia and UAE invest the most on research and development of projects concentrated on energy transition, but it is evident that the Gulf nations have not adopted a practical approach or put procedures and methods into place that would have a major influence on sustainability (Minić and Filipović, 2024).

A robust policy framework is crucial for creating an enabling environment for green energy investments. Policies such as feed-in tariffs, renewable energy quotas, and tax incentives have been identified as effective tools (IRENA, 2023). In the GCC, countries like the UAE and

Saudi Arabia have implemented ambitious renewable energy targets. However, inconsistent policy implementation has occasionally deterred investors (Al-Sarihi, 2020).

The role of international financial institutions, such as the World Bank and regional development funds, has also been significant in offering concessional loans and guarantees. Such interventions reduce perceived risks and improve the overall bankability of projects. Risk perception is a critical determinant of bankability. Strategies such as guarantees, insurance products, and power purchase agreements have been employed globally to mitigate risks (World Bank, 2023). International collaboration has facilitated knowledge transfer, capacity building, and access to funding for renewable energy projects in the GCC. For instance, partnerships with global institutions like the International Renewable Energy Agency (IRENA) have supported project development (IRENA, 2023).

Cost management in green energy projects involves optimizing expenditures while maintaining high project performance and sustainability. In GCC countries, achieving cost efficiency is essential due to the unique challenges posed by the harsh climatic conditions and the reliance on imported renewable energy technologies. The integration of renewable energy sources such as solar and wind requires meticulous planning to manage both capital and operational expenditures effectively enabling it to achieve the lowest levelized cost of energy (LCOE) (IRENA, 2021; Donastorg et al., 2017).

GCC countries have different cost management strategy. For instance, Saudi Arabia's Vision 2030 emphasizes developing local manufacturing capacities for solar components, which has potential cost-saving benefits and economic spillovers (Tyl and Lizarralde, 2017; Al-Sarihi and Mansouri, 2020; Shalhoob, 2023). Despite progress, challenges such as fluctuating oil prices, limited local manufacturing capacity, and the need for grid modernization persist. Future research should focus on integrated energy planning, innovative business models, and the role of digital technologies in optimizing project economics (Al-Sarihi and Mansouri, 2022).

Green energy projects require substantial upfront investments, often making financing a critical component of their success. Capital expenditures for renewable projects include costs related to technology procurement, construction, and grid integration, while operational expenditures encompass maintenance and operational costs (Egli et al., 2018). Recent studies explored the sources of funding for renewable energy projects. Global investment in renewable energy has been increasing over the years, due to the new financial characteristics such as new and improved RE technologies that have been implemented in recent years (Donastorg et al.,

2017; Kutan et al., 2018). As indicated by Steffen (2018) project finance plays an important role in the energy sector, not only in the risky environments of a developing country (Trypolska and Riabchyn, 2022), but also in stable, low-risk countries such as Germany (Roth et al., 2022).

Compared to technology in the fossil fuel industry in GCC, green technologies are frequently in the early stages of research and less commercially feasible. Green technologies become riskier and more costly as a result. The cost of debt (borrowing interest rate) rises when traditional financing sources are unavailable (Taghizadeh-Hesary and Yoshino, 2020). Renewable energy (RE) projects require significant capital investments, making financing a critical aspect of their development. Traditional funding sources, such as government allocations and institutional investments, are often limited by budgetary constraints and competing priorities.

In recent years, citizen funding has emerged as a viable alternative, enabling individuals to contribute directly to renewable energy initiatives (Tyl and Lizarralde, 2017). This approach not only diversifies funding sources but also fosters public engagement and ownership of renewable energy projects. In many Western countries, funding instruments include different sources and mechanisms such as government-funded, Venture capital funds, private equity, loans from commercial banks/financial institutions, green bonds, and tradeable renewable energy certificates (Lam and Law, 2018). For example, in Germany, the energy cooperative as an organizational form has a long tradition, serving as a business model to financially engage citizens in energy projects. This structure allows individuals to pool resources and collectively invest in initiatives such as renewable energy production, fostering local ownership and participation. In the context of energy projects, this model has been particularly effective in driving community-driven initiatives, enhancing public acceptance, and aligning economic benefits with local interests. By leveraging the cooperative model, Germany has successfully mobilized citizen support and financial commitment for sustainable energy transitions (Yildiz, 2014). The suitable financing instrument for RE projects was chosen by RE developers at different developmental stages of the projects. Furthermore, the renewable portfolio standard (RPS) is one of the most common policies used, with a feed-in-tariff (FIT) is a policy used as a support mechanism to accelerate investment in renewable energy (RE) technologies. In contrast to the FIT policy, which is price-based (fixed-price and premium-price), the RPS policy is quantity-based (Abolhosseini and Heshmati, 2014).

In corporate finance, projects are typically financed through a combination of equity and debt on the sponsor's balance sheet, with the ability to fund new projects largely depending

on the strength of that balance sheet. A strong balance sheet, characterized by lower leverage and ample liquidity, enables a company to secure additional funding more easily, while a high debt ratio can limit financing options as lenders may perceive additional borrowing as too risky, potentially raising the cost of debt and affecting credit ratings. Consequently, companies must carefully manage their renewable energy projects to balance growth opportunities with the risks of over-leverage, often exploring alternative financing options such as joint ventures or asset-backed financing when traditional sources become constrained.

Financing mechanisms such as green bonds, green sukuk, and public-private partnerships (PPPs) have proven effective in the GCC context. For example, the issuance of green sukuk by the UAE has provided project developers with access to Sharia-compliant financing, aligning with regional cultural and financial norms. These instruments have reduced financing costs, making projects more attractive to investors. Despite the UAE and Saudi Arabia probably continuing to issue the majority of the region's sustainability bonds, none of the other GCC countries seem to trade the green Sukuk. The majority of issuances are sustainability bonds, with more banks participating and a comparatively low level of corporate engagement. Financing mechanisms such as green bonds, green sukuk, and public-private partnerships (PPPs) have proven effective in the GCC context. For example, the issuance of green sukuk by the UAE has provided project developers with access to Sharia-compliant financing, aligning with regional cultural and financial norms. These instruments have reduced financing costs, making projects more attractive to investors.

Solangi and Magazzino (2025) suggested a more balanced economy for the GCC countries and less reliance on the fossil-fuel industry (Kutan et al., 2018). Additionally, they recommended successful solutions, such as energy source diversification, investments in renewable energy infrastructure, and mineral resource management programs. Innovative financing mechanisms, such as green bonds and public-private partnerships, have been instrumental in enhancing the bankability of projects. GCC countries are beginning to explore these mechanisms, with notable examples including the issuance of green sukuk in the UAE and Saudi Arabia (Shalhoob, 2023). These instruments align with Islamic finance principles, making them particularly suitable for the region.

The profitability of green energy projects in the GCC is influenced by several factors, including policy incentives, market conditions, and operational efficiencies. Long-term PPAs with fixed tariffs have been instrumental in providing predictable revenue streams and enhancing investor confidence (Tagliapietra, 2019). Additionally, the decreasing costs of

renewable energy technologies, driven by global innovation and economies of scale, have improved profit margins. For instance, solar PV module prices have declined significantly over the past decade, making solar energy projects increasingly lucrative (IRENA, 2023). Policy measures, such as tax incentives and renewable energy credits, further enhance profitability. The introduction of carbon pricing mechanisms in GCC countries could also play a pivotal role in creating additional revenue streams for green energy projects (Al-Sarihi, 2020).

Kuwait has been making strides in renewable energy through several flagship projects aimed at diversifying its energy portfolio and reducing its carbon footprint. One of the most prominent initiatives is the Shagaya Renewable Energy Park. Located in the Al-Jahra Governorate, this project is a cornerstone of Kuwait's renewable energy strategy. The Shagaya project is a cornerstone of Kuwait's strategy to generate 15% of its energy from renewable sources by 2030. The government's substantial investment underscores its commitment to reducing reliance on fossil fuels and promoting environmental sustainability. These investments highlight Kuwait's dedication to advancing renewable energy infrastructure and achieving its long-term energy diversification goals.

The Shagaya Renewable Energy Project in Kuwait is a significant initiative aimed at diversifying the country's energy sources and promoting sustainability. The project has seen substantial government investment over the years. The project was initially allocated a budget of approximately 100 million Kuwaiti Dinars (KWD), equivalent to around \$330 million USD. The actual spending varies, as the project progressed, the total investment increased to about 179.13 million KWD, approximately \$591 million USD. The Ministry of Electricity, Water, and Renewable Energy has reported 18% spending rate on its projects in the first six months of 2024. Furthermore, KOC should develop further renewable energy and green hydrogen facilities. The project involves the development of 17 GW of renewable energy and 25 GW of green hydrogen production facilities in Kuwait by 2050.

### 3 METHODOLOGY

This research paper analyses historical data from 2010 to 2023 to link the key factors influencing investment in solar energy capacity (measured in megawatts) in Kuwait. A multiple regression model is used to examine these relationships. The dependent variable in this study is solar energy investment, measured in megawatts (MW). The independent variables consist of financial and operational factors that influence investment decisions. The data was collected

from multiple reliable sources, including the International Renewable Energy Agency (IRENA) and MARKAZ (Kuwait Financial Centre). Furthermore, project simulations for solar investments between 10 MW and 50 MW were developed to estimate financial indicators such as Internal Rate of Return (IRR) and Payback period, incorporating current market data and operational assumptions from comparable projects in the GCC region.

### 3.1 THE DATA

This is an empirical study using secondary annual data from 2010 to 2023 obtained from multiple credible sources, most particularly the International Renewable Energy Agency (IRENA), the Kuwait Financial Centre (MARKAZ). To further assess the financial and economic feasibility of PV solar energy investments, the authors developed project models supported by simulations based on installed capacities ranging from 10 to 50 MW. The main objective of the designed model is to estimate the key investment determinates the internal rate of Return (IRR) and Payback period.

The model data is obtained from current market data from Kuwait as well as performance insights from comparable renewable PV solar energy projects implemented across in Middle East countries. The modelling framework incorporates a range of economic, financial, and operational data and some assumptions to ensure the validity and robustness of the research.

**Table 1**

*Variables of the Model (Source: IRENA, MARKAZ, Authors' calculations).*

<b>Year</b>	<b>Installed capacity RES</b>	<b>Weighted-average capacity factor</b>	<b>LCOE kw/USD</b>	<b>WACC</b>	<b>IRR</b>	<b>PAYBACK</b>	<b>PVOUT - Best</b>
<b>2023</b>	114	16.20%	0.0440	9%	14%	7	1753
<b>2022</b>	114	16.90%	0.0500	10%	16%	8	1753
<b>2021</b>	96	17.20%	0.0520	9%	14%	7	1753
<b>2020</b>	97	16.10%	0.0600	8%	14%	6	1753
<b>2019</b>	106	17.50%	0.0670	7%	12%	8	1753
<b>2018</b>	56	17.90%	0.0770	7%	15%	9	1753
<b>2017</b>	44	17.50%	0.0910	6%	15%	7	1753
<b>2016</b>	33	16.70%	0.1160	7%	14%	6	1753
<b>2015</b>	6	16.50%	0.1320	9%	15%	8	1753
<b>2014</b>	4	16.60%	0.1770	9%	14%	9	1753
<b>2013</b>	3	16.40%	0.1970	5%	13%	7	1753
<b>2012</b>	0	15.10%	0.2560	6%	12%	8	1753
<b>2011</b>	0	15.20%	0.3430	6%	11%	9	1753
<b>2010</b>	0	13.80%	0.4600	5%	10%	6	1753

### 3.2 EXPLANATION OF THE MULTIPLE REGRESSION MODEL

To examine the relationship between the dependent variable – solar investment measured in MW and six independent factors, a general standard linear regression model is used to estimate the relationship. The model is used as follows:

$$\text{Investment in MW } Y_i = \beta_0 + \beta_1 (\text{capacity factor}) + \beta_2 (\text{LCOE}) + \beta_3 (\text{WACC}) + \beta_4 (\text{IRR}) + \beta_5 (\text{PAYBACK}) + \beta_6 (\text{PVOUT}) + \epsilon$$

In this model,  $Y_i$  expresses the solar investment amount, quantified in megawatts (MW), serving as the dependent variable.  $\beta_0$  is the intercept term, expressing the expected value of  $Y_i$  when all independent variables are equal to zero.  $\beta_1$  through  $\beta_6$  are the coefficients corresponding to each independent variable, capturing the marginal effect of a unit change in the respective variable on the dependent variable.  $\epsilon$  is the error term, accounting for unobserved factors and random disturbances that may influence the investment in solar energy but are not included in the model.

Each variable of the model is described as follows: Capacity Factor (Weighted-Average Capacity Factor%). This variable measures the efficiency of energy generation from solar plants. A higher capacity factor indicates better performance and greater output, which can encourage higher investment. The coefficient  $\beta_1$  captures the relationship between operational efficiency and investment level. The Levelized Cost of Electricity (LCOE) shows the average cost associated with producing a single kilowatt-hour of power across the life of the solar project.

When the LCOE is lower, the project becomes financially attractive, potentially resulting in greater investor interest. The coefficient  $\beta_2$  in the regression model indicates how changes in LCOE affect investment levels. The Weighted Average Cost of Capital (WACC) measures financing expenses; higher WACC values typically discourage investment by reducing project profitability. IRR (Internal Rate of Return) indicates the profitability of the project. A higher IRR increases investor confidence and expected returns, encouraging greater investment.

The coefficient  $\beta_4$  measures this effect. The payback period evaluates the overall financial return in years from the investment. As with IRR, and reasonable payback period is likely to promote greater capital allocation to solar projects.  $\beta_5$  represents this influence. PVOUT (Best). This variable estimates the solar energy output under optimal conditions.

Higher output forecasts imply better project performance.  $\beta_6$  reflects the effect of solar resource potential on investment.

#### 4 RESULTS AND DISCUSSIONS

The objective of this model is to examine the relationship between the dependent variable and the independent variables.

**Table 2**

*Regression model output*

Regression Statistics	Format
Multiple R	0.8817421
R Square	0.7774691
Adjusted R Square	0.5867283
Standard Error	30.739157
Observations	0.8817421

Based on the outcomes, the multiple R value of 0.8817 shows a strong link between projected outcomes and observed values. This indicates that the model used is applicable in finding the strengths of the relationship. The R-Square value confirms that 77.75% of the variation in the dependent variable is explained by the given independent variable in the model.

This high percentage shows a good fit and reveals that the model covers up the variability in the outcome. The Adjusted R-Square explains the number of predictors in the model and adjusts for any potential overfitting. The value of 0.5867 is notably lower than  $R^2$ , indicating that some of the independent variables included in the model may not be contributing significantly to the explanation of the dependent variable.

A standard error of 30.74 implies that the model's predictions typically deviate from the observed values. The ANOVA table assesses the overall significance of the regression model:

**Table 3**

*ANOVA (Analysis of Variance)*

ANOVA	DF	SS	MS	F	Significance F
Regression	6	23108.65809	3851.443014	4.076050588	0.044088579
Residual	7	6614.270485	944.8957836		
Total	13	29722.92857			

Based on the regression result given in table 3, we observe 6 degrees of freedom for the model and 7 for the residuals. The F-statistic is calculated at 4.076, with a matching p-value of

0.04408. Since this p-value falls below the common base of 0.05, the model can be considered statistically significant at the 5% level. This implies that the independent variables included in the model help explain the variation in solar energy investment, measured in megawatts (MW).

The total variation (sum of squares) amounts to 29,722.93, of which 23,108.66 is recognized to the regression component. This indicates strong explanatory power. Based on these results, the model is reliable and fit for further interpretation or policy discussion.

**Table 4**

*Regression output*

	<b>Coefficients</b>	<b>Standard Error</b>	<b>t Stat</b>	<b>P-value</b>	<b>Lower 95%</b>	<b>Upper 95%</b>	<b>Lower 95.0%</b>	<b>Upper 95.0%</b>
<b>Intercept</b>	433.1161	373.9200	1.158312	0.284723	-451.0641	1317.296	-451.0641	1317.296
<b>Capacity factor</b>	-602.8632	2269.780	-0.265604	0.798196	-5970.041	4764.315	-5970.041	4764.315
<b>LCOE kw/USD</b>	-454.7936	224.2871	-2.027729	0.082187	-985.1483	75.56116	-985.1483	75.56116
<b>WACC</b>	891.2937	973.6603	0.915405	0.390422	-1411.047	3193.634	-1411.047	3193.634
<b>IRR</b>	-1767.325	981.1582	-1.801264	0.114672	-4087.396	552.7451	-4087.396	552.7451
<b>ROI</b>	-5.896836	10.83867	-0.544055	0.603292	-31.52621	19.73254	-31.52621	19.73254
<b>PVOUT - Best</b>	0	0	65535	#NUM!	0	0	0	0

The table 4 summarizes the output from an ordinary least squares (OLS) regression analysis that examines how several independent variables such as Capacity Factor, LCOE (Levelized Cost of Electricity), WACC (Weighted Average Cost of Capital), IRR (Internal Rate of Return), Payback period, and PVOUT (Photovoltaic Output - Best)—affect the dependent variable.

**Table 5**

*Significance of Variables*

<b>Variable</b>	<b>Coefficient</b>	<b>t-Statistic</b>	<b>p-Value</b>	<b>Significance</b>
<b>Intercept</b>	433.12	1.1583	0.2847	Not Significant
<b>Weighted-Average Capacity Factor</b>	-602.86	-0.2656	0.7982	Not Significant
<b>LCOE (USD/kW)</b>	-454.79	-2.0277	0.0822	Marginally Significant
<b>WACC</b>	891.29	0.9154	0.3904	Not Significant
<b>IRR</b>	-1767.33	-1.8013	0.1147	Not Significant
<b>Payback period</b>	-5.9	-0.5441	0.6033	Not Significant
<b>PVOUT - Best</b>	0	65535	#NUM!	Error

Based on the table 5 where the significance of variables is listed, it shows that LCOE has a negative coefficient (-454.79) and a p-value of 0.082 (marginally significant). This signifies that lower LCOE is linked to increased investment in Kuwait's energy sector. The regression analysis aimed to identify the key financial and operational factors influencing

investment in solar energy projects. The results show that most variables are statistically insignificant at standard levels. The intercept has a coefficient of 433.12 with a p-value of 0.2847, showing it is not statistically significant. The Weighted-Average Capacity Factor and WACC also show no significance, with p-values of 0.7982 and 0.3904, respectively, and very low t-statistics. This suggests that changes in these variables do not meaningfully influence the dependent variable in the model. LCOE (USD/kW) has a coefficient of -454.79 and a p-value of 0.0822. Although not strictly significant at the 5% level, it is marginally significant at the 10% level, indicating that higher LCOE may negatively impact project attractiveness. This result is consistent with regional investor preferences, where lower energy costs enhance project feasibility. IRR and Payback period are not statistically significant, implying limited explanatory power within the current model. The PVOU - Best variable presents an error (NUM!).

Overall, the model indicates that LCOE holds some marginal predictive value, while other variables require re-evaluation. While the model suggests a potential relationship between LCOE and investment, the statistical insignificance of other variables suggests that the model may need refinement with additional data or different independent variables.

The analysis indicates that LCOE has a marginally significant impact on investment in MW capacity. The negative coefficient (-454.79) suggests that as LCOE decreases, investment in MW increases. This finding aligns with economic expectations, as lower energy generation costs make solar projects more financially attractive. However, since the p-value (0.082) is slightly above the standard significance threshold of 0.05, the relationship is not strongly confirming but still indicative of a potential trend.

While these financial indicators are not statistically significant in the model, IRR ( $\beta = -1767.33$ ) shows a relatively large negative coefficient, indicating a negative impact. This suggests that as IRR decreases, investment could potentially increase, which might be due to market conditions, risk factors, or financing structures that affect investor decision-making. However, due to the high p-values, these variables do not show a strong or reliable impact on this specific dataset. The capacity factor (-602.86,  $p = 0.7982$ ) is not statistically significant, meaning that higher efficiency alone does not necessarily drive investment decisions. This suggests that investors in the solar energy sector may prioritize financial factors like cost structures, incentives, and risk management over pure efficiency metrics.

The findings indicate that LCOE plays a critical role in investment decisions, while financial indicators (WACC, IRR, and Payback period) may require additional analysis to

determine their full impact. Capacity factor alone is not a decisive factor, highlighting that investment decisions in solar projects are influenced by a complex mix of economic, financial, and policy-related factors. The regression results show that most economic and financial indicators, such as WACC, IRR, ROI, and Capacity Factor, are statistically insignificant predictors of solar energy investment in Kuwait. This empirical finding aligns with prior literature noting persistent regulatory uncertainty and institutional inertia in the GCC, particularly Kuwait (Tagliapietra, 2017; Atalay et al., 2006). It confirms that economic metrics alone do not drive investment decisions in this context.

Several studies in the literature review (Al-Sarihi, 2020; Minić & Filipović, 2024) emphasize the dominant influence of policy frameworks, institutional commitment, and international support over financial optimization. The lack of significance in traditional investment drivers supports the conclusion that non-economic barriers, such as policy inconsistency, weak enforcement, and limited private-sector confidence, may dominate.

The findings reinforce the need for robust policy tools, such as feed-in tariffs, power purchase agreements (PPAs), and renewable portfolio standards (RPS), to mitigate investment risks and incentivize market entry. Without regulatory certainty, even favourable financial conditions (e.g., low LCOE or high IRR) may not be enough to attract investors. Despite limited significance in the regression model, literature emphasizes several long-term financial benefits of renewables. As IRENA (2023) reported, decreased marginal cost of production due to technological learning and scale. Al-Sarihi & Mansouri (2022) recommended reduced reliance on fossil fuel subsidies.

The regression results show LCOE as marginally significant ( $p = 0.082$ ), with a negative coefficient, confirming that lower LCOE improves investment attractiveness. This empirical link supports the literature's claim that cost-effective solar technologies (e.g., PV systems) are gradually improving the bankability of projects. The literature highlights that renewable LCOE is steadily decreasing, while oil-based generation remains volatile and subsidy-dependent. The regression analysis strengthens this claim, as LCOE's negative coefficient suggests that lower LCOE is a meaningful driver of investment. Although the regression is only marginally significant, it suggests a cost advantage for solar energy in the medium term, aligning with international observations (Donastorg et al., 2017; IRENA, 2021). Initial capital costs, though not explicitly included in the regression, are discussed extensively in the literature as a major barrier. The Shagaya project alone required KWD 179.13 million (~\$591M), revealing the high upfront cost structure of renewables in Kuwait.

The model's standard error of ~30.74 suggests substantial variance around predicted values, possibly reflecting cost-related volatility or project-specific anomalies. Also, the statistical insignificance of ROI and IRR suggests high financial uncertainty, reinforcing the argument for blended finance solutions like public-private partnerships (PPPs), green bonds, or sovereign guarantees (World Bank, 2023). The regression model's inability to show strong statistical relationships supports this. Investment decisions appear less influenced by economic signals and more by state-driven initiatives and external institutional support (e.g., KISR, IRENA, World Bank).

Using project finance can create organizational structures that offer significant advantages from a company-internal perspective (Steffen, 2018). By structuring projects as standalone entities, often through Special Purpose Vehicles (SPVs), companies can isolate financial risks, ensuring that liabilities associated with the project do not directly impact the parent company's balance sheet. This separation allows for a more precise allocation of resources and accountability, improving operational and financial transparency. Additionally, project finance enables the use of non-recourse or limited-recourse funding, where lenders rely primarily on the project's cash flows for repayment, reducing the parent company's exposure to financial risk. This approach also allows for customized governance structures tailored to the specific needs of the project, facilitating more efficient decision-making and stakeholder alignment. Overall, project finance not only mitigates risk but also enhances strategic flexibility and resource optimization for the parent company. The findings indicated three critical insights:

1. Policy trumps economics in driving investment in Kuwait's renewable energy sector.
2. LCOE offers promise as a cost indicator but must be supported by policy tools to unlock its potential.
3. The current investment ecosystem lacks maturity, requiring institutional reform, innovative financing, and stakeholder engagement to move forward.

Although not statistically robust across all variables, the potential for reduced long-term costs, diversified funding mechanisms, and increasing energy security justifies continued investment, particularly when supported by strong institutions. Future policy should benchmark solar LCOE against traditional energy to transparently demonstrate cost advantages to potential investors. Broader adoption of financing mechanisms such as green sukuk and citizen funding can reduce dependence on state allocations and improve financial accessibility.

Furthermore, Kuwait's target to achieve 15% renewable energy by 2030 is still far from realized, with only small-scale demonstration projects and Phase I of Shagaya completed. The

literature and the historical project review show progress has been slow and fragmented, despite high-level policy ambitions. To align better with Vision 2035, Kuwait must enhance its regulatory framework, de-risk investments, and engage more private sector actors through better financial predictability and policy clarity.

## 5 CONCLUSION

This study aims to empirically analyse the influence of traditional economic and financial factors on solar energy investment projects in Kuwait. To achieve this, a multiple linear regression analysis was applied using project-level data from Kuwaiti solar investments between 2010 and 2023. Six independent variables are tested to explore relationship with investment trends in the renewable energy sector. Additionally, a financial model was developed to evaluate the feasibility of solar energy projects, considering varying installed capacities ranging from 10 MW to 50 MW. The model focused on estimating key traditional investment indicators, specifically the Internal Rate of Return (IRR) and the Payback Period, to evaluate the financial viability of such projects.

Most of the dependent variables were not statistically significant, except for a small effect from the Levelized Cost of Energy (LCOE). This suggests that while the general direction is useful, more work is needed to understand the role of specific factors.

The regression model results show that financial indicators like IRR, Payback, and WACC are insignificant as financial metrics that influence solar investment in Kuwait. This suggests that market forces alone are insufficient to drive renewable energy investment at the target and pace required, and that is clearly stated in Kuwait Vision 2035. In such a scenario, public policy must act as the primary control to stimulate investor confidence and promote a sustainable energy transition.

These findings show that relying solely on conventional investment metrics may not be enough to rapidly advance renewable energy development in Kuwait. Therefore, proactive public policy is essential to strengthen investor trust and drive a successful transition to sustainable energy sources.

In this regard, based on regional and global experiences, policy interventions are the primary mechanism for accelerating the investment cycle, enhancing the financial attractiveness of renewable energy projects in Kuwait, and reducing perceived risks. The policy

intervention with attractive tools must guide Kuwait toward a green energy transition that aligns with Vision 2035:

1. Long-Term Power Purchase Agreements (PPAs): The government should introduce long-term Power Purchase Agreements (PPAs).
2. Land Allocation and Infrastructure Facilitation: Establish renewable energy zones with pre-allocated land, access to transmission infrastructure (grid connection).
3. Feed-in Tariffs or Auction-Based Pricing Mechanisms Implement: Feed-in Tariffs (FiTs): Guaranteed pricing for electricity fed into the grid from solar sources.
4. Fiscal Incentives and Soft Loans: Offer tax exemptions on imported renewable energy equipment, and access to subsidized or soft loans through the Development banks or commercial ones.

Despite global advancements in solar energy, Kuwait's renewable energy sector remains underdeveloped compared to regional counterparts such as the UAE and Saudi Arabia. The country's National Renewable Energy Strategy targets 15% of electricity generation from renewables by 2030 (Kuwait Institute for Scientific Research, 2022), yet financial incentives remain limited. The absence of feed-in tariffs and other investment-friendly policies has slowed the pace of solar energy deployment. While projects like the Shagaya Renewable Energy Park demonstrate government interest, financial mechanisms tailored to support small-scale and decentralized solar investments are needed. The research recommends the following:

- Implement mandatory long-term PPAs to stabilize returns.
- Develop a renewable energy law with binding targets and penalties for non-compliance.
- Scale green financing tools (sukuk, green bonds) to attract both domestic and international capital. The same recommendations for new financial models, like green sukuk and citizen funding, offering alternative capital sources, have been recommended by researchers (Lam & Law, 2018; Tyl & Lizarralde, 2017).

In recent years, citizen funding has emerged as a viable alternative, enabling individuals to contribute directly to renewable energy initiatives. This approach not only diversifies funding sources but also fosters public engagement and ownership of renewable energy projects.

Citizen funding can take various forms, including crowdfunding, energy cooperatives, green bonds, and community shares. Crowdfunding platforms, such as Trine and SunFunder, have successfully financed small-scale solar projects in developing regions. These platforms allow individuals to invest small amounts in renewable energy projects and receive financial returns. Energy cooperatives, on the other hand, involve collective ownership and operation of

renewable energy facilities by local communities (Bauwens et al., 2016). For example, the Middelgrunden Wind Cooperative in Denmark demonstrates the potential of community-driven renewable energy development (Huybrechts & Mertens, 2014).

Citizen funding offers several advantages for renewable energy projects. It diversifies the financial base, reducing reliance on government and institutional funding. Additionally, it enhances public engagement by fostering a sense of ownership and accountability among contributors. Moreover, the revenue generated from such projects often stays within local communities, supporting economic development and job creation. Furthermore, regulatory barriers in some regions can hinder the implementation of citizen funding mechanisms. However, the rise of digital platforms and supportive policies can address these challenges. In the GCC region, integrating citizen funding into national renewable energy strategies and aligning them with Islamic finance principles, such as sukuk, could significantly enhance participation (Yildiz, 2014).

Citizen funding represents a promising alternative for financing renewable energy projects. By leveraging individual contributions, it not only addresses financial challenges but also fosters community engagement and social acceptance of renewable energy initiatives. For countries like Kuwait and others in the GCC, adopting citizen funding models can accelerate their renewable energy goals while promoting economic and environmental sustainability. Future research should focus on creating enabling regulatory frameworks and exploring innovative platforms to maximize the potential of citizen funding.

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