ENERGY TRANSITION: PREPARING FOR A LOW CARBON FUTURE

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Content

- Energy Transition is not New
- Energy is the Key to growing GDP
  - Fossil fuels have been an Important Engine for Economic Growth
- Pathways to a Low-Carbon Future
- Strategies and Enablers
  - Policy Initiatives
  - Fiscal (Incentives and Taxes)
  - Tapping into Global Fund
- References.

Introduction:
Energy Transition (ET) is Not New

Energy transition is not new, at various points in the history of economic development in the world energy transition has often led the way, the world has transited from wood to coal, from coal to oil and now new technologies are shaping the transition to renewable forms of energy. The transition from fossil fuels most be seen from the context of politics, in particular the 1973 oil embargo which created an incentive for counter measures striking at the very heart of oil. President Carter's famous retort referring to the energy crises at that time as a moral equivalent of war comes to mind. Energy transition often occurs through market and technological disruptions.

The latest transition can be depicted in the next slide which shows the historical development of the electric vehicles.

Introduction:
Energy Transition (ET) is Not New

The historical development of the steam engine to the internal combustion engine to electric vehicles each marked by significant market disruptions. For example, the development of the steam engine was key to the industrialization, railroad transportation and transportation by sea, of course this coincided with the age of coal.

The development of the internal combustion engine coincided with the discovery of oil which greatly improved transportation and aviation. The oil age has arrived and is till with us. However, the market disruption caused by OPEC in the early 1970's provided another impetus for alternatives to oil and strategic responses in terms of energy security concerns.

Introduction:
Energy Transition (ET) is Not New

Given the predominance of non-OECD countries as suppliers of oil, the IEA became a rallying point for the OECD just as the IREA is now a rallying point for renewable energy. There are clearly complexities to be dealt with any energy transition especially given the mobility that oil has engendered in the wider global economy, the talk of alternatives among what is generally referred to as low carbon transition would remain credible if these are substitute for transportation especially aviation, petrochemicals and other manufactured products and if these can be delivered competitively.

Introduction:

ET is Seen in the Historical Development of Electric Vehicles

1769 — Origin of Steam Engines

1806 — First Internal Combustion Engines Fuel Gas

1860 — First Successful gas driven engine

1893 — First gasoline powered car

1912 — Peak production of EV

Golden Age of Electric Vehicle (1890 -1924)

1924 — Not one EV at Auto show

Domination of Gasoline Cars (1924-1960)

- Gasoline cars dominate Market
- EV disappear

1950 — Concept prototype and design of EV

1960 — Limited production of EV

1970 — Incorporate technological advance into EV design

1980 — First generation of EV

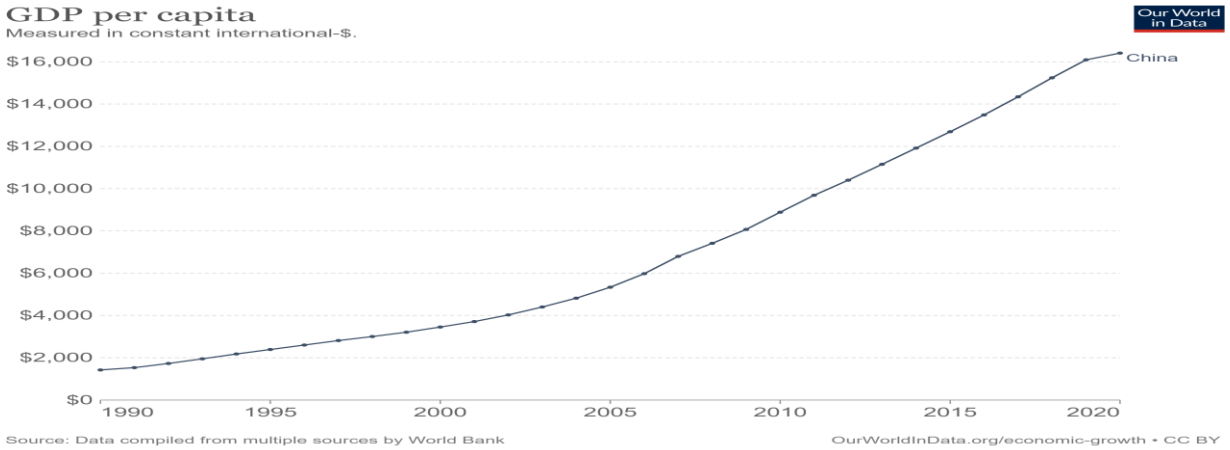
1990 — Hybrids eclipse EV and increasing level as gas supplies demand

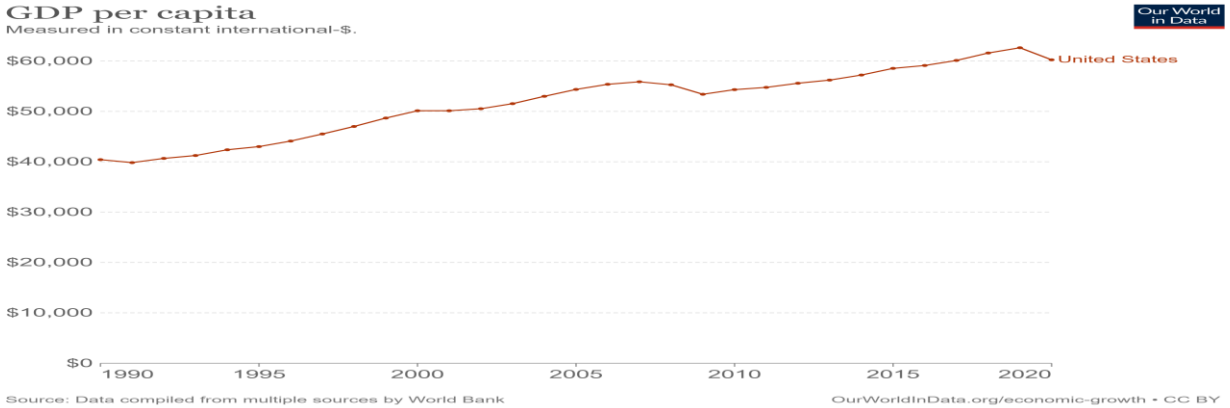
2000

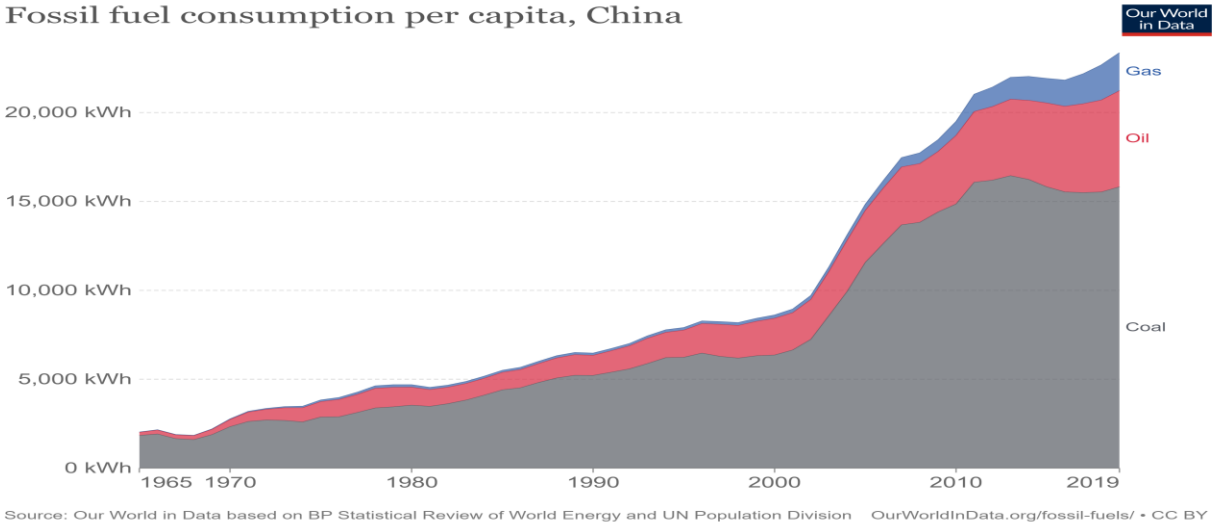
2020

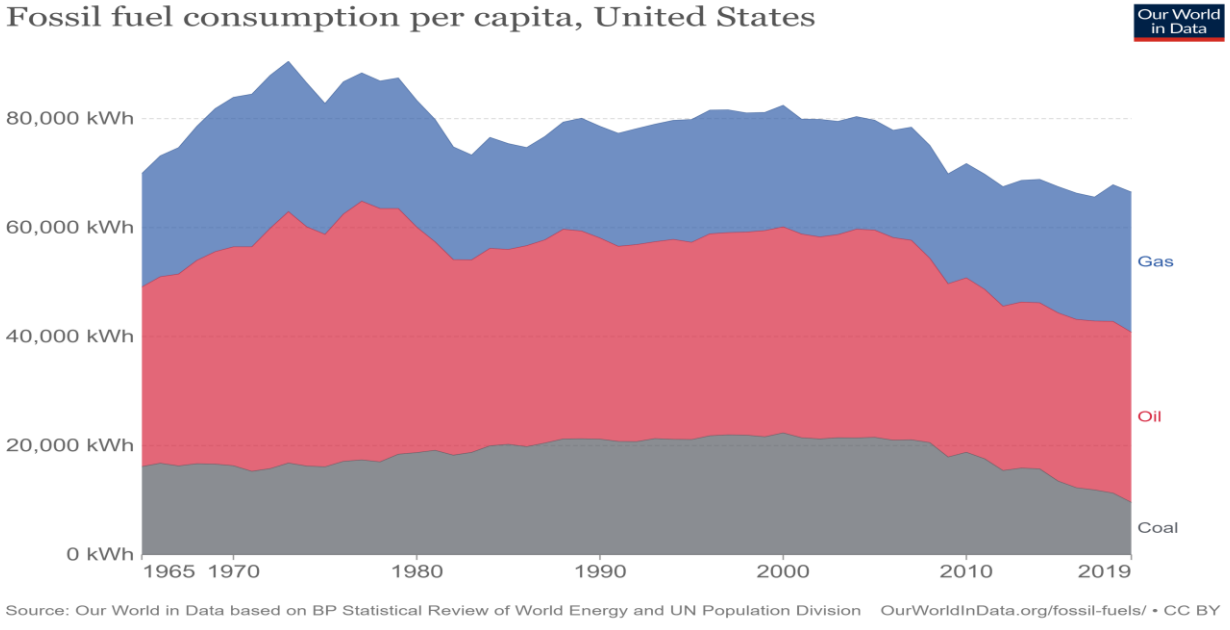
Source: nptel.ac.in, Wikipedia, connecticuthistory.org, pinterest.com supercars.net, emergentfuture.com and economictimes.com, TENO

Fossil Fuel consumption and GDP Per Capita:
A Modern-Day Analogy for China vs US

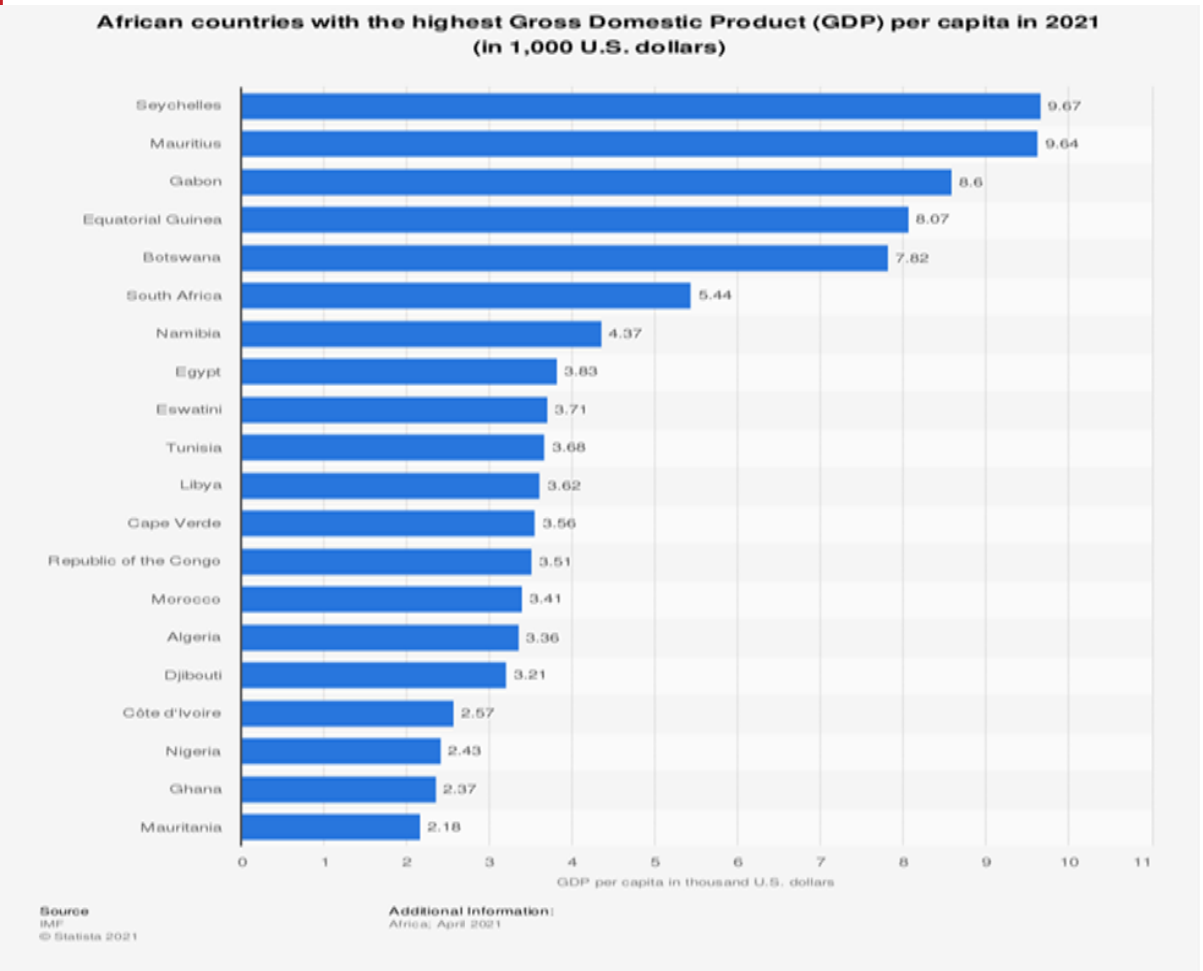








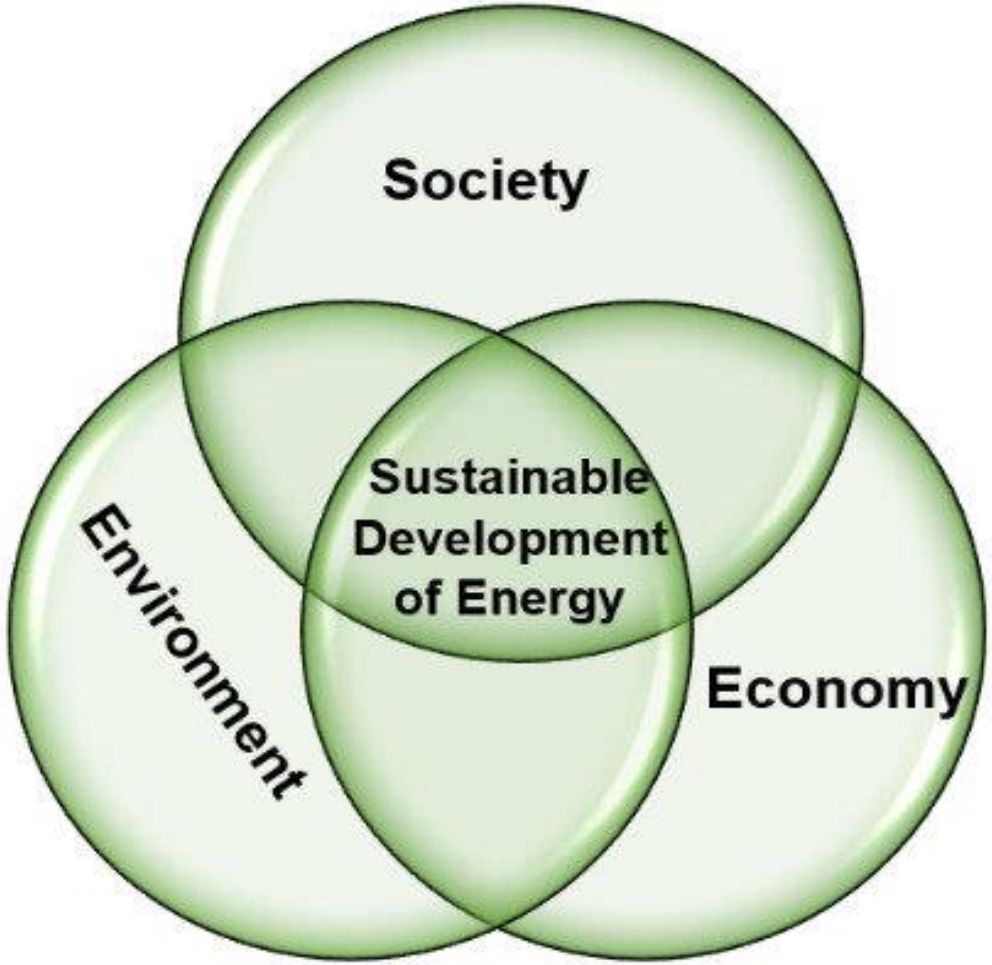
Fossil Fuels' Contributions to the Advancement of Contemporary Industrial Societies



Source: IMF

- With significant countries with GDP per capita less than $10,000 like Nigeria $2430, Egypt $3830 South Africa $5440 etc with China's GDP per capita at over $16400 and still industrializing African countries must utilize fossil fuels to grow their economies
- The question is what will be Africa's response when her trade partners in fossil fuel fully transition to EVs and renewable energy? Such a transformation would not be in Africa's best interest.
- However there is no need for panic. Africa must look internally harnessing its own resources, positioning itself favourably as an investment destination and avoiding economic populism.

Key Takeaways

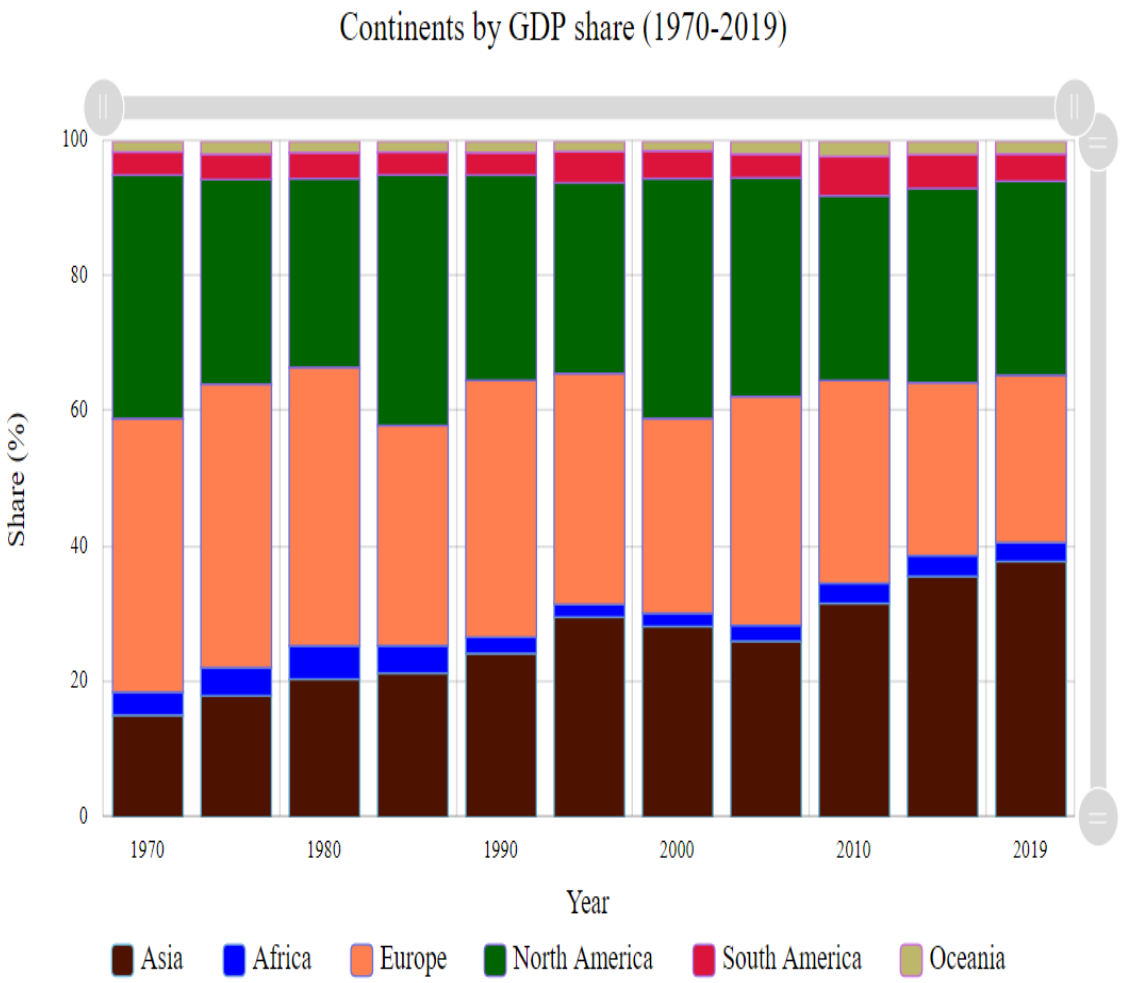


- The linkages between energy and economic development is well understood
- The sustainable development dimension imposes the climate crisis on this linkage. However, **each country's starting point differs and for fragile economies the additional burden of changing its energy mix could aggravate current underdevelopment.**
- **Africa and Nigeria's starting point and trajectory must be different.**

Source: Multidisciplinary Digital Publishing Institute ,2020

The Paradox of Low Carbon Economy:

Africa's GDP at 3% of World's Total is Marginal to the Climate Change Debate



Source: statisticstimes.com, 2020

- Africa today accounts for around 17% of the world's population, but only about 3% of global GDP.
- If Africa sustains and accelerates structural reforms over the next half-century, some believe that the continent can emulate China's rapid rise of the last 50 years. But success is far from guaranteed, even as the consequences of failure would be grave and global.
- If Africa is to match China's dramatic growth in the last 50 years, it can not saddle itself with the additional burden of expensive and untested energy systems.
- The need to reverse the current decline in GDP viz a viz other continents should be the national priority of all African countries resource rich or resource poor.
- New producer groups (NPGs) need to adopt pathways that avoid historical missteps that have led to economic crisis.

Five Major Oil Discoveries in Africa:

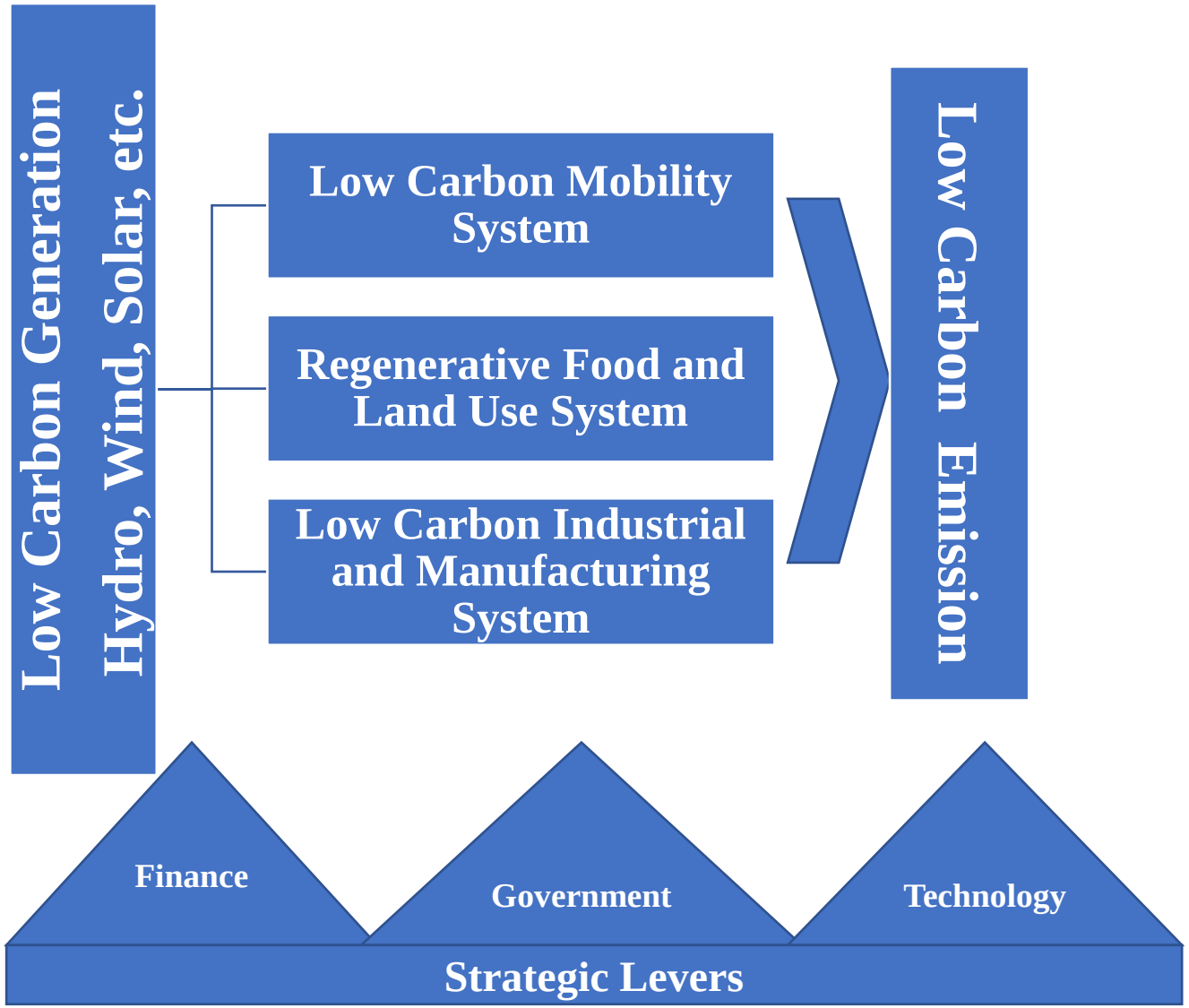
Africa The Final Frontier for Oil and Gas? 25 Giant Discoveries in a Decade.

- **NAMIBIA – 120 BILLIONS OF BARRELS?**
  - Onshore Kavango Basin significant discovery by Reconnaissance Africa
  - Offshore Orange Basin discovery of significant oil and gas field by Total (Venus and Graff)
- **GHANA – 700 MILLION BARRELS**
  - Eni additionally announced a significant oil discovery on the Eban exploration prospect in CTP Block 4, offshore Ghana. Following the Akoma discovery made in 2019, the Eban-1X well has revealed that the complex could hold **between 500 and 700 million barrels of oil equivalent**. Located approximately 50km off the coast and 8km from the Sankofa Hub, the discovery further positions Ghana as a hydrocarbon hotspot.
- **COTE'VOIRE- 2 BILLION BARRELS**

- **ANGOLA – 250 MILLION BARRELS**
  - In April 2021, a light oil discovery made in Angola's deep offshore Block 15/06 by Eni has revealed **between 200 and 250 million barrels of oil**. The well was drilled on the Cuica exploration prospect within the Cabaça Development Area and marks the second significant oil discovery in the area, further positioning the country as a hydrocarbon competitor.
- **GABON – MILLIONS OF BARRELS**
  - In August 2021, oil and gas exploration company BW Energy announced an oil discovery in the Hibiscus North exploration well in Gabon's Dussafu Block. With open hole wireline logging operations expected to reveal the overall hydrocarbon column, the discovery is expected to significantly increase the Blocks current recoverable reserves of 105 million barrels.

Source:energycapitalpower.com

The Low Carbon Economy: Essential Elements

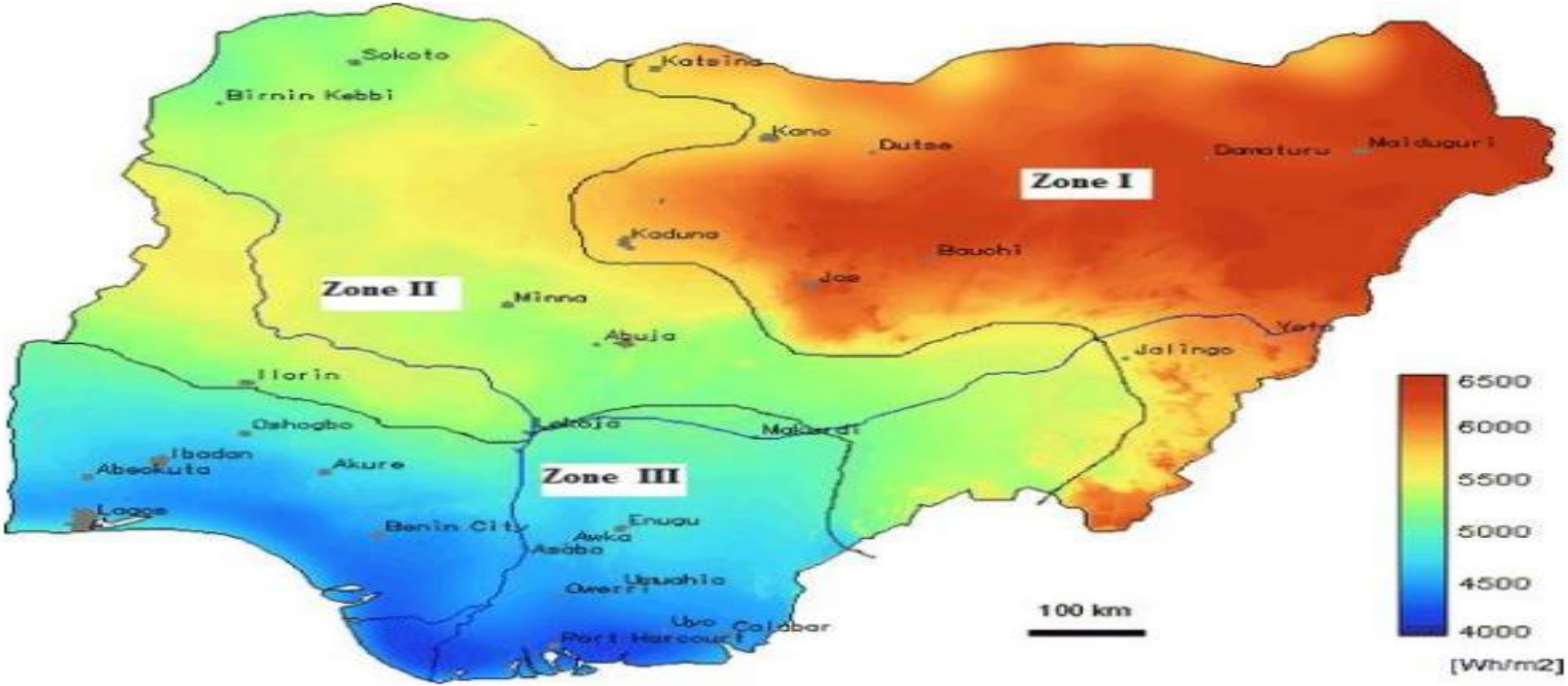


- The system-of-systems approach recognizes that existing industries will be reconstituted as a series of complex, interconnected, emissions-free systems.
- Government, finance, and technology can play a catalytic role to underpin and enable the emergence of those systems. A diverse set of societal and economic forces from fluid and shifting consumer preferences to the rise of stakeholder capitalism and growing demands for climate action now can drive the transition

Low Carbon Generation: Solar Energy

- Energy originated from the sun.
- Solar Energy Technology are of three types Technology
  - Photovoltaics (PV):Directly Converts Lights to Electricity.
  - Concentrating Solar Power(CSP):Uses heat from the sun for cooking to drive utility-scale electric turbines.
  - Solar Heating and Cooling Systems(SHC):Collects thermal Energy to provide hot water and air heating or conditioning.

Nigeria Solar Radiation Map Showing Hottest to Least Hottest Zones



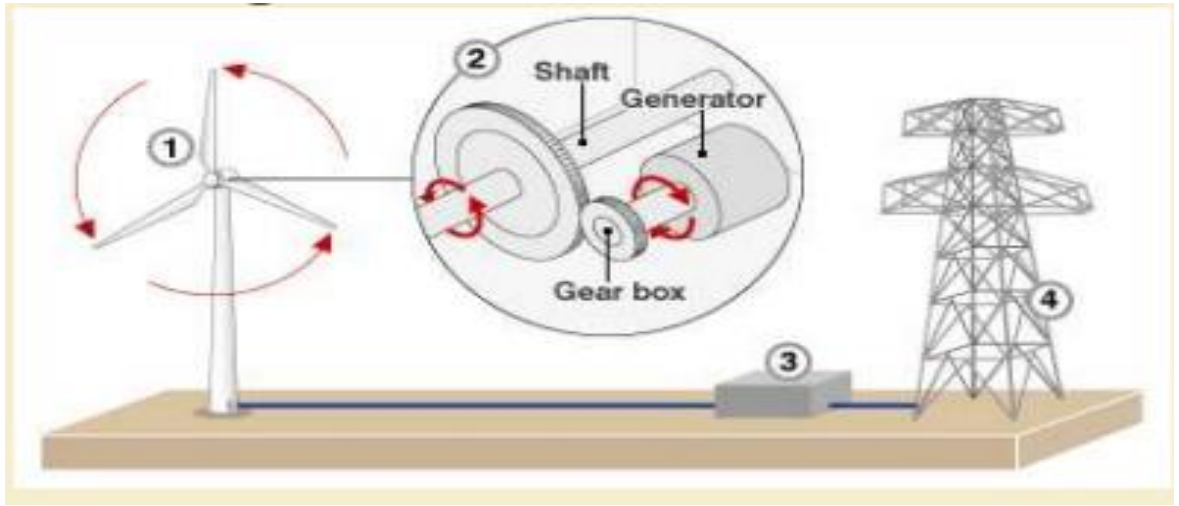
Source: Usman et al,2021

Benefits and Limitations of Solar Energy Technology.

Benefits	Limitations
Renewable ,Clean and Sustainable Energy Source	High Initial Capital Cost and Long Energy Pay back time.
Power Remote Areas and can be installed on rooftops	Produce power during the day
Reduce Electricity Bills	Low PV panel efficiency due to high temperature and dust and humidity effect.
Availability and Low maintenance	Large area for setup (10 sqm/kw)
Silent	Long life Storage System and long-distance transportation.

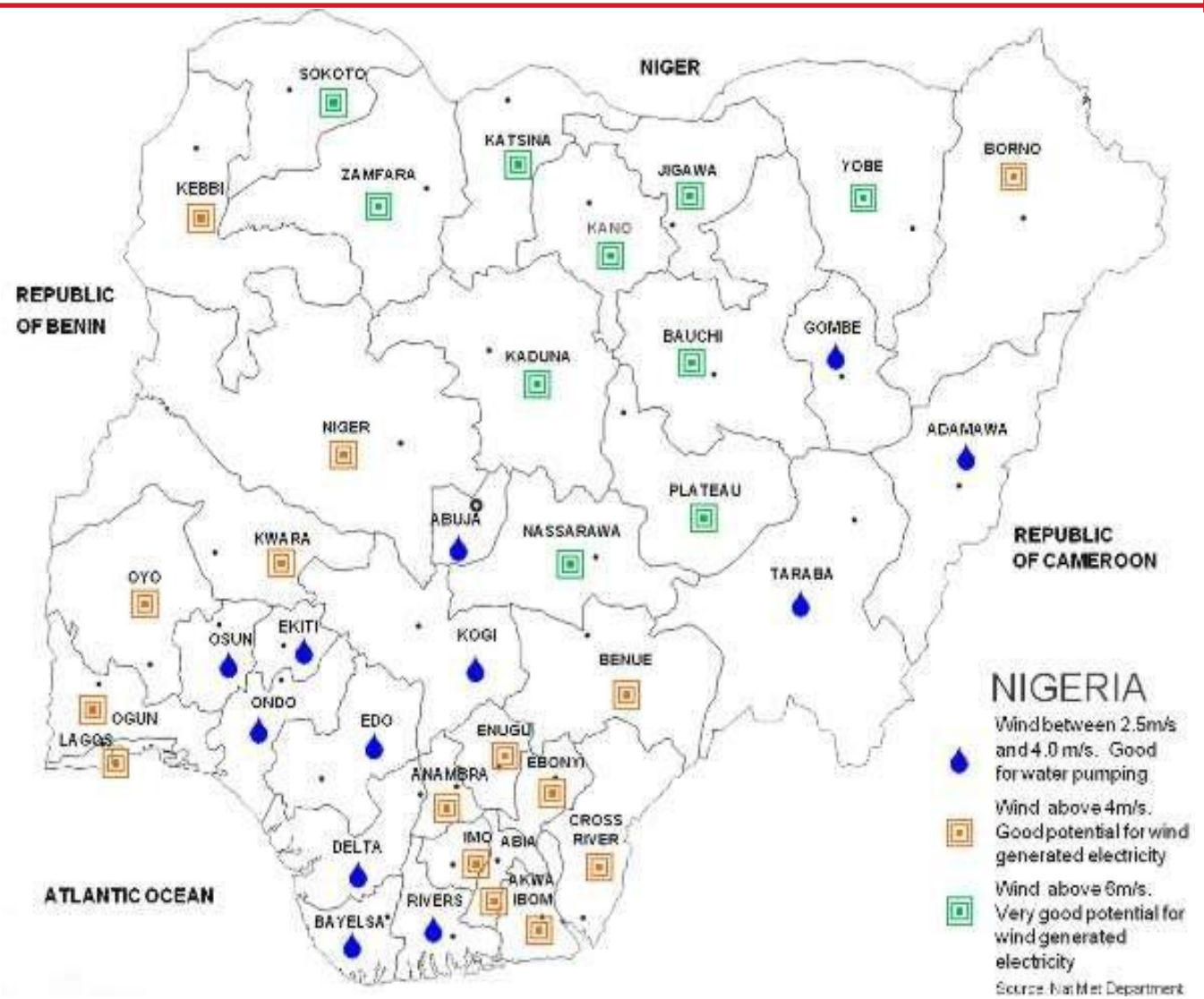
Wind Energy

- **Wind is created when the sun partially heats up the atmosphere.**
- **Wind Energy technology converts Kinetic Energy generated by moving wind turbine blades to electrical energy and used for domestic and industrial purposes.**
- **Good Wind Speed distribution in Locations to move wind turbines is necessary for good electrical output.**
- **Preference of Offshore wind turbines to onshore ones due to geologic difference.**



Nigeria Wind Map showing various Wind velocities ranges

- **Very Good Wind Potential for Electricity Generation: 6 m/s.**
- **Good Potential for Electricity Generation: Between 4m/s and 6 m/s.**
- **Good for Water Pumping: Between 2.5m/s and 4 m/s.**



Sources:oluyemi et al,2018 and Olusola et al,2017

MAGLEV
Wind Turbines

- **Maglev wind turbine unveiled at Wind Power Asia Exhibition in Beijing 2007.**
- **It works based on the principle of magnetic levitation: a process whereby an object is suspended with no support other than magnetic field.**
- **It gives a generation capacity by 20% power over conventional wind turbine and reduces cost by 50%.**
- **Can be designed for use in a moderate scale power generation ranging from 400 Watts to 1 kW.**
- **Higher efficiency because it enables energy lost in form of friction for conventional wind speed to be saved.**
- **Generates electricity for a wind speed that is as low as 1.5 m/s and this increases amount of energy harvested from the mill. An extensive maglev can create 1GW of power that can supply to around 750000 homes.**

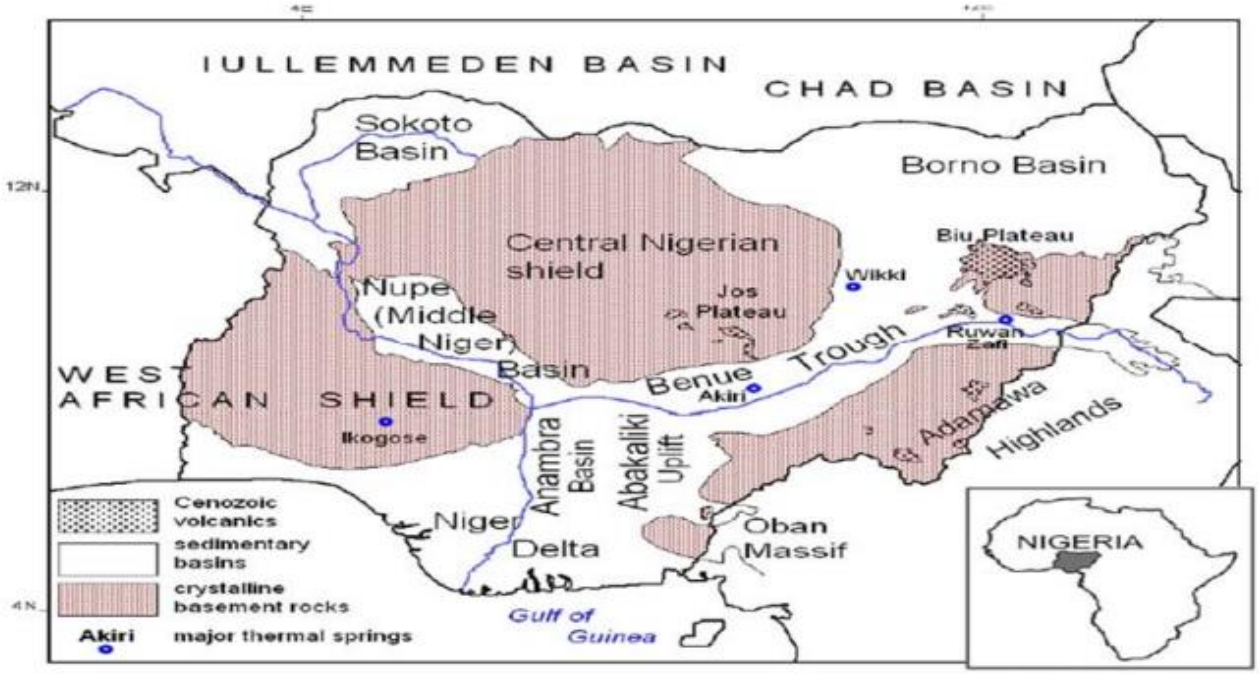
Recent Developments in MAGLEV Wind Turbines Use

- World's largest production site for maglev wind turbine in **China**. Zhongke Hengyuan Energy Technology invested 400 million yuan in building this facility which will produce MAGLEV Wind Turbines with capacities ranging from 400 to 5000 Watts.
- Small MAGLEV Wind Turbine generation of Power in Equatorial region countries – Less wind speed (**Malaysia, Singapore**).
- **US Arizona** based MAGLEV Wind Turbine Technologies will be manufacturing these turbines.
- Prerana Energy Corporation Private Limited in **India** is exploring opportunities to set up MAGLEV Super-Powered Magnetic Wind Turbine.

Geothermal Energy

- **Energy generated from beneath the earth.**
- **Heat or hot water from the Earth subsurface is harnessed as steam or hot water for electricity generation heating or cooling buildings.**
- **Not widespread in Africa. Kenya is the largest geothermal producer in Africa.40% of Kenya's Electricity generation is geothermal energy based. East African Nations like Tanzania, Uganda, Rwanda, Djibouti, Eritrea and Comoros are exploring this energy option.**

Geothermal Energy Potential in Nigeria



Geothermal Setting in Nigeria (Kurowska and Schoeneich, 2010)

Image of Ikogosi warm and cold springs

Nigeria has abundance of potential geothermal resources in

- **Biu Plateau (High land area North East of Benue Trough) and Jos Plateau (North Eastern Nigeria) and**
- **Ikogosi (Ekiti West Local Government of Ekiti) at temperature of 700^{o}C which exceeds the least temperature (148^{o}C) required for geothermal resource viability given by the US department of Energy.**

Source: Okolie et al,2018

Hydropower

- **Hydropower is of water origin.**
- **Energy is created when a turbine drives a body water stored at a dam.**
- **Used for electricity generation.**
- **“..Hydropower provides 20% of West Africa’s electricity with the remainder mostly generated from natural gas and oil…” -sebastien sterl et al ,2020**
- **Nigeria has vast abundance of water resource from water-falls, streams, rivers that can provide Hydropower.**

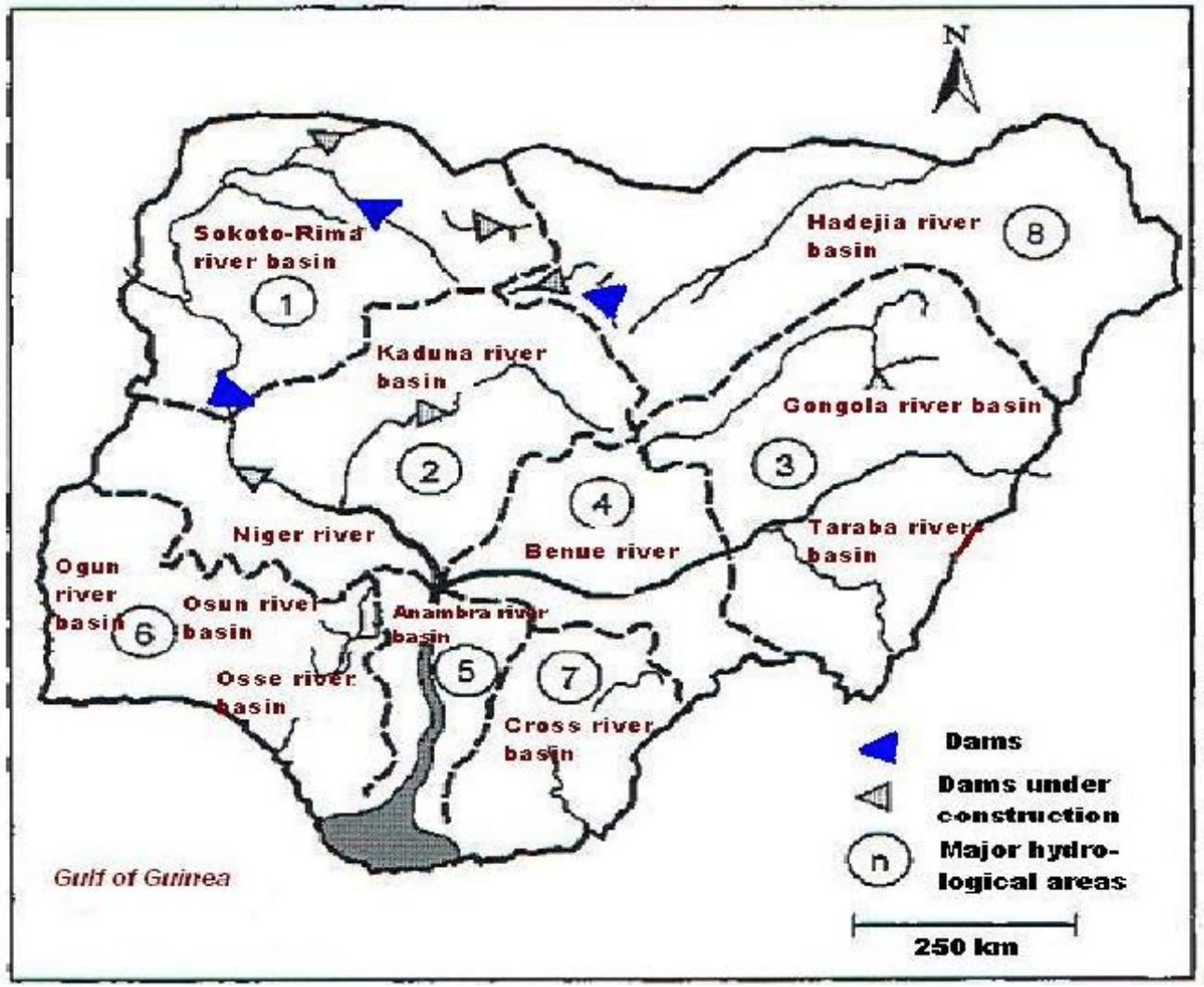
Potential Capacity of Hydropower Sites in Nigeria (Netherlands' Consultants 1959 Report)

S/N	Location	River	Potential Capacity (MW)
1	Taraba	Dongo	3050
2	Makurdi	Niger	1950
3	Lokoja	Niger	750
4	Katsina Ala	Benue	600
5	Jebba	Niger	500
6	Zungeru I	Kaduna	500
7	Zungeru II	Kaduna	450
8	Ifon	Cross	400
9	Yola	Benue	350
10	Shiroro	Kaduna	300
11	Kashimbila	Katsina Ala	260
12	Beli	Taraba	240
13	Donko	Niger	225
14	Ikom	Cross	180
15	Afikpo	Cross	180
16	Garin Dali	Taraba	135
17	Danko	Donga	130
18	Kramti	Kam	115

Source: Abaku,2017

Other Small Hydropower Potentials in Nigeria

S/N	Location	River	Potential Capacity (MW)
1	Sarkin	Suntai	46
2	Gudi	Mada	40
3	Kiri	Gongola	40
4	Richa I	Mosari	36
5	Kombo	Gongola	35
6	Gwaram	Jamaare	30
7	Gembu	Katsina Ala	30
8	Onitsha	Osse	30
9	Kurra II	Sanga	25
10	Richa II	Daffo	25
11	Zurubu	Kaduna	20
12	Mistakuku	Kurra	20
13	Kurra I	Sanga	15
14	Izon	Gurara	10
15	Kafanchan	Kongum	5



Source: Abaku,2017

Mambilla Hydropower Plant

- **Mambilla hydropower project is a 3050 MW hydroelectric facility being developed on the Dongo River near Baruf, in Kakara Village of Taraba State, Nigeria.**
- **The project is being undertaken by Nigeria's Federal Ministry of Power, Construction and Housing, with the help of Chinese investments.**
- **Expected to commence operation in 2030, Mambilla will be Nigeria's biggest power plant, producing approximately 4.7 billion kWh of electricity a year.**
- **The project is estimated to cost $5.8bn and will generate up to 50,000 local jobs during the construction phase.**
- **Chinese Export Import (Exim) Bank is funding 85% of the estimated $5.8bn project cost, while the remaining 15% funding will come from the Federal Government of Nigeria.**
- **This project has the potential to transform Nigeria's socio-economic development when completed.**

Tidal Energy

- Energy derived from rise and fall of ocean waters as a result of inter-attraction forces between celestial bodies.
- Tidal Technologies are of two types
  - Use of Barrages to trap water at high water level and a drives a turbine to generate Electricity
  - Kinetic Energy of the moving water drives the turbine to generate electricity
- Tidal Power Plants exist in France, Russia , US, Canada, South Korea and China

Tidal Energy Potential in Nigeria

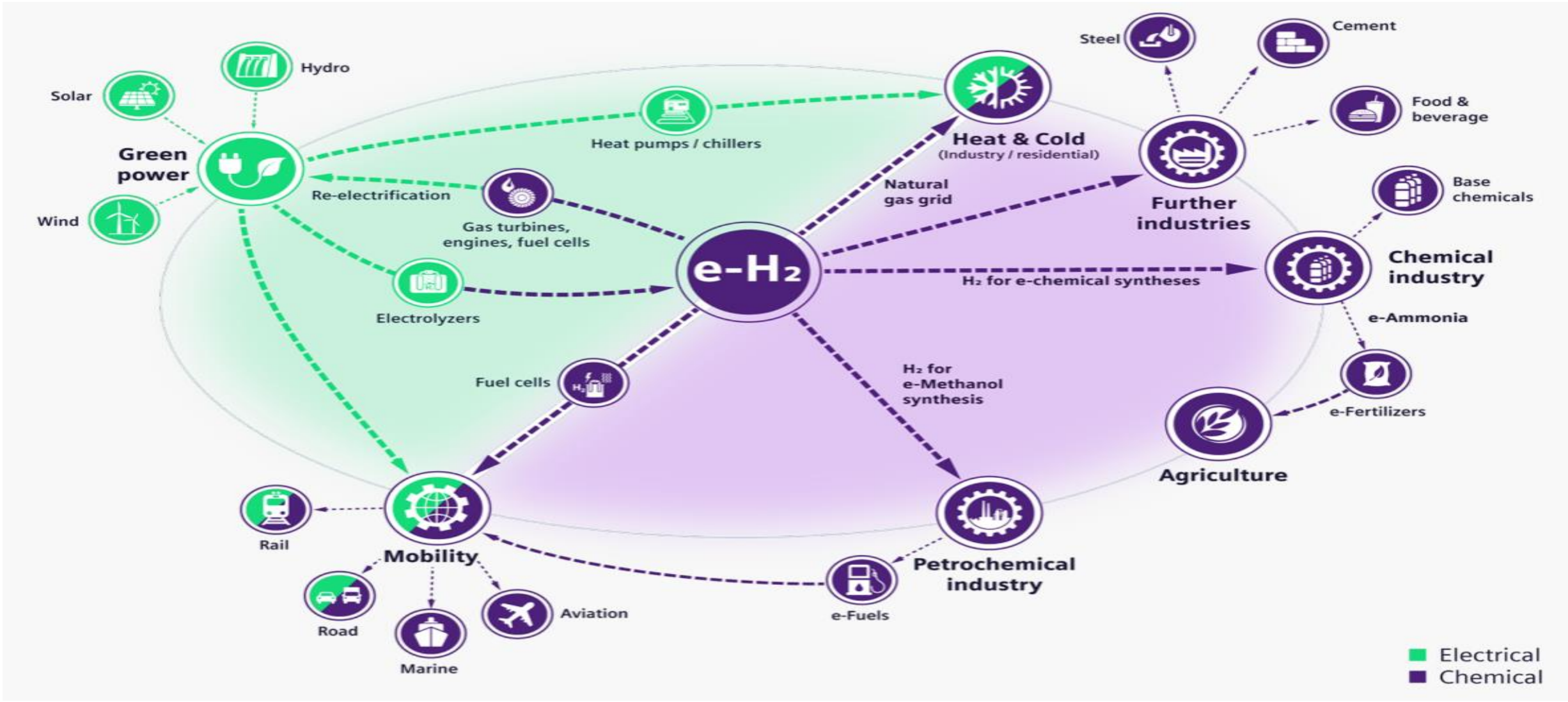
Location	Average yearly Tidal Height (m)
Calabar	3.07
Bonny (Rivers)	2.4
Akasa (Bayelsa)	1.8
Lagos	1.3

"...By way of comparison, the tidal technology in use in the Tacoma region (USA) with average tidal height of 2.5 meters, produces 6.75 MW electric power and has an estimated annual energy capacity of 13 GWh – – thus Calabar coastal site with an average tidal height of 3.07 meters will do better..." – Collins et al.2015

TENO
ENERGY

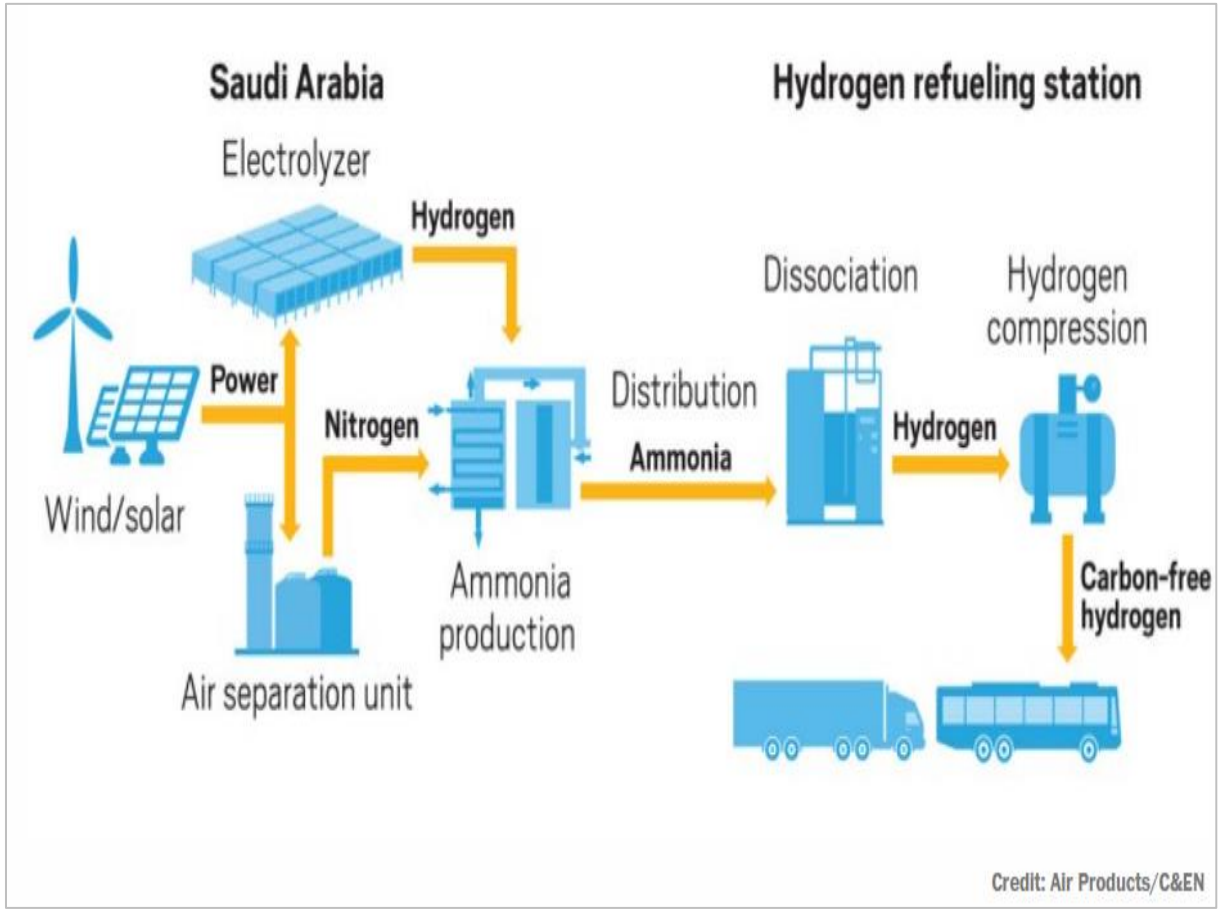
The Future belongs to Hydrogen:

Hydrogen Value Chain

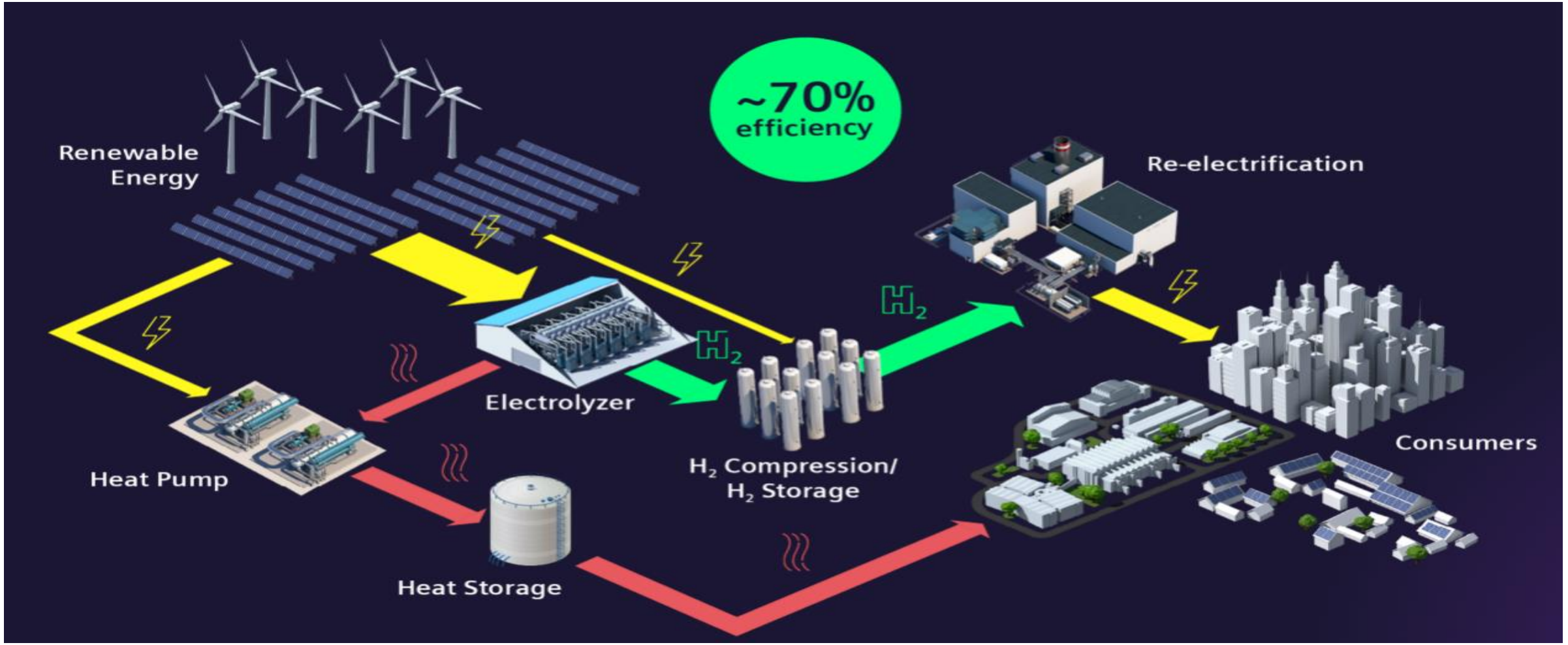


Hydrogen:
Transportation

- Gas produced from various sources such as natural gas, nuclear power, biomass, and renewables (solar, wind and water).
- Clean means of producing hydrogen is to use Solar and Wind electricity to split water into hydrogen and oxygen in an electrolyzer.
- Used for ammonia production and fuels in vehicles and industrial processes.



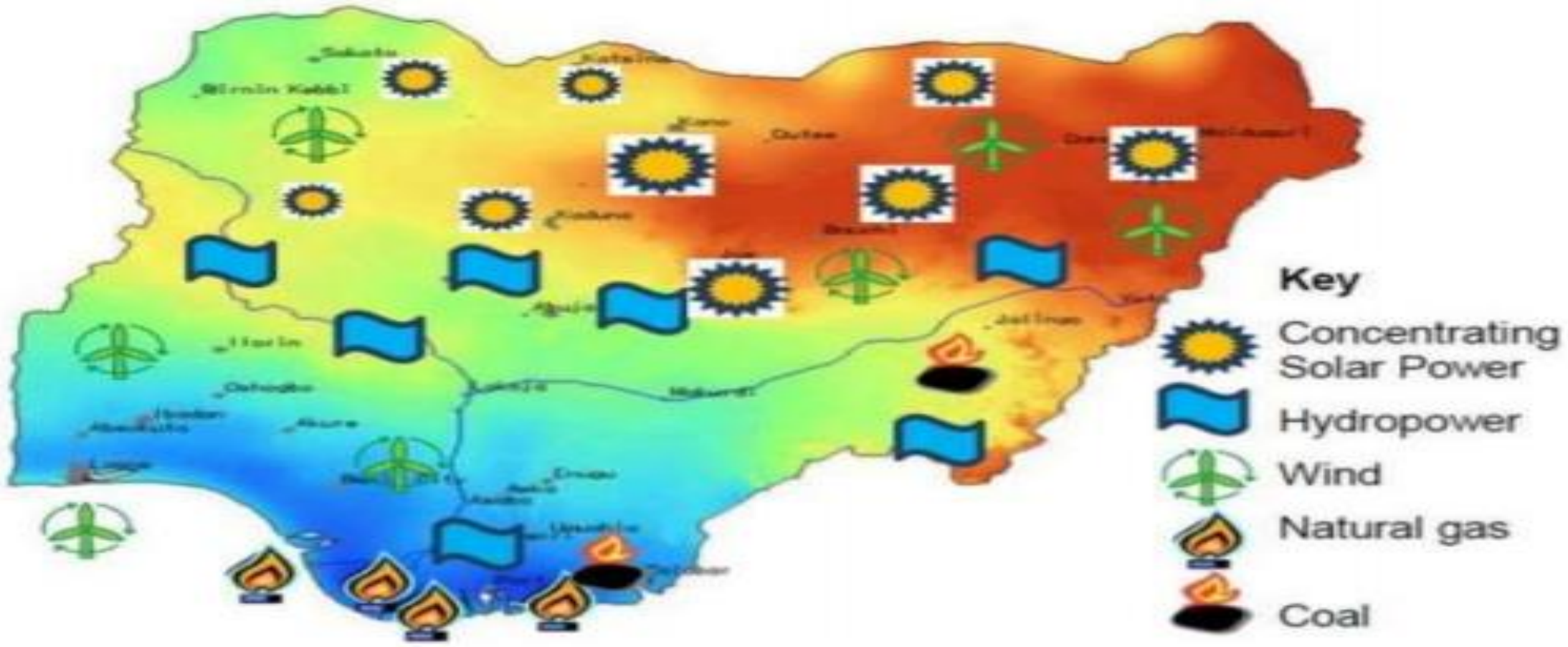
The Future belongs to Hydrogen:
Hydrogen based Power System



Benefits and Limitations of Hydrogen Production

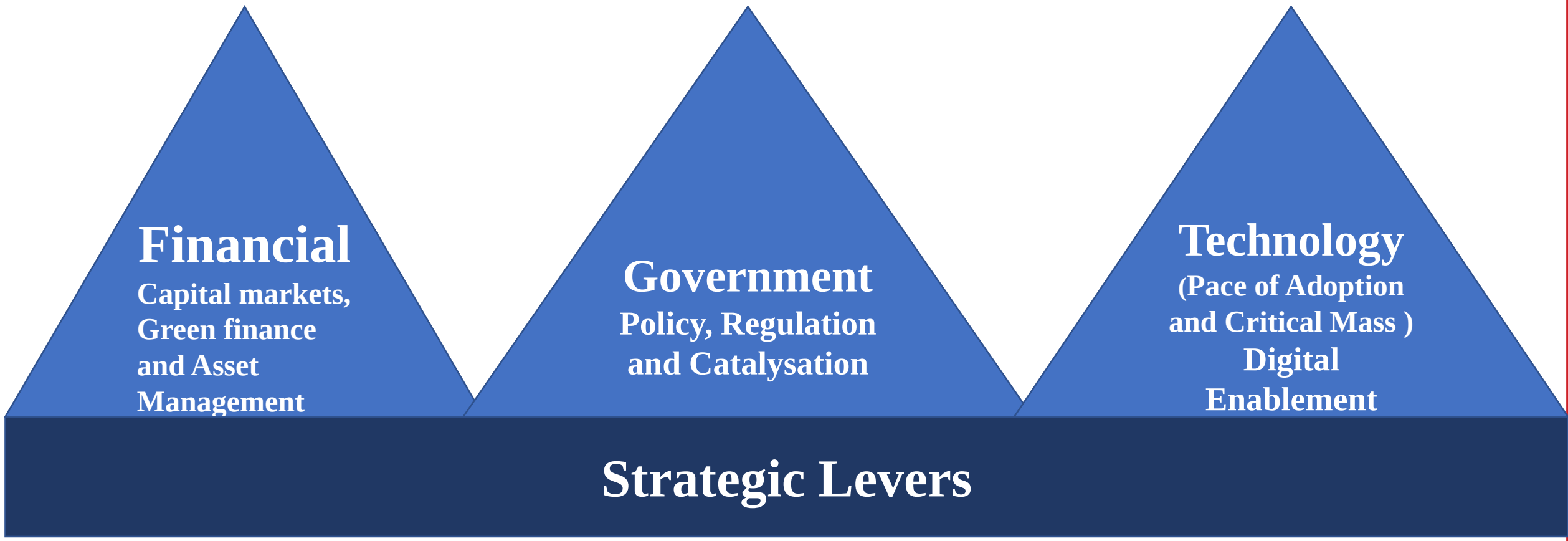
Benefits	Limitations
Clean and sustainable energy	High upfront capital cost
Solar and Wind energy fuel is used to produce hydrogen. No carbon footprint	Storage and transportation of hydrogen to far-away markets
Replace fossil fuels used in vehicles and industrial processes	Availability and Abundance of Solar and Wind Technology (60% of hydrogen production).
Alternative source of electricity. Reduces electricity bills	Energy lost during conversion and re-conversion process.
Efficiency and non-toxicity	Subject to limitations in Solar and Wind Technologies.
Power off-grid and remote Areas	Odourless and highly inflammable

Suggested Energy Map for Nigeria:
Nigeria needs a Combination of Low Carbon and Existing Energy Systems for Sustainability



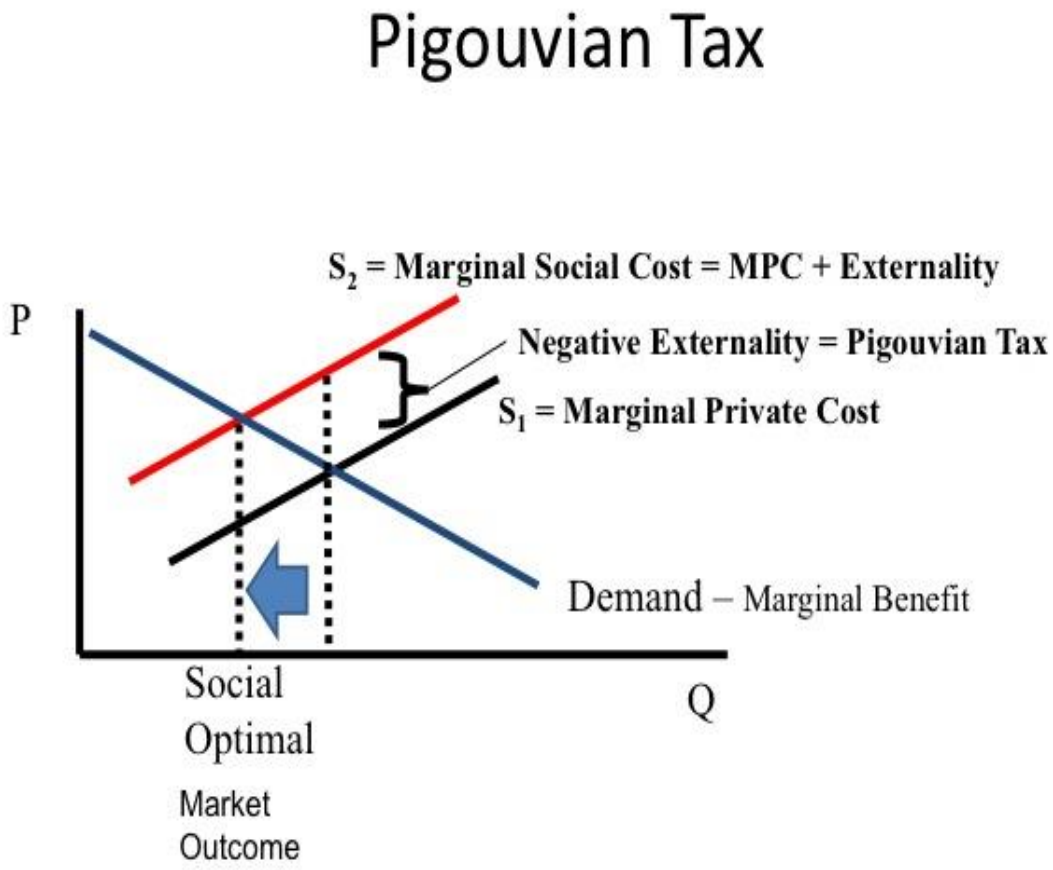
Sources: Oluyemi et al,2018 and wikipedia

Low Carbon Economy: Strategic Levers



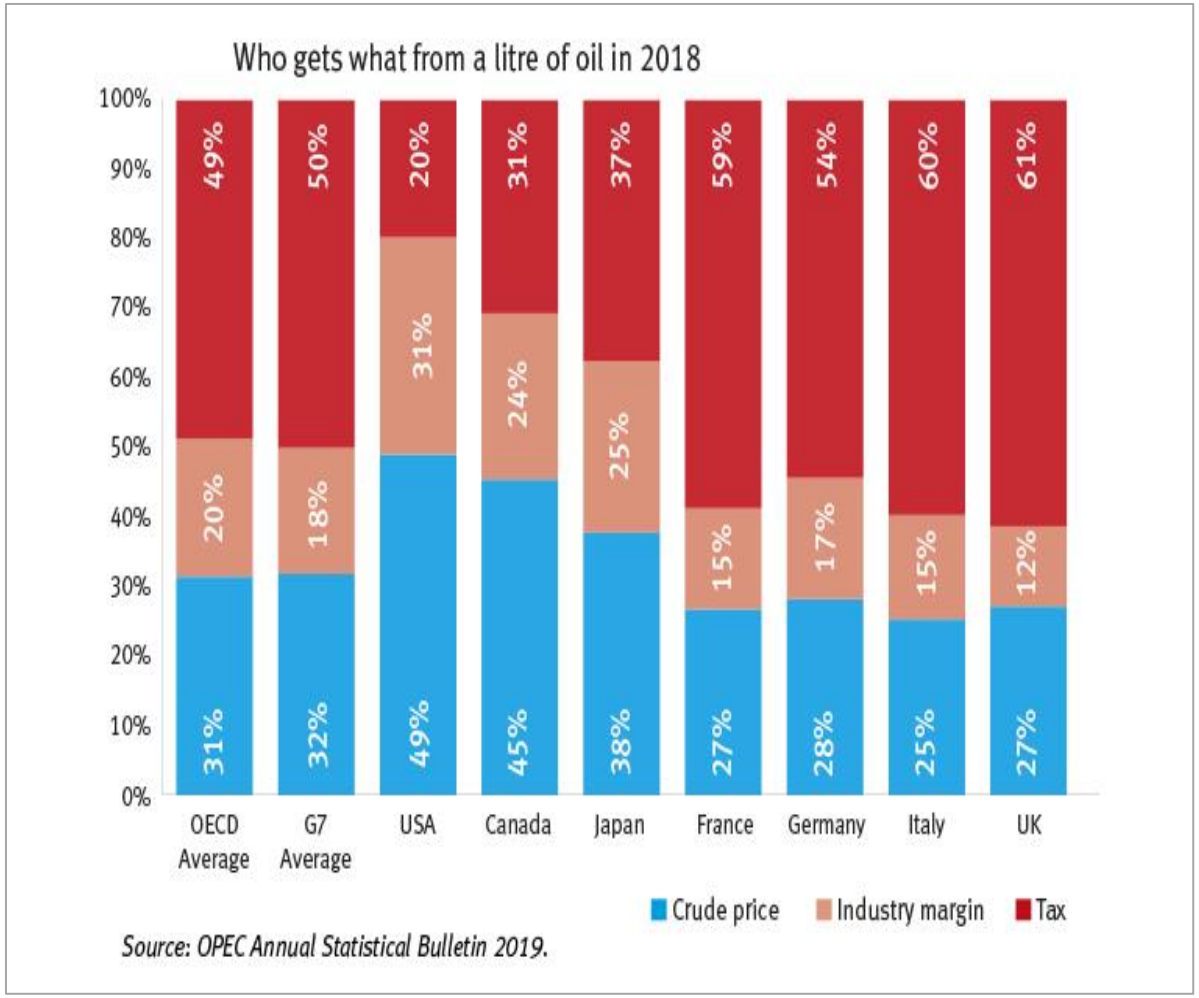
Low Carbon Economy: Financial Enablers: Pigouvian Taxes

- A Pigouvian tax is intended to tax the producer of goods or services that create adverse side effects for society.
- Economists argue that the cost of these negative externalities, such as environmental pollution, are borne by society rather than the producer.
- The purpose of the Pigouvian tax is to redistribute the cost back to the producer or user of the negative externality.
- A carbon emissions tax or a tax on plastic bags are examples of Pigouvian taxes.
- Pigouvian taxes are meant to equal the cost of the negative externality but can be difficult to determine and if overestimated can harm society.



Low Carbon Economy: Financial Enablers: Pigouvian Taxes

- In the duopoly of dominant producers and dominant consumers, pricing is often the most important signal utilized by both parties of the duopoly to manage inelastic demand in energy market.
- The average Pigouvian tax in OECD is 31% and varies considerable from a high of 61% in the UK (once Resource rich), France and Germany 59% and 54% respectively) and 20% in the US(resource rich)
- High Pigouvian taxes may be counter productive and could impact economic growth, however the absence of any Pigouvian tax as is the case in Nigeria is worrisome.



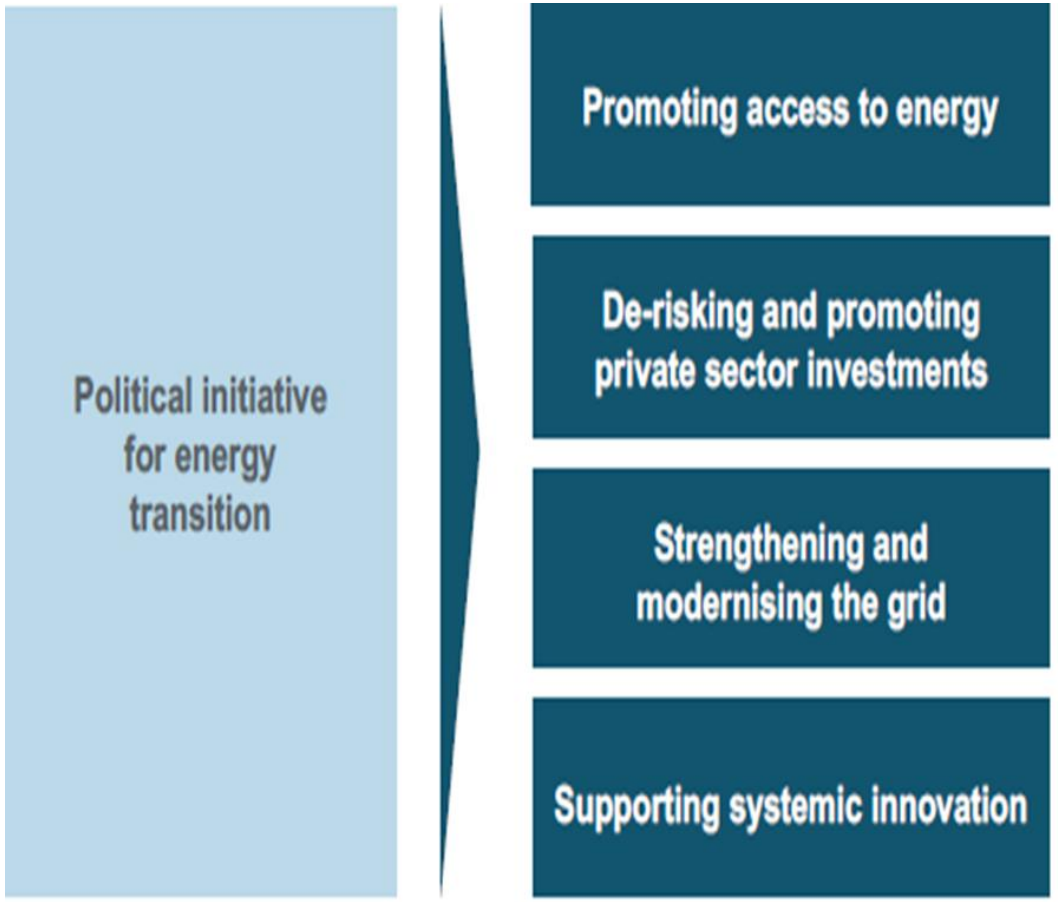
Financial Levers
Access To Global Fund

- The Green Climate Fund (GCF) was adopted by 194 governments as a financial mechanism of the United Nations Framework Convention on Climate Change at the end of 2011.
- Its goal is to limit or reduce greenhouse gas emissions in developing countries and help adapt vulnerable societies to the already-felt impacts of climate change.
- It aims to make an ambitious contribution to attaining the mitigation and adaptation goals of the international community with the goal of keeping the temperature increase of the planet below 2 degrees Celsius. Over time it is expected to become the main multilateral financing mechanism to support climate action in developing countries.

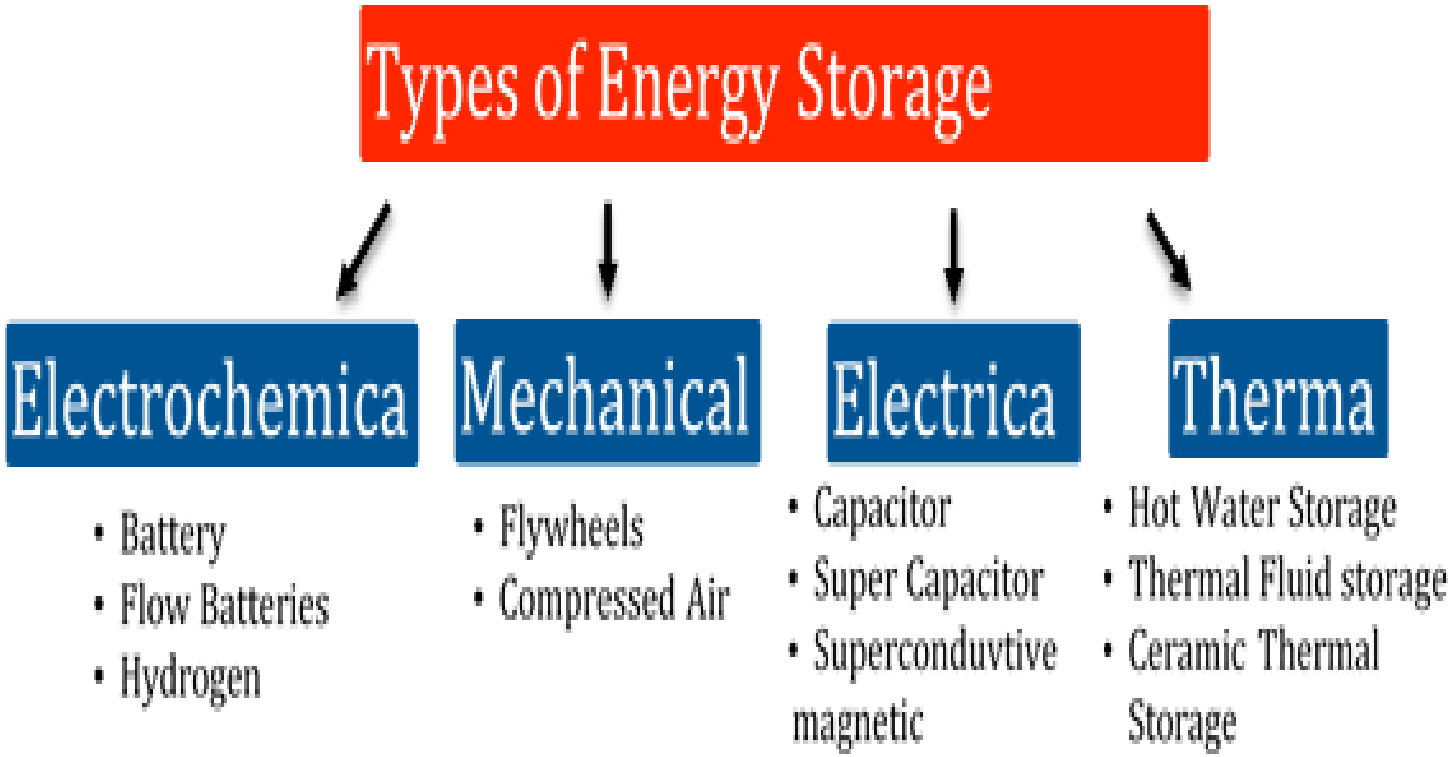
GREEN CLIMATE FUND

Low Carbon Economy: Government Enablers

- Local manufacturing capacity for low carbon energy systems
- Research and Development grants to private sector companies
- Investment incentives for distribution systems for low carbon alternative fuels.
- Capacity building initiatives integrated into the educational system



Low Carbon Economy: Technology Enablers



- Improvement in energy storage and efficiency