

PROSPECT OF ELECTRIC ENERGY STORAGE (EES) SYSTEMS PRODUCTION AND USAGE IN NIGERIA

Engr. Franklin Evbakoe Omusi

C. Eng. M. Eng. B.Sc., MNSE, MNSChE., MISES, MCREN



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INTRODUCTION

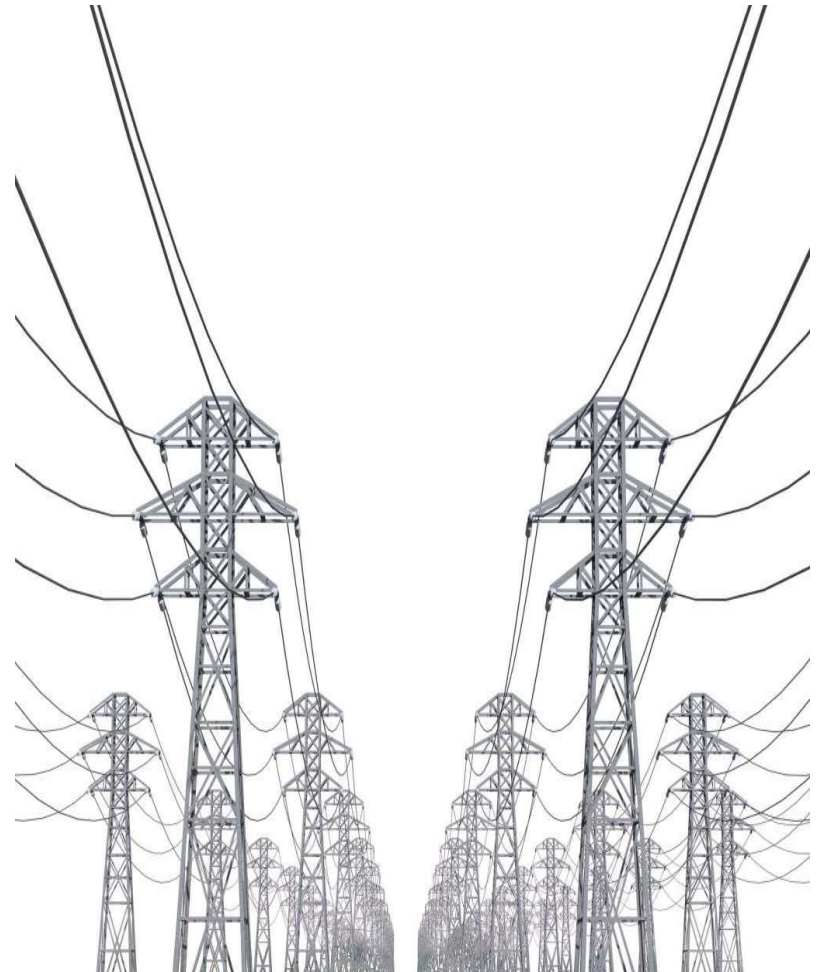
- **Energy storage** is the capture of **energy** produced at one time for use at a later time
- **Energy** comes in multiple forms including radiation, chemical, gravitational, potential, electrical, kinetic etc
- A device that stores **energy** is sometimes called an accumulator
- Electrical energy is the energy made available by flow of electric charge through a conductor.

PURPOSE OF ELECTRICAL ENERGY STORAGE (EES)

- Maintain power quality, voltage, and frequency by supplying/absorbing power from/into EES when necessary thus securing reliable and higher-quality power supply for important factories and commercial facilities
- Provide stable power for off-grid systems (isolated networks) thereby cutting of the extra investment needed for transmission cables
- Reduce total generation costs by storing electricity during off-peak times and provides electricity during peak hours

PURPOSE OF ELECTRICAL ENERGY STORAGE (EES)

- Solve problems of long distance between generation and consumption
- Suppress peak demand and use cheaper electricity during peak periods, i.e. save cost by buying off-peak electricity and storing it in EES. The result is load leveling by time-shifting
- To mitigate the problem of congestion through the power grids



TYPES OF ELECTRICAL ENERGY STORAGE SYSTEMS

- A widely-used approach for classifying EES systems is the determination according to the form of energy used
- Of all the six types of Energy storage systems, the Electrochemical Energy storage is what is used commonly in Nigeria
- This is the storage system that uses chemical reaction to generate electricity. Batteries fall within this category of energy storage devices
- The most common and popular battery types under this storage are Lead Acid Batteries, Lithium-Ion and Sodium Sulphide Batteries
- The most widely known for off grid application in Nigeria is the Lead Acid Battery

TYPES OF ELECTRICAL ENERGY STORAGE SYSTEMS

Classification of Electrical Energy Storage Technologies

Mechanical

Pumped Hydro-PHS

Compressed Air-CAES

Flywheel-FES

Electrochemical

Secondary battery
Lead-acid/NaS/Li-ion

Flow battery
Redox flow/Hybrid flow

Electrical

Capacitor
Supercapacitor

Superconducting
Magnetic-SMES

Thermochemical

Solar fuels
Solar hydrogen

Chemical

Hydrogen
Fuel cell/Electrolyser

Thermal

Sensible/latent
heat storage

GLOBAL TRENDS IN ELECTRICAL ENERGY STORAGE UTILISATION

Below are global trends in the utilisation of electrical energy storage systems in various field such as:

- RENEWABLE ENERGY
- SMART GRID OPERATION
- SMART MICROGRID
- SMART HOUSE
- ELECTRIC VEHICLES

EES APPLICATION IN NIGERIA

- In Nigeria we are presently grappling with the challenge of providing reliable electricity supply before we talk about regular power supply
- There are several areas EES can be applied presently and in the near future in Nigeria. These areas are grouped as:
 - Large Industrial Applications
 - Microgrids & Minigrids
 - Solar Home and Office Systems

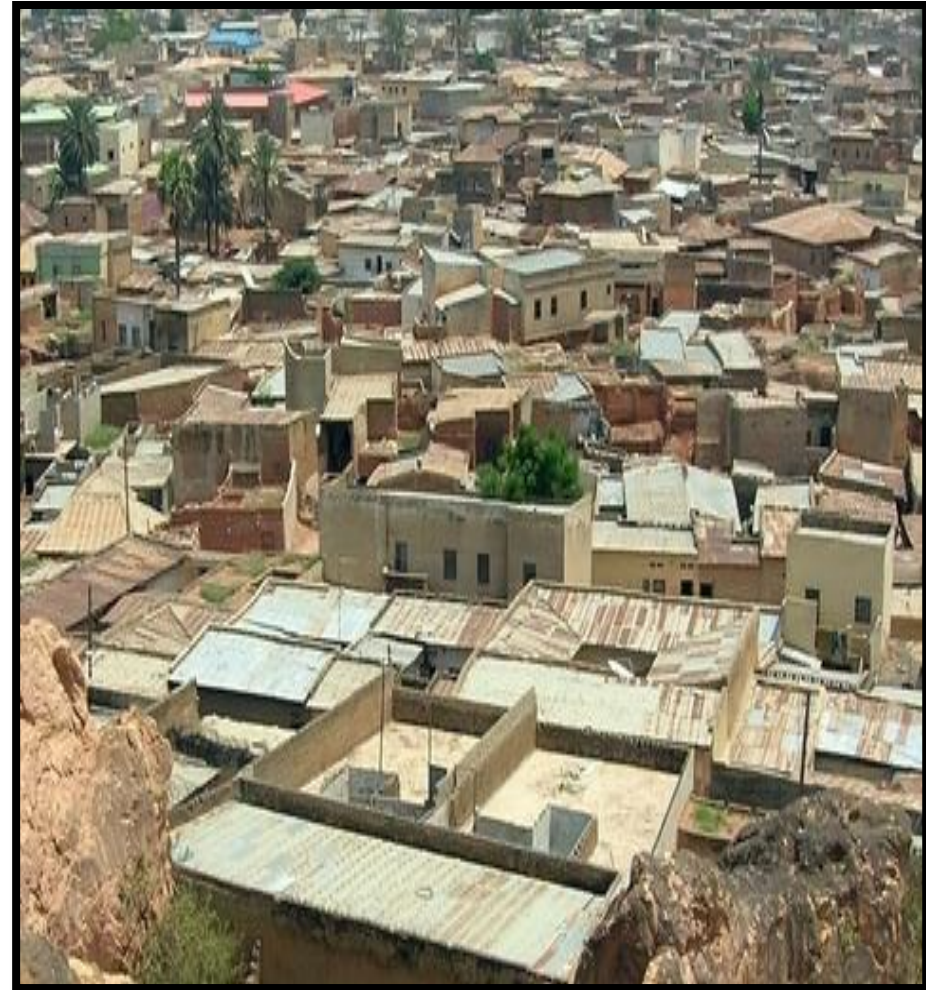
LARGE INDUSTRIAL SOLUTIONS

- EES can be applied to support and provide electricity in large industry especially with renewable energy use
- A case study is a company in Lagos I am consulting for, which plans to set up an Industrial Park powered by Renewable energy of initial capacity of 50 mw in Ilorin Kwara State on a 159Hectares of land space. Electricity generated from the power plant will be used during the day to run the clusters of factories around the Park while some are stored in EES for use at night.



MINIGRIDS AND MICROGRIDS

- These are power solutions designed for areas where in most cases public grid power is not available or areas that want to stay off the national grid
- The general concept is to generate and distribute electricity to a closed cycle of users who form the minigrid/micro grids such as communities in rural areas with a cluster of houses. We have several designs of minigrids



SOLAR HOME SYSTEMS/SOLAR OFFICE SYSTEMS (SHS/SOS)

- This is the development and deployment of renewable solutions to homes and offices. This solution uses lots of EES in the form of Lead Acid batteries
- The energy generated either from solar PV or public grid supply is store in EES. This stored energy is made available during the period of low generation or electricity outage
- A typical home in Nigeria with a middle income family living in a three bedroom flat as commonly built requires an average of 500-750KWh of electricity per month
- With about 1,2 million naira, this home will have uninterrupted power supply 24/7 for the next three years before changing the batteries
- This type of solution will require the deployment of a system containing 2 units of 12/200Ah Deep Cycle Batteries. If we project to deploy 5000 units per state, that will be over 180,000 units or 360,000 units of 12V/200Ah Deep cycle batteries

SOLAR OFFICE SYSTEMS (SOS)

- This is like the Solar Home System but deployed in offices and business centres such as Schools, Banks, IT/Comm companies, Hospitals, Petro Filling Stations , barbing shops etc.
- A typical case: Data Security Company spends an average of 500,000 NGN monthly or 6 million NGN to provide Electricity for its operation monthly by running 60KVA diesel Generator running almost 24/7 with the attendant release of green house gases into the atmosphere
- We have deployed Renewable energy solution using Solar PV system at a cost of about 6.2 million naira using 15 units of 12V/200Ah of Deep cycle Lead Acid batteries as EES
- Suppose 50,000 solutions of this sort can be deployed across the country giving us over 750,000 units of batteries 12V/200Ah. Many needs abound like this.

PROSPECTS OF EES IN NIGERIA

- Nigeria has about 26 power plants with a total installed capacity of 12,341 MW of electricity with a present Transmission capacity about 5000 to 6000 mw. Three of these plants are powered by water or Hydro Plants while the rest are Gas plants.
- The highest electricity ever generated is 5074MW or 42%. There is a large pool of uncaptured electricity generated by Nigerians using diesel and petro generators which are never captured as part of the total installed capacity of electric power. This capacity may run into several thousand megawatts on a good day
- Comparing with other countries, Germany generates over 80,000MW, South Africa generates over 45,000 MW etc.
- With a household population of over 28 million according to 2006 census figures, derived from over 180 million population, there will always be a serious DEFICIT in electric energy supply in Nigeria from conventional means.

PROSPECT OF EES IN NIGERIA

- To tackle this deficit, electricity generation and distribution will soon be decentralised. Solar PV systems utilization in Nigeria for Minigrids/Microgrids, Solar Home and Office Solutions will grow and with this will come large demand for EES
- A state government in the northern part of Nigeria alone has identified 300 communities to be deployed with minigrids/microgrids power solutions. Six pilot projects are already in progress. With 36 states identifying such communities, we may have over 5,000 to 10,000 communities for minigrids project for rural electrification in the country
- Electrochemical storage using batteries is suited for storing low amount of electricity especially in an economy where demand far outweighs supply
- EES already find usage in towns and cities especially with the unreliable power supply from the national grid for time shifting purpose, i.e. saving energy produce/supplied now to be used at a later time. For this, The Lead Acid Technology will be very important

PROSPECTS OF EES IN NIGERIA

- Its obvious that even with production at installed capacity, the electric power available will never be adequate.
- This opens the door for renewable energy generation and also the use of battery EES for time shifting purpose
- The easiest way to fill the Electricity deficit in Nigeria will be through decentralisation by implementing a full consumer based Feed In Tariff.
- This tariff has three parts when fully implemented namely.
 - a. A payment for all the electricity you produce, even if you use it yourself
 - b. Additional bonus payments for electricity you export into the grid
 - c. A reduction on your standard electricity bill, from using energy you produce yourself.
- . This kind of Feed In Tariff will create a “Green Revolution” in Nigeria as most home owners who will earn more money will put solar panels on their roof.
- . There will be a lot of poverty reduction as more citizens earn money for generating electricity and using same
- . The use of battery storage will increase as more solar panels are deployed
- . More Green Jobs will be created as more installers will be , more businesses dealing with renewable components will empowered.

PRODUCTION OF EES IN NIGERIA

- The most commonly know EES type in Nigeria is the Electrochemical storage using various kinds of batteries
- The most commonly used batteries in Nigeria for EES application is the Deep Cycle Lead Acid Batteries
- Most of the batteries used for Energy storage in Nigeria have been imported from India and China. A reasonable percentage comes from Europe and America. The American and European models are more expensive. These batteries are mainly Lead Acid Batteries. The amount of such deep cycle batteries will not be less than 2 million pieces
- There is presently no known companies manufacturing Deep cycle batteries in Nigeria. There may be some attempts to assemble over the years
- In the 80's, there were over thirteen (13) known and established battery manufacturing plants in Nigeria. All of them were focused on SLI batteries for automobile use. By the late 90's and early 2000, most of these factories had closed down due to so many factors
- Only one survived through the years and is still operational producing SLI Dry Charged and Sealed Lead Acid Battery for automobile use

OVERVIEW OF LEAD ACID BATTERIES FOR EES

- Lead acid batteries are the world's most widely used battery type and have been commercially deployed since about 1890
- Lead acid battery systems are used in both mobile and stationary applications
- They are used in stationary devices such back-up power supplies for data and telecommunication systems, and energy management applications
- Lead Acid Batteries comes in various sizes and shapes. They could be sealed of the VRLA (Valve Regulated Lead Acid) technology or non sealed
- The common sizes are 12v/200Ah, 12v/150Ah, 12v/100Ah, 12v/220Ah where (AH stands for Amp Hour and measures the amount of electric energy stored in the battery in Wattage e.g a 12v/200Ah battery will contain 2400 watts of Electricity

OVERVIEW OF LEAD ACID BATTERIES

- Typical service life is 4 to 12 years with a cycle life of 2000 cycles at 80 % depth of discharge, and they achieve cycle efficiency levels of around 80 % to 90 %
- Lead–acid batteries have fast response times, small daily self-discharge rates ($<0.3\%$), relatively high cycle efficiencies ($\sim 63\text{-}90\%$) and low capital costs (50–600 \$/kW h)
- In addition, they may perform poorly at low temperatures so a thermal management system is normally required, which increases the cost
- As EES, Lead Acid Batteries are limited to small systems usage due to certain factors such as low cycling times (up to ~ 2000), energy density (50–90 W h/L) and specific energy (25–50 Wh/kg) etc

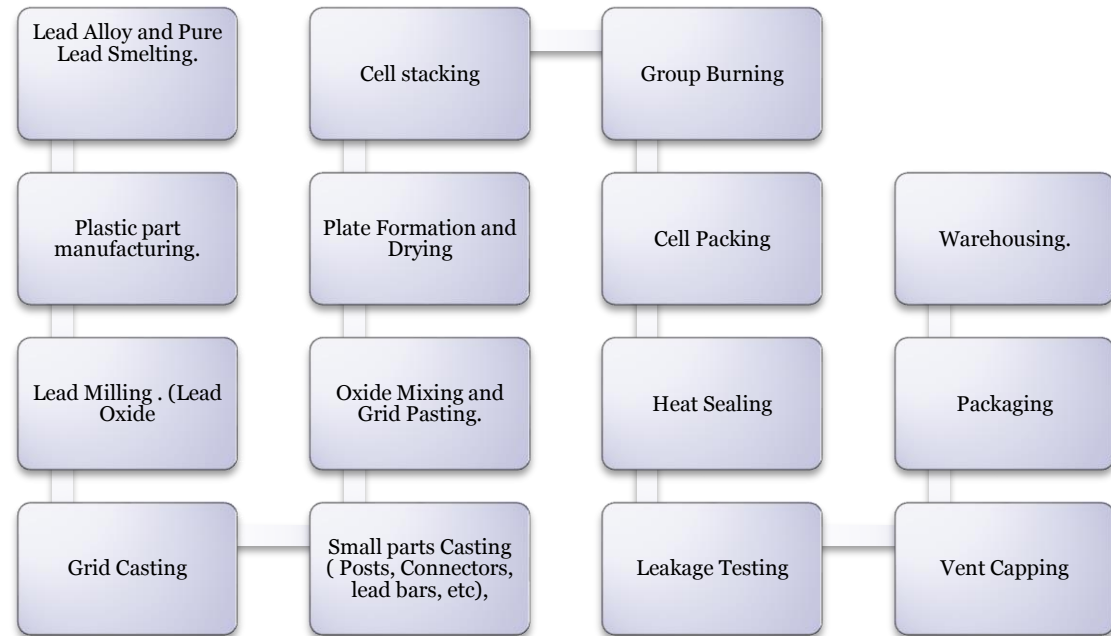


PRODUCTION OF LEAD ACID BATTERIES IN NIGERIA

- I was The Head of Research and Development/Quality Control of Union Manufacturing Co. Ltd for over twelve years. I was a member of the committee on Standards for Automobile Products of the Standards Organisation of Nigeria (SON) and a Lead Auditor in ISO 9001 quality standards
- The Company is based in Nnewi, Anambra State. It's a fully integrated battery manufacturing company producing all the components needed for battery manufacture
- The company produces SLI (Starting, Lighting and Ignition) Batteries either as conventional dry Charged Batteries or Sealed Lead Acid Batteries of the VRLA (Valve Regulated Lead Acid) technology
- While I was there, the company developed power systems for the Nigerian Navy, the Nigerian Airforce and carried out a regular training course on battery management as part of the training requirement of officers and men of the Nigerian Airforce. The program is still running to date
- Through the years we experimented at the R& D dept with the manufacturing of Deep Cycle batteries by adapting some of our machineries. This was done simply by adapting our moulds for Grids casting and changing the Lead Oxide paste formulation. We produced some prototypes which were deployed for use. Lack of investment hampered this project as it was not the core operation of the company

PRODUCTION OF LEAD ACID BATTERY IN NIGERIA

- A typical fully integrated company consists of several other smaller companies organized in form of department producing products which can be sold but are semi finished products in battery manufacturing
- The manufacturing process is organized into the following steps below
- At the end of each step, there is a quality check to assure conformity to standards



COMPONENTS OF LEAD ACID BATTERIES

- The components that make up lead acid batteries are: Battery Case, Battery Plastic Cover, Vent Slip, Positive plates (PbO_2), Negative Plates (Spongy Lead Pb), Separator, Electrolyte eg Sulphuric acid, Connectors, Lead Strap etc.
- Each of these components can be procured and used to assemble a battery in an Assembly Plant
- A fully integrated plant will produce all these components and assemble the batteries. This allows for proper control of the quality

COMPONENTS OF LEAD ACID BATTERIES

- Either an assembly plant or a fully integrated battery plant can be built in Nigeria for manufacture of Deep Cycle Batteries.
- We have the technology and know how. we can import the Machineries and Equipments rather than the finished battery products
- A previous model and design we did in 2012 shows that with an investment of 3-4 million dollars, a fully integrated battery plant of Korean origin can be built and operational with a full 3000 metric tonnes of lead recycling plant and a full complement of Pollution Control Equipment installed. This same plant from China may be slightly cheaper while from Europe will be more expensive

CHALLENGE OF LEAD ACID BATTERY MANUFACTURING IN NIGERIA

- Expensive and unreliable Electrical energy supply. (NB: Electricity is a raw material in Battery manufacturing and not a utility)
- High cost of importation of basic raw materials apart from Lead such as Polypropylene PP and Sulphuric Acid etc.
- Absence of government patronage
- The general craze for imported products
- Low volume output making overhead high and thus selling price high compared to imported products
- General high cost of running business in Nigeria

CONCLUSION

- Energy Storage systems are an important concept in electricity delivery technologies especially when there is already regular electric power supply.
- Of all the types of EES technology available in the world, only the Electrochemical storage using Lead acid batteries is well known and used in Nigeria
- Although all the Lead Acid batteries used for EES are all presently imported from Asia and Europe, Americas etc, these batteries can be produced in Nigeria with the right investment. With an investment of 3-4 million USD, a fully functional Battery Plant can be built with provision for Pollution control system
- Nigerian depended only on centralized electricity generation and distribution over the years that will never bring reliable power supply
- The need to decentralize generation and distribution through the use of renewable energy for industrial complex, minigrids/microgrids and many forms of Solar Home and Office systems is imperative
- There is a large market for the deployment of Energy Storage systems especially batteries of various kinds
- A proper implementation of a consumer based Feed -In- Tariff policy of government will speed up the drive to a reliable and efficient power supply system in Nigeria. It will lead to a “Green Revolution”

Q & A

- THANKS FOR LISTENING
- QUESTIONS

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