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Research Article

Harnessing Renewable Energy for Sustainable Urban Development: Case Studies from the MENA Region

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ABSTRACT

This study examines the potential of renewable energy for sustainable urban development in the Middle East and North Africa (MENA) region, focusing on key case studies such as Masdar City (UAE), the Noor Sour Complex (Morocco), and the Egyptian Gulf of Suez Wind Energy Project. The crisis narrative addresses the MENA region's increasing reliance on fossil fuels, increasing energy demand due to rapid urbanization, and the environmental and economic challenges associated with energy of commonly used sources. The study aims to assess how renewable energy can be incorporated into urban planning to meet growing energy needs while reducing environmental impact and improving energy security. The study examines the geographical advantages of the MENA region, such as the abundance of solar and wind energy, highlighting the success of renewable energy as well as identifying the main barriers to the implementation of renewable energy, including high upfront costs, fossil fuel subsidies, policy inconsistencies, restrictions -and public awareness. The results indicate that although this region has the potential to exploit more renewable energy sources, overcoming economic, technical and social challenges are needed for greater adoption The study provides recommendations a it is used to strengthen regional policies, encourage investment, encourage technological innovation and ends.

1. INTRODUCTION

The global energy landscape is undergoing major changes due to the increasing urgency to address climate change. Greenhouse gas emissions from conventional fuel energy production are a major contributor to global warming, causing severe environmental and social consequences such as rising sea levels, extreme weather, and disruptive agricultural systems these climate challenges require renewable energy. It has intensified as a sustainable alternative. Renewable energy sources such as solar, wind and geothermal provide clean solutions by generating low-carbon electricity [1]. In addition to environmental concerns, increasing energy demand, especially in rapidly growing cities, is increasing the pressure on conventional energy systems. Cities, especially in developing regions, are experiencing unprecedented levels of urbanization, resulting in higher energy consumption and greater strain on existing energy systems [2]. This shift towards energy production has in turn become not only an environmental need but also a need to sustainably support the energy needs of development urban populations Energy efficiency, which refers to urbanization and monitoring is central to this concept, as cities consume large amounts of energy, contributing significantly to global carbon emissions. Renewable energy plays an important role in this intersection of sustainability and urban development [3]. By integrating renewable energy into urban planning and development, cities can reduce their dependence on fossil fuels, reduce their carbon footprint, and help reach the world all climate targets. Urban areas with high population density and energy demand are ideal places to implement renewable energy solutions, such as solar panels for buildings or suburban wind turbines If materials apart from environmental benefits, renewable energy can enhance the socio-economic side of city life by creating green jobs, improving and providing air quality reliable and affordable energy [4]. The Middle East and North Africa (MENA) region faces unique energy challenges, largely due to its reliance on fossil fuels, which have historically shaped its economic growth for many MENA countries in the world some of the largest reserves of oil and natural gas, their

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economies are these are driven by exports but this reliance has led to economic vulnerability to fluctuating global oil prices and environmental a of the great destruction. Furthermore, urbanization in the MENA region is accelerating, putting tremendous pressure on energy systems and intensifying the need for sustainable solutions [5]. The MENA region is also uniquely positioned to benefit from renewable energy because of its geographical and climatic advantages. For example, the region is rich in solar energy, making it one of the best places in the world for solar projects. Similarly, there is considerable potential for wind energy development in some coastal desert areas in MENA [6]. Exploring the renewable energy resources in this region is important to understanding how they can contribute to sustainable urban development and meet the wider energy and environmental challenges in the region [7]. In terms of urban development, renewable energy allows MENA countries to develop resilient, sustainable cities that can meet the needs of their growing populations while reducing environmental impacts meeting problems Table 1 shows the most effective renewable energy strategies for urban sustainability. It classifies the options according to energy types, including solar, wind, geothermal, energy efficiency, waste energy and hydropower [8]. Each approach is described in terms of how it works and linked to relevant case study examples from MENA cities. These techniques, such as embedded solar panels, geothermal power plants and smart grids, play an important role in reducing carbon emissions, meeting growing energy demand and supporting cities sustainable development in the region [9].

TABLE I. BEST METHODS FOR HARNESSING RENEWABLE ENERGY FOR SUSTAINABLE URBAN DEVELOPMENT IN THE MENA REGION

Renewable Energy Type	Method/Technique	Description	Case Study Example
Solar Energy	**Concentrated Solar Power (CSP)**	Uses mirrors to concentrate sunlight and generate heat, which is then converted into electricity.	Noor Solar Complex, Morocco
	Photovoltaic (PV) Solar Panels	Converts sunlight directly into electricity using semiconductors.	Masdar City, UAE
	Building-Integrated Photovoltaics (BIPV)	Solar panels integrated into the architecture of buildings, providing both power and shading.	Smart cities in UAE and urban projects in Jordan
	Solar Water Heating	Solar collectors heat water for domestic and industrial use, reducing the need for conventional energy.	Various residential and commercial projects in Tunisia
Wind Energy	**Onshore Wind Farms**	Large-scale wind turbines installed on land to harness wind energy.	Gulf of Suez Wind Farm, Egypt
	Offshore Wind Farms	Wind turbines installed in bodies of water, typically oceans, to capture stronger and more consistent winds.	Planned offshore projects in Morocco and Egypt
	Small-Scale Urban Wind Turbines	Small wind turbines installed within urban settings to power local buildings or neighborhoods.	Experimental projects in UAE and Tunisia
Geothermal Energy	**Geothermal Heat Pumps (GHP)**	Uses the earth's constant underground temperature for heating and cooling systems in buildings.	Urban projects in Turkey
	Geothermal Power Plants	Taps into underground reservoirs of steam and hot water to generate electricity.	Emerging geothermal projects in Jordan
Energy Efficiency	**Green Building Techniques**	Incorporates renewable energy sources like solar and passive designs for energy efficiency in urban planning.	Masdar City, UAE and Amman, Jordan
	Smart Grids	Integrates renewable energy sources into the electrical grid to optimize electricity distribution and usage.	Implemented in urban centers in UAE, Saudi Arabia, and Egypt
	Energy Storage Solutions (e.g., Batteries)	Stores excess renewable energy for use during periods of low production, ensuring stable energy supply.	Integrated with solar farms in Morocco and Egypt
Waste-to-Energy	**Anaerobic Digestion**	Converts organic waste into biogas, which can be used for electricity generation or heating.	Pilot projects in Tunisia and Egypt
	Waste Incineration for Energy	Burns municipal waste to generate electricity, reducing landfill waste while providing a renewable energy source.	Projects in Jordan and Morocco
Hydropower	**Small-Scale Hydropower**	Uses the energy from small rivers and streams to generate electricity for local urban areas.	Projects in Morocco and Tunisia

2. RENEWABLE ENERGY POTENTIAL IN THE MENA REGION

The Middle East and North Africa (MENA) region is uniquely positioned to exploit renewable energy due to its favorable geographic and climatic conditions One of the most important advantages is the huge potential in the region in solar energy. MENA countries enjoy some of the highest solar radiation in the world, with many areas receiving between 2,500 and 3,500 hours of sunlight per year provided by the Region's vast desert, which is largely desert and unproductive for agriculture plenty of room for large solar power installations[10]. Countries like Morocco, the United Arab Emirates and Saudi Arabia have already taken advantage of this by building massive solar farms, including some of the world's largest solar power plants (CSPs). Where wind speeds are favorable, for example, the coastal regions of Egypt, Morocco and Tunisia have strong and consistent winds that could be used for large-scale wind farms. Egypt's Suez Gulf, for example, is one of the most productive wind energy areas in the region due to its strong year-round winds [11]. In addition, mountainous countries such as Jordan and Turkey also have favorable conditions for wind energy development. The region's geographic diversity enables it to utilize a wide range of renewable energy sources, making it ideally suited for a variety of energy sources through renewable sources Despite favorable conditions for renewable energy, historically the MENA has relied heavily on fossil fuels to meet its energy needs[12]. Many MENA countries have some of the world's largest reserves of oil and natural gas, which has allowed these resources to dominate their energy mix. Countries such as Saudi Arabia, Iraq and the UAE have built their economies around the extraction and export of fossil fuels, while domestic energy consumption has traditionally been fueled by oil and natural gas has contributed to this dependence on fossil fuels contributing to major environmental challenges, including overexploitation of Natural resources with carbon emissions, gas a pollution along with water depletion have further undermined environmental sustainability in the region, with rapid urbanization and population growth in many MENA cities[13].

In recent years, however, many MENA countries have recognized the need for energy diversification and have begun efforts to reduce their reliance on fossil fuels, with countries such as Morocco, the UAE and Egypt dominating leads the charge by integrating renewable energy into energy policy. For example, Morocco has set ambitious targets for renewable energy, aiming for 52% of its electricity generation to come from renewable sources by 2030. Similarly, the UAE has committed to increasing the share of clean energy in its energy mix to 50% by 2050 [14]. To facilitate the transition to renewable energy, many MENA countries have implemented supportive policies and programs aimed at encouraging investment in renewable energy Government policies especially in promoting the adoption of renewable energy by setting clear national energy targets, providing economic incentives and simplifying regulatory frameworks for renewable energy projects It has been done a system that includes solar, wind, hydropower. It includes specific targets for capacity development, supported by government-sponsored management agencies[15]. Similarly, the UAE's Energy Strategy 2050 outlines the country's long-term vision to balance energy efficiency and sustainability, placing greater emphasis on renewable energy and energy efficiency Money investment in renewable energy projects has also been strengthened by international partnerships and investment. MENA countries attracted significant foreign direct investment (FDI) in renewable energy sector, often in partnership with international organizations, private investors and multilateral financial institutions[16]. For example, the World Bank and the African Development Bank have been involved in financing renewable energy projects in Morocco and Egypt, including large-scale solar and wind projects as well as private companies in Europe, China and the US. and MENA governments have collaborated to develop renewable energy projects , which brought advanced technologies and know-how[17]. These policies and investments have enabled some of the world's leading renewable energy projects, te as the Noor Sour complex in Morocco and the Masdar City scheme in the UAE. This effort not only highlights the project's potential in renewable energy but also serves as a model for further development. However, despite these advances, coordinated regional policies and investments in research and development are needed to optimize the renewable energy potential of the MENA region [18].

3. RENEWABLE ENERGY AND URBAN DEVELOPMENT IN THE MENA REGION

Urban areas across the MENA region face major energy challenges due to increased urbanization and subsequent increases in energy demand. Many cities in the region, such as Cairo, Dubai and Riyadh, have experienced extraordinary population growth in recent decades, driven by migration from rural areas and influx of migrants These sprawling urban areas put pressure greater impacts on existing energy infrastructure, which is often outdated or ill-equipped to meet growing demand. Due to the evolution of energy supply systems, the demand for reliable energy needed to power homes, businesses and businesses is rapidly increasing [19]. As cities expand, energy consumption will increase due to increased use of electricity for residential cooling, lighting and transportation. This increasing demand exacerbates existing problems, such as frequent power outages and energy supply inconsistencies, which are especially common in low-income cities Resource constraints energy supply in urban MENA areas is further complicated. Grids were built in many MENA cities decades ago, primarily to cope with low population density and small power demands. As these cities grow, grids struggle to keep up with the load, resulting in inefficient distribution and loss of energy. In addition, urban sprawl in some areas has made it difficult for cities to provide reliable electricity to newly developed suburbs [2]. This situation is further complicated by the region's dependence on fossil fuels, which not only contributes to air pollution, but also makes cities vulnerable to fluctuating global oil prices To eat overcoming these challenges requires the modernization of infrastructure and the integration of renewable energy into the urban fabric. To overcome these energy challenges and promote sustainable urban development, cities across the MENA region are integrating renewable energy into their infrastructure and infrastructure, especially solar energy widely used due to the abundance of sunshine in the region [21]. Many urban developments in the UAE, Morocco and Jordan incorporate solar panels on residential and commercial rooftops to help meet local energy needs and reduce reliance on fossil fuels Solar energy large farms outside urban areas also feed into the renewable energy sector, which supports power urban areas. In addition to solar power, coastal communities are co-generating wind power, and wind turbines on nearby shores provide clean energy. These projects are particularly effective in areas such as Egypt's Suez Canal and Morocco's Atlantic coast, where wind conditions are favorable for energy production [22]. Although less extensive, geothermal energy is being explored in some areas in the region, especially in countries such as Turkey and Jordan, which have favorable geothermal conditions This renewable energy is incorporated into the city planning process a complete prioritizing sustainability and energy efficiency. A prime example is the concept of "smart cities," where technology is integrated into urban infrastructure for efficient use. Masdar City in the UAE, a popular smart city project, is designed to be powered entirely by solar, wind and other renewable energy sources, and uses advanced technology to reduce energy consumption [23]. Similarly, green construction, which emphasizes energy-efficient buildings, is gaining momentum in cities such as Dubai and Doha. These buildings are constructed with materials that reduce heat absorption and incorporate renewable energy such as solar panels and smart water heaters to further reduce energy consumption.

Integrating renewable energy into urban development in the MENA region provides significant economic and social benefits, contributing to both local economies and quality of life One important economic benefit is employment. The renewable energy sector requires a variety of professional skills, from engineers and engineers to construction workers and energy analysts. As countries invest in large-scale renewable energy projects, local businesses benefit from the need for resources, technologies and services, boosting economic growth Countries like Morocco have invested heavily solar power production in solar power plants and related equipment saw the emergence of new industries [24]. These projects not only create direct employment opportunities but also contribute to the local supply chain. Renewable energy projects also promote community engagement by engaging communities in their development and implementation. This is seen in rural and suburban areas near urban centers, where renewable energy installations tend to involve local communities, providing jobs and cheap energy This sharing helps to ensure recognize that the benefits of renewable energy will be shared among different social groups, including marginalized or low-income communities The social benefits are substantial. Improving air quality is one of the immediate benefits, as renewable energy reduces the need to burn fossil fuels, which are major sources of urban pollution This provides good public health results, especially in cities where pollution-related respiratory diseases are common. In addition to improving health, renewable energy also increases energy availability and affordability. In areas where energy distribution is uneven, especially in increasingly suburban areas, decentralized renewable energy systems—such as rooftop solar panels—can provide energy highly reliable and cost-effective source. This is particularly important for low-income urban households, which often bear the brunt of energy price fluctuations and scarce supplies. Overall, the shift towards renewable energy in MENA cities represents an important step towards sustainable cities, economic resilience and affects the whole lifestyle consuming a environmental and human development needs.

Table II presents a comparison of key parameters to evaluate different renewable energy options—solar (PV, CSP, BIPV), wind (onshore and offshore), geothermal (heat pumps and electricity). factory), waste and energy technologies—have a basis for use in urban development. Criteria such as energy source availability, conversion efficiency, cost, scalability, environmental impact, and stability of energy output are used to assess the strengths and limitations of each technology e.g., solar power is abundant in MENA but needed large space and energy storage, geothermal energy -Energy on the other hand keeps it running but with geographical limitations the table emphasizes the importance of each renewable energy technology and its most appropriate location for use will meet based on local conditions and needs[25].

TABLE II. KEY PARAMETERS FOR COMPARING RENEWABLE ENERGY TECHNIQUES AND APPLICATION AREAS IN URBAN DEVELOPMENT

Parameter	**Description**	**Solar Energy (PV, CSP, BIPV)**	**Wind Energy (Onshore, Offshore)**	**Geothermal Energy (GHP, Power Plants)**	**Waste-to-Energy**
Energy Source Availability	How readily available the energy source is in the region.	Abundant sunlight in most MENA countries, especially deserts.	High wind speeds in coastal and high-altitude areas.	Depends on geothermal resources, available in certain countries.	Organic waste availability depends on urban and industrial areas.
Energy Conversion Efficiency	How efficiently the technology converts the energy source into usable electricity or heat.	Solar PV efficiency ranges from 15% to 22%. CSP can reach 40%.	Wind turbines have efficiency rates between 35% and 45%.	Geothermal energy efficiency varies (10%-20% for electricity).	Waste incineration efficiency is around 20%-30%.
Initial Cost/Capital Investment	Upfront costs for setting up infrastructure and technology.	High initial investment for large-scale PV and CSP plants.	High for large wind farms; moderate for small urban wind projects.	Geothermal plants require high upfront costs.	High for infrastructure and waste collection systems.
Operating and Maintenance Cost	Ongoing costs for running and maintaining the technology.	Moderate O&M costs for solar PV; higher for CSP due to complexity.	Wind turbines have moderate maintenance costs, higher offshore.	Low operating costs but high initial maintenance.	Moderate costs, including waste collection and facility upkeep.
Energy Storage Requirements	Need for energy storage to address intermittency of the renewable source.	Energy storage (e.g., batteries) essential for solar due to daily cycles.	Storage may be required for wind to balance supply fluctuations.	Generally low as geothermal provides a constant energy supply.	No significant storage required; waste is continuously produced.

Scalability	Ability to scale the technology for use in different urban areas and project sizes.	Highly scalable, from rooftop solar to large solar farms.	Scalable for both urban small turbines and large offshore farms.	Limited scalability; mainly suitable for areas with geothermal activity.	Moderately scalable depending on the size of urban waste generation.
Space/Area Requirements	The amount of land or space required to install the technology.	Requires large land area for solar farms; rooftop panels for urban use.	Wind farms require large land or sea area; urban turbines are compact.	Requires space near geothermal fields.	Requires land for waste processing plants.
Environmental Impact	The potential environmental effects of the technology's deployment and operation.	Minimal emissions; CSP may impact water resources in deserts.	Minimal emissions, but turbines may affect bird populations.	Low emissions; may affect underground water systems.	Emissions depend on waste type; reduces landfill waste.
Social and Community Impact	Impact on local communities, including job creation and social acceptance.	Solar projects create jobs and are widely accepted.	Wind farms create jobs but may face resistance due to aesthetics/noise.	Job creation is limited; generally accepted in geothermal regions.	Creates jobs in waste management; moderate public acceptance.
Energy Output Consistency	How consistent and reliable the energy output is over time.	Intermittent; dependent on sunlight and weather conditions.	Intermittent; dependent on wind patterns.	Very consistent; provides a stable energy source.	Consistent energy output as long as waste is available.
Application Area	The typical areas or sectors where the technology can be applied.	Urban buildings, residential rooftops, large desert installations.	Coastal cities, mountainous regions, urban centers with wind zones.	Rural and urban areas near geothermal reservoirs.	Urban centers with significant waste generation, industrial zones.

4. CASE STUDIES OF RENEWABLE ENERGY PROJECTS IN MENA CITIES

Located in Abu Dhabi, Masdar is often hailed as one of the world's most progressive examples of sustainable urban development. Founded in 2006, the city was designed as a zero-carbon, zero-waste destination driven by completely renewable energy. Masdar City reduces total energy demand through a wide range of renewable energy technologies including solar and wind energy coupled with energy efficient construction The city is powered by a 10 MW solar photovoltaic (PV) plant, de including 1 distributed across buildings It's powered by megawatts and rooftop solar panels. Additionally, passive construction techniques such as shade and wind towers help reduce the need for air conditioning, while smart grid technology sustains energy efficiency in the city Masdar's success and a pioneering approach to integrating renewable energy and urban infrastructure that encourages sustainable development in every aspect of everyday lives However, the project also faced challenges, especially in terms of the goals of it is a serious comparison with the practical realities of urban development. Originally envisioned as a city of 50,000, Masdar has yet to reach that size, with delayed construction hampering its full realization as well as the high cost of developing such a stunning and green urban space poses financial challenges. Nevertheless, Masdar City has set a benchmark for sustainable urban development and provided valuable lessons for other cities integrating renewable energy into their urban design. It emphasizes the importance of balancing purpose and practical application, and emphasizes the importance of flexible and quality solutions.

Located near Oarzazate, Morocco, the Noor Solar Complex is the world's largest solar power plant (CSP) and is an important milestone in the region's renewable energy efforts The total capacity of the progressively developed company is approximately 580 MW when it is completed. The first phase of the project uses Noor 1, a CSP technology that uses glass to capture and intensify sunlight, which then heats water to produce steam and power turbines to generate electricity The technology is particularly effective in terms of energy a stored inside, allowing the plant to generate electricity even when the sun is not shining. The Nour Solar Complex has had a significant impact on Morocco's energy supply and regional development. It is Morocco's plan to generate more than 50% of its electricity from renewable sources by 2030. The project not only contributes to the country's reliance on fossil fuel imports but gives Morocco the lead in in renewable energy in the MENA region. The project was shaped by the Moroccan government's Renewable Energy Law (2010), while international organizations such as the World Bank and European Bank provided substantial financial support and also benefited from partnerships with the private sector, providing technological infrastructure unity developed. Noor's success demonstrates the power of international networks to grow renewable energy projects and highlights the role of strong policies in ensuring project sustainability.

Tunisia has made significant progress in integrating solar energy into its national urban grid, as part of its broader efforts to diversify its energy sources and reduce its reliance on fossil fuels the Tunisia solar energy system depends on increasing the share of renewables in its energy mix to 30 % by 2030, where Solar-energy is key The country focuses on encouraging solar energy applications in the hands of counties, such as rooftop solar panels for homes and businesses, as well as large-scale solar farms to feed into the national grid. Working with local and international companies in the financing and implementation of solar projects, he fostered a more competitive and innovative energy market Local participation has also been a driving force for Tunisia's solar expansion. Various initiatives such as support for installation of residential solar panels and community solar projects have increased public participation and adoption of renewable energy Not only if these policies contribute to energy it will not only be sustainable but also help alleviate social issues such as energy poverty by providing affordable and reliable electricity to underserved communities. Tunisia's solar energy efforts demonstrate how a combination of government policy, private sector participation and community engagement can lead to the successful integration of renewable energy into urban infrastructure. Egypt has emerged as a regional leader in wind energy development, with several large wind farms in the Gulf of Suez region. The region's unique topography, with strong and consistent winds, makes it an ideal location for wind energy. Egypt's wind energy projects in the region, such as the 545 MW El Zait Gulf wind farm, are among the largest in Africa and the MENA region. These projects contribute significantly to Egypt's goal of generating 20% of its electricity from renewable sources by 2022, a target Egypt is on track to exceed thanks to the rapid expansion of wind power It stands out for energy consistent density in urban areas near wind development in the Gulf of Suez The impact has been Cities like Hurghada and Suez have benefited directly from the clean energy generated by these wind farms, which it helps reduce air pollution and provides more reliable electricity Moreover, the success of these projects has generated interest in further expansion of wind power in the Gulf of Suez and other parts of Egypt, such as the Nile Delta Lessons learned from these projects—especially in terms of technology implementation, wind turbines integration, and environmental considerations—winds provide valuable insights for other countries in the region seeking to implement. The Egyptian experience illustrates the importance of geographically selecting the best locations and investing in large-scale infrastructure to maximize the availability of renewable energy.

Table III highlights the main obstacles and challenges to the adoption of renewable energy in the MENA region, divided into four main areas: economic and financial barriers, technical and infrastructural barriers, political and legal challenges , and sociocultural factors. Economically, the high cost of renewables and fossil fuel subsidies reduce the competitiveness of renewable energy. Technologically, integrating renewable energy into existing energy systems and addressing knowledge gaps are major challenges. On the political front, policy inconsistencies and regional geopolitical tensions impede progress. Lack of social awareness, resistance to cultural change, and educational gaps slow the transition to renewable energy. Addressing these challenges is essential to advancing sustainable energy development in the region.

TABLE III. BARRIERS AND CHALLENGES TO RENEWABLE ENERGY ADOPTION IN THE MENA REGION

Category	Description	Specific Challenges
A. Economic and Financial Constraints	Economic factors limiting renewable energy development.	- **High upfront costs**: The initial investment required for renewable energy projects, such as solar farms or wind turbines, is often prohibitive, especially in less wealthy nations. - **Fossil fuel subsidies**: Many MENA countries have long subsidized fossil fuels, making renewable energy comparatively more expensive and reducing the incentive for both consumers and investors to transition.
B. Technological and Infrastructure Barriers	Technological hurdles and infrastructure inadequacies that hinder renewable energy integration.	- **Grid integration challenges**: Existing energy grids were primarily designed for centralized fossil fuel power generation and are often incompatible with decentralized renewable energy sources, making integration difficult. - **Technological gaps**: Many countries in the region lack the technical expertise and advanced technologies required to fully develop and manage renewable energy infrastructure, necessitating significant capacity-building efforts.
C. Political and Regulatory Challenges	Political and governance issues affecting renewable energy progress.	- **Policy inconsistencies**: Across the MENA region, there is often a lack of cohesive renewable energy policies, with some countries lacking clear targets or comprehensive frameworks for renewable energy adoption. - **Geopolitical tensions**: Ongoing political instability and conflicts in parts of the region disrupt investment in and development of renewable energy infrastructure, while also complicating cross-border energy cooperation.
D. Social and Cultural Factors	Social and cultural dynamics influencing the adoption of renewable energy.	- **Public awareness**: Limited awareness and understanding of the benefits of renewable energy among the general population slow its adoption. - **Cultural resistance**: In some areas, there is resistance to change due to traditional reliance on fossil fuels, or skepticism regarding the reliability of renewables. - **Educational gaps**: The lack of targeted education and training programs hinders the development of a renewable energy workforce and public acceptance of new technologies.

Table IIII lists key policy recommendations for increasing the use of renewable energy in urban development, with specific actions for each sector. It emphasizes the importance of strengthening renewable energy policy by setting clear national targets, harmonizing local policies and streamlining regulatory frameworks and encourages financing mechanisms such as subsidies, tax breaks, green bonds and promoting public-private partnerships to propose investment incentives. The table recommends boosting technological innovation and research by funding R&D, establishing innovation centers and encouraging local manufacturing. Finally, it highlights the importance of public awareness and education campaigns through school programs, media coverage, and community engagement to promote energy efficiency encourage new sustainable use each recommendation includes actions that can be considered to ensure proper use.

TABLE IIII . POLICY RECOMMENDATIONS FOR ENHANCING RENEWABLE ENERGY IN URBAN DEVELOPMENT

Category	Recommendation	Parameters/Measures
A. Strengthening Renewable Energy Policies	Promote more cohesive energy policies and regulatory frameworks for renewable energy development.	- **Clear national renewable energy targets**: Establish long-term renewable energy goals for urban centers. - **Harmonized regional frameworks**: Coordinate policies across MENA countries to encourage cross-border energy cooperation and investment. - **Streamlined regulatory processes**: Simplify approval and permitting procedures for renewable energy projects to reduce delays.
B. Incentivizing Investment in Renewable Energy	Encourage private sector and international investment through financial incentives.	- **Subsidies and tax breaks**: Provide financial incentives such as tax reductions for companies and individuals investing in renewable energy technologies. - **Green bonds and financing mechanisms**: Implement green financing options, including bonds and low-interest loans, to attract investors. - **Public-private partnerships**: Foster collaborations between governments and businesses to develop large-scale renewable energy projects.
C. Enhancing Technological Innovation and Research	Support R&D and innovation in renewable energy technologies to drive local advancements.	- **R&D funding**: Allocate government and international funds specifically for research into solar, wind, and storage technologies. - **Innovation hubs**: Create centers for innovation in renewable energy within universities and research institutions. - **Local manufacturing**: Promote domestic production of renewable energy technologies to reduce dependency on imports.
D. Public Awareness and Education Campaigns	Increase public engagement in renewable energy through targeted education and outreach programs.	- **Educational programs**: Incorporate renewable energy and sustainability into school curriculums and university courses. - **Media campaigns**: Use television, radio, and social media to educate the public about the benefits and feasibility of renewable energy. - **Community engagement initiatives**: Organize public forums and workshops to involve local communities in renewable energy discussions and projects.

5. RESULTS

The study highlights the significant potential of renewable energy to drive sustainable urban development in the MENA region, but also highlights the major obstacles that need to be overcome. The key findings show that the region's abundant solar and wind energy resources, as well as new projects such as Masdar City and Noor Solar Complex, demonstrate the feasibility and practicality of renewable energy integration. However, the region continues to face challenges such as upfront costs, dilapidated infrastructure and inconsistent policies. Furthermore, social and cultural factors including lack of public awareness and resistance to change hinder the expansion of adoption. To fully harness the potential of renewable energy, the study highlights the need for coordinated regional policies, financial incentives, technological innovation and a comprehensive public education campaign. By addressing these challenges, the MENA region can significantly reduce its dependence on fossil fuels, improve energy security, and promote sustainable urban development Case studies of research and policy recommendations offer valuable lessons for the development of renewable energy in the urban landscape of the region.

TABLE V. COMPARISON OF STUDY RESULTS WITH OTHER STUDIES ON RENEWABLE ENERGY IN THE MENA REGION

Parameter	Results from this Study	Comparison with Other Studies
Solar Energy Potential	MENA region has abundant solar resources, with over 2,500-3,500 hours of sunlight per year.	Similar to other studies (e.g., IRENA 2020), which also highlight MENA's vast solar potential due to high irradiation levels.
Wind Energy Potential	Coastal and high-altitude areas, like the Gulf of Suez, have strong wind energy potential.	Matches findings from the World Bank (2019), which identified high wind energy potential in Egypt, Morocco, and Tunisia.
Economic Constraints	High upfront costs and fossil fuel subsidies hinder renewable adoption.	Other studies (e.g., IEA 2019) confirm that capital costs and fossil fuel subsidies are major barriers across MENA.
Policy and Regulatory Barriers	Lack of cohesive renewable energy policies and regulatory frameworks across the region.	Aligns with findings from the ESCWA (2021), which stresses policy fragmentation as a key challenge in MENA's energy transition.
Public Awareness and Engagement	Limited public awareness and cultural resistance to renewable energy adoption.	Similar to studies like AfDB (2020), which also point to public perception and awareness as significant social barriers.
Technological Innovation	Need for increased R&D funding and local manufacturing of renewable energy technologies.	Consistent with the UNEP (2020) report, which recommends greater investment in local renewable technology innovation in MENA.
Energy Output Consistency	Solar and wind energy are intermittent, requiring storage solutions for stable supply.	Other studies (e.g., IRENA 2021) also emphasize the need for energy storage systems to manage renewable intermittency.
Job Creation	Renewable projects like Masdar City and Noor Solar Complex contribute to local job creation.	Matches findings from the World Bank (2020), which showed significant employment benefits from renewable energy investments in Morocco and UAE.

6. CONCLUSION

In conclusion, this study highlights the tremendous potential of renewable energy for sustainable urban development in the MENA region. The region's vast solar and wind potential, exemplified by projects such as Masdar City and Noor Solar Complex, shows the possibility of integrating renewable energy into urban infrastructure but major challenges remain, which remain pre-substantial costs, including fossil fuel subsidies There are aging energy policies and inconsistent policiesSocial barriers such as public ignorance and cultural opposition also hampered the spread of adoption. To address these challenges it is imperative that the province implement coordinated policies, encourage investment, support technological innovation, and engage in public education These issues addressing this enables MENA to unlock the full potential of renewable energy, reduce its dependence on fossil fuels, improve energy security, and sustainable cities in the future - It can also support development Case studies and comparative analysis provide valuable insights into the steps required to develop renewable energy in the region.

Conflicts Of Interest

The authors declare no conflicts of interest regarding the publication of this research.

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