JOURNAL OF SUSTAINABLE ENGINEERING & GREEN TECHNOLOGIES

Solar Energy and Net Zero Emission 2050

Sanjay Koul
Email: sanjay.koul@yahoo.com

Abstract - The conventional sources of energy including Oil and gas significantly contribute in meeting global energy needs. In recent years, the industry has been moving towards implementation of green energy to achieve Net Zero Emission (NZE) 2050 goals. Governments and corporations across globe have started large-scale initiatives to deploy advanced technologies to reduce carbon footprints and prevent global warming.

Currently, engineers and scientists are working on sustainable energy solutions influenced by climate change. The general trend in energy research is based on green energy resources, amongst which solar energy stands out as a viable option, being the most environmentally friendly clean energy technology, reduces carbon footprints, prevents global warming and is freely available in abundance in most parts of the globe.

This paper highlights solar energy as a viable option and focuses on its role to provide sustainable clean energy and in the process reduce carbon footprints and prevent global warming.

Key Words - Green energy sources; Reducing carbon footprint; Oil & Gas Industry; Energy transition; Sustainability, Renewable energy, and Solar energy

1. Introduction

The Net Zero Emissions by 2050 Scenario (NZE Scenario) is a normative scenario that shows a pathway for the global energy sector to achieve net zero CO_2 emissions by 2050, with advanced economies reaching net zero emissions in advance of others. This scenario also meets key energy-related Sustainable Development Goals (SDGs), in particular universal energy access by 2030 and major improvements in air quality. It is consistent with limiting the global temperature rise to 1.5 °C (with at least a 50% probability), in line with emissions reductions assessed in the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report.

The 2023 Net Zero Emissions by 2050 Scenario also describes a pathway for the global energy sector to reach net zero CO_2 emissions by 2050 by deploying a wide portfolio of clean energy technologies, without offsets from land-use measures. Decisions about technology deployment driven by costs, technology maturity, market conditions, available infrastructure and policy preferences.

The COP28 UN Climate Change Conference in Dubai, the United Arab Emirates, was held in November 2023. Some 85,000 participants, including more than 150 Heads of State and Government, were among the representatives of national delegations, civil society, business, Indigenous Peoples, youth, philanthropy, and international organizations in attendance at the Conference from 30 November to 13 December 2023.

COP28 was particularly momentous as it marked the conclusion of the first 'global stock take' of the world's efforts to address climate change under the Paris Agreement signed in 2015. Having shown that progress was too slow across all areas of climate action – from reducing greenhouse gas emissions, to strengthening resilience to a changing climate, to getting the financial and technological support to vulnerable nations – countries responded with a decision on how to accelerate

action across all areas by 2030. This includes a call on governments to speed up the transition away from fossil fuels to renewables such as wind and solar power in their next round of climate commitments.

COP 28 closed with an agreement that signals the "beginning of the end" of the fossil fuel era by laying the ground for a swift, just and equitable transition, underpinned by deep emissions cuts and scaled-up finance. As COP 28 President Dr. Sultan Al Jaber said: "We have language on fossil fuel in the (COP) final agreement for the first time ever." It clearly points to the direction of travel in the energy transition, and that the scale and pace of change can't be stopped or reversed.

Reference Kuwait Energy Outlook 2023 by Kuwait Institute of Scientific Research (KISR), The State of Kuwait pledged net-zero carbon emissions by 2060, while committing to deliver net-zero carbon emissions in its oil and gas sector a decade earlier, by 2050.

2. Renewable Energy

The future of global energy is dominated by four trends: declining role for hydrocarbons, rapid expansion in renewables, increasing electrification, and growing use of low-carbon hydrogen.

Electricity demand grows robustly over the outlook, driven by growing prosperity in emerging economies and increasing electrification of the global energy system.

DNV Energy Outlook 2023, Over the last five years (2017–2022) renewables have met 51% of new energy demand and fossil sources 49%. In absolute terms, fossil-fuel use is still growing.

World electricity demand has been growing by about 3% per year since the 1980s, in line with economic growth. By 2050, we anticipate a surge in global electricity demand, more than doubling from 29.5 petawatt-hours (PWh, or 29,500 terawatt-hours TWh) demanded in 2022 to reach 60.8 PWh in 2050.

Economics play a pivotal role in this shift towards renewables. Solar, with its dwindling levelized costs, will command a 39% share in the 2050 global power mix.

The growth of solar PV has been nothing short of astonishing. In 2004, solar installations were at a modest 1 GW per year. By 2019, that number had skyrocketed to 100 GW. Despite setbacks in 2021, caused by the COVID-19 pandemic, 150 GW were added. By 2022, solar installations approached a staggering 250 GW. Unsurprisingly, the future trajectory is sharply upward. By 2040, we see global installations rising further to about 500 GW annually. It is worth noting that within a decade, 10% of all new PV will integrate dedicated storage, and by 2050, that number will ascend to 62%. If we look at the bigger picture, by 2050, we will witness solar PV capacities of 8.8 TW and an additional 6.5 TW for solar + storage, bringing the total to 15.3 TW, a 13-fold growth from 2022.

The past decade has seen the rapid development of renewable energy in GCC countries, starting from virtually nothing and transforming into a growth market.

3. Middle East and North Africa (MENA)

The Middle East and North Africa region, blessed with high solar irradiation, will harness solar for almost half of its electricity by 2050.

The region is a cornerstone of the global energy system, accounting for more than half (57%) of the world's oil reserves and two-fifths (41%) of its gas reserves. In 2022, it produced more than a third (36%) of the world's oil and nearly a quarter (24%) of its gas.

Ample solar irradiation and areas with suitable wind resources make conditions favorable for renewables-based electricity generation.

Renewable capacity reached a record high 12.8% (3.2 GW) increase in 2022 with Iran, Israel, United Arab Emirates (UAE), and Jordan leading in the region.

4. MENA Energy transition: Oil for export and renewables at home

Renewable electricity is primed for rapid expansion with countries targeting increasing shares of renewables in power generation. Tunisia is aiming for 30%, Israel 40%, Morocco 52%, and KSA 50% by 2030, while Egypt is aiming for 40% by 2035. The UAE targets 14.2 GW renewable capacity by 2030 (from current 3.7 GW).

Renewable electricity will meet soaring domestic electricity consumption, free up oil and gas for exports, and facilitate electrification in extractive industries.

The Greece-Egypt (GREGY) interconnection prospect, currently in an accelerated development phase, would enable clean electricity supply to Europe.

In the Gulf, KSA, UAE, and Oman have issued ambitious hydrogen strategies, and are set to exploit abundant access to solar and wind power and to use natural gas reserves for blue hydrogen.

By 2050, with 27% renewables in the primary energy supply mix, this oil- and gas-rich MENA region will still rely predominantly on fossil fuels to provide its energy, even though today's shares of oil (35%), gas (58%), and coal (4%) in primary energy are expected to fall to 22%, 45%, and 2%, respectively, by mid-century. The overall regional picture can be described as oil giving way to solar to a significant degree, natural gas persisting as a 'transition fuel', and wind being slow to take off; large areas in the region with abundant low altitude wind resources and advances in wind turbine design to cope robustly with hot, sandy conditions will enable this.

5. Kuwait

Reference Kuwait Energy Outlook 2023 by Kuwait Institute of Scientific Research (KISR), Kuwait is experiencing ever-increasing domestic energy demand. As this demand grows, more crude oil and oil-derived products that could be exported will be diverted to meet local demand. Most of the primary energy devoted to meeting local demand is fulfilled by oil, averaging 55 percent share, followed by natural gas at 45 percent. While Kuwait has begun exploiting renewable energy, its share in the overall energy mix to meet local demand is currently negligible but will largely grow in order to achieve the national target of reaching Net-zero emissions by 2060.

In Kuwait, the existing renewable capacity stands at 200MW today, split between the Shagaya pilot project (combined 70MW, of which 50MW in CSP, 10MW in wind and 10MW in solar PV), KPC (Kuwait Petroleum Company) projects, residential rooftop projects and others.

In order to achieve its target of sourcing 15% of energy from renewable sources by 2030, Kuwait is working on multiple phases of the 4GW Shagaya solar project, with a plan to connect the various phases of the grid by 2027-28.

As per the Ministry of Electricity and Water (MEW), Phase 1 of the project will be a 1.1GW solar PV farm, while Phase 2 will comprise a 200MW CSP plant with an estimated five hours of storage capacity. In addition to this project, the government is planning to launch a series of solar projects at utility scale, including rooftop solar projects (5MW and below) and larger projects of around 10-150MW. Overall, we see scope for 5-6GW in capacity to be connected by 2030, including the 4GW Shagaya project and other distributed solar projects, with potential for further announcements of new projects as the market gradually becomes more accessible to the private market.

As per Kuwait's Ministry of Electricity, Water, and Renewable Energy (MEWRE) status as of year 2022, the total installed capacity of Power generation comprised mostly of conventional generation consisting of steam turbines, open-cycle gas turbines, and combined cycle gas turbines was approximately 20 GW.

In 2018, Kuwait appointed a Higher Energy Committee to oversee the adoption of renewable energy technologies. This committee revised Kuwait's renewable energy target previously set in 2012 from 15 percent total electric energy to 15 percent of electric capacity by 2030. This change will allow Shagaya, a centralized multi-technology renewable power plant, to fulfill Kuwait's renewable energy target upon its completion. In addition, decentralized renewable energy installations as well as other grid scale power plants will all contribute to the fulfillment of Kuwait's 2030 energy goals.

6. Solar Energy

Researchers suggest that the amount of sunlight that strikes the Earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year.

Reference International Renewable Energy Agency (IRENA), Renewable Energy Markets, GCC 2023, the GCC countries are blessed with high solar resource potential: their average annual global horizontal irradiation (GHI) ranges between 1700 and 2500 kilowatt hours per square metre (kWh/m^2).

This is an unlimited source of energy which is available at no cost. The major benefit of solar energy over other conventional power generators is that the sunlight can be directly converted into solar energy with the use of smallest photovoltaic (PV) solar cells. Solar energy technology is classified into two key applications: solar thermal and solar PV.

PV systems convert the Sun's energy into electricity by utilizing solar panels. These PV devices have quickly become the cheapest option for new electricity generation in numerous world locations due to their ubiquitous deployment.

The cost of generating electricity by solar PV plants decreased substantially. However, solar PV installed capacity progress expanded exponentially. Consequently, solar PV has emerged as a key component in the low-carbon sustainable energy system required to provide access to affordable and dependable electricity, assisting in achieving the Net Zero Emissions by 2050.

The installed capacity of solar energy worldwide has been rapidly increased to meet energy demands. The installed capacity of PV technology from 2010 to 2020 increased from 40.334 to 709.674 MW, whereas the installed capacity of concentrated solar power (CSP) applications, which was 1266 MW in 2010, after 10 years had increased to 6479 MW. Therefore, solar PV technology has more deployed installations than CSP applications. So, the stand-alone solar PV and large-scale grid-connected PV plants are widely used worldwide and used in space applications.

Solar cells are devices that convert sunlight directly into electricity; typical semiconductor materials are utilized to form a PV solar cell device. PV devices, sometimes called solar cells, are electronic devices that convert sunlight into electrical power.

Solar PV systems can be incorporated to supply electricity on a commercial level or installed in smaller clusters for mini-grids or individual usage. Utilizing PV modules to power mini-grids is a great way to offer electricity to those who do not live close to power-transmission lines, especially in remote areas. In the most recent decade, the cost of producing PV modules has dropped drastically, giving them not only accessibility but sometimes making them the least expensive energy form. PV arrays

have a 30-year lifetime and come in various shades based on the type of material utilized in their production.

Concentrated PV (CPV) technology uses either the refractive or the reflective concentrators to increase sunlight to PV cells. High-efficiency solar cells are usually used, consisting of many layers of semiconductor materials that stack on top of each other. This technology has an efficiency of >47%. In addition, the devices produce electricity and the heat can be used for other purposes.

For CSP systems, the solar rays are concentrated using mirrors in this application. These rays will heat a fluid, resulting in steam used to power a turbine and generate electricity. Large-scale power stations employ CSP to generate electricity. A field of mirrors typically redirect rays to a tall thin tower in a CSP power station. Thus, numerous large flat heliostats (mirrors) are used to track the Sun and concentrate its light onto a receiver in power tower systems, sometimes known as central receivers. The hot fluid could be utilized right away to produce steam or stored for later usage. Another of the great benefits of a CSP power station is that it may be built with molten salts to store heat and generate electricity outside of daylight hours.

7. Solar energy in Sustainable development

Sustainable energy development is defined as the development of the energy sector in terms of energy generating, distributing and utilizing that are based on sustainability rules optimizing efficiency, reduce emissions, economically viable, share long-term climate benefits, clean air and energy access targets.

The framework for energy sustainability development, by the application of solar energy, is one way to achieve that goal. With the large availability of solar energy resources for PV and CSP energy applications, we can move towards energy sustainability.

The environmental consideration of such applications, including an aspect of the environmental conditions, operating conditions, etc., have been assessed. It is clean, friendly to the environment and also energy-saving. Moreover, this technology has no removable parts, low maintenance procedures and longevity.

Economic and social development are considered by offering job opportunities to the community and providing cheaper energy options. It can also improve people's income; in turn, living standards will be enhanced. Therefore, energy is paramount, considered to be the most vital element of human life, society's progress and economic development.

As efforts are made to increase the energy transition towards sustainable energy systems, it is anticipated that the next decade will see a continued booming of solar energy and all clean-energy technology. Scholars worldwide consider research and innovation to be substantial drivers to enhance the potency of such solar application technology.

8. Conclusions

Most of the people are aware about non-renewable energy resources. Solar energy has become increase more popular due to their economic benefits. By on Battery Backup, Solar Energy can even provide Electricity 24x7, even on cloudy days and at night. This also used with inter-grid System with Continuously Power supply. It has more benefits compared to other forms of energy like fossils fuels and petroleum deposits. It is an alternative which is promise and consistent to meet the high energy demand being the most sustainable, environmentally friendly clean energy technology, reduces carbon footprints, prevents global warming and is freely available in abundance in most parts of the globe.

9. References

9.1. International Energy Agency (IEA), Global Energy and Climate Model Documentation 2023

9.2. International Energy Agency (IEA), Electricity Market Report 2023

9.3. International Energy Agency (IEA), The Oil and Gas Industry in Energy Transitions, 2020

9.4. International Energy Agency (IEA), The Oil and Gas Industry in Net Zero Transitions, October 2021

9.5. International Energy Agency (IEA), World Energy Outlook 2023

9.6. International Renewable Energy Agency (IRENA), Renewable Energy Markets GCC 2023

9.7. Kuwait Energy Outlook 2023 by Kuwait Institute of Scientific Research (KISR)

9.8. Goldman Sachs, The Equity Research, The Rise in Low Carbon Capex, November 2023

9.9. McKensey & Company, The Energy Transition a Region by Region Agenda for near term action final, December 2022

9.10. DNV Energy Transition Outlook 2023

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.