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A Comprehensive Economic Assessment of Renewable Energy Deployment: Solar, Wind, and Hydropower Potential

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Abstract: After a decade of conflict, Syria's electricity sector has suffered $40 billion in direct losses and $80 billion in indirect losses, leaving more than 50% of the electrical grid incapacitated and public electricity supply limited to 2–4 hours per day. This paper provides a techno-economic assessment of Syria's renewable energy potential in three geographical contexts: utility-scale solar photovoltaic development in the Palmyra desert, wind energy deployment near Homs, and Euphrates River hydropower generation. Syria has abundant renewable energy resources, including solar irradiation exceeding 5.5 kWh/m²/day in Palmyra, wind potential of 80,000 MW nationwide with promising conditions west and east of Homs, and hydroelectric infrastructure with 880 MW installed capacity at the Euphrates Dam. Solar PV systems have LCOE values of $0.094–0.125/kWh in inland governorates, significantly lower than diesel generator expenses, which are the main energy source for households and businesses. A 40–50 MW wind farm near Homs, which will generate 150 million kWh per year, offers comparable economic benefits. Hydropower has the lowest marginal operating costs, but drought and transboundary water management issues limit it. The paper recommends incorporating these renewable resources into Syria's post-conflict reconstruction framework, emphasizing their strategic importance for energy security, economic diversification, and sustainable development.

Keywords: Renewable Energy; Solar PV; Wind Power; Euphrates Dam; Levelized Cost of Electricity; Post-Conflict Reconstruction; Energy Security; Global Horizontal Irradiance.

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1. Introduction

Syria's electricity sector has been left reeling from one of the worst infrastructure crises in modern history, after more than a decade of armed conflict has resulted in a fragmented and underfunded power system that cannot meet even basic national demand [1]. The conflict has caused extensive damage to power plants, transmission lines, substations, fuel infrastructure, and maintenance facilities, reshaping the country's energy landscape and creating an urgent need for sustainable reconstruction strategies [2]. The direct losses in the electricity sector have been estimated at around USD 40 billion. In contrast, indirect economic losses exceed USD 80 billion, reflecting not only the destruction of physical infrastructure but also the wide social, industrial and economic impacts of unreliable electricity supply [3]. Over half of Syria's electrical grid is out of service, forcing millions of citizens to rely on expensive, environmentally damaging alternative energy sources to meet basic household and commercial needs. The country's energy crisis is thus a humanitarian and developmental challenge, with renewable energy becoming increasingly important in post-conflict recovery. Before the conflict, Syria's electricity system was relatively integrated, relying on thermal power generation complemented by hydropower. Most of the electricity was generated from natural gas and fuel oil [4]. There were large hydro plants along the Euphrates River that added a fair amount of generation capacity when water levels were sufficient.

But years of conflict have interrupted fuel production, damaged pipelines, slashed natural gas supplies and reduced the operational capacity of conventional power stations [12]. Therefore, electricity generation has declined, leading to chronic shortages in both urban and rural areas. The Ministry of Electricity needs about 23 million cubic meters of natural gas per day to operate the generating stations properly, but only about 6.5 million cubic meters are available [5]. Similarly, less than half of the approximately 10,000 tons of fuel required daily is provided, severely constraining electricity generation. Therefore, much of the country receives only 2 to 4 hours of power from the grid, leaving households, hospitals, schools, businesses and industries heavily dependent on diesel generators and other costly options. The heavy dependence on diesel generators has resulted in additional economic and environmental costs [20]. Fuel prices have become erratic as supply shortages, transport challenges and fluctuating market conditions add to the financial burden of households already reeling from years of economic instability. Small businesses often allocate a significant share of their operating expenses to generator fuel, thereby reducing profitability and constraining economic recovery [16]. Diesel generators also produce considerable air pollution from the emission of particulate matter, carbon dioxide, nitrogen oxides, and other pollutants, leading to significant public health concerns in densely populated areas.

Renewable energy technologies in this respect offer a promising opportunity to rebuild Syria's electricity infrastructure while enhancing energy security, reducing dependence on fuel, lowering electricity prices and supporting sustainable development goals [19]. Syria has specific renewable energy resources that are largely untapped and have high technical potential. The country's geographical diversity offers favorable conditions for producing renewable electricity in various forms, such as solar photovoltaic, wind and hydropower. In large desert areas, there is plenty of sun year-round; on high plains, there is reliable wind for power generation; and major river systems still offer opportunities for hydroelectricity despite environmental challenges [18]. The chance to tap into these resources is not merely for rehabilitating damaged infrastructure but for upgrading Syria's electricity system with cleaner, more resilient and economically competitive energy technologies [17]. Among renewable energy sources in Syria, solar photovoltaic energy is the most attractive in the short term, given the country's very high levels of solar radiation. The Palmyra desert area in central Syria receives an average daily solar irradiation of more than 5.5 kWh per square meter, making it one of the most promising areas for utility-scale solar development in the country [1]. The large amounts of open land, relatively low population density and favorable climatic conditions create ideal conditions for building large photovoltaic installations capable of delivering substantial amounts of electricity.

Unlike conventional thermal power plants, solar photovoltaic systems do not need a constant fuel supply, making them less vulnerable to fuel shortages that have plagued Syria's electricity sector during the conflict [13]. The modularity of PV technology enables phased implementation, enabling projects to grow incrementally as financial resources allow. Over the past decade, the economic competitiveness of solar photovoltaic technology has improved dramatically, due to falling equipment costs, improved conversion efficiencies and advances in installation techniques [14]. Recent LCOE analyses show that solar PV projects in inland Syrian governorates can achieve electricity production costs of approximately USD 0.094 to USD 0.125 per kWh, making solar generation significantly more affordable than electricity produced by privately operated diesel generators [15]. These economic benefits are particularly relevant as diesel generation is a common solution for households and businesses to generate electricity during long-term power outages. Lower electricity prices can raise household welfare, raise business productivity, spur industrial recovery and reduce total energy expenditures across the economy [11]. Wind energy is another key renewable resource that can contribute to Syria's energy transition. According to national assessments, the theoretical wind energy potential is close to 80,000 megawatts, but only a small part of this potential can be exploited for immediate commercial development [6].

Good wind conditions are observed in areas around Homs, especially to the West and East of the city, which can support medium- and utility-scale wind farms. The current plans envisage the construction of a 40–50-megawatt wind farm, expected to generate about 150 million kilowatt-hours a year, demonstrating the practical viability of wind power development amid

Syria's reconstruction [7]. Wind energy is a good complement to solar generation because wind production often occurs when solar output is decreasing, thereby improving the overall reliability of the electricity system when both technologies are working together [8]. The successful realisation of wind energy projects depends on the careful evaluation of technical, environmental and economic aspects. Paper performance is influenced by wind resource assessments, grid integration planning, transmission infrastructure improvements and maintenance capabilities. But internationally, it has been proven that wind power can be a cost-effective source of electricity in regions with adequate wind resources [9]. The development of wind power near Homs, Syria, could diversify electricity generation, reduce reliance on imported fuels and bolster regional electricity supply.

Hydropower remains a significant part of the Syrian electricity system, though it faces growing environmental challenges. Several major hydroelectric plants are located on the Euphrates River, including the Euphrates Dam, which has a generating capacity of about 880 MW. Historically, these plants have provided significant power and benefits for irrigation, flood control, and regional water management. Once the infrastructure is in place, hydropower has relatively low operating costs compared to thermal generation, making it an economically attractive renewable resource in the long term [10]. However, the hydropower sector in Syria is facing growing constraints from declining river flows, longer drought periods, climate variability, reservoir sedimentation, and transboundary water management issues with upstream countries. Water availability directly influences electricity generation capacity and creates operational uncertainty in dry years. These limitations underscore the importance of considering hydropower as part of a broader renewable energy portfolio rather than as the exclusive foundation for future power generation [1]. Also, integrating hydropower with solar and wind resources can improve the overall system's resilience by compensating for seasonal and diurnal variations in electricity generation [11]. In addition to the availability of technical resources, the development of renewable energy generates broader socioeconomic benefits, especially significant in Syria's post-conflict context.

Renewable energy projects can create jobs in construction, installation, operation and maintenance, helping to rebuild the economy and technical know-how in the energy sector. Local production of certain components, workforce training programs and international investment partnerships can further enhance domestic capacity [4]. Improved access to electricity also benefits healthcare facilities, educational institutions, telecommunications networks, agricultural production, and small enterprises, generating positive multiplier impacts throughout the economy. It is also consistent with the global Sustainable Development Goals and international climate commitments to move toward renewable energy. While rebuilding Syria's critical infrastructure is a priority for immediate action, integrating renewable energy into reconstruction planning can help reduce long-term greenhouse gas emissions, improve energy affordability and enhance system resilience. Distributed renewable systems such as rooftop solar installations can provide electricity to remote communities where extending damaged transmission networks may be economically challenging. Community-scale renewable projects can increase local energy independence and cut transmission losses. Realising Syria's renewable energy potential will require coordinated policy reforms, investment incentives, institutional strengthening, and international cooperation.

To attract domestic and foreign investment, stable regulatory structures, transparent procurement mechanisms, financing arrangements, grid modernisation initiatives, and technical capacity-building programs will all be important. Public-private partnerships could accelerate the deployment of renewable energy and ease the financial burden on government institutions responsible for reconstruction. This study thus constitutes a comprehensive techno-economic assessment of renewable energy potentials in Syria across three distinct geographic contexts: solar PV at the utility scale in the desert region of Palmyra, wind energy around the city of Homs, and hydropower in the Euphrates River system [8]. The analysis indicates that by evaluating resource availability, economic competitiveness through levelized cost of electricity comparisons, existing infrastructure and ongoing development initiatives, renewable energy is one of the most viable pathways to rebuilding Syria's electricity sector. Renewable energy provides an opportunity to build a cleaner, more resilient, economically competitive, and sustainable electricity system that can contribute to long-term national recovery, enhance energy security, spur economic diversification, and improve the quality of life for millions of Syrians who have been affected by years of conflict, rather than simply replacing damaged conventional infrastructure [12].

1.1. Research Objectives

This paper aims to:

- Quantify the renewable energy resource potential across three strategic Syrian locations—Palmyra (solar), Homs (wind), and the Euphrates River system (hydropower).
- Assess the economic viability of renewable energy deployment in each context using LCOE analysis and avoided-cost methodologies.
- Evaluate the macroeconomic implications of renewable energy adoption for Syria's post-conflict reconstruction.
- Provide evidence-based policy recommendations for renewable energy integration.

2. Literature Review

As energy infrastructure is often one of the most heavily impacted components of national infrastructure during lengthy conflicts, the overlap between renewable energy deployment and post-conflict reconstruction has become an increasingly important field of study. In fragile and conflict-affected states, centralised electricity systems are particularly vulnerable because damage to power plants, transmission networks, substations and fuel supply routes can lead to widespread and prolonged electricity shortages. Many systems are well-suited to decentralised, modular deployment, so renewable energy offers an alternative path. Al-Attar [1] highlights that renewable energy can provide significant benefits in conflict conditions by decreasing reliance on damaged centralised infrastructure and enhancing energy resilience. Also, renewable systems can be important not only for energy policy but also for broader post-conflict reconstruction strategies, as they can contribute to employment creation, technical capacity building and economic recovery. The Syrian case in particular clearly illustrates these characteristics. The ongoing conflict has severely damaged conventional electricity infrastructure and disrupted the supply chains needed to operate thermal power plants. This has increased interest in decentralized and renewable energy solutions among communities, businesses and public institutions. Xinhua [3] mentions the destruction of traditional energy infrastructure, the lack of fuel, population displacement and the rising cost of electricity as important factors affecting the energy transition in Syria. The rising costs of conventional electricity have also encouraged households and businesses to look for renewable alternatives as a cost-effective alternative to unreliable public electricity and expensive private generators.

According to Enab Baladi [4], the economic argument for alternative energy systems is also reinforced by the heavy burden of electricity costs on Syrian households. Syria's geography provides a strong natural foundation for renewable energy development. Solar energy is the most widespread renewable resource in the country, with average solar irradiation of approximately 5.5 kWh/m2/day and some areas with levels close to 7 kWh/m2/day. Naouf and Elek [7] showed, through geospatial analysis, that large areas in Syria are highly conducive to large-scale solar electricity generation. Such conditions are particularly favourable in inland and desert areas where large areas of relatively low population density can accommodate utility-scale photovoltaic projects. Hatem et al. [5] further investigated the solar power potential in the Syrian desert and demonstrated the importance of optimising solar generation technologies based on local environmental and geographical conditions. The economic importance of solar energy is especially relevant in the current situation in Syria. The higher cost of conventional electricity and the financial burden imposed by diesel generators have improved the relative competitiveness of solar photovoltaic systems. Electricity bills have become a significant burden on Syrian households, diverting resources from food and other basic needs, according to Viktor and Amer [16]. Solar energy is a way to lessen this dependence by using an abundant domestic resource to generate electricity without the need to constantly purchase fuel. Naouf and Elek [7] also showed the huge geographical potential for large-scale solar generation, supporting the development of utility-scale and distributed photovoltaic systems. Wind energy is another major component of Syria’s renewable energy resource base. The total theoretical wind potential of the country has been estimated at around 80,000 MW. Promising sites have been found near Homs, on the eastern slopes of the coastal mountains, on Al-Sheikh Mountain and in the marine areas along the Syrian coast.

QazaqGreen [9] said it signed an agreement for 700 MW of wind power in Syria, showing growing interest by institutions and companies in tapping the country’s wind. The development of wind power can diversify electricity generation, reduce dependence on fossil-fuel-based generation, and create opportunities for local industrial development. Hydropower is another key part of Syria’s renewable electricity infrastructure. Before the war, large hydroelectric installations were built along the Euphrates River. The Euphrates Dam, also known as the Tabqa Dam, has eight generating units with a total installed capacity of about 880 MW, according to the Hidropolitik Akademi [6]. The Euphrates system is further augmented by the Tishrin Dam (adding 630 MW) and the Baath hydroelectric plant. These facilities demonstrate that Syria already has an extensive renewable energy infrastructure that could support reconstruction if technical, security, water resource and operational constraints are adequately addressed. Recent policy developments indicate that renewable energy is being integrated into Syria’s strategy for the reconstruction of its electricity sector. Ramadan and Elistratov [10] noted some progress in alternative energy development in Syria, indicating a growing institutional focus on renewable power generation. The country’s renewable energy targets, including the goal of deriving around 10% of electricity from renewable sources by 2030, indicate a gradual shift away from reliance on conventional generation toward a more diverse energy system. This shift is also reflected in recent big-ticket investment deals. Recent reports on the energy sector, such as by Amer and Hamed [11], cover new initiatives in electricity generation with solar and other renewable technologies. These include planned solar projects across various Syrian locations, including Widian Al-Rabee, Deir Ezzor, Aleppo and Homs.

The geographical spread of renewable projects can help reduce regional disparities in electricity availability and assist in the rehabilitation of electricity infrastructure in areas affected by long-term conflict. Wind development has also picked up speed. In February 2026, the Ministry of Energy of Syria signed a 700 MW wind-power agreement with Marv Energy, with the manufacturing of turbines planned in the company’s facility in Homs, reported QazaqGreen [9]. Such a project could yield benefits beyond electricity generation, as domestic turbine manufacturing can create skilled jobs, enhance technical capabilities, and promote industrial diversification. Hatem et al. [5] therefore supply evidence for an emerging link between renewable energy deployment and industrial reconstruction in Syria. Other solar development projects show the increasing interest in utility-scale photovoltaic generation. PVknowhow [8] reported a new 50 MW solar-farm project in Syria, reflecting the country's growing attention to large-scale solar power generation. Such projects should be judged not only by installed capacity, but also by expected annual electricity production, capacity factors, grid integration requirements, financing arrangements, environmental effects and long-term operation and maintenance requirements. Naouf and Elek [7] provide an important geographical basis for such assessments by showing the availability of sites suitable for large-scale solar generation. International cooperation is also an important enabler of Syria's renewable energy transition. The elaboration of a Renewable Energy Master Plan, with support from the Norwegian government and the United Nations Development Programme, is an important step toward establishing a coordinated national framework for renewable energy development.

Such planning can help determine future electricity demand, suitable renewable resources, the potential contribution of various technologies, and investment priorities. Al-Attar [1] stresses the significance of strategic energy planning in conflict and reconstruction contexts. Ramadan and Elistratov [10] note the growing policy attention to the development of alternative energy in Syria. Overall, Syria has a diverse renewable energy resource base that can make a significant contribution to post-conflict electricity reconstruction. Naouf and Elek [7] highlight the country's great potential for solar power, while QazaqGreen [9] highlights the growing development of wind power. Hidropolitik Akademi [6] discusses the importance of Syria's existing hydroelectric infrastructure, while Hatem et al. [5] demonstrate the technical potential of advanced solar generation technologies in Syrian desert conditions. These resources allow moving beyond mere replacement of broken conventional infrastructure and developing a more diversified, resilient and sustainable electricity system. Therefore, the renewable energy transition in Syria should be seen as an integrated approach, including utility-scale solar, wind energy, existing hydropower, distributed renewable systems, grid rehabilitation, energy storage and institutional reform. Al-Attar [1] emphasises the importance of renewable energy in improving energy resilience in conflict situations, and Enab Baladi [4] notes the significant economic burden of high electricity prices. At the project level, the work of PVknowhow [8], QazaqGreen [9], and UNDP Syria [18] shows an increasing trend in practical investments in renewable energy. Combined, these developments indicate that renewable energy could play a central role in Syria's post-conflict reconstruction strategy by enhancing energy security, reducing fuel dependency, supporting economic recovery, and contributing to long-term sustainable development.

3. Methodology

In this study, a mixed-methods research approach was used to evaluate the technical, economic and strategic potential for renewable energy development in Syria. This paper describes a methodology that combines quantitative resource assessment, technoeconomic analysis, comparative evaluation and scenario-based analysis to provide a thorough understanding of the feasibility of developing solar photovoltaic (PV), wind and hydropower in post-conflict settings. This approach is particularly relevant, as the renewable energy potential of Syria cannot be assessed solely on the availability of technical resources but also requires consideration of economic costs, infrastructure constraints, financing conditions, policy support and energy security needs. The purpose of the resource assessment is to determine the availability and geographic distribution of the major renewable energy resources in Syria. The potential for solar energy is assessed using satellite measurements of solar irradiance, particularly over the Palmyra Desert and other interior areas with high solar exposure. Parameters like average daily solar irradiation, annual sunshine duration, geographical location and suitability for large-scale PV deployment are taken into account. Wind resource assessment is based on wind speed measurements from meteorological observations and existing regional resource assessments. In evaluating the feasibility of wind-energy development, areas such as those surrounding Homs, the eastern and western city regions, coastal mountain slopes, Al-Sheikh Mountain, and selected coastal locations are considered. The hydropower potential is estimated by examining the existing dam infrastructure and installed generating and turbine capacities, as well as the historical electricity generation potential associated with major facilities such as the Euphrates, Tishrin and Baath dams. The techno-economic component employs a Levelized Cost of Electricity (LCOE) approach to estimate the average cost of electricity produced over the lifetime of the renewable energy project operations.

The analysis covers key investment and operational parameters, including initial capital expenditure, operating and maintenance costs, expected electricity generation, project lifetime, financing assumptions and discount rates. Discounted cash flow analysis is also used to assess the economic viability of proposed renewable energy projects, accounting for the time value of money and expected future cash flows. Where appropriate, sensitivity analysis is conducted to assess the potential effect of changes in capital costs, financing terms, energy production, and operating costs on project economics. Then, a comparative analysis is conducted to evaluate renewable energy technologies against conventional electricity generation alternatives. Special attention is given to diesel generators, which have become an important source of electricity for homes and businesses amid constraints in public electricity supply. The comparison considers the costs of electricity generation, fuel dependency, operating costs, emissions, reliability and susceptibility to fuel price changes. In addition to LCOE, solar PV, wind and hydropower are therefore assessed on their potential contribution to energy security and long-term resilience of infrastructure. Finally, scenario analysis is used to explore alternative renewable energy deployment pathways under different financing, investment and policy conditions. The scenarios model differences in the availability of project finance, government support, private-sector participation, technology costs, grid rehabilitation, and renewable energy targets. This enables the identification of potential opportunities and constraints associated with different reconstruction strategies. The methodology is based on a systematic approach to assessing the role of renewable energy in Syria's post-conflict electricity reconstruction and sustainable energy transition, incorporating resource availability, economic feasibility, comparisons with conventional energy and alternative policy scenarios.

4. Result and Discussions

4.1. Solar Energy Potential in the Palmyra Desert

4.1.1. Resource Assessment

The Palmyra region, located in central Syria, represents one of the country's most promising locations for utility-scale solar energy development. Solar radiation reaching the Earth's surface in Palmyra city is exceptionally high, making it ideal for solar electric power generation. The region's combination of high global horizontal irradiance (GHI), low cloud cover, and abundant available land creates optimal conditions for photovoltaic (PV) deployment. Syria's average horizontal solar irradiation is approximately 1,800 kWh/m²/annum (5 kWh/m²/day), with Palmyra among the highest-irradiance areas in the country. The region receives more than 5 kWh/m² of solar radiation daily, with some areas receiving as much as 7 kWh/m². This resource quality places Palmyra in the global top tier for solar energy potential, comparable to leading solar markets in the Middle East and North Africa.

4.1.2. Current and Planned Projects

A 50 MW solar farm project near Palmyra has been announced as part of a partnership between the Syrian government and French energy giant TotalEnergies. This facility could potentially power tens of thousands of homes, providing much-needed electricity to central Syria and supporting the revival of local communities and industries. The project represents one of the largest renewable energy ventures in Syria to date and offers a glimpse into a future less dependent on volatile fossil fuel imports. Beyond the Palmyra project, Syria's broader solar expansion plans include 1,000 MW of solar capacity across four locations under the UCC Holding agreement. These projects collectively represent one of the largest planned solar expansions in the country, aimed at diversifying the energy mix and reducing reliance on thermal generation.

4.2. Techno-Economic Analysis

4.2.1. Levelized Cost of Electricity (LCOE)

Recent techno-economic assessments of concentrated solar power (CSP) systems across 14 Syrian governorates have revealed substantial spatial variation in performance.

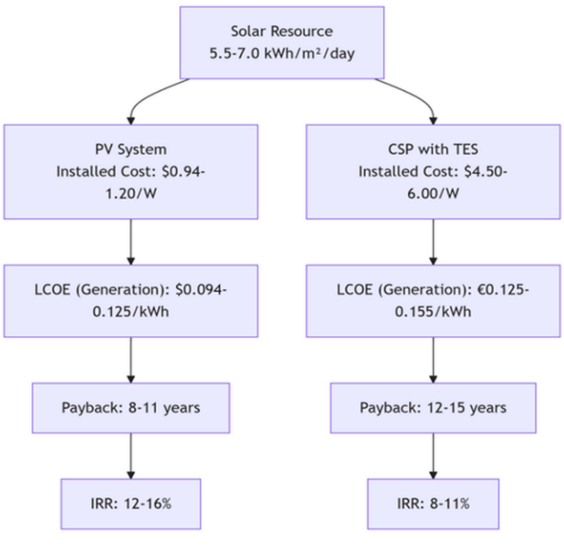

Figure 1: Comparative techno-economic framework for solar technologies in Syria

Inland governorates demonstrate significantly higher energy yields and lower LCOEs than coastal regions. Rif Dimashq exhibits the most favourable techno-economic performance, achieving up to 190 GWh of annual electricity generation with an LCOE of €0.1255/kWh under high Direct Normal Irradiation (DNI) conditions. For photovoltaic systems, economic calculations yield an LCOE of approximately $0.094/kWh, a discounted payback period of about 11 years, an internal rate of return of 14%, a profitability index of 1.46, and a net present value of $190,587. Solar power tower systems in the Syrian desert have been optimised to achieve an LCOE of 8.91 ¢/kWh and a total installed cost of $7,380/kW. Technical Note*:* The LCOE values shown represent *Generation-level* costs. In Syria's post-conflict context, *System-level* LCOE (which includes battery energy storage and transmission rehabilitation) would add approximately 40–50% to the Figures in Figures 1 and 2, making $0.18–0.22/kWh a more realistic, delivered cost threshold.

4.2.2. Avoided Fuel Import Costs

Syria's daily fuel cost for electric generation stations is 500 million SYP, equivalent to 170 billion SYP annually. With 5.3 million electricity subscribers, each receiving annual subsidies of approximately $320, the fiscal burden of the current energy system is immense.

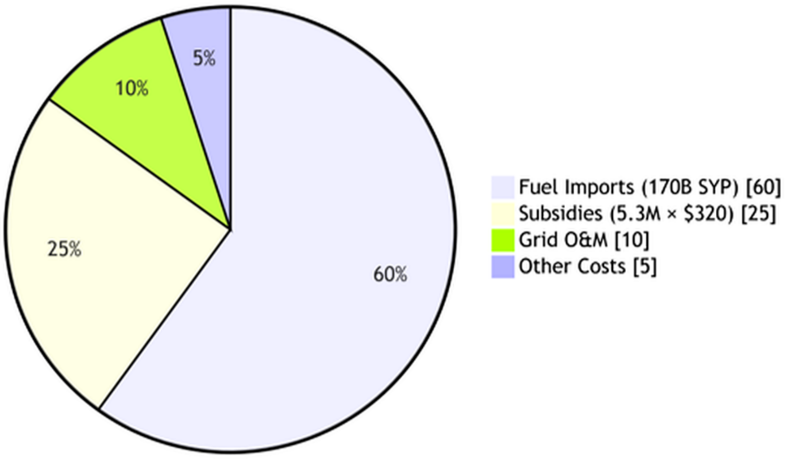

Figure 2: Composition of Syria's annual electricity sector costs

A 50 MW solar farm in Palmyra, operating at a capacity factor of 20–25%, would generate approximately 87.6–109.5 GWh annually. At avoided diesel generation costs of approximately $0.20–0.30/kWh (accounting for fuel imports, transportation, and generator maintenance), annual savings would range from $17.5–32.9 million. Over a 25-year project lifetime, total avoided costs would reach $438–822 million, substantially exceeding the estimated $50–75 million capital investment for a project of this scale.

4.2.3. Job Creation and Economic Multipliers

The solar energy sector offers significant employment potential. The broader UCC Holding project is expected to create over 50,000 direct jobs and nearly 250,000 indirect jobs. Solar installations create employment across manufacturing, project development, construction, and operations and maintenance, with particularly strong local employment multipliers in installation and O&M activities.

4.3. Wind Energy Potential Near Homs

4.3.1. Resource Assessment

The Homs region, particularly the area west and east of the city, has been identified as one of Syria's most promising wind energy locations. Wind speed measurements have been conducted at more than 20 stations across the country, with the Homs area demonstrating wind speeds within the economic investment range for wind farms using 2 MW wind turbines. The theoretical wind potential in Syria is estimated at 80,000 MW, with primary evaluations indicating that actual wind potential is close to theoretical levels. The National Centre for Energy Research has announced a tender for a typical wind farm of 40–50 MW in the Qutina area on the north side of Qutina Lake, west-southwest of Homs. This wind farm is expected to provide approximately 150 million kWh to the electric network annually.

4.3.2. Current and Planned Projects

Syria's wind energy sector is experiencing significant momentum. In February 2026, the Ministry of Energy signed a "Wind Power Project" agreement with Marv Energy to generate 700 MW of electricity. The paper relies on qualified Syrian expertise in turbine manufacturing and installation, with production taking place at the company's plant in Homs. Implementation will proceed in phases over five to seven years. The 700 MW capacity will be connected to the national grid rather than allocated to a specific province, ensuring benefit to all regions. Turbine installation sites will be selected based on available wind resources and speeds across Syria. This paper represents a "proof stage" of Syria's industrial capacity to compete regionally and internationally in wind energy technology.

4.4. Techno-Economic Analysis

4.4.1. Project Economics

For a 40–50 MW wind farm near Homs generating 150 million kWh annually, revenue projections can be estimated based on avoided generation costs. At a conservative wholesale electricity price of $0.10/kWh, annual revenue would reach $15 million. At a more realistic avoided diesel cost of $0.20/kWh, annual savings would be $30 million (Figure 3).

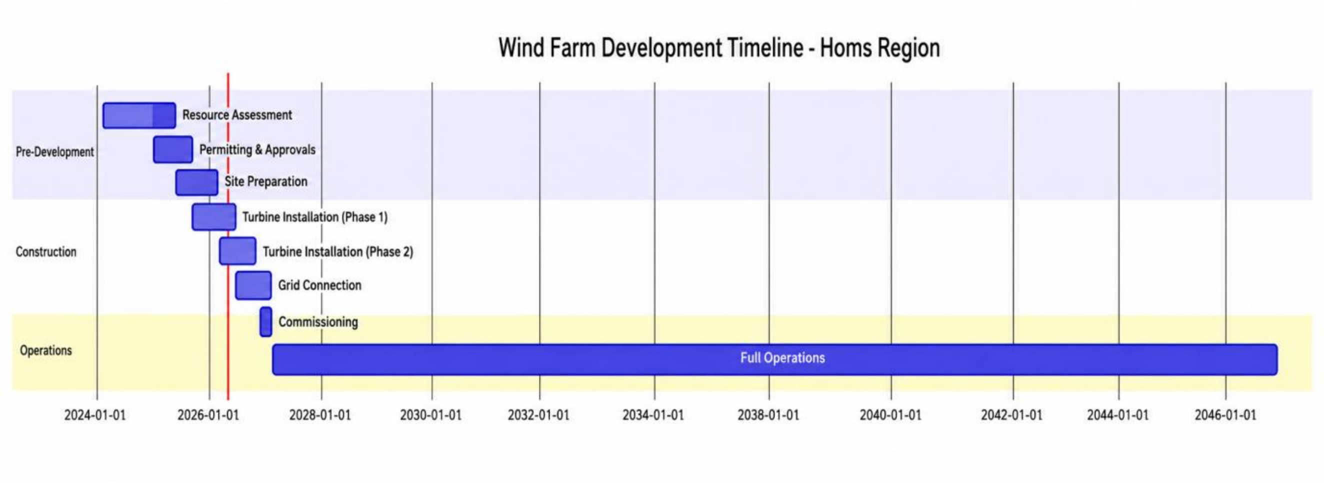

Figure 3: Indicative wind farm development timeline for Hom’s region

With typical wind turbine costs of $1.2–1.6 million per MW installed, a 50 MW project would require capital investment of $60–80 million. At $15–30 million annual revenue, simple payback periods would range from 2.0 to 5.3 years, with project lifetimes of 20–25 years yielding substantial returns.

4.5. Comparison with Thermal Generation

4.5.1. Hydropower Potential from Syrian Rivers

Wind energy has several advantages over thermal generation in Syria, such as independence from fuel, stable operating and maintenance costs, and zero direct greenhouse gas emissions. Wind power also doesn’t require cooling water, which makes it particularly well suited to Syria’s water-stressed environment.

4.5.2. Existing Infrastructure

Syria has constructed several dams on the Euphrates River to harness its potential for economic and social development. The Euphrates Dam (Tabqa Dam) plays a central role in Syria's water and energy supply. Its hydroelectric power station, located on the dam's right bank, contains eight generating units, each with a capacity of 110 MW, supplying electricity to large parts of the region. The dam's reservoir, Lake Assad, has a maximum storage capacity of 14.1 billion cubic meters, with a maximum level estimated at approximately 304 meters above sea level. The Tishrin Dam adds 630 MW with six turbines and an expected annual production of 1.6 billion kWh. The Baath hydroelectric plant provides additional capacity. Together, these facilities represent over 1,500 MW of installed hydroelectric capacity, substantial infrastructure that, if fully operational, could provide base-load renewable power to Syrian communities.

4.5.3. Current Operational Status

The Euphrates Dam's strategic importance has made it a focal point of conflict. In January 2026, the Syrian Army regained control of the Euphrates Dam, restoring water and power. This restoration represents a critical step toward rehabilitating Syria's hydroelectric capacity. However, hydropower generation faces significant challenges. Severe drought and climate change have led to reduced precipitation and snowfall—the primary sources of water for Syrian rivers. Syria has experienced frequent and severe drought waves in recent decades, leading to declines in rainfall and snowmelt. These hydrological constraints limit hydropower's contribution to Syria's energy mix, despite the substantial infrastructure in place.

4.6. Techno-Economic Analysis

4.6.1. Generation Economics

Once the infrastructure is in place, hydropower has very low operating costs, with most costs stemming from maintenance and personnel. The main benefits include dependable base-load power, operational flexibility, energy security from reservoir storage, and zero fuel costs (less susceptible to fuel price fluctuations) (Figure 4).

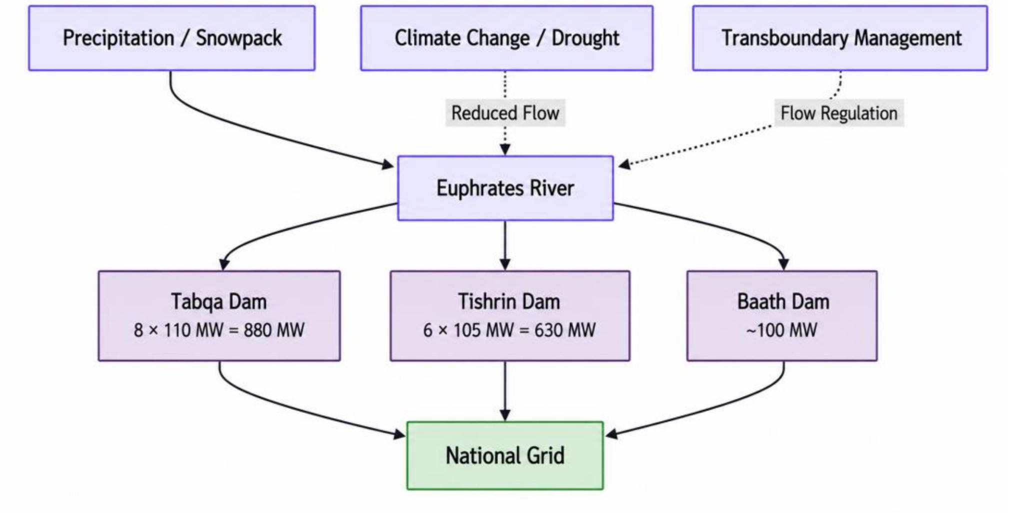

Figure 4: Syrian hydropower infrastructure on the Euphrates River system

Technical Note: Although nameplate capacity exceeds 1,500 MW, actual generation at the Euphrates complex currently operates at roughly a 30% capacity factor due to severe drought and upstream regulation. Consequently, the effective system LCOE for hydropower surges to roughly $0.12–0.18/kWh during dry years, diminishing its traditional cost advantage.

Rehabilitation Economics: Rehabilitating existing hydropower infrastructure offers superior economics compared to new construction. The marginal cost of restoring generation capacity at existing dams is typically 30–50% of the cost of new build. For Syria's damaged hydropower assets, rehabilitation investments could yield rapid returns through restored generation capacity.

Transboundary Considerations: The Euphrates is a transboundary river, with upstream dams in Turkey affecting downstream flow to Syria. Hydro-economic modelling has demonstrated the potential benefits of cooperative water management. Syria would benefit in most years, both in terms of increased power generation and flood abatement, from the regulation of flows in Turkey imposed by storage projects on the Euphrates River (Figure 5).

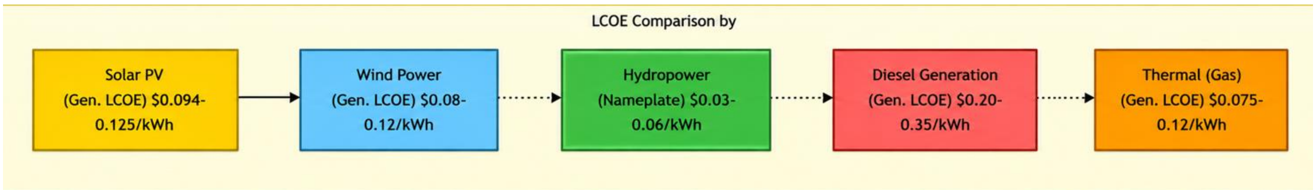

Figure 5: Comparative LCOE across generation technologies in Syria

While Generation LCOE values are presented above, the *System-level LCOE* (including battery storage to mitigate intermittency and transmission upgrades) for solar PV and wind rises to approximately \$0.18–0.22/kWh and \$0.14–0.19/kWh, respectively. This distinction is critical when budgeting for the reconstruction of Syria's decentralised grid. The analysis reveals that the lowest LCOE is for hydropower, \$0.03–0.06/kWh, but is limited by hydrological conditions and infrastructure. Wind power costs are in the range of \$0.08-0.12/kWh, which is competitive with thermal generation, while solar PV costs \$0.094-0.125/kWh and is still substantially cheaper than diesel generation. Diesel generation is the most expensive option (\$0.20-0.35/kWh), but still widely used due to unreliable grid electricity (Figure 6).

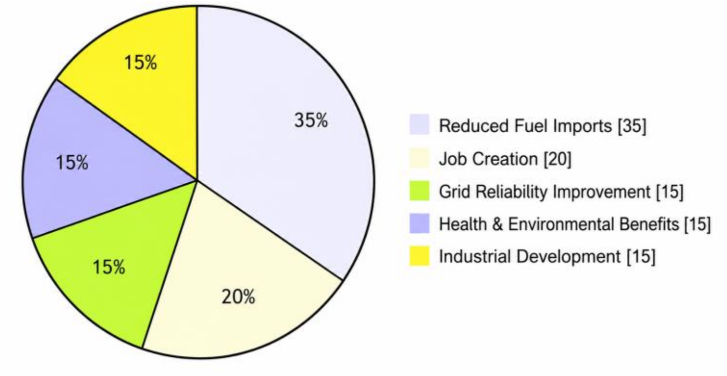

Figure 6: Projected economic benefits of renewable energy deployment in Syria

The use of renewable energy can yield significant macroeconomic benefits for Syria, such as reduced fuel import costs and an improved trade balance. Using domestic renewable resources can enhance energy security by decreasing dependence on vulnerable fuel supplies. The sector can also create jobs in manufacturing, installation, operation and maintenance, and in projects such as wind-turbine manufacturing in Homs, which can help support local industrial development and economic diversification (Figure 7).

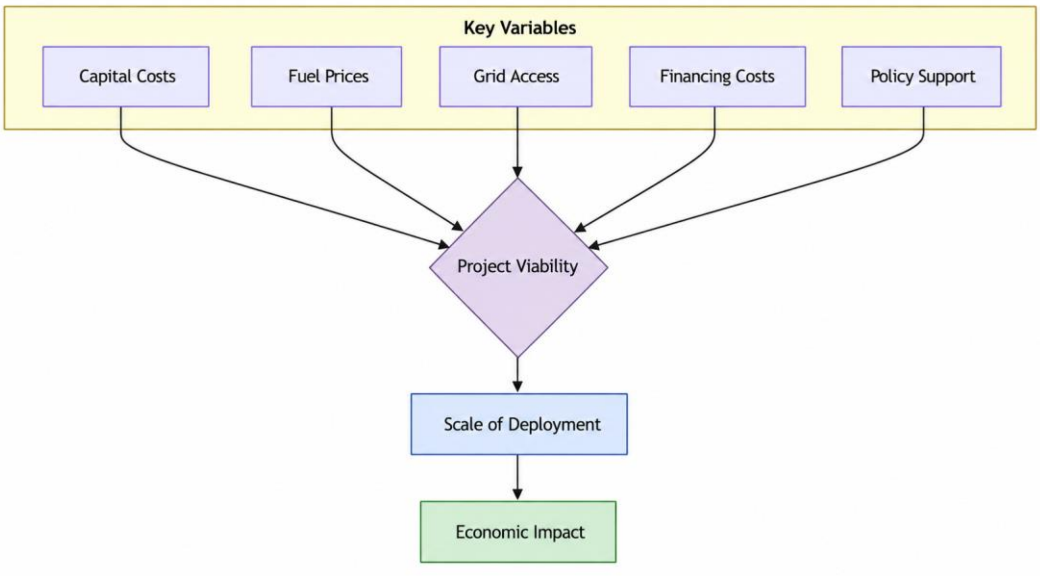

Figure 7: Sensitivity analysis framework for renewable energy viability

Sensitivity analysis indicates that the key drivers of renewable energy project viability are capital costs, fuel prices, financing costs and grid access. A 20% reduction in PV capital costs could increase the IRR by about 3–4 percentage points. A 50% increase in diesel prices could shorten the payback period of renewable energy by 2–3 years. Lower financing costs are also a significant factor in project economics; for example, a 5-percentage-point reduction in interest rates could increase NPV by 30–40%. Thus, concessional finance can be instrumental in the high-risk investment environment in Syria, enabling positive project returns. Finally, if the transmission grid were rehabilitated, larger renewable projects could be connected to the electricity system, thereby improving their overall economic performance. Syria needs to develop a transparent renewable energy regulatory framework that incentivises investment through feed-in tariffs, power purchase agreements and net-metering systems and streamline project approval and permitting processes. International financing should also be strengthened by leveraging UNDP and Norwegian support, seeking funding from multilateral development banks for grid rehabilitation, and exploring appropriate exemptions or mechanisms for humanitarian and reconstruction-related energy projects (Figure 8).

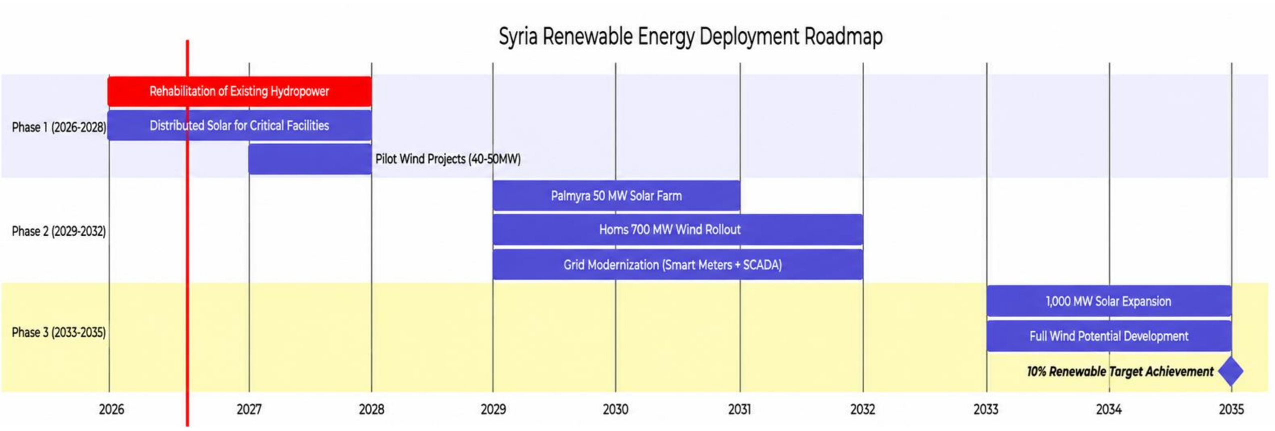

Figure 8: Phased renewable energy deployment roadmap for Syria

Investment in transmission and distribution infrastructure is critical for integrating renewable generation. The emphasis should be on network rehabilitation, smart-grid development, and energy-storage systems to enhance grid stability. Meanwhile, Syria ought to boost its local technical capacity through renewable-energy training programs, university-level engineering courses, and support for domestic manufacturing, including possibly wind-turbine production in Homs (Figure 9).

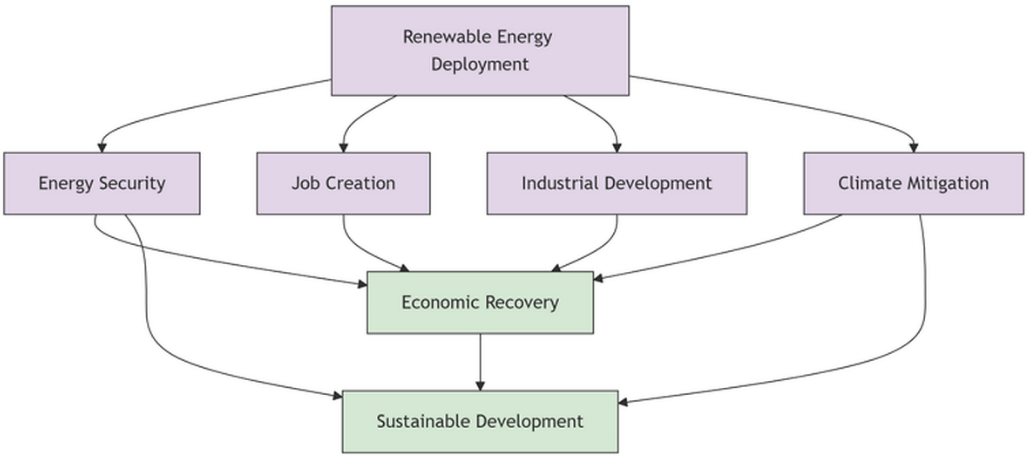

Figure 9: Synergistic benefits of renewable energy deployment

Finally, renewable energy should be integrated into broader post-conflict reconstruction planning, prioritising distributed systems for critical facilities such as hospitals and schools, and renewable electricity to support agricultural and industrial recovery.

5. Conclusion

This in-depth economic analysis shows that Syria has considerable renewable energy resources, which can play an important role in post-conflict reconstruction, energy security and economic recovery. The results suggest significant opportunities for solar, wind and hydropower, but their deployment must be supported by appropriate financing, infrastructure rehabilitation and policy support. Solar energy is one of the most promising renewable resources in Syria, especially in the Palmyra region, where mean solar irradiation ranges from 5.5 to 7.0 kWh/m2/day. The high solar potential provides favourable conditions for utility-scale PV development. Among announced projects is a 50 MW solar farm, a sign of rising investment interest. Evidence of solar PV's competitiveness is seen in generation-level LCOE estimates of about \$0.094–0.125/kWh. However, for realistic planning, system-level costs of \$0.18–0.22/kWh should be considered, as battery energy storage systems (BESS), transmission rehabilitation, and grid integration requirements can significantly increase total project costs. Wind energy also provides great opportunities, especially in the areas to the west and east of Homs. With a theoretical potential of around 80,000 MW, Syria has plenty of room for long-term growth. The 700 MW deal with Marv Energy is a significant prospect not only for power generation but also for industrialisation through planned turbine manufacturing in Homs.

The investment could help reduce dependence on imported energy, create jobs, develop local technical capacity and contribute to Syria's wider economic recovery. Hydropower remains a major part of Syria's renewable energy infrastructure. The Euphrates Dam has an installed capacity of about 880 MW, and the Tishrin and Baath dams add additional generation capacity. Hydropower has very low marginal operating costs, but severe droughts and cross-border water management challenges can significantly affect generation. The effective load factor may fall to about 30%, leading to a significant increase in the real cost of electricity. As such, hydropower will need to be increasingly considered a flexible resource that can respond quickly to complement variable solar and wind generation, rather than as a base-load source. The economic analysis suggests that solar, wind and hydro power can all contribute to Syria's future electricity system if appropriate financing mechanisms are in place. Where commercial borrowing costs are high at 12% or more, this can greatly reduce the profitability of the project. Where concessional financing is available at around 7%, it can greatly improve the project's viability. International financial institutions, development partners and multilateral organisations thus have an important role to play in reducing investment risks and enabling renewable energy projects to deliver sustainable financial returns. Renewable energy deployment can also generate significant macroeconomic benefits.

More use of domestic solar, wind and hydropower resources can cut dependence on imported fuels and costly diesel generation and boost energy security. Renewable energy development can create jobs in manufacturing, construction, installation, operation and maintenance. Furthermore, local manufacturing initiatives – such as the possible manufacture of wind turbines in Homs – have the potential to boost industrial capacity and encourage economic diversification. Renewable energy's strategic value extends beyond environmental sustainability. For Syria, renewable energy is a key element of long-term energy security and post-conflict economic reconstruction. The Renewable Energy Master Plan, with support from Norway and UNDP, can offer an important framework for establishing priorities, coordinating investments, improving grid integration and setting realistic renewable-energy targets. To summarise, moving Syria toward renewable energy requires coordinated efforts in policy formulation, international financing, grid rehabilitation, energy storage, technical capacity building, and industrial development. The country's solar, wind and hydro resources, with the right institutional and financial support, can play a major role in restoring reliable electricity services, reducing dependence on fuel, creating jobs and improving economic resilience. Renewable energy should be part of Syria's broader reconstruction strategy as a long-term investment in energy security, economic recovery and sustainable national development.

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