THE FUTURE OF SOLAR ENERGY: INNOVATIONS AND CHALLENGES IN ACHIEVING GLOBAL ENERGY TRANSITION

A Presentation at the NSE Benin Monthly Technical Session

By

Engr. Darlington Okoka

January 30th, 2025

Contents of Presentation

Introduction

Solar Energy is the radiant energy from the sun that can be transformed into electricity for both residential and commercial use. It is one of the most promising sources of renewable energy as we tend to transition into the green energy era.

How Does this Work?

SOLAR PANELS

- Solar panels usually called the Photovoltaic (PV) panels uses the PV cells to absorb the energy from the sun which then makes it to release electrons and produce an electric charge. PV panels are usually made from semiconductor materials such as silicon, gallium, boron etc but as of today, silicon doped panels are widely in use. When semiconductors are exposed to light/sun, it absorbs energy and transfers it to the negatively charged particles in the semiconductor material called electrons which then allows the electrons to flow through the material as an electrical current.

CHARGE CONTROLLERS

- Considering the varying intensity of the sun which invariably will lead to the decline in current flow, it is not safe to directly connect the output from the PV panels to the inverter, it is first of all connected to a charge controller. The charge controller helps to deliver the proper current and voltage that meets the rated capacity of the electrical loads. For off-grid systems, the charge controllers are used to maintain batteries at their highest state of charge without overcharging them.

INVERTERS

- The output of the charge controller is then connected to the inverter system. The inverter is used to convert the current (DC) from solar panels to alternating direct current (AC) which is required to power homes and commercial services. It should be noted that some inverters are hybrid systems which combines the functionality of a charge controller to itself.

BATTERY

- The battery is used to store power for use when there is no sunlight. The output from the charge controller is connected to the battery to charge it. Also, the output from the battery is connected to the inverter to ensure that power is inverted from DC to AC when there is need to use the stored power.

In summary, to power your building, it is quite simple especially for residential, what you need are:

1. Solar Panels – Your battery storage and load, will determine the number you need
2. Charge Controller – The rating will depend on the number of panels to be installed and how you intend to connect them i.e in series and parallel.
3. Inverter – The size/rating will depend on the required load to be powered.
4. Battery – This will depend on the number of hours you intend to power load during outage or in the absence of sunlight.

It is simple, and it is an investment you can do gradually without breaking the bank

SCHEMATIC OF A SOLAR INSTALLATION

Some Installed Projects in Benin

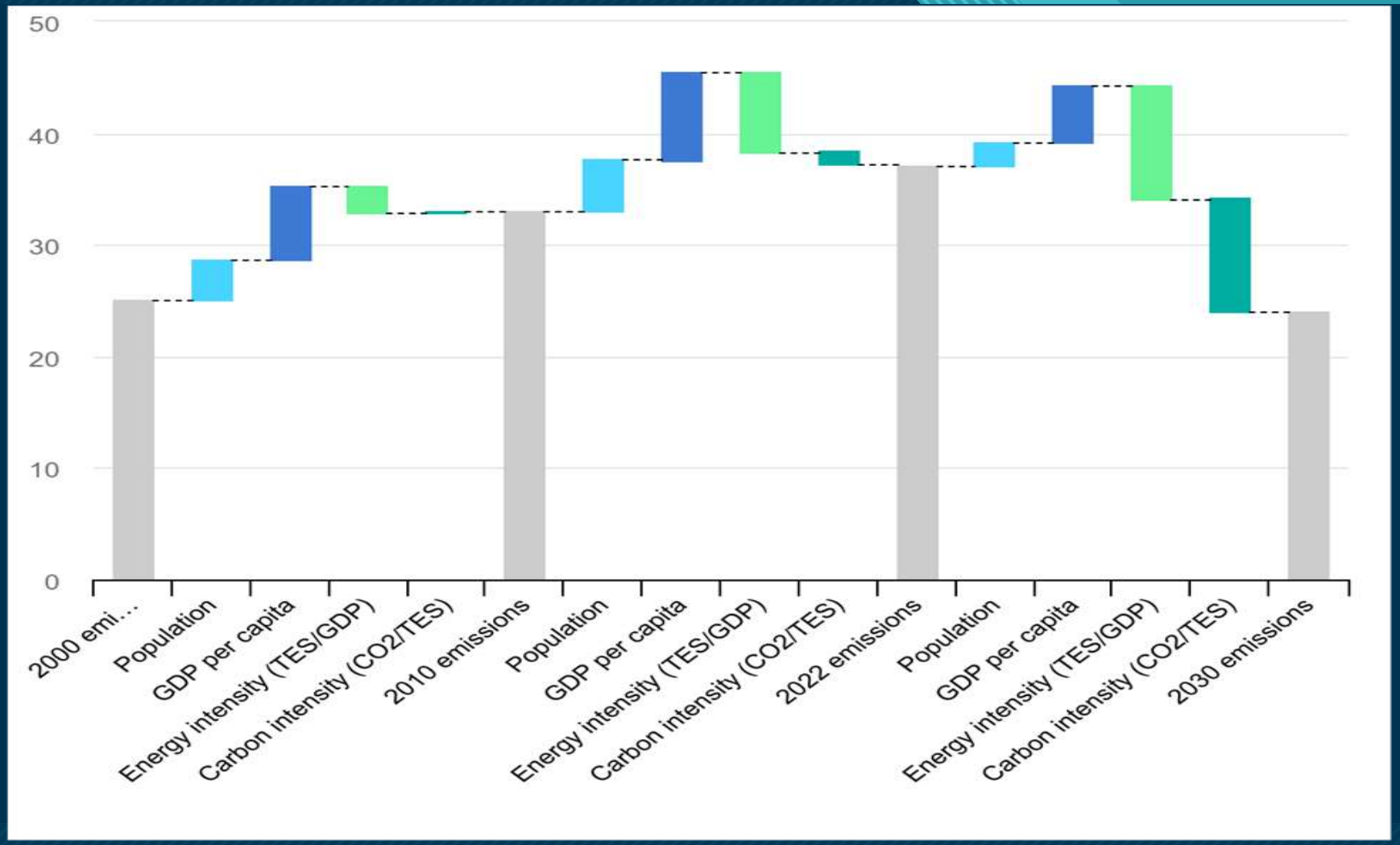
Global Energy Transition

Energy transition refers to the global shift from fossil fuel-based energy systems to low-carbon and renewable energy sources. It involves a fundamental transformation in the way we produce, distribute and consume energy.

The main reasons for energy transition are:

1. To mitigate climate change
2. To reduce greenhouse emissions
3. To promote sustainable development by providing access to clean energy in remote areas
4. To improve energy mix

The success of the energy transition depends on a transformation of the global energy sector from fossil-based to zero carbon sources by 2050, reducing energy related CO_2 emissions to mitigate climate change and limit global temperature.



IEA (2024), Global energy-related CO2 emissions and drivers

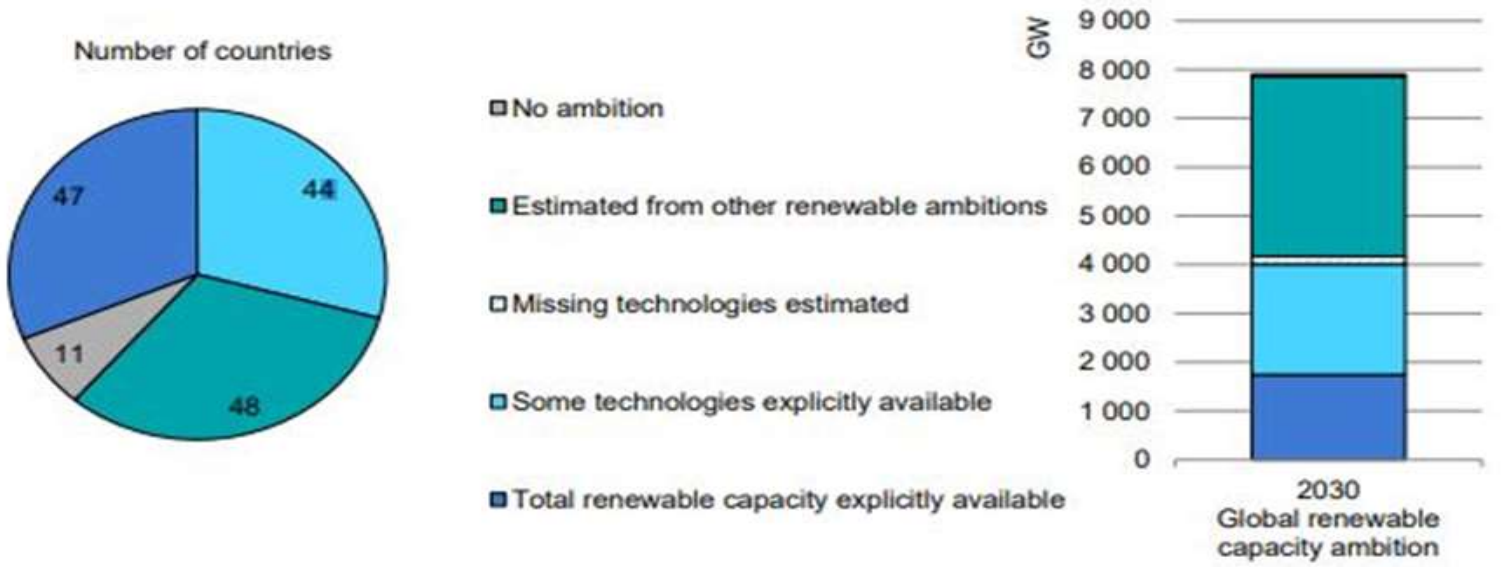
UN -COP28

During the conference of the parties to the UN framework Convention (COP28UN) on climate change in December 2023, Governments of various countries including Nigeria agreed to work together to triple the world's installed renewable energy capacity by 2030.

Although, from forecast by the International Energy Agency (IEA) it states that Global Renewable Capacity is expected to grow by 2.7times by 2030 surpassing countries current ambitions by nearly 25% but it still falls short of tripling which was agreed at the COP 28.

Considering the existing policies and market conditions, IEA also forecasts that 5500GW of new renewable capacity will become operational by 2030, this implies that global renewable capacity additions will continue to increase every year reaching almost 940GW annually by 2030.

Global renewable capacity in 2030 by ambition type and number of countries (left), and level of ambition (right)

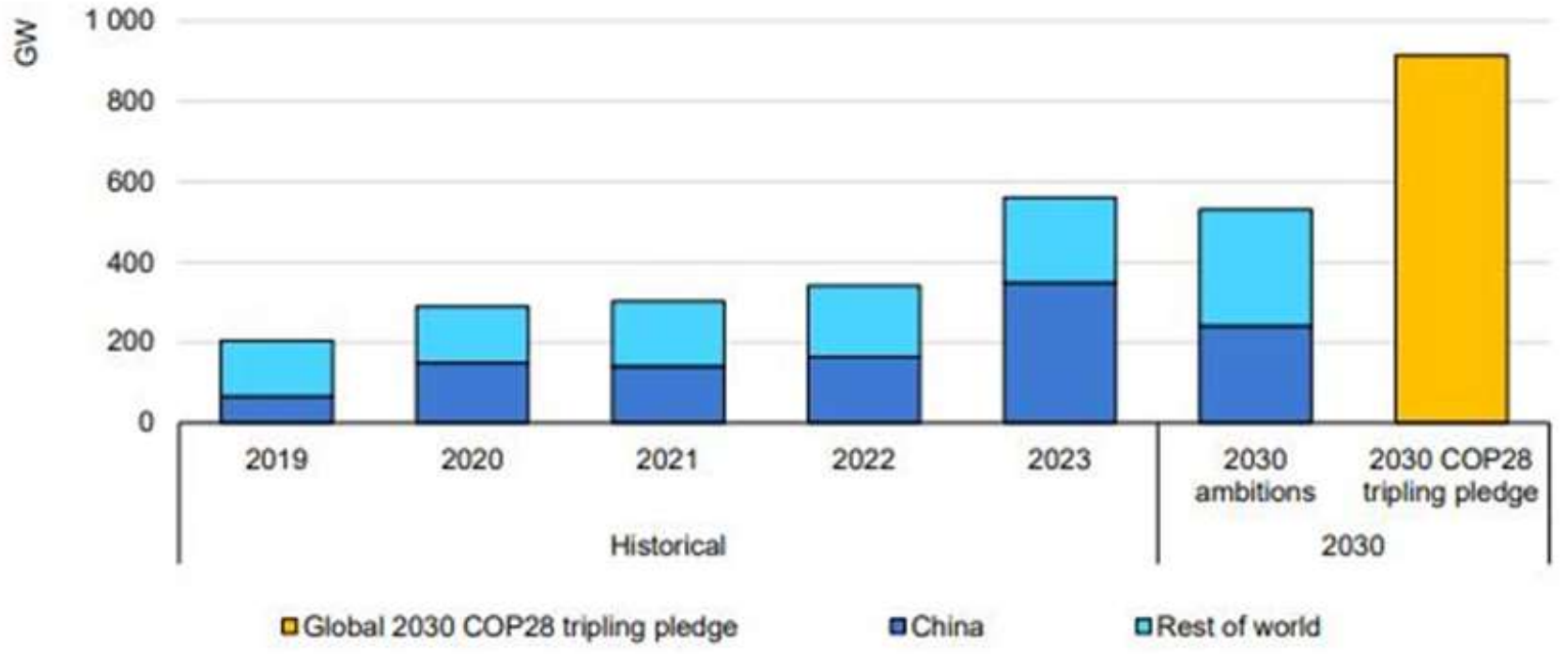


Notes: "No ambition" refers to countries that have not announced any quantitative ambitions for renewable electricity. "Estimated from other renewable energy ambitions" refers to quantitative ambitions for renewable energy expressed in terms other than total installed capacity, such as generation or net additions. "Missing technologies estimated" refers to the amount of estimated capacity missing for countries that have capacity for some technologies available, but not all. "Some technologies explicitly available" refers to countries that have capacity ambitions explicitly available for some technologies. "Total renewable capacity explicitly available" refers to countries that have a total installed renewable capacity value available. All these elements refer exclusively to 2030.

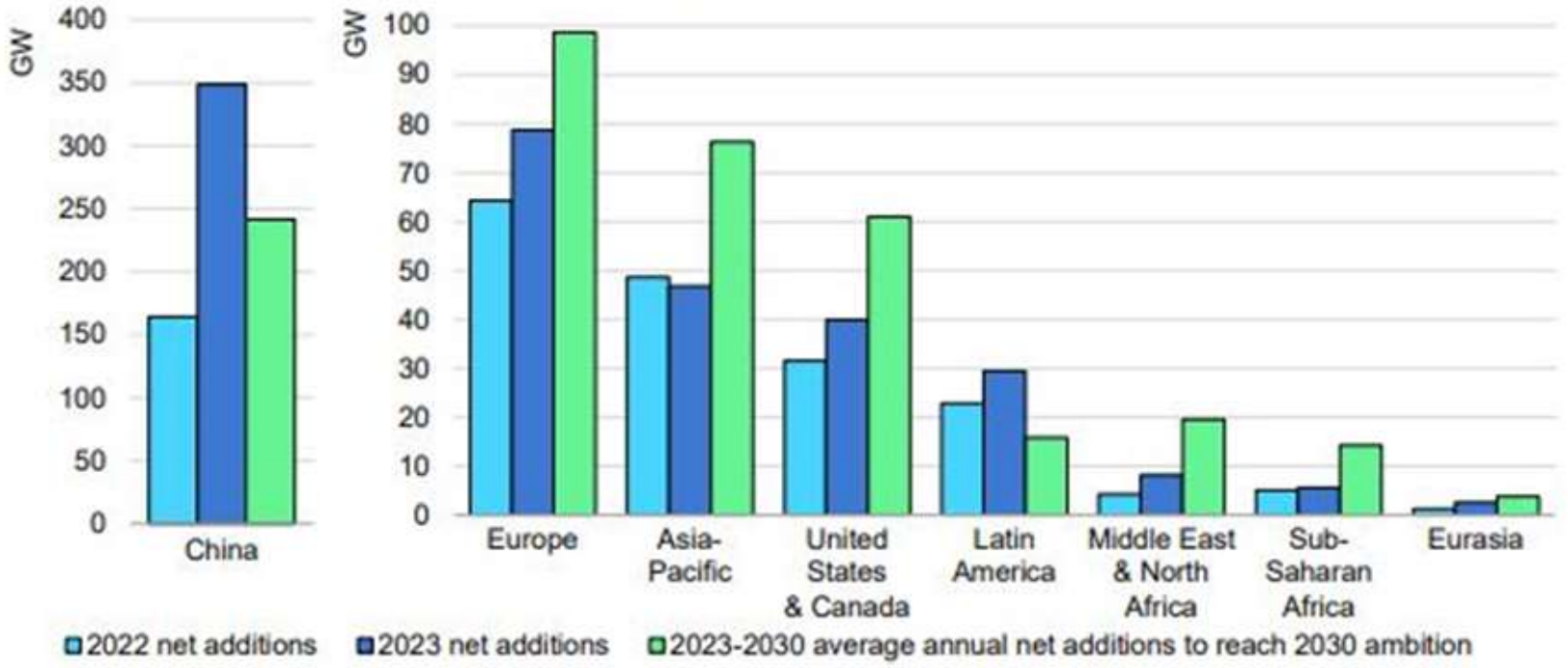
Drivers to IEA 2030 Forecast

1. China will cement its position as the global renewable leader accounting for 60% of the expansion in global capacity by 2030.
2. The EU and USA will double the pace of renewable capacity growth by 2030 while Indian will see the fastest growth among other large economies.
3. New solar capacity added between now and 2030 will account for 80% of the growth in renewable power globally by the end of this decade
4. Renewable will account for almost 50% of global electricity generation by 2030
5. China to continue to maintain leadership in solar PV manufacturing.

Global annual net capacity additions (2015-2023) vs average annual net additions needed to realise countries' ambitions for 2030 and the COP28 tripling pledge (2022-2030)



Annual net renewable capacity additions in 2022 and 2023 vs average annual net additions needed to realise country/regions' ambitions for 2030 (2022-2030)



Sources: IEA (2023), 2022 data from Renewables 2023.

INNOVATIONS

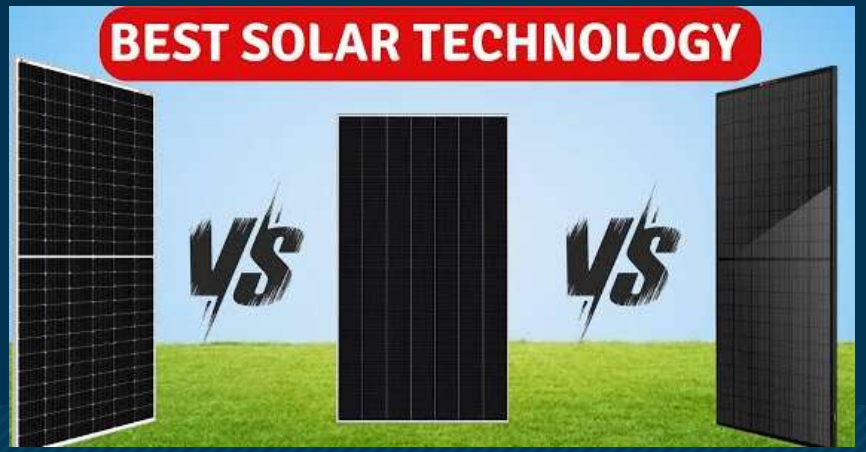
Innovations in renewable energy are propelling the transition towards a sustainable future with breakthrough across various sections of the solar power system. Some notable innovations are:

Innovations on PV Panels

- Recent technology on Perovskite solar cells promises higher efficiency and lower cost. Perovskite are semiconductor material known for its crystal structure.
- Passivated Emitter and Rear Cells (PERC) cell, these are more efficient than the traditional solar cells, they are mostly bi-facial meaning they can produce energy from both sides.
- Solar Roof Tiles/Walls and Transparent Solar panel Windows.
- TopCon Solar Cells – Tunnel Oxide Passivated Contact (TOPCON) are the novel innovation of the PV industry. They are a type of the N-type solar cell. N-type cells are made with a semiconductor material that has been doped with phosphorus which gives the material a negative charge. This type of cell has better advantages over the P-type cells including higher efficiency and better performance in low light conditions.

In PERC cells, the rear surface of the solar cells is passivated with a thin layer of Aluminium Oxide Al_2O_3, this layer helps to reduce recombination losses which can improve the efficiency of the cell.

In TOPCON cells, a thin layer of silicon dioxide (SiO_2) is deposited on top of the Al_2O_3 layer creating a tunnelling junction which allows electrons to flow more easily from P-type emitter to the n-type substrate, this tunneling junction helps improve the efficiency of the cell by reducing the series resistance.



Innovations on Charge Controllers

Maximum Power Point Tracking (MPPT), is the advised charge controller to be used currently in the market, Pulse Width Modulation (PWM) though cheap but its not advised because of the following benefits of MPPT:

i. Remote sensing

ii. Smart Monitoring

iii. Voltage Balance

iv. Max power harvesting

Innovations on Inverters

Based on waves, the following improvement have been made:

i. From Square wave to Modified Sine Wave to the current Pure Sine Wave Inverter

We also have:

a. Standalone Inverters

b. Grid Tied Inverter

c. Hybrid Inverter

d. Smart Inverter which has the following qualities:

i. Remote Monitoring

ii. Predictive Maintenance

iii. Advanced Thermal Management.

Innovations on Batteries

Batteries have received so much innovations such as:

i. Tubular Batteries /Absorbent Glass Mat (AGM) Lead-Acid Batteries

ii. Sealed Maintenance Free (SMF)

iii. Solar Thermal Storage

iv. Lithium-Ion battery: This battery has the following qualities:

a. Remote Monitoring

b. BMS

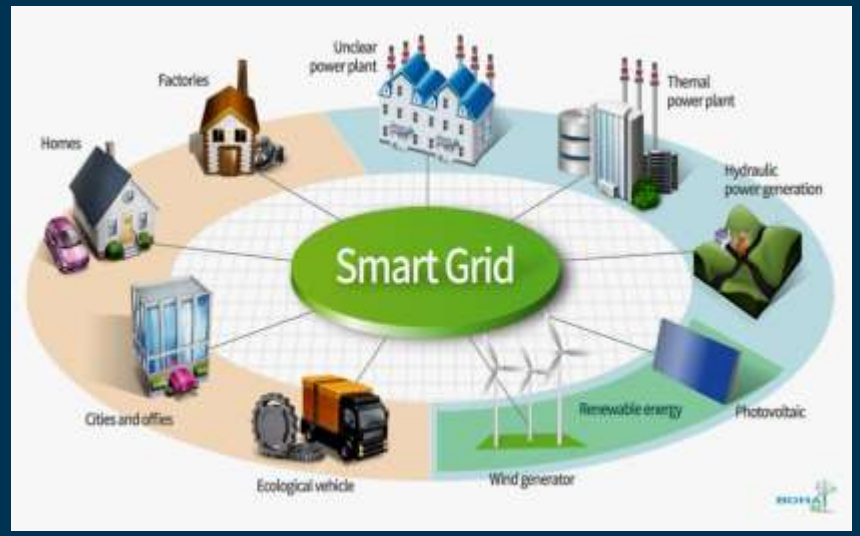
c. Fast Charging

d. Stackable

CHALLENGES

The global energy transition faces several significant challenges such as technical, economic, political and social; some of the key challenges are:

1. Grid Modernization – many countries including Nigeria have aging/outdated electrical grids that were not designed for renewable energy integration, upgrading these grids to support decentralized power generation could lead to a very significant challenge.
2. Energy Storage – considering the variability of renewable energy source which is climate/time bound, large scale energy storage solutions are necessary to ensure constant power when the renewable source is out, however, these large-scale storage solutions remain quite expensive and technologically challenging.



3. Political and Policy Challenges – there is no unified global framework for energy transition, different countries have their different priorities, capacities and political will leading to fragmented efforts. Last week, after the new president of the United States was sworn in, he ordered the pull out of the United States from the Paris Climate Agreement and he intends to promote fossil fuels and mineral mining.

4. Economic and Market Factors – Transitioning to renewable energy infrastructure requires substantial upfront capital, this upfront capital can be very prohibitive for both Government and Businesses, although the operational and running cost is usually lesser on the long run.

5. Land Requirement – the large span of land required for renewable energy project is quite massive, and this poses a great challenge to some countries without vast portion of land.

6. Raw Material Availability – renewable energy rely on raw materials like lithium, silicon, cadium and some other rare earth materials which are domiciled in some regions with unstable political climate.
7. Technological Development – while there has been significant progress in energy efficiency, continuous innovation is needed to improve the efficiency and scalability of renewable energy technologies.
8. Fossil Fuel Dependence – so many countries are still very dependent on fossil fuels both for energy production and as a source of revenue, this dependence can slow down the transition as political and economic systems tend to resist change.

THE FUTURE OF SOLAR ENERGY

The future of solar power looks good with the continuous growth and innovation being experienced in the industry. The following key trends and developments are likely to shape the future of solar energy:

1. Increasing Adoption – the use of solar energy is expected to continue to grow rapidly with many countries setting ambitious targets for the deployment of solar power.
2. Innovations in Technology – the solar industry is constantly innovating with new technologies being developed to help improve efficiency and performance of the solar system.
3. Growing Role in the Transportation Sector – with the development of solar powered vehicles, and the use of solar panels for electric vehicles, solar energy is expected to play a pivotal role in this sector.

4. Increased Storage Capacity – with the development of new technologies in the solar storage system, the confidence of solar energy usage is beginning to increase.
5. Policy and Regulatory Support – Governments and policy makers around the world are increasingly recognizing the importance of solar energy and are taking steps to support its adoption.

NIGERIA'S PREPAREDNESS

Nigeria is faced with both challenges and opportunities in the ongoing global energy transition. A lot of preparedness and government policies are already in place to ensure the transition process is seamless. Some of the key aspects are:

1. Energy Transition Plan – Nigeria has developed an energy transition plan (ETP) with the goal of achieving net-zero emissions by 2060.
2. National Renewable Energy and Energy Efficiency Policy (NREEEP) – This policy aims at providing a framework for the development of renewable energy and energy efficient projects across the country.

3. Electricity Act 2023 – The Electricity Act 2023 signed by President Tinubu reflects the prioritization of the country especially this new administration on electricity both on renewable and other forms of power generation. The Act aims to make the electricity industry more efficient, sustainable and consumer oriented. In the Act, we had sections 164 and 167 outlining the measures to support the development and use of renewable energy including tax incentives and establishment of renewable purchase obligation. It also encourages private investment in renewable energy, creates a power consumer assistance fund and establishes the REA, a feed-in-tariff policy that guarantees a fixed price for renewable electricity fed into the grid and recognizes the power of federating states to regulate their electricity markets, most importantly by licensing investors for mini-grids and power plants.

4. Natural Gas – Although, Nigeria is a major oil producer, it is increasingly focusing on natural gas as a cleaner alternative to coal and oil.
5. International Partnership and Investments – Nigeria has received support from international bodies such as World Bank, EU, AFDB to help finance energy projects. In 2025, Nigeria is expected to benefit from $750million from World Bank under the Distributed Access through Renewable Energy Scale-up (DARES) project aiming to provide clean energy to 17.5million Nigerians. Also, there is an approved $500million loan to Nigeria by AFDB to help the government close the financing gap in energy transition.

6. Most energy projects to un-served rural areas in Nigeria are usually renewable mini-grid, showing the government interest in renewable energy.
7. Despite the efforts by NASENI, the government and the business world are not yet keen for commercial manufacturing of solar products such as panels, batteries and even inverters, we are still keen on importing from China. This should be looked into so that we can use this emerging era to stamp our feet down as the real giant of Africa.

What the Nigeria Government Needs to Do

1. Invest in Research and Development
2. Collaborate with international companies/partners to setup Lithium-ion plants and PV plants in Nigeria, NASENI PV plant is not economically competitive.
3. Encourage and Support local manufacturing
4. Facilitate technology transfer from countries with more advanced solar energy system.
5. Public-Private Partnership
6. More incentives to private investors
7. Public awareness and education as well as technical training to increase skilled man-power for ease of installation.

CONCLUSION

We can see that the future of solar energy is great, with the 2030 and 2050 targets, if carefully followed, a full transition would have been attained. Nigeria as a country, needs to key into this technological advancement so that we may not be left behind. The future is green, we cannot remain a consumer of technology, let us try to be part of the implementation, innovation and manufacture of this green energy which has come to revolutionalise the world and save it from the depletion of the ozone layer and greenhouse effect.

Thank You for Your Attention

Engr. Darlington Okoka

(+234) 803-9233-787
darlington@delwit.com
www.delwit.com