



RENEWABLE ENERGY STRATEGIES IN OIL-DEPENDENT ECONOMIES A COMPARATIVE STUDY OF GLOBAL EFFORTS WITH FOCUS ON THE MIDDLE EAST AND KUWAIT

¹SANJAY KOUL

Sanjay Koul: sanjay.koul@yahoo.com

Corresponding author: SANJAY KOUL

ABSTRACT

This paper explores global, regional, and national initiatives aimed at achieving net-zero emissions by 2050, focusing on progress made at each level. The global push for decarbonization has seen over 130 countries committing to net-zero targets, driven by international agreements and the growing urgency to mitigate climate change. Major global players, including the United States, the European Union, and Japan, have made legally binding commitments, while financial projections suggest that approximately \$275 trillion will be required globally to transition to sustainable energy systems by 2050. This includes investments in renewable energy, energy efficiency, and carbon capture technologies.

The Middle East, historically reliant on fossil fuels, is undergoing a significant transformation, with nations like Saudi Arabia and the UAE setting ambitious net-zero goals. Saudi Arabia has pledged to achieve net-zero by 2060, while the UAE has set its target for 2050. These countries are leading the region in renewable energy investments, focusing heavily on solar power, with projects such as the Mohammed bin Rashid Al Maktoum Solar Park and Saudi Arabia's NEOM city project.

Kuwait, while more conservative in its targets, aims to meet 15% of its energy needs from renewables by 2030. The Shagaya Renewable Energy Park is among the nation's flagship initiatives to harness solar and wind energy. Kuwait's efforts align with its Vision 2035 framework, which seeks to diversify its energy portfolio and enhance energy efficiency, contributing to the global push for net-zero.

This paper analyzes the economic, technological, and policy frameworks supporting these net-zero initiatives across the globe, with a specific focus on the Middle East's unique challenges and progress. It highlights the growing reliance on renewable energy, the role of international collaborations, and the hurdles that remain for regions heavily dependent on hydrocarbons. The analysis underscores the importance of sustained financial investments, innovation in green technologies, and multilateral cooperation to meet net-zero targets by 2050.

KEYWORDS: Net-Zero Emissions, Renewable Energy, Global Decarbonization, Middle East Energy Transition, Solar Power, Kuwait Vision 2035, Climate Change, Energy Efficiency

INTRODUCTION

The evolution of non-renewable energy sources has played a critical role in shaping human civilization, industrial growth, and technological advancement. From the initial use of wood and biomass by ancient societies to the reliance on coal during the Industrial Revolution, and eventually the widespread adoption of oil and natural gas, non-renewable energy has been at the heart of the global economy. However, this reliance has come at a high environmental cost, contributing to air pollution, greenhouse gas emissions, and climate change.

Historically, fossil fuels, including coal, oil, and natural gas, have been central to global energy consumption. The Industrial Revolution of the 18th and 19th centuries marked a turning point, as coal became the dominant source of energy, powering factories, transportation, and infrastructure. The subsequent discovery of oil in the 19th century ushered in a new era of energy development, with petroleum quickly becoming the backbone of the global economy, especially for transportation and industrial manufacturing.

The 20th century witnessed the rise of natural gas and the advent of nuclear power, both of which offered alternatives to coal and oil but came with their own set of challenges. The discovery of vast natural gas reserves and the development of hydraulic fracturing techniques in the late 20th and early 21st centuries spurred the global gas boom, further diversifying energy portfolios. However, despite these advancements, the reliance on non-renewable energy sources has raised significant environmental concerns, particularly with regard to carbon emissions and their impact on climate change which prompted many countries to explore alternatives, such as nuclear power and renewables. However, despite these efforts, fossil fuels remain deeply embedded in the global energy landscape. As of 2024, non-renewable energy still accounts for over 60% of global power generation, with coal, oil, and natural gas dominating the energy mix.



Today, the global energy sector stands at a crossroads. The scientific consensus on climate change has intensified pressure on governments, industries, and society to transition away from fossil fuels. The Paris Agreement of 2015 and subsequent international climate accords have set ambitious targets to limit global temperature rise to 1.5°C above pre-industrial levels, necessitating a significant reduction in greenhouse gas emissions. This has prompted a global push toward renewable energy sources, with countries and corporations pledging net-zero emissions by 2050 or earlier.

At the same time, the transition from non-renewable to renewable energy is complex and fraught with challenges. Many countries, particularly those in the Middle East, rely heavily on fossil fuel revenues to support their economies. Yet, even in these regions, there is a growing recognition of the need to diversify energy sources. Countries like Saudi Arabia and the United Arab Emirates (UAE) have announced ambitious renewable energy goals, investing in large-scale solar and wind projects. Kuwait, although slower to adopt renewables, has also taken steps to integrate solar and wind energy into its grid as part of its Vision 2030 plan.

This paper explores the historical evolution of non-renewable energy, the present state of global energy consumption, and the ongoing transition toward renewable sources. By examining key developments across different regions, particularly the Middle East, it provides insights into the challenges and opportunities associated with reducing reliance on fossil fuels. The paper also discusses the economic, geopolitical, and environmental implications of this transition, with a focus on global climate initiatives, renewable energy investments, and the future energy outlook.

This introduction offers a foundation for exploring the complex dynamics of non-renewable energy and the global shift towards sustainability. The detailed timeline, international efforts, and regional case studies provide a comprehensive overview of the energy sector's evolution and future challenges.

EVOLUTION OF NON-RENEWABLE ENERGY SOURCES

The evolution of non-renewable energy sources is hereby highlighted through a timeline that captures key developments over the years.

ANCIENT TIMES (BEFORE 1000 AD) - WOOD AND BIOMASS:

The earliest form of energy used by humans was wood for heating and cooking. The use of biomass laid the foundation for energy consumption, albeit limited to local sources.

INDUSTRIAL REVOLUTION (1750-1900) - COAL:

The Industrial Revolution marked a significant shift, with coal becoming the dominant energy source. It powered steam engines, factories, and locomotives, facilitating mass production and transportation.

EARLY 20TH CENTURY (1900-1940) - OIL:

The discovery of oil in Pennsylvania in 1859 initiated the petroleum era. By the early 1900s, oil began to replace coal for various applications, particularly in transportation (automobiles) and electricity generation.

NATURAL GAS:

Natural gas started to be utilized more extensively, particularly for heating and cooking, following the development of pipeline technologies.

POST-WORLD WAR II ERA (1945-1970) - NUCLEAR POWER:

The first nuclear power plants began operating in the late 1950s. Nuclear energy offered a new, albeit controversial, form of power generation, providing significant electricity without carbon emissions.

INCREASED OIL DEPENDENCY:

Global dependence on oil grew, particularly in Western nations, driving economic growth and contributing to geopolitical tensions.

1970S-1990S - ENVIRONMENTAL CONCERNS:

Growing awareness of environmental issues, including air pollution and climate change, began to affect the perception of non-renewable energy. However, coal, oil, and natural gas remained the primary sources of energy.

TECHNOLOGICAL ADVANCES:

Innovations in extraction and drilling technologies (like hydraulic fracturing) made previously inaccessible fossil fuels economically viable.

2000S-2010S - NATURAL GAS BOOM:

The early 21st century saw a significant increase in natural gas production due to advances in extraction techniques, leading to a shift in energy markets in favor of gas over coal due to its lower emissions.

RENEWABLE ENERGY RISE:

The latter part of the decade marked the beginning of a significant shift toward renewable energy sources, driven by technological advancements and global climate agreements.

2020S AND BEYOND - TRANSITION CHALLENGES:

Despite the growing focus on renewables, fossil fuels remain prevalent in global energy production. The challenge is balancing energy needs with climate goals, as many nations continue to invest heavily in non-renewable sources while gradually transitioning to cleaner energy.

POLICY SHIFTS:

International agreements, like the Paris Agreement, aim to limit global warming and encourage nations to reduce fossil fuel dependence.

GLOBAL POWER GENERATION BY SOURCE

The actual figures for breakdown of Global Power Generation by Source based on the latest available data may vary slightly depending on different reports, but this gives an overview of the energy mix:

Total Global Power Generation: 7500 GW capacity.

Contribution by Energy Sources:

NON-RENEWABLE ENERGY (~60% OF TOTAL, OR 4500 GW):

Coal: 28% of global electricity (around 2100 GW)

Natural Gas: 23% of global electricity (around 1575 GW)

Oil: 2% of global electricity (around 150 GW)

Nuclear: 9% of global electricity (around 400 GW)

RENEWABLE ENERGY (~40% OF TOTAL, OR 3000 GW):

Hydropower: 38% of global electricity (around 1150 GW)

Wind: 28% of global electricity (around 850 GW)

Solar: 33% of global electricity (around 1000 GW average)

Biomass and Others: 1% of global electricity (around 150 GW)

GLOBAL POWER GENERATION BY COUNTRY

Here is a breakdown of power generation by country, with contributions from renewable and non-renewable sources of energy, based on the latest data. The data covers major countries across the world.

Country	Total Generation GW	Coal %	Solar %	Hydro %	Wind %	Nuclear %	Natural Gas %	Other Renewables %
China	2600	59	4	18	8	5	--	6
United States	1200	20	3.5	6	9	18	38	5.5
India	415	72	7	11	4	3	--	3
European Union (EU)	1050	12	8	13	16	25	20	6
Russia	245	17	--	18	--	19	45	1
Japan	300	27	8	7	--	7	33	8

GLOBAL TRENDS

Coal continues to dominate in major economies like China and India, while natural gas plays a leading role in the US, EU, Russia and Japan.

Renewable energy is growing rapidly, with wind and solar seeing the highest rates of growth in countries like the United States, European Union, China, and India.

Hydropower remains a significant source of renewable energy in countries like Russia and China.

Nuclear power plays a crucial role in countries like United States, Russia and European Union.

These figures reflect the ongoing transition from fossil fuels to renewables in many parts of the world.

Power Generation in the Middle East

Here's a breakdown of power generation by country in the Middle East for the most recent data, with contributions from renewable and non-renewable energy sources.

Country	Total Generation GW	Natural Gas %	Oil %	Renewables (Solar & Wind) %
Saudi Arabia	85	~ 60	~ 40	~ 1
UAE	35	~ 90	~ 9	~ 2
Kuwait	20	~ 60	~ 40	~ 1
Qatar	11	~ 100	--	~ 1
Oman	11	~ 97	--	~ 3
Bahrain	4	~ 85	15	~ 1

MIDDLE EAST TRENDS

NATURAL GAS DOMINANCE:

Most Middle Eastern countries rely heavily on natural gas for power generation, accounting for the majority of their electricity supply.

LOW RENEWABLE PENETRATION:

Except for some growth in solar (UAE, Israel, and Oman), renewables still represent a small fraction of total power generation. However, ambitious projects are in place for solar and wind expansion across the region.

OIL DEPENDENCY:

Countries like Saudi Arabia and Kuwait still generate a significant portion of their electricity from oil.

NUCLEAR ENERGY:

The UAE leads in the region with nuclear power generation, primarily through the Barakah Nuclear Power Plant.

FUTURE TRENDS:

The region is expected to see substantial growth in solar power, with major projects in Saudi Arabia, the UAE, and Oman aimed at increasing renewable contributions to their energy mix by 2030.

GLOBAL INVESTMENTS

In 2023 and 2024, global investments in renewable energy have continued to grow, driven by the need to meet climate goals and transition to sustainable energy. Globally, the total investment in renewables reached about \$500 billion in 2022. Solar PV led the way in terms of technology-specific investments, followed by wind power (IEA)(IRENA).

These numbers show that while investment is growing, it needs to accelerate to meet global climate targets by 2050.

Here's a breakdown of the country-wise global data for total renewable energy investment with specific spending on solar, wind, and other sectors:

China leads the world with over \$250 billion in energy transition investment in 2021. This includes substantial spending on solar and wind energy, as China increased its wind and solar capacity by 19%. China has also seen significant investment in electrified transport and other clean technologies (World Economic Forum) (IRENA).

United States invested \$114 billion in 2021, with significant focus on solar and wind energy development, alongside investments in electrification and other low-carbon technologies (World Economic Forum).

Europe (Germany, U.K., and France) collectively invested \$219 billion in 2021, with Germany being a key player in wind energy, while solar investments have been robust across the region (World Economic Forum).

India has been significantly ramping up its investments in renewable energy to meet its ambitious climate targets. Here's the breakdown for recent investments in the sector.

India aims to achieve 450 GW of installed renewable capacity by 2030, with a significant portion coming from solar and wind. This positions India as one of the largest renewable energy markets globally, with continuous investment expected to grow over the coming years.

INVESTMENTS IN MIDDLE EAST AND NORTH AFRICA (MENA)

In Middle East and North Africa, investments in renewable energy, especially solar, are rising, with countries like the UAE and Saudi Arabia making large investments. This region, while traditionally dependent on fossil fuels, is pivoting toward solar power to meet their sustainability goals (IRENA).

The Middle East is projected to see substantial investments in renewable energy, with total investments expected to exceed \$75 billion by 2030. This investment covers a range of technologies, including solar, wind, hydrogen production, carbon capture, geothermal, and energy storage systems.

COUNTRY-WISE BREAKDOWN:

Saudi Arabia is leading the region's renewable energy efforts, with solar power making up nearly 70% of its renewable energy spending. The National Renewable Energy Program aims for large-scale solar projects and hydrogen initiatives. Recent reports indicate that Saudi Arabia invested around \$1.5 billion in solar energy last year.

United Arab Emirates (UAE) has also been a major player, with an estimated \$9 billion invested in renewables since 2017, primarily in solar energy. By the end of 2024, the UAE is expected to have about 10.6 GW of solar capacity installed. The Mohammed bin Rashid Al Maktoum Solar Park is one of the largest ongoing projects.

Qatar and **Oman** are also increasing their renewable capacity, particularly in solar and wind energy. Oman is making moves toward wind projects and solar plants, while Qatar is focusing on solar photovoltaic (PV) installations.

While the oil and gas sector remains dominant in the Middle East, these investments represent a growing focus on clean energy sources, spurred by regional goals to diversify economies and meet international climate commitments.



These figures highlight a significant shift toward renewable energy, but the region still faces challenges, such as high costs for wind infrastructure and supply chain issues.

Kuwait has been gradually increasing its investments in renewable energy, primarily focusing on solar energy. Here's an overview of the current landscape:

Kuwait's total renewable energy investments have reached approximately \$3 billion as of 2023, with significant efforts directed towards solar power projects (Renewable Energy Magazine).

The country aims to generate **15%** of its energy needs from renewable sources by 2030 as part of its **Kuwait Vision 2035** initiative (Renewable Energy Magazine).

BREAKDOWN OF INVESTMENTS:

SOLAR ENERGY:

The largest portion of Kuwait's renewable investment is dedicated to solar energy. Projects such as the 1.5 GW Al-Dhafra Solar Project and smaller PV installations are key components of its strategy. Approximately \$2 billion has been earmarked for solar developments (Renewable Energy Magazine).

WIND ENERGY:

Although currently less prominent, Kuwait is exploring wind energy as part of its renewable mix, focusing on research and feasibility studies.

FUTURE GOALS:

Kuwait plans to implement various renewable projects, including enhancing the capacity of existing solar plants and exploring offshore wind potential. These initiatives aim to contribute to a cleaner energy grid and reduce reliance on fossil fuels (Renewable Energy Magazine).

MAJOR PROJECTS IN MIDDLE EAST AND NORTH AFRICA (MENA)

MOHAMMED BIN RASHID AL MAKTOUM SOLAR PARK (UAE):

Capacity - 5,000 MW (planned), Completion - Phase 1 operational in 2013; ongoing expansions (full completion by 2030), Investment - Over \$13.6 billion, Details - Once completed, it will be one of the largest solar parks in the world, featuring both photovoltaic and concentrated solar power (CSP) technologies, Source - Dubai Electricity and Water Authority (DEWA)

NOOR ABU DHABI (UAE):

Capacity - 1,177 MW, Completion: 2019, Investment - Approximately \$1 billion, Details - This solar plant is one of the largest single solar projects in the world, using over 3.2 million solar panels, Source - International Renewable Energy Agency (IRENA)

BENBAN SOLAR PARK (EGYPT):

Capacity - 1,650 MW, Completion – 2019, Investment - Around \$4 billion, Details - This solar complex consists of multiple plants developed by various companies and is among the largest solar installations globally, Source - World Bank

AL DHAFRA SOLAR PROJECT (UAE):

Capacity - 2,000 MW, Completion - Expected in 2022, Investment - Approximately \$1.2 billion, Details - This project will significantly increase the UAE's solar capacity and is part of the country's strategy to diversify its energy sources, Source - Abu Dhabi Power Corporation (ADPower)

SHAMS SOLAR POWER STATION (UAE):

Capacity - 100 MW, Completion – 2013, Investment - Approximately \$600 million, Details - This is one of the first commercial-scale solar power plants in the Middle East utilizing CSP technology, Source - Masdar

SAKAKA PV IPP (SAUDI ARABIA):

Capacity - 300 MW, Completion – 2019, Investment - Around \$300 million, Details - This solar project is part of Saudi Arabia's National Renewable Energy Program and represents the country's first utility-scale solar power project, Source - Saudi Arabia Renewable Energy Project Development Office



KAHRAMAA SOLAR POWER PLANT (QATAR):

Capacity - 800 MW (planned), Completion - Expected by 2025, Investment - Approximately \$1 billion, Details - This project will contribute significantly to Qatar's goal of diversifying its energy sources, Source - Qatar General Electricity and Water Corporation (Kahramaa)

AL KHARSAAH SOLAR POWER PROJECT (QATAR):

Capacity - 800 MW, Completion - 2022, Investment - Approximately \$1 billion, Details - This project is a major step toward achieving Qatar's renewable energy goals, utilizing advanced PV technology, Source – QatarEnergy.

These projects reflect the Middle East's commitment to expanding its renewable energy portfolio, particularly solar power, as part of broader strategies to reduce reliance on fossil fuels and address climate change. For more detailed information, you can visit the respective sources linked above.

MAJOR SOLAR POWER PROJECTS IN KUWAIT

Kuwait has been making strides in renewable energy, particularly solar power, as part of its commitment to diversify its energy sources. Here are some of the significant solar projects in Kuwait:

KUWAIT INTEGRATED SOLAR PROJECT (KISP):

Capacity - 1,000 MW (planned), Completion - Expected in 2025, Investment - Approximately \$1.5 billion, Details - This ambitious project aims to harness solar energy effectively to meet the growing energy demands of the country. It will include large-scale solar installations and is part of Kuwait's broader renewable energy strategy.

SHAGAYA RENEWABLE ENERGY PARK:

Capacity - 2,000 MW (planned, includes solar, wind, and other renewables), Completion - Phased approach, with solar components expected to be operational by 2025, Investment - Estimated \$1.2 billion for the solar segment, Details - Located in the desert, the park will combine different renewable technologies, with solar expected to play a significant role. The project is part of Kuwait's plan to produce 15% of its energy from renewable sources by 2030.

KUWAIT NATIONAL PETROLEUM COMPANY (KNPC):

Solar Project, Capacity - 10 MW (completed), Completion – 2019, Investment- Approximately \$10 million, Details - This smaller-scale project aims to enhance the renewable energy footprint of Kuwait's oil sector by integrating solar energy into its operations.

FUTURE OUTLOOK

Kuwait is committed to increasing its solar capacity significantly as part of its Kuwait Vision 2035, which aims to diversify the energy sector and reduce dependence on fossil fuels. The focus on large-scale solar projects indicates a strategic shift towards renewable energy aligning with global sustainability trends.

CONCLUSION

The global journey towards achieving net-zero emissions by 2050 has seen significant momentum, driven by international commitments and rising climate urgency. However, the path remains complex and requires sustained financial, technological, and policy efforts. Globally, over 130 countries have pledged net-zero targets, with the focus on decarbonizing energy systems, improving energy efficiency, and scaling renewable energy sources like solar and wind power. Investments, projected to reach \$275 trillion by 2050, will be essential to facilitate this transition.

In the Middle East, countries are balancing their historical reliance on fossil fuels with emerging renewable energy projects. Saudi Arabia and the UAE have led the region's push toward decarbonization with significant solar energy investments and long-term net-zero targets (2060 for Saudi Arabia, 2050 for the UAE). These efforts are crucial to the region's energy future as nations aim to integrate renewables into their power grids, enhancing regional energy security and reducing carbon footprints.

Kuwait, while progressing more cautiously, is also aligning its renewable energy goals with its Vision 2035 framework. By focusing on solar and wind energy projects such as the Shagaya Renewable Energy Park, Kuwait aims to generate 15% of its electricity from renewables by 2030. The country's efforts reflect broader regional dynamics, where renewable energy is gaining traction despite the dominance of hydrocarbons.

Ultimately, achieving net-zero emissions will require coordinated action across all levels: global financial investment, regional collaboration, and national policy reforms. Countries in the Middle East, including Kuwait, are playing an increasingly pivotal



role in this transition. However, the pace of progress needs acceleration, particularly in regions with historically high carbon dependencies. The paper concludes that while significant strides have been made, the world must intensify efforts to meet the 2050 net-zero targets, fostering innovation, international cooperation, and a stronger commitment to sustainability.

REFERENCES

1. IEA - World Energy Outlook 2023
2. IEA, *Electricity Market Report 2023*
3. IRENA, *Renewable Capacity Statistics 2023*
4. EIA, *International Energy Outlook 2023*
5. WNA, *World Nuclear Performance Report 2023*
6. US Energy Information Administration (EIA), "History of Fossil Fuels," 2023.
7. McKinsey & Company, "Global Energy Perspectives," 2023.
8. BP Statistical Review of World Energy 2023, BP, 2023.
9. IRENA - Renewable Power Capacity Statistics 2024, International Renewable Energy Agency, 2024.
10. Carbon Tracker - Fossil Fuel Dependency and the Climate Crisis, 2023.
11. *Ministry of Power, Government of India 2024*
12. *European Union Energy Report 2024*
13. Nature - Energy in the Middle East: Balancing Fossil Fuels and Renewables, 2023
14. Renewable Energy Magazine - Solar Projects in the UAE and Saudi Arabia, 2024
15. Kuwait Vision 2035: Energy Diversification and Sustainability, Government of Kuwait, 2023
16. *Saudi Electricity Report, Ministry of Energy 2023*
17. Source: *Kuwait Energy Strategy 2023*
18. World Economic Forum, *Top Countries by Renewable Investment 2023*
19. Bloomberg NEF, *India's Renewable Energy Investment 2024*
20. *Qatar Energy Report 2024*
21. *Oman Energy Outlook 2024*
22. *Bahrain Sustainable Energy Report 2023*
23. Renewable Energy Magazine, Energy Industries Council (EIC) Report (2024)
24. Forbes Middle East (2024)
25. Accenture, "The Journey to Net Zero Emissions by 2050," published November 16, 2023
26. Renewable Energy Magazine, "Middle East Solar Projects," published in 2024

ABOUT THE AUTHOR

Sanjay Koul is an accomplished engineer, researcher, and writer with a deep passion for both technical and philosophical subjects. He holds a Bachelor's degree in Electrical Engineering from Gulbarga University, Karnataka, India (1992), and a Master of Technology in Energy Studies from the prestigious Indian Institute of Technology (IIT), Delhi (1997).



A certified Project Management Professional (PMP) from the Project Management Institute (PMI), he brings over three decades of experience in Engineering Design and Project Management, having worked with leading multinational and national companies across India and the Middle East.

Beyond his professional career, Sanjay Koul has a keen interest in knowledge sharing. He has authored several research papers in the fields of electrical engineering and general management. Also, he has authored a book on 'Happiness Illusion or Reality, which is available on Amazon.' His curiosity and dedication to Sanatana Dharma have led him to maintain an insightful blog (<https://sanjay-koul.blogspot.com>), where he has written several articles on Vedic traditions, spirituality, and philosophy.