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# Harnessing Solar Energy in Post-Conflict: Transforming the Electricity Crisis into Renewable Energy Opportunity

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**Abstract:** Syrian electricity generation, once capable of generating 9.5 GW to serve over 22 million people, has been devastated by 14 years of civil war, leaving the country generating less than 20% of its pre-war capacity and providing only 3–4 hours of electricity in most regions. This article discusses solar energy's revolutionary potential to address Syria's electricity crisis and aid post-conflict development. Syria's exceptional solar resource endowment—exceeding 300 sunny days annually—the grassroots solar revolution that has increased off-grid solar capacity from 249 MW in 2022 to over 2,060 MW in 2025, and major international investments like the $7 billion Qatar-led consortium deal, the $1 billion Saudi solar agreements, and the ACWA Power 2.5 GW renewable energy framework are By 2025, Syria will rank fifth in the Arab world with 3,806 MW of renewable capacity, 59% from solar. The $35 billion legacy of electricity sector infrastructure destruction, the gap between installed capacity and actual generation, the dominance of off-grid residential systems over utility-scale infrastructure, and the need for coherent policy frameworks to transition from a survival-driven solar boom to a strategic national energy programme remain major challenges. The paper emphasises integrated utility-scale and distributed generation, regulatory frameworks, foreign investment, and human capital development to rebuild Syria's solar energy infrastructure. Syria and other conflict-affected nations seeking renewable energy recovery can apply these findings.

**Keywords:** Solar Energy; Total Renewable Capacity; Renewable Energy; Civil Conflict; Saudi Solar Agreements; Electricity Crisis; Distributed Generation; International Investment; Energy Reconstruction.

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## 1. Introduction

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A basic requirement for post-conflict reconstruction, economic recovery and institutional rebuilding is access to reliable, affordable energy [1]. The destruction of energy infrastructure in conflict-affected states is not simply an attack on electricity generation capacity but a systemic disruption that affects almost every aspect of social and economic life. Electricity networks underpin healthcare systems, water supplies, telecommunications, education, industrial production and public administration, and their collapse therefore has cascading humanitarian and development consequences that last long after the end of armed conflict [2]. Recent post-conflict reconstruction research shows a growing consensus that reconstructing energy systems should not be seen as simply re-establishing pre-war infrastructure, but as an opportunity to build more resilient, decentralised and sustainable systems that can support long-term national recovery. One of the most complex examples of energy infrastructure destruction in the contemporary world is the Syrian Arab Republic [3]. The Syrian electricity sector has been badly affected, with damage to generation plants, transmission lines and distribution networks after more than 14 years of conflict. Before the war, the country had about 9.5 GW of electricity generation capacity, enough for a population of more than 22 million. Long-term military operations, targeted attacks, poor maintenance and economic constraints have severely depleted national electricity production. Today, electricity generation is less than 20% of pre-war capacity, and many parts of the country get only three to four hours of power a day [4]. Such a steep drop has turned access to electricity from a run-of-the-mill public service into one of the country's most pressing humanitarian and economic challenges. Syria's electricity crisis affects far more than power availability.

The unreliable power supply causes serious problems for health facilities, especially for medical equipment, refrigeration systems, emergency services and hospital operations. Water infrastructure has also been badly hit, as pumping stations and treatment plants need reliable electricity. Educational institutions struggle to provide effective learning environments, especially as digital technologies become increasingly important in modern education systems [5]. Frequent power outages and dependence on expensive diesel generators have hampered economic activities such as manufacturing, agriculture and small businesses. Rebuilding Syria's social and economic foundations therefore requires restoring its electricity infrastructure. But the scale of destruction also provides an opportunity to reconsider Syria's future energy model. Renewable energy offers a path to a more resilient and sustainable energy architecture, rather than simply rebuilding centralised, fossil-fuel-dependent electricity systems. Decentralised systems can reduce exposure to infrastructure disruption, reduce dependence on imported fuels, and enhance energy security [6]. Renewable energy is a strategic tool for conflict-affected countries worldwide. In particular, solar energy offers many benefits in areas with high solar irradiation because it can be deployed at different scales, from household systems to large utility-scale solar farms. For countries emerging from conflict, this flexibility enables gradual renewable energy development while supporting immediate humanitarian needs and long-term economic transformation [7]. Syrian territory has unique solar potential, which can serve as a strong basis for renewable-energy-driven reconstruction. Syria lies within the global solar belt and enjoys more than 300 sunny days per year, providing favorable conditions for photovoltaic (PV) development across its fourteen governorates. Recent assessments find that a substantial part of Syria's territory is moderately to highly suitable for solar energy development, with some areas showing outstanding potential for large-scale solar deployment [8].

This resource edge allows Syria not only to address its domestic electricity shortage but also to fundamentally reshape its energy sector. Unlike traditional energy sources, solar energy does not rely on complex fuel supply chains and centralised infrastructure; instead, it enables distributed generation models that are especially beneficial in post-conflict contexts where grid infrastructure remains damaged [9]. The emergence of a community-based solar revolution reflects Syrian society's flexibility amid energy shortages. Without reliable grid electricity, households, businesses, and local communities have increasingly turned to off-grid solar systems. Solar capacity outside the traditional electricity network jumped from about 249 MW in 2022 to more than 2,060 MW in 2025. A desperate need for reliable electricity and falling solar technology prices drive the rush to build. Though it began out of necessity rather than strategy, this decentralised solar growth provides a vital base for a broader national renewable energy strategy [10]. Syria's renewable energy sector has attracted increasing international investment and regional cooperation. International energy firms and foreign investors sign major deals, reflecting growing awareness of Syria's renewable energy potential [11]. Major strides in rebuilding Syria's power sector include a Qatar-backed $7 billion energy development deal, Saudi solar investment projects worth $1 billion-plus, and ACWA Power's 2.5 GW renewable energy strategy. These investments represent a shift from emergency energy measures to building out large-scale renewable infrastructure [12]. Moreover, with suitable governance frameworks, such partnerships could promote technology transfer, employment generation and institutional capacity building.

However, these positive developments do not erase the significant challenges that must be overcome before solar energy can become a revolutionary pillar of Syria's national reconstruction strategy [13]. One big hurdle is the gap between installed renewable energy capacity and actual electricity generation. Much of Syria's existing solar capacity is deployed in off-grid systems, primarily intended for individual use rather than integration into a national electricity grid. Although these systems have increased access to electricity for many users, they are not, by themselves, a solution to national electricity shortages. To build a balanced energy system, Syria will need to integrate distributed solar generation, utility-scale solar farms, energy storage technologies, and modernised transmission infrastructure. Another major concern is the state of Syria's electrical infrastructure.

Decades of conflict have damaged power plants, substations and transmission lines, and estimates say losses to the electricity sector have topped $35 billion. Only by deploying renewable energy and investing in grid rehabilitation and modernisation can these structural limitations be overcome [14]. Therefore, a future energy strategy must combine renewable generation growth with infrastructure reconstruction, digital grid management, energy storage options and operational efficiency. Institutional and regulatory constraints also impede sustainable solar development. A successful transition to renewable energy requires clear policies, investment frameworks, land-use regulations, electricity pricing mechanisms and institutional co-ordination. Weak governance structures and fragmented decision-making in many post-conflict contexts can delay infrastructure development and discourage private-sector investment [15]. To transition to a renewable energy-based system, Syria will need transparent regulations that balance opportunities for foreign investment with national energy sovereignty and long-term public interests. Another important aspect of rebuilding renewable energy is developing human capital [16]. Deploying and maintaining large-scale solar infrastructure requires engineers, technicians, researchers, and policymakers to have specialised knowledge of renewable technologies, grid integration, and energy management. Conflict has long disrupted educational systems and caused large-scale migration of skilled professionals [17].

Therefore, rebuilding Syria's energy sector is not simply about investing in physical infrastructure, but about investing in technical education, workforce development and knowledge transfer. Engaging the Syrian diaspora could bring valuable expertise and speed up capacity building. Studies have examined Syria's energy destruction, renewable energy potential and individual investment projects. Still, integrated assessments of solar energy as a transformative mechanism for post-conflict reconstruction remain limited. Previous studies have mostly focused on aspects of the energy challenge, such as electricity shortages, solar resource assessment or investment opportunities [18]. However, few analyses link Syria's solar potential to broader reconstruction goals, including energy security, economic recovery, infrastructure resilience and sustainable development. This research fills this gap by examining solar energy not as an alternative electricity source, but as a strategic basis for reconstructing Syria's energy system. This paper examines how solar energy can support Syria's transition from a war-damaged electricity system to a resilient, sustainable energy future. It assesses Syria's solar resource potential, traces the development of distributed and utility-scale solar capacity, discusses new international investment trends, and highlights the technical, institutional, and policy challenges that may hinder implementation [19]. The study contributes to broader discussions on renewable energy use in conflict-affected states by offering a holistic framework for solar-based energy reconstruction. The Syrian case offers significant lessons for countries beyond its borders. Conflict-affected countries face similar challenges, including damaged infrastructure, limited financial resources, energy insecurity and reliance on external aid. The Syrian case shows how renewable energy technologies can not only generate electricity but also build resilience, revitalise the economy and support sustainable development [20]. Shifting solar energy from a crisis-response mechanism to a national strategy in Syria could turn one of the country's biggest reconstruction challenges into an opportunity for long-term transformation.

## 2. Literature Review

### 2.1. Solar Energy in Post-Conflict Reconstruction in Syria

The destruction of energy infrastructure has become a key challenge in post-conflict reconstruction, given the close links between energy systems and health care, water supply, education, economic productivity, and institutional recovery. Existing research shows that electricity networks are among the most vulnerable infrastructures in prolonged conflicts, as they are often targeted, damaged as collateral damage from military operations, or deteriorate due to lack of maintenance and investment [1]. Over a decade of conflict in Syria has damaged power generation plants, transmission networks and distribution systems, leading to a collapse in the country's energy reliability. The war has reduced the electricity generation capacity from approximately 9.5 GW to 1.6 GW, with more than half of the electricity grid damaged or rendered dysfunctional [22]. The economic cost of this destruction is estimated at around $35 billion in direct infrastructure losses, with indirect losses exceeding $80 billion [20]. These conditions prove that energy rehabilitation is not just an engineering challenge but also a basis for broader social and economic recovery. Recent literature increasingly identifies renewable energy as a strategic route for reconstructing energy systems in conflict-affected states. Unlike centralised fossil fuel-based systems, renewable energy technologies, especially solar photovoltaic (PV) systems, offer decentralisation, reduced reliance on imported fuels, and greater resilience to future disruptions [14]. Distributed renewable energy systems can improve energy security and support wider digital, economic and institutional reconstruction goals, as shown by countries like Ukraine and Somalia [7]. Renewable energy offers post-conflict settings an opportunity not only to restore damaged capacity, but to redesign energy systems for sustainability, resilience and local accessibility. Syria has strong renewable energy potential, especially in solar energy. The country has high solar irradiation and more than 300 sunny days per year, making it well-suited for large-scale solar deployment [10].

Recent GIS-based spatial modelling studies show that about 81% of Syrian territory is moderately to highly suitable for solar development, and identify 51 highly suitable zones totaling nearly 4,000 km2 as priority sites for photovoltaic projects [21]. These results suggest that Syria's solar potential could exceed domestic recovery needs and support a sustainable energy

transition. This huge solar potential offers Syria a unique chance to move beyond traditional reconstruction methods and build a more decentralised, sustainable energy system. Techno-economic assessments also evaluated the suitability of various solar technologies across Syria's governorates. Using simulation platforms like GREENIUS, the study comparatively evaluated concentrated solar power (CSP) and photovoltaic systems. The results show that areas such as Rif Dimashq, Homs, and As-Suwayda have favorable conditions for implementing CSP. This is due to high direct normal irradiance and improved economic results [13]. Integrating thermal energy storage can improve dispatchability and lower the levelized cost of electricity by up to 20% in appropriate locations [23]. At the same time, PV systems are economically feasible across various climatic conditions, particularly in coastal regions where diffuse solar radiation supports stable electricity generation [5]. These results suggest that Syria should pursue a diversified renewable energy strategy that combines utility-scale solar farms and distributed PV with storage technologies. Electricity shortages are one of the biggest hurdles to Syria's recovery. Before the conflict, Syria produced around 45 TWh of electricity annually, but production plummeted after 2011 and has remained well below pre-war levels [1]. In many areas, electricity is available for only a few hours a day. This has serious humanitarian and economic consequences. Healthcare facilities struggle to maintain medical equipment, vaccine storage systems, and emergency services. This also affects water supply systems. Pumping stations need reliable electricity to pump water. Schools are suffering from poor lighting, heating and digital infrastructure. Reliance on expensive diesel generators and an unreliable grid also constrains businesses [17].

In response, Syria has recently increased efforts to attract investment in renewable energy and develop large-scale solar projects. The developing energy strategy increasingly hinges on international partnerships and private-sector participation. Agreements with Saudi Arabian investors, including projects developed through cooperation between Syrian authorities and Saudi energy companies, seek to expand solar generation capacity and improve electricity reliability [15]. Further agreements for solar-plus-storage projects totaling roughly 760 MW with more than 1,000 MWh of battery storage capacity indicate a growing focus on pairing renewable generation with energy storage [16]. These developments reflect a wider trend in which renewable energy is emerging as a key pillar of Syria’s reconstruction strategy. However, significant challenges remain in converting solar potential into operational capacity. Barriers include limited financial resources, damaged grid infrastructure, regulatory uncertainty, technological dependency, and the need for effective institutional co-ordination. Studies emphasise that deploying renewable energy successfully in post-conflict settings requires not only investment in physical infrastructure but also policy reform, technical capacity building, and long-term planning frameworks [17]. International partnerships can speed up development, but sustained energy sovereignty requires national ownership and sustainable technology transfer. Abundant literature has analysed Syria's electricity crisis, the potential of renewable energies, and specific solar projects. However, holistic assessments of solar energy as a transformative tool for post-conflict reconstruction remain scarce. Recent studies tend to analyse technical feasibility, investment opportunities or policy challenges in isolation. A holistic framework linking solar resource assessment, infrastructure rehabilitation, investment strategies, energy resilience and sustainable development is still lacking. This research seeks to fill this gap by examining solar energy not only as an alternative electricity source but also as a strategic foundation for Syria's economic recovery, institutional reconstruction, and long-term energy self-sufficiency. The findings may offer broader lessons for other conflict-affected states seeking to use renewable energy as a pathway to resilient, sustainable reconstruction.

## 3. Methodology

The research uses a mixed-methods approach, combining quantitative data analysis, documentary analysis, and case study analysis to assess solar energy's transformative potential for post-conflict reconstruction in Syria. Together, these methods aim to provide a comprehensive picture of Syria's transition to renewable energy, including the physical and technical availability of solar energy resources, the policy framework, institutional capacity, investment opportunities and practical experience in deploying solar energy. A mixed-methods approach is especially suitable for the Syrian context, since several interrelated factors drive the transition to renewable energy. Solar irradiation and technological feasibility determine the physical deployment potential. Infrastructure conditions, investment availability, government policy, institutional capacity, electricity demand and socio-economic conditions determine how this potential translates into actual energy generation.

The methodology thus integrates scientific evidence with policy and case interpretation to provide a complete assessment of solar energy's role in reconstruction. The quantitative part of the study evaluates Syria's solar energy potential and the state and trends of renewable energy development. This analysis draws on several datasets and sources. A key source is the IRENA Renewable Energy Statistics 2026, which provides information on trends in renewable energy capacity and electricity generation. These statistics allow monitoring the evolution of renewable energy over time and establishing the relative contribution of solar energy to the wider power system. In addition to national and international energy statistics, the study uses GIS-based spatial modeling to assess solar suitability across Syria. Spatial analysis matters because solar energy potential varies across the country. Differences in solar irradiation, geography, infrastructure access, population distribution and distance to electrical networks can affect site feasibility for different solar projects.

The quantitative study also includes a comparative techno-economic analysis of concentrated solar power (CSP) and photovoltaic (PV) technologies across Syria's governorates. Comparing technologies helps clarify differences in generation potential, investment needs, operating characteristics, land requirements and applicability across regional contexts. The versatility of PV systems and their ability to be used at the residential, commercial, institutional, and utility levels makes them particularly appropriate for dispersed applications. CSP technologies can offer advantages for some large-scale applications, provided the right solar resources and infrastructure are available. However, financial costs and technological complexity can pose further barriers. Industry estimates of household and off-grid solar growth are also included to capture developments not fully reflected in national electricity data. Taken together, these datasets provide the basis for assessing resource availability, technology suitability, deployment patterns and solar energy's longer-term potential to add to Syria's electrical supply. The documentary analysis examines the policy, institutional, regulatory and investment aspects of solar energy development. Syrian government announcements, national energy strategies, energy policy pronouncements, investment agreements, renewable energy programs, and collaboration frameworks. Documentary analysis is crucial because large-scale renewable energy capacity development requires an enabling regulatory framework that clearly defines the duties and incentives of investors, utilities, developers, local authorities, and communities. The study thus examines government institutions' efforts to provide frameworks for renewable energy development and how these policies align with broader aspirations for post-conflict rehabilitation. It focuses on regulations, investment conditions, public-private partnerships, power sector reform, land access, grid expansion and integrating additional renewable energy into the national power grid. This study also discusses the role of international organizations and development partners in facilitating Syria's transition to renewable energy.

The report examines the experience of organizations like UNDP and others in delivering international development aid to understand how such assistance might help rehabilitate energy infrastructure, expand access to electricity and promote decentralized renewable energy alternatives. Such actions are especially critical in areas where traditional grid infrastructure has been devastated or where communities still endure unpredictable electricity supplies. International organizations can provide financial resources, technical expertise, project management, institutional support and knowledge transfer. Researchers use media reports as an additional documentary source to identify recent developments, investment commitments, project announcements and emerging trends in Syria's renewable energy sector, especially where developments are fast-moving and formal statistical data may not yet be available. Researchers use media sources with caution and, where possible, cross-check them with official or institutional sources. The third main methodological component is case study analysis. Selected cases examine distinct approaches to solar energy growth in Syria's reconstruction context. The grassroots rooftop solar revolution is the rapid proliferation of decentralized solar systems in response to chronic electrical shortages. This scenario shows how families, businesses and communities can use distributed renewable energy technologies independently of or semi-independently from large-scale national infrastructure plans. Such systems can boost energy resilience and reduce reliance on unstable grid electricity, but affordability, battery costs, equipment quality, maintenance, and unequal access to financing may limit their expansion. The study reviews major international investment and development cases including the $7 billion Qatar-led consortium agreement signed in 2025, the $1 billion Saudi solar investment agreements announced in 2026, the ACWA Power 2.5 GW renewable energy framework, and UNDP-supported solar rehabilitation programs.

These stories illustrate distinct approaches to renewable energy development. Large international investment agreements underscore foreign capital's potential to accelerate utility-scale renewable deployment. Meanwhile, major developer frameworks show how experienced energy companies can contribute technical expertise, project development capacity, and long-term investment. UNDP-backed projects, by contrast, show a more humanitarian, development-oriented strategy in which renewable energy rebuilds key services and improves energy access. Comparing these situations allows the research to explore community-led, commercial, international-investment, and humanitarian approaches, rather than presenting solar development as a single, undifferentiated process. This study's analytical framework examines Syria's transition to solar energy along four interrelated dimensions. The first dimension is resource and technical potential, including the availability and geographic distribution of solar irradiation, ideal locations, technological feasibility, infrastructure requirements and the techno-economic performance of PV and CSP systems. This dimension provides the physical basis for the transformation and identifies places and applications where solar deployment can be technically and economically beneficial. The second aspect is about current deployment. It evaluates existing renewable energy capacity, electricity-generating patterns, the growth of distributed rooftop systems and the interaction between off-grid, decentralized and utility-scale development. This dimension matters because resource potential does not guarantee real progress in renewable energy adoption. The deployment patterns examined show how families, businesses, organizations, utilities, and investors are responding to electricity shortages and changing market conditions. Third dimension: investment and project pipelines. This includes large-scale renewable energy projects, international partnerships, financial commitments, foreign investment, developer participation and proposed generation capacity. Investment is critical to post-conflict reconstruction, as Syria faces substantial infrastructure-financing needs.

The analysis thus considers how announced investments can realistically translate into operating generating capacity, and the institutional, financial and infrastructure conditions needed for successful implementation. The fourth dimension concerns policy and institutional arrangements. These include regulatory arrangements, national energy planning, governance capacity,

institutional co-ordination, investment rules, grid-management arrangements and mechanisms for integrating renewable energy into the electricity system. Strong solar resources and large investment commitments are desirable. Still, institutional weaknesses, regulatory uncertainty, infrastructure constraints and fragmented governance prevent effective project implementation, so a successful energy transition will not happen automatically. Because these four dimensions depend on one another, they are analyzed as a whole. High solar potential is a necessary but not sufficient condition and requires appropriate technologies and infrastructure. Deployment requires investment and market mechanisms. Investment requires predictable policies and institutions. Effective policy implementation requires sufficient technical and administrative capacity. This research distinguishes Syria's theoretical solar potential from its realistic capacity to undergo a large-scale renewable energy transformation during post-conflict reconstruction. It combines quantitative evidence, documentary analysis, and comparative case studies across these dimensions. Ultimately, the approach offers a systematic framework for evaluating solar energy's role in electricity security, infrastructure rehabilitation, economic recovery, decentralized energy access, and Syria's broader reconstruction objectives.

## 4. Results and Discussions

### 4.1. Syria's Solar Resource Potential

#### 4.1.1. Solar Resource Endowment

Syria's position within the global solar belt gives the country exceptional solar resources. The country enjoys "exceptional solar potential exceeding 300 sunny days annually". This places Syria among the sunniest countries in the world, with solar radiation levels that compare favorably with leading solar markets such as Spain, Morocco, and the United Arab Emirates. The high number of sunny days translates into significant annual solar irradiation. While specific irradiation values vary across governorates, consistent sunshine nationwide means solar energy can be deployed effectively in all regions, though optimal technology choices may vary.

#### 4.1.2. Spatial Distribution of Solar Suitability

Recent GIS-based spatial modeling has mapped solar suitability across Syria in detail. The analysis, published in 2026, revealed that "a vast 81% of Syria shows moderate to high suitability" for solar development. The study identified "51 prime zones totaling 4,000 km² that are exceptionally well-suited for development" (Figure 1).

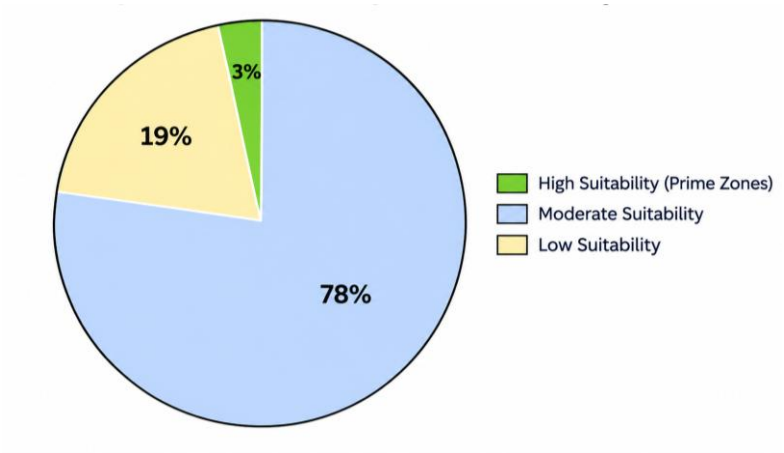



**Figure 1:** Syria's land suitability for solar development

This finding is significant. The "potential energy yield from these optimal sites alone could surpass Syria's peak pre-war consumption". This means Syria's solar resource is sufficient not merely to replace lost conventional generation capacity, but to fundamentally transform the country's energy system.

#### 4.1.3. Techno-Economic Comparison of Solar Technologies

A comprehensive techno-economic evaluation of concentrated solar power (CSP) and photovoltaic (PV) systems across Syria's 14 governorates has provided valuable insights for technology selection. The analysis used the GREENIUS v4.5.0 simulation

platform with high-resolution meteorological data from Meteonorm 7.3 to simulate a benchmark 50 MW parabolic trough CSP plant modeled after the Andasol-1 configuration alongside an equivalent 50 MW PV system.

#### 4.1.4. Key Findings

- **CSP Favorable Regions:** Rif Dimashq, Homs, and As-Suwayda offer the most favorable conditions for CSP deployment, with the lowest LCOE and highest net annual electricity generation.
- **Thermal Energy Storage Benefits:** Incorporating a 7-hour thermal energy storage system "enhanced energy dispatchability and reduced the LCOE by up to 20% in regions with high direct normal irradiance."
- **PV Versatility:** PV systems showed "stable performance across all governorates, demonstrating superior economic viability in coastal areas where diffuse irradiance predominates."
- **Complementary Deployment:** The findings suggest that both technologies have roles in Syria's energy future, with CSP for regions with high direct normal irradiance and PV for coastal and diffuse-irradiance areas (Figure 2).

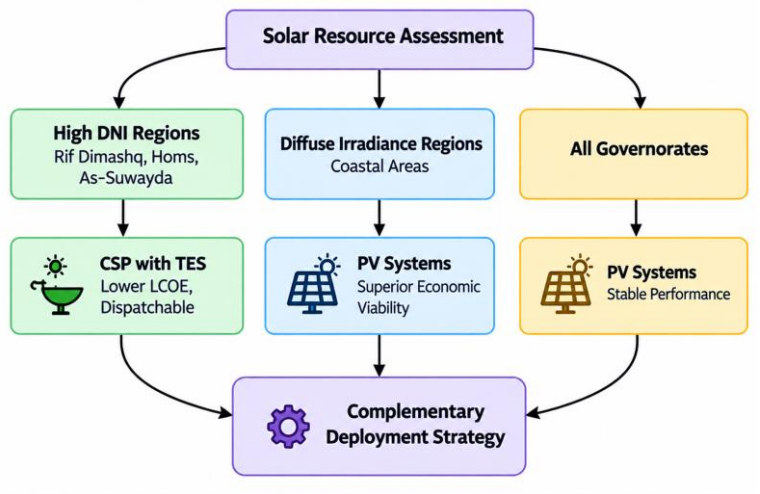



**Figure 2:** Complementary solar technology deployment strategy

### 4.2. The Solar Revolution: From Crisis to Opportunity

#### 4.2.1. The Grassroots Solar Boom

Perhaps the most remarkable aspect of Syria's solar energy story is the grassroots revolution that has emerged from the ashes of the country's electricity crisis. As one analysis observed, "Syria's sunrise is a story not of government leading, but of people taking their energy needs into their own hands." The data tells a compelling story of accelerating deployment. The International Renewable Energy Agency began reporting Syria's off-grid solar capacity in 2022, standing at 249 MW. This surged to 931 MW in 2023, 1,500 MW in 2024, and 2,060 MW in 2025. By 2025, "renewable power made up a third of national generating capacity, outstripped in the region only by Lebanon and Jordan". "A quarter of Syrian households have some kind of solar power" (Figure 3).

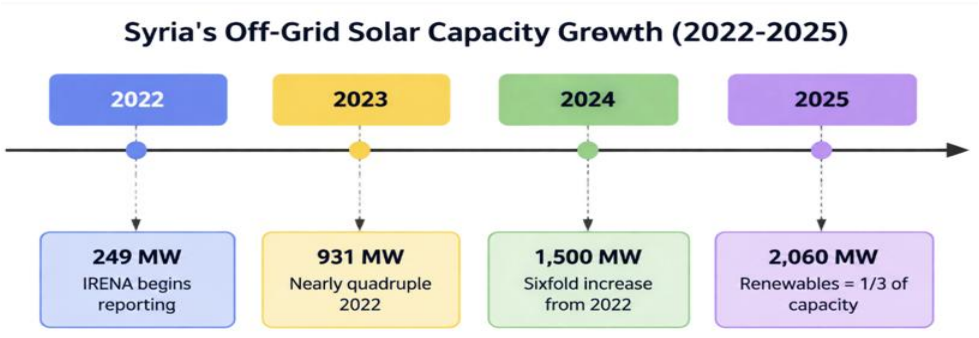



**Figure 3:** Syria's off-grid solar capacity growth (2022-2025)

In Damascus, the transformation is visible everywhere. “Panels adorn almost every apartment building, villa and hotel, with workers hammering away to install more.” In “war-battered Aleppo, too, panels are everywhere.” The drivers of this grassroots boom are clear:

- **Grid Failure:** With the national grid providing only 3–4 hours of electricity daily, households and businesses had no choice but to seek alternative sources.
- **Fuel Scarcity and Cost:** Local diesel generators are widely used, but fuel is still scarce and expensive for most people.
- **Affordable technology:** The sudden influx of cheap, China-made panels and batteries made solar systems accessible to more people.
- **Ease of Installation:** Local engineers can easily install the systems.
- **Economic Necessity:** With electricity prices rising more than sixfold, “alternative energy has become an inevitable choice.”

### 4.2.2. The Scale of Deployment: IRENA Data Analysis

IRENA's Renewable Energy Statistics 2026 provides authoritative data on Syria's renewable energy capacity. By the end of 2025, Syria's total renewable energy installed capacity reached 3,806 MW. This represents 153.6% growth over 2016–2025 and ranks Syria fifth among Arab countries, behind Saudi Arabia (12,332 MW), Egypt (9,258 MW), the UAE (8,001 MW), and Morocco (4,851 MW), but ahead of Jordan, Lebanon, and Iraq. This mix shows solar energy's dominance. By the end of 2025, solar energy accounted for 2,249 MW (59%) of total renewable capacity. Hydro remained relatively stable at approximately 1,490–1,545 MW, while wind and biomass contributed minimally. The analysis indicates a large disparity between Syria's installed solar capacity and actual electricity generation. In 2024, renewable electricity generation was 862 GWh, down from 902 GWh in 2016, despite a 153.6% increase in reported renewable capacity. Several structural and operational issues can explain the gap between Syria’s position in renewable energy capacity, fifth in the Arab world, and its position in generation, twelfth. Another major contributor is the predominance of off-grid household solar systems, many of which serve as backups and may therefore not be used at their theoretical capacity.

Moreover, many dispersed systems do not connect to the national grid, limiting their direct impact on centralized electricity supply. The actual amount of electricity generated is also uncertain because decentralized generation is difficult to measure. Grid instability, equipment constraints, inadequate maintenance, and changes in solar resource availability also prevent established systems from operating at full capacity. Historically, Syria has developed far less utility-scale solar, while grassroots and residential solar has grown significantly. By 2025, traditional large-scale, grid-connected solar installations reached only around 189 MW, a relatively small share of the country’s total solar capacity. This discrepancy shows how decentralized Syria's solar shift is, with households and businesses installing small-scale systems in response to electricity shortages, ahead of large centralized installations. However, with the political transition in December 2024, the pipeline of utility-scale projects has increased significantly, with several large projects and investment agreements announced for 2025 and 2026. These improvements could represent a shift from an emergency-driven decentralized solar market to a more structured national renewable energy system (Table 1).

**Table 1:** Installed renewable energy capacity by source in Syria, 2016–2025 (MW)

| Year | Total (MW) | Hydro (MW) | Solar (MW) | Wind (MW) | Biomass (MW) |
|---|---|---|---|---|---|
| 2016 | 1,501 | 1,494 | — | — | 7 |
| 2018 | 1,498 | 1,490 | 1 | — | 7 |
| 2020 | 1,508 | 1,490 | 12 | — | 7 |
| 2021 | 1,532 | 1,490 | 33 | 3 | 7 |
| 2022 | 1,806 | 1,490 | 307 | 3 | 7 |
| 2023 | 2,524 | 1,490 | 1,022 | 5 | 7 |
| 2024 | 3,108 | 1,490 | 1,606 | 5 | 7 |
| 2025 | 3,806 | 1,545 | 2,249 | 5 | 7 |
| ***Source:*** *IRENA Renewable Energy Statistics 2026* | | | | | |

One of the most important developments came in May 2025 when a deal was reached for a $7 billion Qatar-led consortium. Syria has inked a deal with a consortium comprising Qatar, Turkey and the United States to help rebuild the country’s energy industry. The initiative, scheduled to take about three and a half years, is for four combined-cycle gas turbine plants with a combined production capacity of about 4,000 MW, plus a 1,000 MW solar farm. The solar component is expected to be developed in about 2 years. The total scheme is projected to add about 5 GW of generation capacity, which could meet a

significant part of Syria's current electricity shortage. The project therefore marks a shift from mostly small-scale solar deployment to major infrastructure investments that can directly support the national electricity supply. Another key breakthrough came in September 2025, when the Syrian Ministry of Energy and Saudi Arabia's ACWA Power inked a joint agreement for roughly 2.5 GW of solar and wind power. The framework includes around 1 GW of solar photovoltaic capacity, around 1.5 GW of wind power, and potentially grid-scale energy-storage technologies.

The deal is noteworthy not only for its proposed generation capacity, but also for its provisions for technological cooperation and a proposed national technical training center. This is essential to Syria's long-term energy transition because sustainable renewable-energy development requires not only capital investment but also indigenous talent in project development, engineering, operations, maintenance, grid management, and energy-system planning. In August 2026, the Syrian Electricity Company signed three agreements with the Saudi company Al-Harafi Contracting to implement three solar power projects valued at over $1 billion. The projects are proposed in Wadiyan al-Rabi in Rural Damascus with a total generation capacity of around 760 MW. Their battery energy-storage systems have a combined capacity of roughly 1,077 MWh. The deals cover solar projects with and without storage, with implementation timelines of four to five years and a goal of completing projects within three years, if practicable. Battery storage matters because it can reduce solar intermittency, shift electricity to periods of higher demand, and increase the reliability of renewable electricity delivered to the grid. In November 2025, Syria signed an agreement for several solar energy projects with a combined capacity of almost 1,000 MW in several locations, and other utility-scale activities were reported (Figure 4).

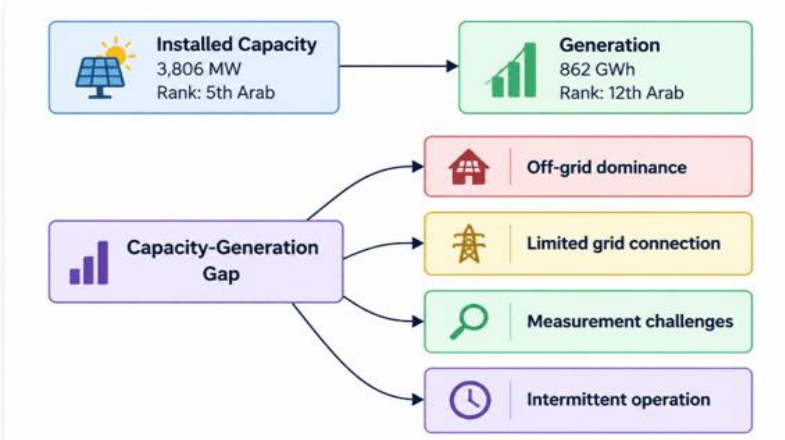



**Figure 4:** Capacity-generation gap analysis

The proposed projects at the designated sites are installations at Widian Al-Rabee, Deir Ezzor and Aleppo with capacities of roughly 200 MW, 300 MW and 300 MW, respectively. In February 2025, Syria's Ministry of Electricity announced plans to build a 100 MW photovoltaic power station in the Wadi al-Rabi area in the Damascus countryside. The project was built under a usufruct that allows investors to operate the facility for 25 years. The state was not directly involved in production or management. These arrangements show how public-private investment mechanisms can accelerate renewable energy deployment while limiting the state's immediate financial burden. International investment must be understood in the context of a shifting sanctions environment. International sanctions have historically limited Syria's access to energy technology imports, financing, commercial relations and foreign investment. Sanctions also hampered reconstruction by limiting access to certain telecommunications, energy, banking and dual-use technology. The political transition after December 2024 changed the sanctions climate, opening fresh opportunities for reconstruction and investment. On 24 February, the European Union said it was taking major steps to suspend various sanctions in energy, banking, transport and reconstruction, as the United States and European authorities pushed wider sanctions relief. As such, the changing sanctions climate has created a more conducive environment for international participation in Syria's renewable-energy sector, while financial, regulatory, compliance, and political concerns remain major considerations for investors. Saudi Arabia has been a particularly important source of investment for Syria's renewable-energy sector.

The Al-Harafi agreements include a commitment of up to about $1 billion, and the ACWA Power framework could facilitate development of about 2.5 GW of renewable capacity. Hence, Saudi involvement is not only about single projects, but also about broader cooperation in renewable energy development and technical capacity building. A Qatari-led consortium is another key source of overseas financing, with an energy-sector deal totaling almost $7 billion, including a large solar component. Turkey has also played a role in Syria's energy recovery, including electricity provision, and wants to raise supplies from around 210 MW to 300 MW. The US also has a stake through Power International, a consortium member, and Siemens

Energy has been involved in power-sector transactions. These developments show that Syria's energy rehabilitation is rapidly becoming an area of international investment and geopolitical cooperation. Several investment vehicles are emerging as part of this shift. Public-private partnerships and usufruct arrangements can reduce direct governmental involvement in project management by enabling private investors to fund, construct and operate renewable-energy installations for predetermined durations. Another strategy for selling the generated electricity is through Power Purchase Agreements, long-term contracts; the Al-Harafi projects are said to include PPAs of around 20-25 years. Joint Development Agreements, such as the ACWA Power framework, help assess and develop large renewable-energy projects before final investment and construction decisions. Technical cooperation is also growing in importance, particularly where agreements include training facilities and technology-transfer components. Such approaches can support institutional growth if transparent regulation, local workforce development and appropriate knowledge-transfer requirements back them. Despite the growing project pipeline, Syria's solar-energy sector still faces major obstacles. The biggest issue is the persistent gap between installed capacity and actual electricity generation. Syria's relatively high installed renewables capacity and substantially lower renewable electricity output suggest that capacity growth alone is not a sufficient indicator of energy sector reform.

This disparity stems from widespread off-grid use, limited grid connections, measurement challenges, equipment performance and grid instability. Future assessments should therefore clearly distinguish between nominal installed capacity, operational capacity, capacity factor, power actually generated and electricity provided to consumers. Another major barrier is infrastructure destruction. More than 70% of Syria's power plants and transmission lines have allegedly been extensively damaged, making it difficult to add more renewable generation to the electricity system. Solar panels can produce electricity, but broken transmission and distribution networks can keep it from reaching customers, limiting the national value of generating capacity. In this regard, Syria has identified energy-sector rehabilitation needs of about $30 billion. The overall reconstruction task is even larger, with UNDP estimating physical capital destruction at around US$ 123.3 billion. The increase in renewable energy must therefore be coordinated with restoring transmission lines, substations, distribution networks, storage infrastructure and other power-system components. Financial restrictions remain a serious challenge despite substantial promises of international investment. Currency instability affects equipment imports, construction contracts and long-term service agreements, while high upfront costs limit households' and small businesses' access to solar technology. A basic family solar installation of around 1.5-3 kW is projected to cost between $2,500 and $4,500, which is still significant relative to an anticipated per-capita income of around $800. Therefore, access to affordable finance will determine whether solar deployment remains limited to wealthier homes and commercial customers or becomes universally available. Sanctions and financial compliance procedures can delay payments, procurement and equipment sourcing even after legal penalties are removed. But rapid growth has brought technical and quality issues.

The decentralized solar market has grown through emergency-driven and informal procurement, leading to ad-hoc wiring, mismatched inverters, poor battery designs and low-quality components. Flooded lead-acid batteries can degrade rapidly under high loads, and improper installation procedures can reduce system performance and create safety hazards. The availability of cheap equipment has therefore raised concerns about dependability, durability and life cycle costs. Maintenance capability is likewise inconsistent, and the lack of common standards, certification procedures and permitting requirements across regions can complicate efforts to assure uniform technical quality. Therefore, national requirements for equipment, installation, electrical safety, battery systems, grid connection and professional certification are essential. Policy and regulatory gaps are also slowing change. Syria appears to be developing a Renewable Energy Master Plan with UNDP funding. Still, it has not built a comprehensive, fully defined policy framework to manage all facets of the rapidly growing solar business. The political shift has also created regulatory uncertainty over investment restrictions, institutional roles, electricity prices, land access, grid connections and project approval procedures. Limited institutional capacity may also constrain even well-designed policies. Clear rules for connecting dispersed solar systems to the power grid will be particularly important if Syria is to move from isolated household generation to an integrated renewable-energy system. Overall, the findings support a comprehensive evaluation of Syria's solar-energy transformation. The country's resource potential is deemed extremely great, with more than 300 sunny days a year and about 81% of its land apparently moderately to highly suitable for solar production. On this basis, the resource-potential dimension is estimated at 95%. With off-grid solar capacity expected to expand to about 2,249 MW by the end of 2025, current deployment is around 70%. However, the relatively low actual generation shows that installed capacity does not automatically translate into equivalent electricity output.

The pipeline for utility-scale projects is valued at roughly 65%, reflecting the high number of announced projects and signed agreements. However, many projects are still in the early stages of planning, finance, construction or implementation. The policy framework is rated at about 40% because policy development is ongoing but not yet finalized, and the Renewable Energy Master Plan is currently being prepared. Institutional capacity is estimated at 35 percent, given the substantial administrative and regulatory hurdles of managing a rapidly changing energy industry during reconstruction. Grid infrastructure is rated lowest, at roughly 25%, as continued substantial damage to generation, transmission, and distribution infrastructure limits renewable energy integration. An estimated 45% have access to finance, demonstrating strong international investment, but also ongoing challenges in funding local initiatives and home systems. Technical capacity is estimated at around 50%,

suggesting Syria has a pre-existing pool of installation and maintenance skills, but technical quality, certification and professional standards are uneven. The main task, therefore, is to shift Syria's solar expansion from a survival response to electricity shortages to a coordinated national energy policy. The rapid rise of rooftop and off-grid solar systems has been driven more by the need for reliable electricity by individuals and companies than by a properly coordinated national renewable-energy program. Still, this haphazard expansion has laid an important groundwork for a more methodical energy transformation. The next step should be to build on this base through concerted policy development, grid restoration, quality assurance, sustainable finance, institutional strengthening and workforce development. The goal shouldn't be to expand the number of solar panels installed, but to increase reliable power output and improve the amount of electricity generated that can actually reach consumers. Balanced future energy systems will likely require complementary development of utility-scale and distributed solar power. Large projects like the proposed 1,000 MW solar projects and the 760 MW Al-Harafi projects could significantly contribute to the national electricity supply, especially when paired with adequate energy-storage systems and infrastructure upgrades.

Distributed rooftop and community-scale systems can build local resilience, reduce dependence on fragile transmission networks, and improve electricity access in areas where centralized infrastructure is unreliable. Hybrid systems with batteries and, where applicable, additional generation sources, combined with solar energy, can further increase reliability and keep electricity available beyond periods of peak solar production. Other countries' crisis experiences further underline the need for this complementary strategy. Lebanon shows how decentralized solar systems can grow quickly when conventional power infrastructure collapses, but it also underscores the risks of fragmented development without proper regulation and quality control. Ukraine shows the importance of distributed energy infrastructure in enhancing resilience during grid disruptions and conflict. Somalia is a strong example of the value of combining institutional and technical capacity with disciplined investment planning and infrastructure development. Thus, Syria can draw on these experiences, not by duplicating any specific country's model, but by applying pertinent ideas to its own political, economic, geographical and institutional circumstances. Central to this transformation is the Renewable Energy Master Plan, which UNDP is helping prepare.

The strategy is planned to be built over 12 months. It aims to boost energy security, reduce dependence on energy imports and improve energy reliability and access for communities across Syria. The broader goal is to establish a framework for the future evolution of energy in Syria and to set clearer goals for investment, policy, infrastructure and the rollout of renewable energy. Syria likewise has an ambitious goal of producing 10% of its electricity from renewable sources by 2030. Although this target is modest compared with the renewable-energy aspirations of some regional economies, achieving it would still require major transformation given the state of Syria's electricity infrastructure and the institutional and financial constraints of post-conflict reconstruction. Meeting the target will require not only installing new renewable capacity, but also rehabilitating the grid, developing storage, improving regulatory institutions, mobilizing sustainable financing, establishing technical standards and building sufficient domestic capacity to operate and maintain the emerging solar-energy system.

## 5. Conclusion

Syria's solar energy journey represents one of the most remarkable energy transformations in recent history. From the devastation of a fourteen-year civil war that reduced electricity generation to less than 20% of pre-war capacity and left the national grid providing only 3–4 hours of electricity daily, Syrians have built a grassroots solar revolution that has seen off-grid solar capacity surge from 249 MW in 2022 to over 2,060 MW in 2025. A quarter of Syrian households now have some form of solar power, and renewables make up a third of national generating capacity. This grassroots revolution has been complemented by significant international investment. The $7 billion Qatar-led consortium deal, the $1 billion Saudi solar agreements, and the ACWA Power 2.5 GW renewable energy framework capacity of 3,806 MW rank fifth in the Arab world, with solar accounting for 59% of total capacity. Yet significant challenges remain. The gap between installed capacity and actual generation, the legacy of infrastructure destruction exceeding $35 billion in the electricity sector alone, the need for grid rehabilitation, and the absence of comprehensive policy frameworks all constrain the realization of Syria's solar potential.

The transition from a survival-driven solar boom to a strategic national energy program requires coordinated action across multiple dimensions: policy development, grid rehabilitation, institutional capacity building, human capital development, and investment mobilization. The Renewable Energy Master Plan, developed with UNDP support, offers a framework for this transition. Syria's ambitious goal of generating 10% of its electricity from renewable sources by 2030, while modest compared to some regional peers, represents a significant commitment to renewable energy development. Syria's exceptional solar resource—with 300+ sunny days annually and 81% of land showing moderate to high suitability—provides the foundation for a transformed energy system. As Syria rebuilds after fourteen years of conflict, solar energy offers more than a solution to the electricity crisis. It offers an opportunity to build a more resilient, sustainable, and equitable energy system that can support economic recovery, enhance energy security, and contribute to environmental sustainability. The decisions made in the coming years will determine whether Syria's solar potential is fully realized, transforming the electricity crisis into a renewable energy opportunity that can power the country's recovery for decades to come.

### 5.1. Recommendations

Technical assistance can help develop regulations, institutional reforms, project appraisal, renewable energy procurement and grid integration, and investment frameworks. International support should also directly strengthen Syrian institutions by building local expertise and administrative capacity, rather than replacing domestic institutions. Attracting international investment is more than luring capital; it is about mitigating the risks of investing in a post-conflict environment. International financial institutions and development partners can provide concessional finance, guarantees, political-risk mitigation, credit-enhancement methods, and project-preparation funding. These mechanisms may improve project financial sustainability and encourage private investors to participate in infrastructure development. International partners can also promote technology transfer by linking Syrian institutions and companies to established renewable energy producers, equipment manufacturers, engineering firms and research groups. Such collaboration would allow Syria to strengthen its domestic capabilities in project design, equipment assembly, installation, operation, maintenance and system administration. Capacity-building should remain a key element of international assistance. Funding for training and education can support universities, vocational institutions, government agencies, utilities and private-sector groups. Technical support programs can offer hands-on knowledge in renewable-energy planning, grid integration, project finance, environmental evaluation and system maintenance. Knowledge sharing efforts, professional exchanges, workshops and cooperative research programs can further expose Syrian professionals to international expertise. These initiatives should support long-term institution building so Syrian organizations retain knowledge beyond individual international projects. Co-ordination among foreign partners is just as vital. Several donors, development agencies, governments, financial institutions, technology suppliers and humanitarian organizations may be involved in Syria's energy restoration, which can lead to duplicated projects or conflicting approaches.

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