

The transformation and development of renewable energy in Qatar: Reality, challenges, and future vision**Received date: 26/11/2025****Accepted date: 27/12/2025**

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Abstract:

This article reviews the growth of Qatar's renewable energy sector over the past decade within the framework of Qatar National Vision 2030. It highlights the shift toward clean energy, focusing on major projects such as the 800-MW Al

Kharsaah Solar Plant and the new Ras Laffan and Mesaieed facilities, which together raise total capacity to over 1.6 GW. It also outlines key technical and economic challenges, as well as future opportunities driven by innovation and smart technologies. The paper concludes that Qatar is steadily advancing toward a sustainable and balanced energy system.

Keywords: *State of Qatar; Renewable energies, solar energy, sustainable energy, environmental balance.*

Introduction:

Over the past two decades, the State of Qatar has witnessed a gradual transformation in its approach to energy management, driven by growing global environmental and economic challenges, and by its quest to build a development model based on sustainability and innovation. Despite being one of the world's leading producers of natural gas, Qatar realized early on the importance of diversifying its energy sources and directing a significant portion of its investments towards renewable energy, especially solar energy, which represents the most abundant resource in the Qatari environment. This trend coincided with the country's international commitments under the Paris Climate Agreement and with Qatar National Vision 2030, which made environmental sustainability a strategic focus for development.

These trends have contributed to launching giant clean energy infrastructure projects, developing national capabilities in the fields of research and innovation, and strengthening international partnerships to transfer technical knowledge. This path reflects a clear shift in the country's energy thinking, from near-total reliance on hydrocarbon

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sources toward building a more diverse, flexible, and efficient energy system.

From this perspective, this paper aims to analyze the development of the renewable energy sector in Qatar, review the key transition stations, evaluate the institutional and legislative frameworks supporting it, and discuss future challenges facing the energy transition. The paper also seeks to highlight the role of the national experience as a regional model that can be used and compared in sustainable development contexts.

-The importance of the topic: *The importance of this study stems from the profound transformations taking place in the global energy sector, which have made renewable energy a strategic choice for ensuring energy security and reducing carbon emissions. The importance of research in the country case increases due to several considerations, the most prominent of which are:*

- The economic and energy context of a country that is one of the largest exporters of natural gas, and at the same time seeks to diversify the energy mix.

- The regional leadership role that Qatar aspires to in the field of sustainability and low-carbon economy.

- There are few specialized Arab studies that address the Qatari energy transition using a comprehensive analytical approach that combines technical, institutional, and policy aspects.

- The applied dimension in evaluating the impact of clean energy projects in supporting the goals of Qatar National Vision 2030 and its climate commitments.

- Research objectives: *The study aims to achieve a set of scientific and analytical objectives, the most important of which are:*

- Analyzing the development trajectory of Qatar's renewable energy sector in recent years.

- Identify the economic, technical and institutional factors that contributed to driving energy transformation.

- Evaluating government policies and national initiatives related to clean energy.

- Anticipating future challenges that may face renewable energy projects.

- Highlighting the position of the Qatari experience within the

regional and international context of sustainable energy.

- The problem of research: Qatar's energy sector has witnessed rapid transformation due to environmental, economic and technological changes that are pushing fossil fuel producing countries to reconsider their traditional energy models. In this context, renewable energy has emerged as a strategic path to enhancing energy security and adhering to international standards for reducing emissions. However, understanding this transformation requires analyzing the factors that led to it, the effectiveness of the policies adopted by the state, and its ability to build a sustainable energy system.

Hence the problem that the study seeks to address through the following question:

How has the renewable energy sector developed in the State of Qatar, and to what extent are national policies and initiatives effective in supporting the transition towards a sustainable energy system capable of meeting future development requirements?

A group of auxiliary questions branch out from the main question, including:

- What are the most prominent development stations in renewable energy projects in Qatar?
- What factors drove this shift?
- What technical and institutional challenges remain?
- To what extent are current policies consistent with Qatar's international commitments and with Vision 2030?

- Research methodology: This Article adopts a descriptive analytical methodology based on the descriptive approach–analysis to describe the development of renewable energy projects in Qatar and analyze their economic, technical and institutional dimensions, in addition to the comparative approach to compare the Qatari experience with some regional and global experiences related to energy transformation.

First. Renewable energies in Qatar.. Numbers and indicators:

Renewable energy in Qatar has witnessed rapid development in recent years, as the country has gradually begun to move from almost complete reliance on natural gas to produce electricity to a more diverse and sustainable energy mix. Although natural gas continues to be a major source of energy, the share of renewable energy -especially solar energy- is recording clear growth thanks to the launch of major

projects such as the Al-Karsa'a Solar Power Plant, in addition to the adoption of a national strategy aimed at enhancing energy security, reducing carbon emissions, and expanding reliance on clean sources. This transformation comes within the framework of Qatar's commitment to achieving the sustainable development goals and supporting the transition path towards a low-carbon economy.

The State of Qatar has the largest LNG fleet in the world, comprising more than 70 vessels, and 100 new LNG vessels will be added starting in 2024. The new ships will use liquefied natural gas as the primary fuel and low-sulfur fuel oil as the secondary fuel, reducing emissions and supporting the achievement of the goals set out in the IMO's initial strategy to reduce greenhouse gas emissions from ships⁽¹⁾.

Renewable energy production in Qatar reached June 2024, distributed between the "Siraj 1" solar energy project in Al-Kharsa'a, with a production capacity of 800 megawatts, and more than 9 megawatts of distributed solar energy projects.

The percentage of renewable energy reached about 5 percent of the total electricity production in Qatar until the end of 2025, with the goal of reaching 18% by 2030 and raising the capacity to 4,000 megawatts

Qatar's energy mix is based on thermal generation, with the total electricity generation capacity of thermal power plants approaching 12 gigawatts, representing more than 90% of the country's total electricity generation capacity⁽²⁾

Qatar has a tremendous potential to increase the use of renewable energy in the country, thanks to the high quality of its solar energy resources. Its horizontal radiation level is among the highest in the world, with an average total radiation rate of more than 2,000 kilowatt-hours per square meter annually.⁽³⁾

The Qatari leadership believes that renewable energy is not the only solution to reduce emissions in the energy sector. Natural gas and renewable energy sources are partners in the journey to reduce global carbon emissions. Gas will remain "a source of energy to manage problems that interrupt the continuity and quality of resources, and to compensate for fluctuations in demand on a seasonal and daily basis." The transition to low-carbon energy must take the requirements of the developing world into account Including up to one billion people today

who lack electricity and basic fuel.⁽⁴⁾

According to data from the International Renewable Energy Agency (IRENA), there are significant disparities in installed renewable energy capacity among GCC countries (Table 1). The United Arab Emirates and Saudi Arabia lead the region, while Qatar occupies a middle position in terms of total installed capacity⁽⁵⁾

Country	Installed Capacity (GW)
United Arab Emirates	6.1
Saudi Arabia	4.7
Qatar	1.7
Oman	0.72
Kuwait	0.11
Bahrain	0.07

Table2: Renewable Energy Capacity by Country in GCC (2022)⁽⁶⁾

Country	Renwable Energy Capacity (MW)
United Arab Emirates	3.592
Qatar	824
Oman	705
Saudi arabia	443
Kawait	97
Bahrain	48.3
Total GCC	5.709

In 2022, the total renewable energy capacity in GCC countries reached 5,709 MW. The United Arab Emirates accounted for the largest share, followed by Qatar and Oman, while Bahrain and Kuwait recorded the lowest capacities.

Second: Strategic plans and initiatives for renewable energies in Qatar

1-Renewable energy in Qatar National Vision 2030:

Qatar National Vision 2030 pays great attention to environmental sustainability and sustainable development, as renewable energy is one of the basic pillars for achieving these goals, by diversifying energy

sources and reducing dependence on fossil fuels.

The desired goals in the field of renewable energies, according to Qatar Vision 2030, are evident through the following:

- **Promoting environmental sustainability:** This is achieved by reducing carbon emissions from the electricity sector and contributing to compliance with international environmental standards, which requires improving air quality and reducing Qatar's carbon footprint.

- **Diversifying the national energy mix:** by integrating renewable sources (especially solar energy) into the national electricity grid, and achieving a renewable production capacity of approximately 4 gigawatts by 2030, including distributed projects such as small domestic and industrial plants.⁽⁷⁾

- **Relying on modern technology and infrastructure,** by developing major solar power plants such as Ras Laffan, Mesaieed, and Khor Dukhan, and implementing smart grid management systems to ensure stability while increasing the proportion of renewable energy.

- **Developing human and economic capabilities:** by training national cadres to design, operate and maintain renewable energy projects, supporting local and international investment in this sector and creating new economic opportunities.

It is expected to raise the proportion of clean energy in the national energy mix to about 18% by 203, reduce millions of tons of carbon emissions annually during the life of operational projects, and strengthen Qatar's position as a leading example in the region in the field of environmental sustainability and renewable energy.⁽⁸⁾

- *National energy strategies show that Qatar aims to generate approximately 18% of its electricity from renewable sources by 2030, which is considerably lower than the targets set by Saudi Arabia and the UAE.⁽⁹⁾*

<i>Country</i>	<i>Renewable Energy Target</i>
<i>United Arab Emirates</i>	<i>50%</i>
<i>Saudi Arabia</i>	<i>32%</i>
<i>Oman</i>	<i>30%</i>
<i>Qatar</i>	<i>18%</i>
<i>Kuwait</i>	<i>15%</i>
<i>Bahrain</i>	<i>10%</i>

This variation reflects different national energy priorities, particularly Qatar's continued reliance on natural gas as its primary energy source.

2- Qatar Energy Strategy for Sustainability:

Qatar Energy launched its updated sustainability strategy in March 2022, which includes multiple initiatives to reduce greenhouse gas emissions.

Carbon dioxide capture and storage is the most important of these initiatives and efforts implemented by the State of Qatar, which has become a leader in this field in the Middle East and North Africa region. With the largest operational capacity for carbon capture and storage in the region, and the capacity to inject more than 2.2 million tons of carbon dioxide annually, Qatar Energy aims to enhance these capacities to capture more than 11 million tons of carbon dioxide annually by 2035. These efforts will contribute to further reducing the amount of carbon in the liquefied natural gas facilities in the State of Qatar by 35% And in exploration and production facilities by at least 25%.⁽¹⁰⁾

In another context, the State of Qatar is keen to continue its efforts to stop routine gas burning and reduce methane emissions leaking along the gas industry chain.

At the same time, the State of Qatar continues to invest in renewable energy technologies, recognizing their important role in sustainable development.⁽¹¹⁾

On April 27, 2024, the Qatar General Electricity and Water Corporation "Kahramaa" announced the launch of Qatar's National Renewable Energy Strategy, which aims to diversify and increase the rate of use of renewable energy sources, especially solar energy, in

Qatar and integrate them into the electricity mix thanks to the high quality of solar energy resources, in addition to several goals summarized in the following details⁽¹²⁾

- *Aims to increase renewable energy generation at central stations by about 4 gigawatts by 2030;*
- *Adopting distributed solar generation technology with a capacity of approximately 200 megawatts by 2030;*
- *Generating more local energy to take advantage of the country's global horizontal radiation level, which is among the highest in the world, with an average total radiation rate of more than 2,000 kilowatt-hours per square meter annually, which reduces pressure on the central grid infrastructure and enhances energy sustainability.*
- *Reducing carbon dioxide emissions through established trends and policies that enhance environmental sustainability and contribute to improving air quality;*
- *Reduce annual carbon dioxide density by 27 percent per unit of electricity produced;*
- *The energy mix recommended in the strategy will reduce the average cost of electricity generation by 15 percent in 2030 due to the competitive costs of renewable technology solutions;*
- *The strategy focuses on ensuring that the transition to renewable energy does not threaten the reliability and resilience of the electricity system. To achieve this, the strategy adopts a balanced approach that combines large-scale renewable energy facilities with the use of highly efficient thermal generation powered by natural gas;*

The strategy seeks to implement a net billing mechanism that enables consumers to sell their surplus consumption to Kahramaa at a fixed price. A two-way meter will be used to measure the amount of electricity consumed and the surplus exported to the public electricity grid. Kahramaa will record the surplus in the consumer's account for future consumption. This mechanism will contribute to reducing subscriber bills and encouraging investments in solar energy projects⁽¹³⁾

Within the framework of Qatar National Vision 2030. The country has launched a series of initiatives aimed at reducing emissions and enhancing energy efficiency, most notably the National Strategy for Environment and Climate Change (2021-2030. Which includes a clear plan to reach carbon neutrality by 2050.

Qatar is betting on liquefied natural gas as a transition fuel. It is less polluting than oil and coal, but it is not the final solution. The country has also begun to invest seriously in renewable energy projects, including the station project.

Solar energy silencer as a prime example. The station is the oldest solar power station in the country, and produces about 800 megawatts of electricity, which exceeds about 10 percent of Qatar's electrical needs, and contributes to reducing about 26 million tons of emissions annually

The country is also witnessing a tangible improvement in energy production efficiency, through the implementation of strict energy consumption standards in modern buildings and the encouragement of the use of electric and hybrid vehicles. In this context, the Ministry of Transportation announced a plan to fully electrify 25% of the public bus fleet by 2030, representing an important step toward sustainable transportation.

On the industrial side, Qatar Energy is implementing carbon capture and storage technologies, which are expected to reduce emissions by approximately 11 million tons annually by 2035, making Qatar one of the leading countries in adopting this technology in the Middle East⁽¹⁴⁾

Third: Renewable energies in Qatar.. Gains and achievements

1 -Al-Khorasah Solar Power Plant:

In 2022, Qatar inaugurated the Al Kharsa'a power plant, the country's first solar power plant, with a capacity of up to 800 megawatts, as a result of Doha's commitment to reducing environmental impacts and promoting the use of renewable energy sources.

It is the world's largest photovoltaic project that uses a sun tracking system and bifacial solar modules.

The station was built on an area of 10 square kilometers, and provides about 10% of the demand for electricity. Since its launch, it has contributed to avoiding the emission of about one million tons of carbon dioxide annually.

The Kharsa station is an advanced model, as it uses more than 1.8 million solar panels, is managed through a sun movement tracking system, and cleans the panels using night robots that rely on treated water, which improves operating efficiency and enhances sustainability.⁽¹⁵⁾

The project could provide Qatar with approximately 1.8 billion kilowatt-hours of clean electricity annually, and reduce carbon dioxide emissions by about 900,000 tons annually.

Moreover, as a pioneering green energy project for the Qatari government, it not only provided green and clean energy for the World Cup in Qatar, fulfilling its commitment to the "Green World Cup" but also paved the way for sustainable development, allowing Qatar to gradually reduce its dependence on oil and gas resources, implement its energy transition, and diversify its economy.⁽¹⁶⁾

2-Khor Dukhan Solar Energy Project:

In terms of future projects, the Dukhan Solar Power Plant is under construction - the project was announced in September 2024 - the Khor Dukhan Solar Power Project is a huge solar power plant in Qatar, and it is one of the largest plants in the world, with a production capacity of up to 2000 megawatts when completed by mid-2029. The first phase of its 1,000 MW production will begin in late 2028. The project aims to double Qatar's solar energy production, reduce carbon dioxide emissions, and contribute to achieving the goals of Qatar National Vision 2030.⁽¹⁷⁾

3-Solar power plants in Ras Laffan and Mesaieed areas:

In April 2025, Qatar launched the Ras Laffan and Mesaieed solar power plants, and the capacity of the two plants to generate electrical energy is 875 megawatts, distributed among 417 megawatts for the Mesaieed plant and 458 megawatts for Ras Laffan. The two stations were implemented on an area of 10 square kilometers with investments amounting to 2.3 billion riyals (\$631 million). In August 2022

These projects are added to the national solar energy grid, bringing Qatar's total solar energy production capacity to approximately 1,675 megawatts. During their operational life, these stations are expected to contribute to reducing millions of tons of carbon dioxide emissions, which will enhance Qatar's efforts in the field of environmental sustainability.⁽¹⁸⁾

The solar power plants project in industrial cities enables the reduction of direct emissions of more than 28 million tons of carbon dioxide; The production of the two plants contributes to reducing greenhouse gas emissions from Qatar Energy facilities in the industrial cities of Mesaieed and Ras Laffan, especially the projects to expand the

production of liquefied natural gas from the North Field, in addition to increasing the network capacity in other locations.

The two plants use highly efficient bifacial panels mounted on single-axis tracking devices, in addition to cleaning robots that will operate daily in order to reduce generation losses due to pollution, by removing dust from the photovoltaic modules, which leads to increased additional energy productivity produced by the bifacial modules.⁽¹⁹⁾

- *Below is a list of solar power plants in Qatar:*
- *Solar power plant in Dukhan area (under development): production capacity 2000 MW.*
- *Al-Khorasa Solar Power Plant: Production capacity 800 MW.*
- *Solar power plant in Mesaieed Industrial City: production capacity 417 MW.*
- *Solar power plant in Ras Laffan Industrial City: production capacity 458 MW.*

4- Ammonia7 Project:

In August 2022, Qatar Energy Renewable Solutions and Qatar Chemical Fertilizers signed an agreement to build the Ammonia-7 facility, the world's largest blue ammonia project worth nearly \$1 billion, with a production capacity of 1.2 million tons per year. The project will enter production during the second quarter of 2026.

Blue ammonia is one of the most important solutions in reducing carbon dioxide emissions in coal-fired electricity production plants, or by using it as fuel for ships in the field of shipping, and thus we contribute to achieving balanced growth that supports human development in a responsible, reliable and practical manner.

The plant consists of a production unit with a capacity of 1.2 million tons per year of ammonia, and a carbon dioxide injection and storage unit with a capacity of 1.5 million tons per year. Qatar Energy provides more than 35 megawatts of electricity to the new plant from the solar power plant currently being built in Mesaieed Industrial City. The project will use the latest technology available in the world during its implementation, in terms of safety, environment, operating processes, and plant control Ammonia production will also involve capturing carbon dioxide and injecting it into wells more than two kilometers below the Earth's surface, where 1.5 million tons of captured emissions are safely stored annually under layers of non-porous rock⁽²⁰⁾

Qatar is at the forefront of solar energy development efforts in the

region by implementing pioneering projects that contribute to achieving a sustainable electricity mix. These projects represent key pillars of the National Energy Strategy, which aims to increase reliance on clean sources to achieve energy security and provide long-term economic options. In this context, the Dukhan Solar Power Plant project is preparing to begin operation in the coming years, while Qatar Energy continues to launch various initiatives to enhance the use of solar energy in the industrial, educational and institutional sectors. These efforts come within the context of an integrated plan aimed at achieving carbon neutrality and promoting long-term sustainability.

In addition to the above, some of the gains and achievements achieved by Qatar in the field of renewable energies can be highlighted, as follow ⁽²¹⁾

- The transportation sector depends in large part on electrical energy;

The efforts of the State of Qatar led to the success of the FIFA World Cup Qatar 2022, as the first carbon-neutral tournament in the history of the FIFA World Cup competitions;

- Technologies used by Qatar to cool stadiums in one of the hottest places in the world, as well as to light tournament stadiums using solar energy;

- Completing the initiative to plant one million trees, which aims to reduce carbon emissions;

Qatar's National Environment and Climate Change Strategy aims to maintain and enhance the quality of life over the long term by reducing carbon emissions by 25 percent by 2030.

The State of Qatar encourages investment in renewable energy and energy conservation by providing financial, administrative, and media incentives that make

such investment attractive, safe, and economically viable, in addition to providing support to leading companies active in the field of renewable energy.

Fourth: Challenges of clean energy transition in Qatar

Qatar faces a number of challenges in developing renewable energy, despite progress in major solar energy projects.

- The heavy reliance on natural gas is one of the most prominent obstacles, as gas is the main source of electricity production, which

makes the transition to clean sources a gradual process linked to the restructuring of the energy system

- **Harsh climatic conditions:** *where extremely high temperatures and increased dust density impose-direct challenges that affect the performance of solar energy systems, as they contribute to a decrease in the efficiency of the panels and high operating and maintenance costs as a result of the need for continuous cleaning and protection from sand deposits⁽²²⁾*

- **Limited suitable land:** *The limited suitable land to establish huge renewable energy stations near transmission and distribution networks is one of the main problems in Qatar, as this requires careful urban planning and the development of storage capabilities capable of balancing the natural fluctuation of solar energy and ensuring the stability of the electricity supply⁽²³⁾*

- *The increasing demand for electricity The increasing demand resulting from population growth and industrial expansion poses an additional challenge, as it imposes great pressure on the distribution system, making the integration of renewable energy -with fluctuating production- a complex process, especially during summer peak periods⁽²⁴⁾*

- *The absence of large-scale storage technologies is one of the most significant obstacles limiting the expansion of renewable energy projects in Qatar. This shortage constitutes a major barrier to increasing the contribution of clean energy to the national mix, given the role of storage in stabilizing electricity supply and reducing the impact of natural fluctuations in solar production.⁽²⁵⁾*

- *The high initial investment cost of establishing renewable energy and smart connectivity infrastructure projects has posed a significant challenge to the expansion of this sector, given that these projects require advanced technical equipment and highly efficient control systems.⁽²⁶⁾*

- *The need to develop local competencies and skills in the areas of clean energy, along with internal competition with sectors related to natural gas that still achieve high economic returns, which reduces the attractiveness of investing in renewable energy in the short term.⁽²⁷⁾*

Conclusion:

Qatar's experience demonstrates that prioritizing renewable energy, particularly solar power, has become a strategic necessity, even in a

country with abundant hydrocarbon resources, aligning with Qatar National Vision 2030 and the pursuit of environmental sustainability. Key findings indicate that large-scale renewable energy projects have enhanced electricity generation capacity and begun reducing relative dependence on natural gas, yet they also reveal structural and technical challenges, including harsh climatic conditions, limited suitable land, high investment costs, and the lack of large-scale storage technologies.

These insights underscore that the transition to clean energy requires integrated policies focused on developing smart infrastructure, strengthening local human capital, and promoting research and innovation in renewable technologies. Achieving a balanced investment strategy between conventional and renewable energy sources is essential for securing sustainable electricity supply and meeting national development goals.

Looking forward, future research should explore advanced energy storage solutions, the integration of solar energy with smart grid systems, and innovative financing models for large-scale projects as avenues to overcome current limitations. Additionally, assessing the impacts of climate change and regional and international policy dynamics will be critical for designing flexible and effective renewable energy strategies. Addressing these dimensions strategically can position Qatar as a regional leader in the global transition to clean energy.

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