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A Review of Electrical Distribution Line Construction Practice in Riverine (Rural) Niger Delta, Nigeria

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Abstract: **Absence of national grid to supply coastal regions necessitates provision of rural electrification. Electrical distribution network become the best option. Experience has shown that most of the projects executed within the region do not last due to numerous challenges such as workforce not familiar with environment, community relation issues, security, transportation, seasonal and tidal variations, no access roads, river-crossing, swampy soil, sand filling, high cost of operating and maintaining generating plants amongst others. All these invariably lead to either producing substandard projects or outright abandonment. Practical approach was adopted in the study. Sustainable development in rural communities can only be achieved when the suggested solutions in this study is properly applied to ensure an improved social, commercial and industrial life for rural dwellers.**

Keywords: **Community, Distribution, Riverine, Rural, Management.**

1. INTRODUCTION

Life in most rural coastal communities in the Niger Delta appears extremely dull due to absence of National grid. Shell Petroleum Development Company of Nigeria Limited (SPDC) confirms that communities in the Delta area consider their standard of living poor and are increasingly looking to oil companies to provide help in improving their situation (SPDC,1995). During the establishment of Oil Mineral Producing Area Development Commission (OMPADEC) in 1992, the first goal was to provide electricity for all the communities it serves (SPDC, 1995). The easiest way to supply electricity to such isolated communities is through a distribution network. Distribution system takes electrical energy from supply (transmission line or generating set) and deliver to consumers.

There are two basic distribution networks, namely, radial and ring networks. Radial network is the focus in this work. It is a distribution network in which straight line distributor supply electrical energy to consumers (Vikash 2022). Power flow is from only one end and current flows away from feeding point while voltage across the loads decreases towards farthest load end (Gupta, 2007). There are three stages of distribution systems. Primary stage is from a 33kv voltage level, secondary distribution 11kv and the tertiary stage 400v/230v system (Pillai, 2009).

The work is aimed at providing the desired knowledge (practical approach) to ease construction activities within the riverine areas. Supplies are normally from generating sets, say, 500kva – 1000kva to supply 400v/230v. Experience has shown that working in such locations require extra efforts from parties involve. Difficulties within these locations include; no access roads, river crossings and swampy soil culminating into high project cost. Solutions suggested here may lead to improve standard of living.

Project design. Designs are normally provided by intervention (financing) bodies.

Site management. This has to do with managing staff, materials, equipment, tools, energy sources and the environment (Rao, 2007). It is part of project management involving integration of personnel, materials, equipment and money to complete a given project (Chikara,2008).

It also covers pre-mobilization checks, mobilization, execution, monitoring, completion, closeout and demobilization.

2. MATERIAL AND METHODS

From experience over the years, handling of rural electrification requires thorough understanding of every task involve. Hence, practical approach was adopted in this study in order to share knowledge gained.

Work procedure;

Preliminary survey. Activities here involves selecting the shortest possible rout, highways and roads, farm lands, likely future loads., avoid obstructions, ridges, swamps without damaging the environment (Integrated Publishing (nd)

Detail survey. The objective is to draw up a planned pole distribution. Tasks at this stage depend on the nature of contract designed by the electricity supply authority (Amazon stuff, 2023). Position of poles, river- crossing, streams, trees, straight lines, generating plant location determination

Site clearing. Site clearing refers to removing or cutting down of trees or bush along the line route (US Department of Labor, nd). Clearing in rural (coastal) areas, is always difficult such that equipment designed to be used in urban locations may not be deployed here, because, there are no accessible roads. These equipment includes tractors, bulldozers, excavators, wheel loaders, cranes, graders, insulated buckets, long reach boom amongst others. Commonly available hand tools include hand held motor saw, cutlass, axe and iron rake. Power line clearing should be done in such a way that distribution lines are kept clear of bush growth in at least three years (Treework, 2023).

Right of Way; this is the distance (width) covered by an overhead line route on both side in which the electrical distribution company have rights. For safety reasons, the right of way distance of 11metres (5.5m) that is on each side of the 400v/11kv/33kv, 30metres (15m) that is on each side of 132kv and 50metres (25m) on each side of 330kv power line is observed (Ekedc,2023; Uzodinma,2019; Gupta,2007; Thiele, Brewer and Estep, 2021))

Material Procurement

Items required to carry out the construction activities include but not limited to the following; concrete poles, pin insulators, 70mm2 for street lights, 50mm2 for earthing, 100mm2 ACSR, 25mm galvanized earth rods, cement, sand, granite, danger plate, generating plants, 500mm2 PVC armoured cable where river crossing is encountered, D-iron, shackles, gear switch, charcoal and salt, draw vice, ladder, safety belt, truck, wheel-barrow, hand tools, stay assembly, cable drums, wooden truck etc.

Transportation

There are vehicles equipped with facilities for transporting concrete poles on land (point of purchase in urban cities). But poles, other items including generating sets are conveniently transported using tugboat and barge or large wooden boats to site locations.

Material distribution

There are no surveyed access roads within most rural areas, therefore, pole distribution is by using wooden trucks to desired locations (position).

Civil works

a) Building of power house, provision of armoured cable entries for connection to generator connection terminal box, generator base casting, fixing of generating sets to base. Super structure works and roofing, construction of riser pole, construction and installation of metal stand for changeover switch and lights.

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b) **Pole erection**. Manual approach is usually adopted in rural settings at the points marked for poles, excavation of pole foundation pit is carried out to a depth of 1.5m in compliance with standard. About seven persons handles this process. Skid board is employed at one point of the pit in which the pole base rests. The concrete pole is dragged and pushed to touch the board which serves as stop end. Then, the other end of the pole is raised gradually from ground, until it is vertical with the aid of ladder and two ropes controlled by two persons. Once the pole attains a vertical position, the skid board can then be pulled out for the pole foundation to be properly filled with soil and rammed.

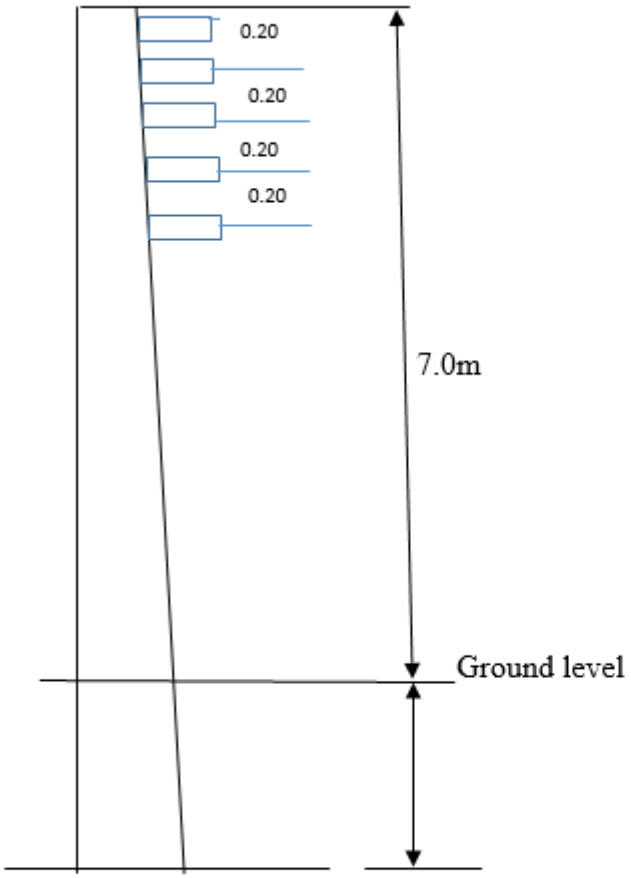

Figure 1. LV 8.5m Concrete pole

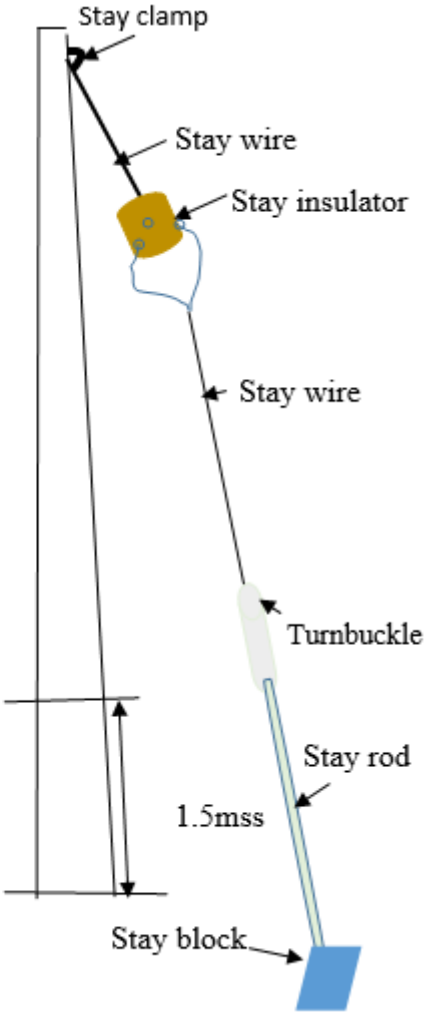

Figure 2. Stay Assembly

Pole span. Electric pole is designed to support the overhead lines (ETechnoG,2022). Span is distance between two adjacent poles of a power lines (Pillai, 2009). For a low voltage system of 400/230v, the minimum pole span is 30m and maximum of 45m (Pillai,2009). However, the rural areas are dominated by damp and swampy soils which could be a critical factor in determining the actual pole span. The implication here is that either casting of the base depth is increased or increasing the pole depth beyond the 1.5m (Electrical4U (2020).

Ground clearance. Nominal distance between the last conductor and ground should be 5.8m over road crossing (Electricity Act, 1996, Pillai,2009). In some cases, residential houses may have been there before the construction work in which case, the clearance should not be less than 3m (Pillai,2009).

Stay installation;

Stay counter balance the forces resulting from conductors connected to poles. Stay support poles at terminal ends, angles, end of tee-offs of distribution lines. It is positioned at angle between 30^0 and 45^0 from the poles. A stay assembly as shown

in figure 2, is consist of stay rod, stay wire, thimble, stay insulator, anchor plate/concrete block. The stay rod is usually of the adjustable type. The upper part of the stay rod right hand thread, is fixed to a thimble for connection to the stay wire, while, the lower section of the stay rod right hand thread terminates at the stay plate. Locknuts provides coupling at both ends of the turnbuckle.

Porcelain insulators connected in series and inserted along the stay wire is for safety to humans' in the event of electrical fault (Gupta,2007; Pillai,2009)

Electrical works;

a) Internal lighting systems items includes light fittings, changeover switch, socket outlets, consumer unit, generating set, gear switch amongst others

b) **Dressing**; this process involves fixing conductor supports on the concrete poles, such as insulators, shackles, D-clamps, spindles, etc. Lineman climbs the poles employing approved equipment and tools. There must be a helper to assists the lineman.

c) **Conductor erection**; proper attention is required as the strength, durability, functionality, neatness of the network depends on it. It involves six steps which include; conductor delivery, running out, stringing of conductors, tensioning, sagging and joining of conductors

i. **Conductor delivery**: the conductors after procurement are in wooden drums. Careful handling is very necessary in order to avoid damage. The drums are usually transported to site in either big wooden boats or dump craft (barge).. Distribution to pole positions marked during survey is done with the aid of wooden trucks.

ii. **Running out**; this is removing the conductors from the drums. Drum carrier constructed and the drum with spindle fixed in the desired position (lowered to a wedge). Personnel numbering about four shall be sufficient to handle this operation. Cable reel is employed to rotate (loose) the conductor from the drum with carefulness to prevent kinks and damages.

Whenever, a twist is noticed, the operation must stop until after corrective action taken.

iii. **Stringing**; mounting conductors on planted poles is termed stringing. Running out process and stringing may be done simultaneously. This become necessary as the conductor leaves the drum, it is raised to the lineman who ensure conductors are carefully placed on the insulators already fixed on the poles. In case of crossing rivers in rural settings, small dump crafts are commonly employed in laying armoured cables across rivers. Derricks plying rivers may interfere with distribution lines crossing if overhead lines are constructed. Precautionary measures must be observed for safety reasons

iv. **Tensioning**.; this step is taken after stringing. Lineman uses equipment and tools such as winch termed come – along (draw vice), aluminium ladder, safety belt, approved hand tools to draw conductors placed on the poles to obtain near straight line. Tension is carried out at line breaking points, tee-offs and end points.

v. **Sagging**; sag is the vertical displacement of overhead conductors between pole supports (Pillai,2009). Properly tensioned line, produces small sag, but, a loosely tensioned line lead to sagging that can cause short-circuit. Sight over method of checking straight lines are commonly employed in rural areas.

vi. **Joining of conductors**; for distribution lines in rural areas, joining of conductors is inevitable considering difficulties in getting materials procured to arrive site after commencement of work and the need to reduce cost and time without necessarily compromising quality, durability, reliability. The most suitable method of joining conductors is the married joint producing mechanically strong joint.

Earthing; this means deliberate connection of electrical system to earth in order to obtain zero reference voltage. Earthing is to guaranty safety to human and animals, prevent equipment from damage due to leakage or fault current. It also enhances system reliability. It is important to earth all metal frameworks or items that may come in contact with current carrying conductors. Items to earth include; generators, gear switch, rack, electric motors, power driven water pumps, transformer, feeder pillar, socket, water pipes, gas pipes, lightning arrester, electric pole, line conductors. In rural distribution lines, TN-C-S earthing system is preferable. In this system, the supply neutral is earthed at every fourth pole along the line. Some

countries called this system protective earthing neutral (PEN) meaning, the neutral apart from functioning as a return cable also serve as the protective cable. It is unique such that the supply side is TN-C, but, the installation TN-S. The common term associated with it is Protective Multiple Earthing (PME), demonstrated in figure 3

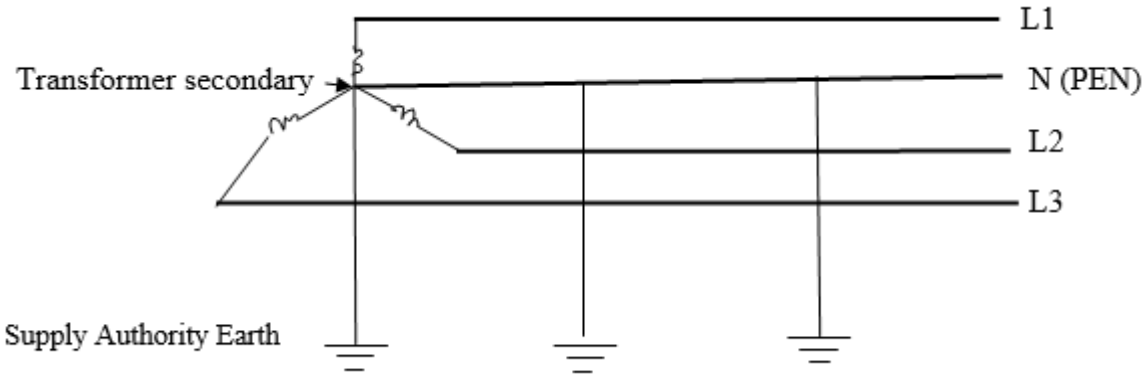

Figure 3. TN-C –S System {MPE}

Some important tests required

i Earth resistance (soil resistivity) test. Before earthing, soil resistivity test be carried out first. For a new installation, the four spike (Winner method) is necessary employing an approved earth resistance tester (Admin,2021). Different soil type produces varying resistivity values. Lowest soil resistivity soil is most economical and effective for earthing.

ii Insulation resistance test. This test is to determine the resistance offered by an insulation covering a given conductor to current leakage. (SparkyFacts.comuK,2018). The instrument popularly used is the **Megohmmeter tester** (Carelabs,2023). A test voltage, 500v is usually adopted for a single phase system,230v. Ordinarily, infinity reading will suffice, however, there is no perfect insulation, hence, the high the value the better.

Table 1. Acceptable minimum test values (Carelabs,2023; SparkyFact.com.uk, 2018).

Circuit voltage	Test voltage	Minimum Resistance Value
0v-50v ac	250v dc	0.5Mohm
50v ac – 500v ac	500v dc	1Mohm
500v ac – 1000v ac	1000v dc	1Mohm

Conductor insulation deteriorate with time, particularly, in coastal regions, where the environment is corrosive, high moisture content, oily, chemically dangerous, polluted, degraded, atmosphere contaminated with acid rain and particulates.

iii Continuity test. Continuity means there is complete current flow path (Fluke, 2023). This test shall indicate or verify that there is no broken contact points or open circuit through the current flow path in a circuit. BS 7671:2008 stipulates that before an installation is powered (energized), it must be inspected and tested to ensure compliance with this Regulation (Carelabs, 2023).

The instrument for continuity test is the Multimeter and Ohmeter. There is also a special continuity test set that incorporates light bulb which glows whenever current flow through the circuit (Rouse,2016).

Reading: the instrument readings should be low or zero meaning good, while very high or infinity ohms implies open or broken contact in the circuit, (Rosenblum,2019). The Ohmeter usage is applicable only to circuit that is not energized or else, the equipment will be damaged. Points where continuity test is to be applied include, fuses, switch contacts, lighting points, terminal box, etc (Rosenblum,2019).

Pre-Commissioning

Pre-commissioning processes are carried out to identify defects or deficiencies and remedied before commissioning. Activities involves both off-site and on-site. For off-site has to do with preparations during pre-mobilization checks in terms of items and equipment availability, quality, quantity, reliability, safety plan, Quality Assurance, Quality control, staff

qualifications and experience. Inspection, open-circuit, short-circuit, earthing, bounding, equipotential bounding, phase sequence, position of riser, insulation resistance, continuity test, earth resistance test, mechanical checks, fuses, relay, circuit breakers, transformers, feeder pillar, etc, (Huber, 2023; Rao, 2007).

Deficiencies are categorized into type A, B and C (Turner, 2022).

Type A; these are deficiencies that must be corrected before commissioning.

Type B; defects under this category does not stop commissioning, but, has to be addressed before handing over to client.

Type C; These are minor defects which may not affect either commissioning or system functions. However, must be corrected within warranty or retention period.

On-site pre-commissioning involves mechanical, electrical and physical testing and operation of items. Completion of pre-commissioning activities confirm that the system is ready for commissioning.

Commissioning

Commissioning is defined as the process of planning, documenting, scheduling, adjusting, verifying, and training to provide a facility that operates as a full functional system (Huber,2010). Electrical commissioning may be defined as the systematic process of verifying, documenting, and placing into service newly installed or rehabilitated electrical power system (Dansa and Hoegberg, 2023). Commissioning starts when pre-commissioning ends. On-site processes commence at this stage.to confirm that facility was properly designed, installed and tested. Tests are conducted to ensure that equipment or system failures are prevented or reduced on energizing to achieve efficient and reliable performance (Rao,2007). During commissioning, the system may run for a trial period of not less than seventy-two hours, after which the facility is handed over for normal operation and maintenance. Three parties are normally expected during commissioning namely; benefiting community representatives, contractor and the financing body (facility provider).

CHALLENGES

Experience has shown some challenges during construction of distribution lines in rural settings which includes but not limited to;

- Workforce, not familiar with the environments
- Choice of vessels and equipment for transporting materials to site and distribution of poles to marked locations for erection
- Non-availability of approved equipment and tools to carry out various activities on site
- In some cases, personnel engaged lack community relation skills
- Earthing work on sand filled soil (high soil resistivity) as against the swampy soil with low soil resistivity observed during survey (feasibility studies)
- Violation of right-of-way.
- Basil Omiyi while presenting Shell Nigeria Annual Report, 2006 under Sustainable Community Development acknowledged that “the challenge still remains to find a better solution for power supply in coastal communities where there is no national electricity grid” (Omiyi,2007)
- Cost of operation and maintenance of generating plants to power coastal rural distribution networks are beyond the financial capability of members of such communities. Consequently, most projects became idle and abandoned immediately after commissioning, thereby, failing to meet the objectives of providing electrification to improve the standard of living of the people. For instance, Shell Petroleum Development Company of Nigeria Limited (SPDC) in commitment to its social responsibilities to host communities within the coastal regions, provided rural electrification to some host communities and spent $4.7 million for fuelling alone in 2006 (Omiyi,2007).
- Seasonal and tidal variations should be considered as flood level, high or low tide in coastal rural regions, also influences site clearing, sighting and pegging, pole distribution, excavation and pole erection

The above challenges increase cost, culminating into project abandonment or substandard projects. Strictly speaking, the points raised here influences project constrains such as cost, time, quality and personnel in one way or another, hence require proper attention.

Solutions

- Staff must be familiar and be trained in line with safety, marine related and also to understand the topography.
- The choice of vessel is dictated by the environment; deep river, shallow river, narrow canals, swampy, tidal variations either low or high tide calls for either a flat top barge or speed boats or large wooden boat. Loading and offloading in the rural areas is normally manual and pole distribution to locations is by wooden trucks or hand carriage.
- Due to lack of navigable rivers, canals and access roads in some areas, equipment's approved for use in urban locations to aid pole erection cannot be deployed. However, it is still possible to erect poles in a straight line manually and safely. During sighting and pegging, three to four light wooden poles or equivalent materials can be pinned to the earth, adjusting them and when viewed from either end seeing only two end poles means the line is straight. Final marking of the pole positions can then be determined.
- Community discussions must focus on employment, provision of items for the youths, community development, sub-contractors to be engaged and compensation or acquisition fund where applicable. Ensure to engage the right members of communities. The negotiating team need be patient to obtain Memorandum of Understanding (MOU) prior to receiving Free to Operate (FOT) from communities before mobilizing to site.
- Earthing of electrical systems become more economically viable and effective when low soil resistivity is available. In most cases, within the mangrove forest areas, during feasibility studies, the swampy soil with low resistivity was used for design. But, such locations are usually sand filled before actual work commences, in which case earthing on sandy soil with high resistivity produces earth electrode resistance values higher than the designed limits, leading to existence of hazardous step and touch voltages. Under such circumstances, soil enhancement should be carried out before commencing earthing.
- Seasonal and tidal variation data should be considered when electric poles are to be erected. Most coastal areas, easily flooded, as such locations are almost all round rainy season annually. The best period shall be between early December to early March. According to NiMet (2018), rainfall was predicted to commence in early march to end December around the southern coastal communities in Nigeria. It will be extremely costly to plant poles during the rainy season, longer poles may be required, digging of pole pits become difficult, more difficult when sand filled soil is involved, longer formwork required for casting concrete pole foundation. All these culminates into additional cost, delay or substandard job or abandonment in extreme cases.
- Operation and maintenance cost of generating plants should be handled by various local government councils where such facilities are installed or State governments or intervention agencies so as to achieve sustainable development of rural communities.

3. CONCLUSION AND RECOMMENDATION

Distribution network to supply electricity to isolated (rural) coastal areas of the Niger Delta in Nigeria is presented. The study become inevitable due to the absence of national grid. Difficulties inherent within the locations identified and solutions highlighted.

The challenges usually lead to poor quality jobs, higher cost or project abandonment. Practical approach was adopted as it focused on field experiences worth sharing. The paper has established some basic facts which were taken for granted by those not familiar with such environments and the activities.

The operation and maintenance cost of generating plants is too high for the rural dwellers, as it is expenditure intensive, therefore, oil companies as part of their social responsibilities or local government councils or state governments or other intervention agencies should takeover such expenditure. Social, industrial and commercial standard of the rural people can only improve when electricity was made available through the distribution network.

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