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Shaping Tomorrow's UAE: A Blueprint for Sustainable Energy

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ABSTRACT

This paper explores the United Arab Emirates' strategic shift from a hydrocarbon-based economy toward sustainable energy, focusing on national efforts like the UAE Energy Strategy 2050 and Vision 2071. Utilizing John Scott's document analysis model, the study evaluates government publications, policy plans, and global energy reports through the lens of ecological modernization theory. Findings reveal significant investments in solar, nuclear, and renewable infrastructure, including landmark projects such as Masdar City and the Mohammed bin Rashid Al Maktoum Solar Park. Despite strong political will, the transition is challenged by high initial costs, a shortage of skilled labor, and socio-political inertia. The paper highlights the environmental, health, and economic benefits of adopting photovoltaic, concentrated solar power, and biomass technologies. Ultimately, the UAE's energy transition presents a replicable model for other resource-rich nations, aiming to balance economic growth with environmental responsibility and climate resilience.

Keywords: *UAE, Renewable Energy, Fossil Fuels, Environmental Degradation, Energy Transition*

INTRODUCTION

The United Arab Emirates (UAE), a country that shines in tall skyscrapers, rich lifestyles, and vast deserts, is currently at a crossroads. Moving into the future without this oil-based form of energy and moving into solar and renewable forms is paramount. The change is not only about environmental change but also the overall changing aspect in the areas involving new energy security, health systems and sustainability development. Throughout most of the current century, the economic welfare of the UAE was anchored on the drainage of its native oil resources. As much as this resource has placed the nation on the global

economic map, it has, on the other hand, posed enormous environmental pollution, air contamination and health hazards due to extraction, processing and burning of fossil fuels. The excessive use of oil has aggravated the emission of greenhouse gases, disturbed local ecosystems and weakened air quality. The UAE is progressively allocating more money towards developing solar-based technology like photovoltaic (PV) systems, concentrated solar power (CSP) and biomass plants to contain these negative impacts. This is not only in tandem with the international climate pledges but also helps clean the air and make living conditions more healthful and energy independence in the long run. Through its adoption of renewable energy, the UAE is leading in the welfare of the globe by combating the impacts of the changing climate. They hope the moves will make the country a prototype of sustainable development and environmental conservation. This paper explores why the UAE is changing to solar energy, studies the anticipated advantages and effects on the environment and economy, and points out why the world has to change its use of fossil energy to build a more stable and equal future.

Historical Background

Incorporated in 1971, the United Arab Emirates (UAE) came to be associated with a high-speed economic growth as a result of great amounts of oil discovery in the 1950s turned out to be a landmark in the existence of the emirates, as it had turned a set of small desert principalities into an abounding federation with one of the highest GDP per capita worldwide. In the 1970s and 1980s, Abu Dhabi and Dubai cities became globally important financial and tourist centers in light of petroleum export revenues alone. By the early 2000s, oil provided over 30 per cent of GDP in the UAE, making it too dependent on hydrocarbons. Nevertheless, the ecological and health environmental long-term ramifications of oil dependence were being revealed increasingly. Refining and combustion of fossil fuels gave rise to increasing greenhouse gas emissions, urban heat islands, and dangerous air pollution that produced respiratory and cardiovascular diseases in residents. The environmental burden, desertification, air quality, and rising sea levels made the national leaders reconsider the development model. The UAE has truly believed in sustainability and clean energy in recent years. The example of such initiatives as Vision 2021 or the UAE Net Zero by 2050 Strategic Initiative represents a growing mind shift in the focus of the policies. It has come to the point where the country is spending billions of dollars on renewable energy projects such as the Mohammed bin Rashid Al Maktoum Solar Park and Masdar City. The developments aim to curb carbon emissions, energy mix, and energy generation for future generations. The transition of solar energy in history is an environmental prerequisite and a wise economic decision. Obtaining the leading position on the international scale among countries that adhere to the movement of clean energy, the UAE expects that it will be demonstrated as an example of sustainable development of the state, providing long-term prosperity for the state and people, their good health and environmental sustainability in the future.

Research Questions

1. How has the UAE's historical dependence on oil influenced its economic growth and environmental challenges?
2. What are the potential benefits of shifting to renewable energy sources, particularly solar energy, regarding health, environment, and energy security in the UAE?
3. What are the key barriers and opportunities in implementing the UAE Energy Strategy 2050 and related sustainable energy initiatives?

Research Objectives

1. To explore the historical context of oil dependency in the UAE and its role in shaping its economy and global image.
2. To examine the environmental degradation and health issues caused by fossil fuel consumption in the UAE.
3. To evaluate the feasibility and effectiveness of solar and biomass energy solutions in the UAE's climatic and infrastructural context.
4. To analyze the UAE's current policies, strategies, and international commitments toward renewable energy adoption (e.g., COP28, UAE Energy Strategy 2050).
5. To recommend practical and policy-oriented steps to accelerate the UAE's transition toward a sustainable and diversified energy economy.

Significance of the Study

The shift towards solar power production in the United Arab Emirates (UAE) can hardly be considered an environmental project; instead, it is a sweeping change with lengthy socioeconomic, health, and geopolitical consequences. This paper is important because it explores a more vital point of the UAE development cycle when the previously oil-dependent economy tries to become a leader in sustainable energy. To begin with, the research emphasizes the relevance of sustainable environments. The UAE region is located in one of the hottest parts of the world, meaning climate change's impact is already felt in rising temperatures and desertification. With solar energy, especially photovoltaic (PV) and concentrated solar power (CSP), the UAE could heavily decrease its carbon emissions and develop an environmental footprint. Secondly, health benefits of clean energy are highlighted in this research study. By getting out of oil-based energy, the air emitting pollutants like sulfur dioxide, nitrogen oxide, and particulate matter will decrease, all contributing to respiratory and cardiovascular diseases. Therefore, such transition enhances the health effectiveness of the population and reduces the costly national medical burden. Third is that the research is vital in economic and strategic diversifications of the UAE. The economy is prone to fluctuation when dependent on oil because oil prices are subject to changes. As energy demands are redistributed, it leads to economic fluctuations. By becoming more diversified by developing renewable energy, energy security is improved, green jobs are created, and international investments are attracted, critical to long-term financial strength. Finally, the research is relevant both in regions and internationally. As one of the most successful countries in the market as in oil-exporting countries, the UAE may become an example of a successful transition to others in the Gulf and other developing market countries. It also shows that economic modernization and environmental responsibility do not exclude each other, and how this can serve as an example that any 21st-century country can build a successful model of sustainable development.

LITERATURE REVIEW

The United Arab Emirates (UAE) has always been denoted as a global oil giant, and its future vision increasingly relates to the type of sustainable development. Since introducing the UAE Vision 2021 and Energy Strategy 2050, this shift has been under the close gaze of scholars and policy analysts, signaling an official move towards decreasing hydrocarbons compulsion and investing in renewable energy sources. Traditionally, when oil was found in Abu Dhabi in 1958 (Davidson, 2013), the economic change was initiated that brought the UAE out of the tribal confederations to become one of the wealthiest countries per head. But with the advent of climate change awareness and the unstable oil markets in the first decades of this century, the diversity of energy mixes among the Gulf countries, particularly the UAE,

was also triggered (Al-Sarihi, 2018). Several studies point out the environmental aftermath of reliance on fossil fuels. El-Katiri (2014) adds that oil-based energy production entails high carbon emissions, which lead to air pollution and heat island effects in the cities of the UAE. According to the research published by the International Renewable Energy Agency (IRENA) (2020), the green shift is not only a compulsion of environmental destruction but also a matter of economic necessity as the global oil markets have remained highly volatile. The UAE has already taken the first steps toward renewable energy. The story of clean energy creates a $22 billion development-Masdar City in Abu Dhabi, which has become a worldwide icon of green energy innovation (Reiche, 2010). Moreover, Dubai expects its solar plant at Mohammed bin Rashid Al Maktoum to produce 5,000 MW of solar energy by the year 2030, making it one of the largest solar farms around the world (DEWA, 2023).

Although the UAE has performed well in enhancing its sustainable energy initiative, a number of issues adversely affect the complete realization of its vision. The second theme recurring in the literature is the high initial investment cost in the renewable energy infrastructure. Other technologies, including solar photovoltaic systems, energy storage units, and smart grids, have an intensive capital investment at the initial stages, which may discourage private sector participation and slow implementation timelines. Although its long-term advantages, such as a decrease in the costs of operation and a reduction of carbon emissions, are well-known, its initial financial investment still raises a sense of urgency. The region's minimal numbers of technical expertise also constitute another major obstacle. The shift in the economy to using renewable energy sources, instead of fossil fuels, requires a highly qualified workforce with skills in renewable energy approaches, systems integration and environmental engineering. Al-Maamary et al. (2017) reckon that the UAE relies massively on imported technical workforce and foreign consultancy to establish and manage renewable energy projects. This dependency not only increases project budgets but also reduces the rate of buildup of local knowledge and self-sufficient in the industry.

In addition, there is more insidious yet also very powerful socio-political inertia. Historical entrenchment of oil dominance in the national systems has led to establishing institutional arrangements, political aspirations, and cultural expectations that do not easily yield to change. Such embedded systems may cause a lag in policy implementation, barriers to regulatory change, and constriction of innovation. Nevertheless, such initiatives as the UAE Energy Strategy 2050 can form a strong opposition to these impediments. The plan poses the high goals to achieve 44 percent of clean energy by 2050. It provides a multi-layered plan with further interventions, namely policy incentives, public-private collaboration, investments in education and innovation. This shows that the UAE is determined to realize sustainable energy to become one of its long-held national visions.

Literature Gap

Although there has been increasing literature on the transition to renewable energy in the UAE, there is much less in-depth, scope, and critical analysis. Most current research is biased toward technical feasibility and policy systems and emphasizes the solar potential, clean energy goals, and state plans like the UAE Energy Strategy 2050 (Al-Maamary et al., 2017; IRENA, 2020). Nevertheless, these studies rarely describe the aspects of implementation barriers at the level of socioeconomic and institutional factors, particularly, the relationships between federal and emirates-level policies. In addition, although it is mentioned that Masdar City and Mohammed bin Rashid Al Maktoum Solar Park are pretty successful projects, there is hardly any literature to assess these endeavors' long-term economic sustainability and ROI. Little research is available to quantify the contribution of renewable energy to job creation, entrepreneurship in the local communities, and GDP contribution in the UAE context. The other key missing point is no comparative scope to the regional perspective.

Most studies study the UAE in isolation without addressing the concept of cross-Gulf cooperation, knowledge dissemination and benchmarking against competitors with a similar vision (such as Saudi

Arabia Vision 2030). Moreover, the UAE's study on how people view the idea of a green energy transition and behave concerning behavioral preparedness on the issue is scarce. There is little research done on the role of civil society, consumer behavior and education outreach. Finally, there is hardly any empirical evidence around the socio-political opposition to decommissioning hydrocarbons. Literature also presupposes that transition can be simplified with the help of national visions and state-based investments without considering the adverse influence on vested interests, subsidies on energy, and employment through oil on improving conditions. A much more inclusive, sustainable, and realistic UAE energy policy would be developed upon filling these gaps.

Theoretical Framework

Sustainable Development Theory and Energy Transition Theory are the two major theoretical models that will help grasp the transition process to sustainable energy within the UAE. Such constructs bring the systematic means to assessing the UAE's changing energy environment concerning integrating environmental priorities, economic agendas, and policy courses of action. The Brundtland Commission (1987) suggested that there is the Sustainable Development Theory, which focuses on satisfying the needs of the current generations without impairing the capability of the subsequent ones to address their needs. The UAE strategic energy vision, particularly the UAE Energy Strategy 2050, is based on this theory and aims to diversify the energy mix by incorporating 44 per cent of clean energy by 2050. The theory assists in examining the long-term equilibrium between economic development, social equity, and environmental sustainability that the UAE aims at attaining. Energy Transition Theory, in its turn, provides a framework within which one can perceive the transition process between a society using fossil fuel-based systems to one using renewable energy-based systems.

This theory's energy transition drivers include technological innovation, policy instruments, institutional change and societal adaptation. It is particularly applicable to the situation with the UAE, where the state not only invested in the flagship initiatives like the Mohammed bin Rashid Al Maktoum Solar Park and Masdar City, but also currently restructures regulatory frameworks to enable the involvement of the private sector in renewables. Moreover, one can even incorporate the aspects of Political Economy Theory to evaluate the role of the rentier state gyrations, in which the oil-based economic framework would influence the speed and design of the clean energy transition. This theory assists in clarifying the institutional tensions and opposition of stakeholders, which is likely to be inbuilt as there is current economic reliance on hydrocarbon. The identified frameworks in combination allow examining the energy transformation of the UAE in a multidimensional manner, focusing not only on the technical and environmental questions but also political, economic and institutional processes that determine its sustainable energy future.

RESEARCH METHODOLOGY

This paper takes a qualitative research design of the document analysis model, assessing the UAE's strategic change towards renewable energy based on John Scott. Document analysis is a formal method to analyze the textual information recognized by the authorities and enables a contextual and historic overview of the policies, strategies, and energy infrastructure. According to John Scott (1990), there are four main criteria to evaluate a document: authenticity, credibility, representativeness and meaning. These are criteria for selecting and analyzing documents to assess reliability and scholastic integrity. Authenticity makes sure that the document is legal and of unquestionable origin. Credibility looks into the objective score and the accuracy of the document. Representativeness determines whether the document represents a general trend on a policy or an independent view.

Meaning emphasizes how the content is clear and understandable. The research is based on the secondary data composed of policy documents (e.g., the UAE Energy Strategy 2050, UAE Vision 2030 and Vision

2071), annual sustainability reports of the UAE-based company (Masdar, DEWA, and ADNOC), and publications of global associations (e.g., IRENA, World Bank, IEA). Additional knowledge from peer-reviewed journal articles, energy think tanks, and sustainability reports buttresses the research. To find the common themes, the selected documents undergo qualitative content analysis to detect such themes as "clean energy integration," "carbon neutrality," "public-private partnerships," and "policy innovation." Such themes are then evaluated to determine the strategic vision of the UAE and how it can meet its global sustainable development goals (SDGs), especially SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). Using the method of John Scott, this research excludes inappropriate and non-policy-relevant documents to confer an understanding of the sustainable energy blueprint of the UAE with a strong academic basis without using interviews and on-field work.

Main Explanation (Timeline)

UAE located in the Middle East, specifically in the eastern portion of the Arabian Peninsula. The area primarily consists of arid and parched desert landscapes. The UAE comprises seven emirates (Dicce, 2011) Abu Dhabi is the most extensive among them. Abu Dhabi holds authority over approximately 90% of the nation's oil and natural gas reservoirs. Abu Dhabi is the largest, controlling 90% of the country's oil and natural gas reserves. The UAE has experienced significant financial growth. One way to measure this is through the ratio of money and quasi-money to GDP (M2/GDP) can be expressed as the proportion of broad money supply (M2) to the Gross Domestic Product (GDP), indicating the scale of the financial system. This ratio experienced a significant increase from 1975 to 2014, reaching a peak in 2009.

Additionally, in 2015, the domestic credit to the private sector, relative to GDP, was approximately five times greater than in 1975. (Juaidi, Montoya, Gázquez, & Manzano-Agugliaro, 2015) From 1971 to 2013, there was a rise in per capita energy consumption and electricity use per capita, mainly due to a rising electricity demand. This led to increased power production from alternative sources. Furthermore, carbon dioxide (CO2) emissions in the UAE grew significantly from 1971 to 2013, peaking around 2009. However, there were reductions in emissions in 2010, 2011, and 2013, along with an increase in 2012. Trade openness also increased from 1975 to 2015, with a peak in 2013. During this time, the total population of the (Kazim & Veziroglu, 2001) grew considerably.

Since 1980, the UAE has consistently been one of the top per capita CO2 emitters globally from fuel combustion. This reflects the country's significant contribution to global CO2 emissions. (Khondaker, et al., 2016) Electricity production accounted for a significant portion. In 2012, the largest contributors to these emissions were the energy sector, with manufacturing industries, construction, and transportation also playing significant roles. In recent decades, the UAE has been driven to explore alternative energy sources due to fluctuations in oil prices and the desire to mitigate greenhouse gas emissions. Carbon dioxide emissions have seen a notable increase in emissions. The UAE in the Middle East has experienced substantial financial growth and rising energy consumption. (Munawwar & Ghedira, 2014) The country has also been a notable contributor to global CO2 emissions, particularly from fuel combustion. These factors have led to increased efforts in exploring renewable energy sources and reducing greenhouse gas emissions in the region (Farkhod Aminjonov, 2023).

Challenges facing the UAE due to using oil

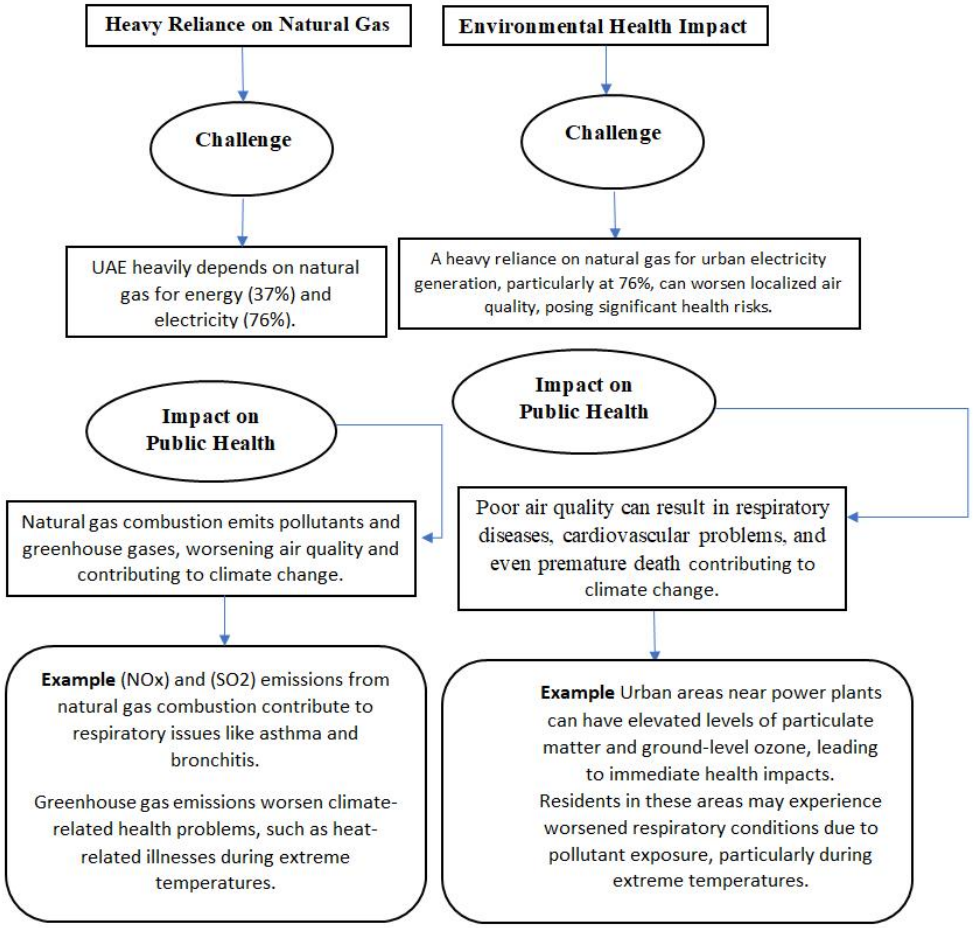
The UAE's heavy reliance on fossil fuels, particularly natural gas and oil, for energy consumption and production, as evident in Table 1, presents challenges related to sustainability, environmental impact, and vulnerability to global energy market fluctuations. While acknowledging the historical reliance on hydrocarbons in the region, the UAE must prioritize investments in renewable energy projects to diversify its energy mix, mitigate its carbon footprint, and address environmental concerns. The future direction of

the UAE's energy policy and investments is key to shaping a more sustainable and environmentally friendly energy landscape.

Table 1: challenges related to sustainability, environmental impact, and vulnerability to global energy market fluctuations

Total energy consumption (quadrillion Btus)	Total energy consumption (percentage)	Total energy production (quads)	Total energy production (percentage)	Electricity generation (Tera Watt Hours)	Electricity generation (percentage)
1.7%	37%	7.7%	76%	from the natural gas (127.1%)	from the natural gas (94%)
from the natural gas (28%)	from the natural gas (60%)	from the natural gas (2.4%)	from the natural gas (23%)		
Renewables and other 0.1%	1%	0.1%	1%		

Figure 1: Reliance on Natural Gas and Health Impacts



Climate Change

- ✓ Fossil fuel combustion, including oil, releases greenhouse gases, driving global climate change.
- ✓ Climate change results in extreme weather events, changing disease patterns, and resource shortages, all impacting public health directly and indirectly.

Heavy reliance on UAE oil has economic and environmental consequences, affecting public health and climate (Chaichan, february 2017) . Diversification and environmental actions are vital for a healthier, sustainable future.

Smart choice for the UAE

Renewable energy (RE) is becoming economically viable as an alternative to fossil fuels, despite uncertainties in greenhouse gas (GHG) inventories (Abdullah, 2021) . Fossil fuels and cement still contribute to 91% of CO2 emissions, exacerbating global warming. With a high per capita energy consumption, the UAE heavily relies on natural gas for over 99% of electricity generation. Population growth, though slowing, necessitates additional power plants by 2030. Implementing RE power plants is crucial to reduce greenhouse gas emissions. Carbon allowances and taxes are essential tools to curb emissions (Munawwar*, 2013). Transitioning to RE is vital for the UAE to combat environmental issues and reduce fossil fuel dependence.

Figure 2: Trend of Population Growth in UAE

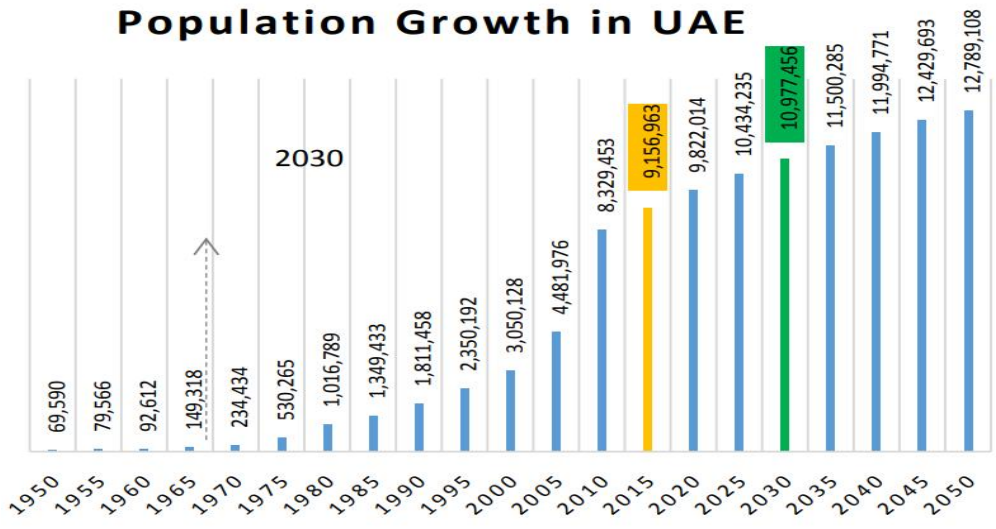
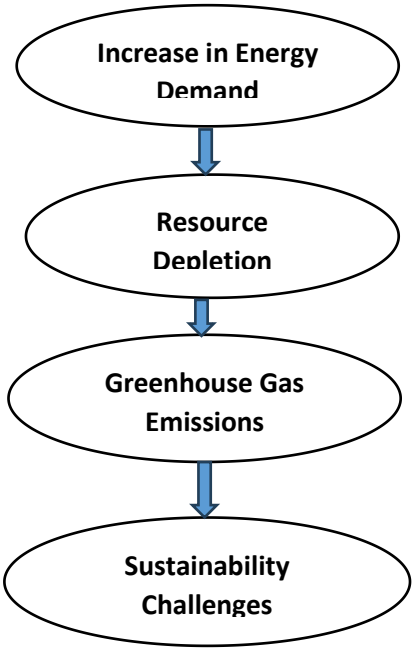


Figure 3: Population Growth and Sustainability Challages



Research Findings

- The UAE Energy Strategy 2050 aims to achieve 44 percent clean energy in the total energy mix by the year 2050.
- Another objective of the strategy is the increase of 40% in energy efficiency and the reduction of carbon emissions by 70%.
- There is a definite movement couched in policy documents of abandoning the use of hydrocarbons and transitioning to the use of renewable energy sources.
- Masdar City is featured as a green innovation and green city.
- Its Mohammed bin Rashid Al Maktoum Solar Park is one of the world's references in terms of solar energy projects.
- The focus of renewable energy project execution and financing revolves around the so-called Public-Private Partnerships (PPPs).
- Integration between federal and emirate-level energy plans is rising; therefore, policy coherence can prevail.
- Cooperation with international organizations like IRENA and such corporations as Siemens is encouraged.
- The UAE Vision 2071 has aligned the energy objectives with end-state national development.
- The compliance with UN Sustainable Development Goals (SDGs) is often mentioned in the official reports.
- Incentive systems and regulatory changes draw foreign investment in clean energy.
- The problem of skills shortage in renewable energy is consistently present.
- The financial issue is associated with high capital investments in clean energy infrastructure.

- Others have documentations that expose the socio-political inertia as an obstacle to the swift energy change.
- Despite all the challenges, the national narrative depicts rich political will and long-term sustainability.

Recommendations

After analyzing all these facts and figures, Photovoltaic (PV), Concentrated Solar Power (CSP), and biomass power plants play a crucial role in helping the UAE transition from oil-based energy sources to renewable energy (RE). Here's how each of these technologies contributes to this transition:

Photovoltaic (PV) Power Plants

- UAE's year-round sunlight is ideal for efficient PV power generation
- PV power diversifies the energy mix, lessening oil dependence.
- PV plants produce clean electricity, curbing carbon emissions.
- Domestic solar energy reduces reliance on imported fossil fuels, enhancing stability.

Concentrated Solar Power (CSP) Power Plants

- CSP technology captures and stores solar energy, ensuring a stable electricity supply even during cloudy periods and addressing the intermittency of PV power.
- CSP plants and desalination facilities combat water scarcity, improving resource efficiency and sustainability.
- CSP power is diversified, displacing the oil requirement and providing a greener energy production alternative such as PV electricity.
- Construction and operations of CSP plants result in jobs that contribute to economic development and social growth. Biomass Power plants: Biomass power plants are very productive but costly.

Waste-to-Energy

- Organic waste materials are burnt to produce electricity in biomass power plants, which limits waste problems and helps tap unexploited resources. Sustainability: Biomass is renewable, in compliance with sustainability requirements. It lowers the environmental implications of waste materials and produces clean energy.
- Utilization UAE makes use of local biomass resources, and it uses of less imported fuels.
- Biomass power emits fewer greenhouse gases, improving air quality and reducing carbon emissions.

Figure 4: Power Plants' Capacities

Figure 4 highlights the significant advantages of different power plant types in the UAE's energy transition, each with its unique strengths:

PV Power Plants (40%): Noted for solar energy abundance, diversification, emissions reduction, and energy security.
CSP Power Plants (40%): Emphasized for energy storage, desalination capabilities, diversification, and job creation.
Biomass Power Plants (20%): Recognized for waste-to-energy potential, sustainability, local resource utilization, and emissions reduction.

These advantages collectively demonstrate the diverse benefits of renewable energy sources, contributing to the UAE's multifaceted energy transition goals.

Table 2: Impact of Renewable Power Plants Across UAE

PV Power Plants	**Location** Sweihan, Abu Dhabi Emirate	**Role:** In Sweihan, a vast solar farm covered in panels captures abundant sunlight, converting it into electricity.	**Transition Impact:** On sunny days, Sweihan's solar power meets a significant part of Abu Dhabi's electricity needs, reducing reliance on oil-based generation, cutting emissions, and enhancing energy independence.
CSP Power Plants:	**Location** Let's say a large CSP facility is built in the desert near Dubai, given Dubai's commitment to clean energy.	**Role**: CSP plants concentrate sunlight using mirrors or lenses to produce electricity via steam. Crucially, they store heat for continuous energy	**Transition Impact**: Dubai's CSP plant provides stable power even after sunset or on cloudy days, reducing fossil fuel dependence and boosting energy security.

		supply during non-sunny periods.	
Biomass Power Plants:	**Location**: Biomass power plants in various cities or regions across the UAE, focusing on efficient waste management	**Role**: Biomass plants use local agricultural residues for clean electricity generation while addressing waste management challenges.	**Transition Impact** Biomass plants reduce fossil fuel reliance, cutting carbon emissions, and fostering sustainability by converting organic waste into energy.

CONCLUSION

The official document analysis, initiated following the model developed by John Scott, clearly shows that the United Arab Emirates is strategically moving from running a fossil-based economy to a sustainable and diversified energy path of the future. UAE Energy Strategy 2050 and Vision 2071 are just some of the initiatives proposed by the country that show a detailed but ambitious plan on how to develop with the idea of global sustainability in mind. The Masdar City and the Mohammed bin Rashid Solar Park projects are the practical representations of this vision. Its political will to change its energy structure is debatable because, despite the presence of issues, including the great cost of initially investing in energy transformation, scarcity of technical competencies, and socio-political inertia, the UAE has a high political commitment towards energy transformation. The existence of public-private partnerships, international cooperation, and supportive regulation improves the country's ability to dominate the region's renewable energy source. Nonetheless, to meet the year 2050 goals, the UAE must incorporate the missing parts of workforce growth, innovation, and localized energy solutions. A sustained, successful policy coherence, institutional integration, and knowledge-sharing must be undertaken. Essentially, by redefining its energy profile, UAE is not only forming its energy profile but also promulgating a model that can be emulated by other Gulf and developing economies that seek to explore a middle ground between environmental sustainability and economic development.

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