

TIME OF NEED SUPPLY CONCEPT: A TOOL FOR OPTIMAL ELECTRICITY DISTRIBUTION IN NIGERIA

Agwu, D. D.¹ Eze U.C.² Obishai F. N.³

1. daviddaberechi@gmail.com 2. charlesraymond4all@gmail.com 3. ndukafidelis@gmail.com

^{1,2}Dept. of Elect. Engr. FUTO ³ SO/MO-TCN , Abuja

ABSTRACT

Today in the Nigerian Electricity Distribution business, organisational profit lies in the ability of a distribution company to manage the supply demand of her customers when they need power and collect all revenue due for the power supplied. Electricity Distribution Companies generally categorise customers into Maximum Demand and Non-Maximum Demand customers. In customer population mix, Maximum Demand customers are usually small in number compared with Non-Maximum Demand customers. Payment response from Maximum Demand customers are usually very high, while payment response from Non-Maximum Demand customers are yet to come up to a satisfactory level. With the challenges of Aggregate Technical, Collection and Commercial Losses and non- cost reflective tariff rocking the utility companies in Nigeria, a Distribution Company may be left with no better alternative than to supply more power to the class of customers that will respond promptly to payment of energy consumed. However, the existing distribution network infrastructures in Nigeria does not actually support supplying preferential customers and leaving out others. This paper seeks to introduce a new load management strategy which has not been in practice in Nigeria that can help tackle this electricity distribution challenge in order to attain maximum profit.

Key words: Nigeria, energy management, electricity distribution, network improvement, selective supply

1.0 INTRODUCTION

In Nigerian electricity market mix, there exist several types of customers with different behaviours in terms of payment response. These customers are generally categorised into Maximum Demand (MD) and Non-Maximum Demand (Non-MD) customers. For Nigerian DISCOs to remain in business, they need to ensure they collect all the revenues due for supply made to customer and also try supplying more to the class of customers that not only have high payment response but also being charged with higher tariff in order to maximise profit [1][2]. However, the existing distribution network infrastructure in various DISCOs territories does not actually support supplying preferential customers and leaving out others [3]. The network is in such a way that once a feeder is energized, all the substations under the feeder get energized unless manually opened with an isolator (or J&P fuse drop) for whatever reason.

Presently, if a feeder is energized as illustrated in fig. 1, all the substation feeding from it get energized.



Figure 1: Illustration of Feeder during supply

And if there is power outage on the feeder all the substations feeding from it goes down too as illustrated in fig. 2.



Figure 2: Illustration of Feeder during power outage

Note: Red Arrow indicates energised line while blue indicates de-energised line. Green box represents energised substation while grey box indicates de-energised substation.

Hence, Nigerian DISCOs are faced with “inability to give selective power supply to their paying (preferred) customers and to regulate the supply that gets to less preferred customers as may be dictated by management” as a major challenge.

2.0 OBJECTIVES

The objectives of this paper include:

- i. To draw the attention of Nigerian DISCOs towards making optimum use of the equipment they already have.
- ii. To vindicate that DISCOs already poses what they need to fix their network
- iii. To challenge the Nigerian DISCOs towards looking inward for solution instead of continuous use of funding limitation as excuse for failure.
- iv. To compare costs of network improvement alternatives available to DISCOs

3.0 PROBLEM STATEMENT

Nigerian electricity distribution network is said to be poor because the network configuration is presently in such a way that DISCOs cannot distribute for optimal profit.

4.0 IMPROVING EXISTING DISTRIBUTION NETWORK

Two major approach that can easily be adopted for upgrading Nigerian electricity distribution network are:

- i. Construction of new lines (special feeders)
- ii. Proper application of Automatic Metering Infrastructure

4.1 CONSTRUCTION OF NEW LINES

To overcome the challenge of poor distribution network, some DISCOs are constructing new distribution lines (special feeders) to supply customers with high payment response. Yes this solution will increase their distribution capacity and possibly help them to achieve the aim of selective power supply, but it has its own demerits.

Considering the nature of our urban centres like Umuahia, Benin city, Enugu, Port Harcourt, Lagos and so on, the following are possible construction styles for Distribution network upgrade and their limitations:

i. Double Circuit on Sections Style

Beside high cost of construction, DISCOs may likely encroach into people’s real estate properties. This of course may result to litigations and or demand for compensations considering that DISCOs are now a profit oriented company. In terms of safety, it will constitute hazard to maintain any of the two circuits while the other is energised, hence the double circuit is meant just to increase distribution capacity which is not the major interest here.

ii. Double Circuit on Single Pole

Though this style has reduced cost as compared with Double Circuit on Sections Style because of poles saved at each section, it still has all the challenges associated with Double Circuit on Sections Style.

iii. Two Single Circuit on Single Pole Across the Road Style

In terms of cost, this is very similar to Double Circuit on Sections Style. However, it is safe to work on any of the lines while the other is energised, provided all necessary safety precautions are maintained.

iv. Underground Cable Feeder Network

Beside high initial cost of investment, laying underground cables in already built densely populated areas such as our urban centres may not just encroach into people’s real estates but also interfere with municipal facilities like water lines, communication fibre optical cables, etc.

4.2.1 APPLICATION OF AUTOMATIC METERING INFRASTRUCTURE

Fortunately, the DISCOs can actually redesign and upgrade their network (feeders) so as to selectively supply substations of their choice like the MD (point load) substations while leaving some others like the Non-MD (public utilities) out, as illustrated in fig. 3.

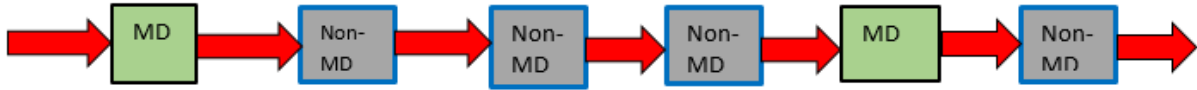


Figure 3: Illustration of selective supply to MD customers

DISCOs can also choose to supply Non-MD customers at some point in time and leave out MD customers as illustrated in fig.4.

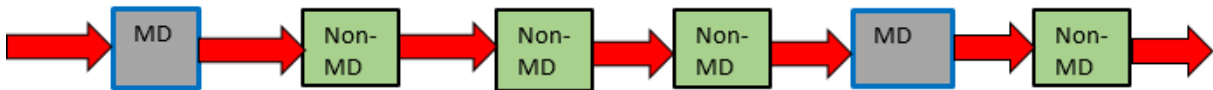


Figure 4: Illustration of selective supply to Non-MD customers

DISCOs can also mix the customers as may be desired by management as illustrated in fig. 5.

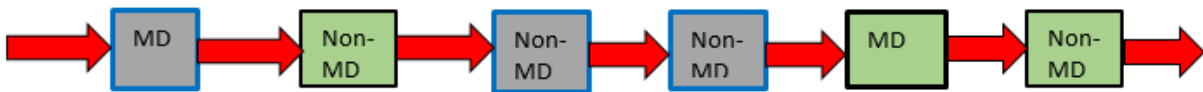


Figure 5: Illustration of selective supply to some Non-MD and MD customers

This paper wishes to propose a more scientific methodology of solving this problem so that DISCOs should explore the option of the remote control system which they ought to have already acquired (via Automatic Metering Infrastructure embedded in the smart meters they are presently issuing to customers) to control their network and selectively supply their desired customers using same feeder instead of constructing new lines just to supply few customers. Details will be discuss as this paper progress.

4.2.2 ADVANTAGES OF THIS SOLUTION

This solution will proffer among others the following advantages:

i. Ability to selectively supply customers

This will enable DISCOs achieve the business aim of supplying more power to customers who can pay for their consumed energy and are always willing to pay.

ii. Ability to supply customers at time of need

Beside the opportunity to selectively supply customers, it will give DISCOs the advantage of supplying specific categories of customers at more suitable time to them. Imagine how a customer will feel if his area of residence gets supply between 10am to 4pm and his working place gets supply between 4pm to 10am daily [4][5]. Table 1 below shows suitable supply period with respect to the peak hours of power supply demand.

Table 1: Power Supply Schedule Reflecting time of need

Type Customer	Nature of Business	Supply Period	Outage Period	Reasons
MD	Industrial (Eg Gbemitan Inv. Akure)	8am to 5pm 9pm to 6am	5pm to 9pm 6am to 8am	Supply period is during peak manufacturing hours as workers ought to have arrived and take their working positions.
MD	Commerce (Banks)	8am to 5pm 9pm to 6am	5pm to 9pm 6am to 8am	Supply period is the peak banking operation hours.
MD	Hospitality (Hotels)	5pm to 10am	10am to 5pm	Supply period is their peak business hours
MD	Govt. Offices, Markets, etc	9am to 5pm	5pm to 9am	Supply period is office hours, afterwards workers return to home.
NON-MD	Residential	6am to 8am 5pm to 9pm	8am to 5pm 9pm to 6am	This is residential peak supply period
MD	Fast Food	10am to 9pm	9pm to 10am	Supply period is their peak business hours

Most of our areas today as built-up are mixed customers based, hence effectiveness of this scheme will in no small measure solve this problem.

iii. Improving customer's payment response

This solution will enable DISCOs supply power to their customers when they need it more. Thus increasing the likelihood of meeting our customers' power supply expectations, which in turn will increase their trust in such DISCO and make them have positive behavioural change, which will ultimately increase and maintain good payment response.

iv. Ability to remotely disconnect non-paying customers

Instead of spending resources on MD customers' task force, DISCOs can disconnect non-paying customers remotely. This disconnection can even be done by anyone irrespective of technical specialization, provided the person has been trained to operate DISCO's server.

v. Enable network load balancing

On event that Nigeria's System Operator (SO) requires a DISCO to pick or drop load, the despatch office of such DISCO can simply look at the server to know a particular or few Distribution Substations that has good or poor payment response (irrespective of customer type) to either pick or drop.

vi. Network Security

In the time past, many unapproved projects get hooked to DISCOs' network during the outage period. To connect without permission, the culprits just study the supply pattern of the particular feeder and connect during outage period. To ensure safety, they tease our distribution lines, if lines are dead they will ground it and carry out their operation safely else they will wait till outage period. Same happens when vandals vandalise power utility equipment. With this solution, Distribution networks will be constantly energised up to the transformer level; even when we take out supply from the customers.

vii. Operating within NERC codes while maximising profits

Nigerian Electricity Regulatory Commission (NERC) distribution codes seeks to protect the customers from being taken undue advantage of by the DISCOs. Hence instead of switching off an entire area, a DISCO may choose to supply any customer that is willing to comply with NERC supply terms while leaving out others. This will increase

such DISCO's collectable revenue. In the course of implementing this concept, DISCOs will end up metering of all their Distribution Substation as specified in NERC distribution codes, thus avoiding future sanctions.

4.2.3 CHALLENGES OF THIS CONCEPT

Implementation of this concept simply implies that the DISCOs are embarking on smart grid projects. Smarts grids of course has the disadvantage of high initial cost of implementation and the need for highly skilled personnel to implement them. However, we are making these proposal because most of the DISCOs has already acquired the infrastructure but it may not occur to them to fully utilise what they have acquired.

4.2.4 DISCOs CURRENT TECHNOLOGY THAT CAN HELP

It has been observed that several DISCOs have acquired Advanced Metering Infrastructure facilities with which they can remotely configure the new smart meters they now install for their customers. With these smart meters DISCOs can selectively switch on or off any customer (substation) of their choice that has a smart meter installed.

4.2.5 IMPLEMENTATION BLOCK DIAGRAM

Fig 6 is a block diagram that indicate how Smart meters can be integrated in distribution substation, whether point load (for MD customers) or public utility substation to enable us selectively supply desired customers.

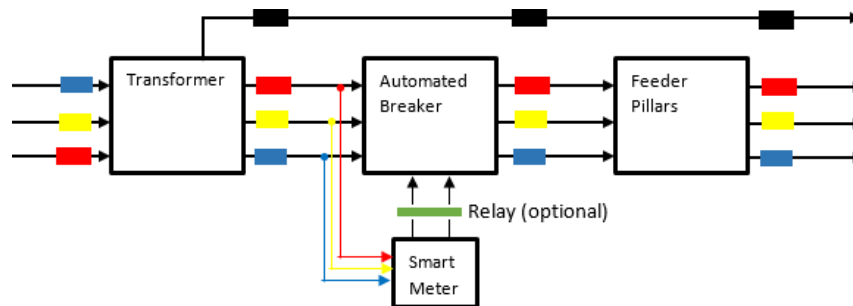


Figure 6: Block Diagram for Selective Power Supply system

4.2.6 DESIGN PHILOSOPHIES

1) Use of Low Voltage Switch

The cost of power equipment usually increases with increasing voltage level because of difficulties in achieving relative insulation. 415V contactors are quite cheaper than 11KV or 33KV breaker or Isolator. Moreover, 415V contactors (switches) are readily available in the market to the tune of 800A, which supposes the maximum obtainable current ($I = 696A$ at nominal voltages) from a 500KVA transformer, which is the most common biggest transformer used in distribution substations.

Isolating the low voltage (LV) side instead of the High Voltage (HV) side will ensure that the substation and lines are energized at all times, unless on fault. In addition, it will also reduce the magnitude of switching arc experienced at the contactor terminals, thus enhancing the switch's life span and reliability.

2) Switch and meter Position

As illustrated in the block diagram, the automated breaker is to be placed between the transformer and feeder pillar, while smart meter is to be placed between the transformer and the contactor. This is to say that both the metering Current Transformers (CTs) and voltage tapings for the meter and smart meter should be between the transformer and contactor.

3) Flexibility of Switch Position

While our LV, CT operated smart meters must remain in this fixed position (i.e. feeding between transformer and feeder pillar), the automated breaker position can be changed for more design robustness. For instance, Assuming there's an MD customer feeding from a public distribution substation, if we should allow our automated breaker to remain between the transformer and feeder pillar, the MD customer will be disconnected alongside non-MD. To overcome such condition, the automatic breaker can be placed between the feeder pillar and up-riser. Also,

instead of one automatic breaker and smart meter, we will now need two sets. A set will be for the MD customer while the other will be for the non-MDs. The connection block diagram for this scheme is as illustrated fig 7.

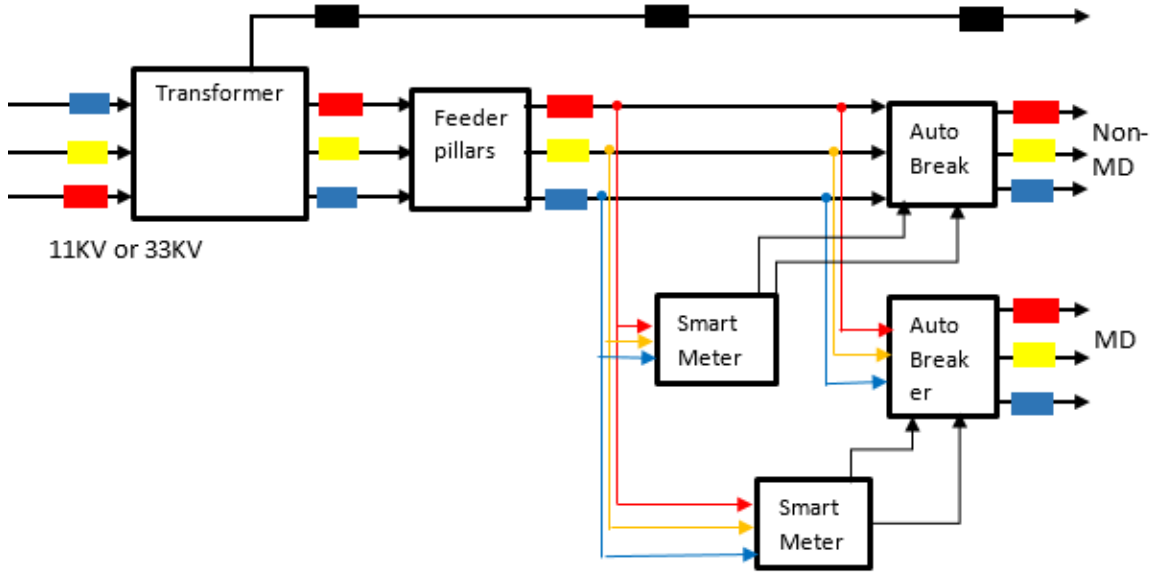


Figure 7: Block diagram for flexible switch position

5.0 FINANCIAL PERSPECTIVES

A. Cost of Implementing AMR and Remote Control

Table 2 above shows an estimated cost of metering a substation using a smart meter and Automatic breaker (contactor) for disconnection and reconnection of the customer as may be desired and dictated by a DISCO's management. The estimates presented in table 2 is for a 500KVA distribution substation, which is the most common biggest distribution substation for public utility substation. Labour cost was not evaluated because DISCO's metering department are to carry out the installations and if metering department undertake the project, labour cost will remain a part of such DISCO's operating expenses with little or no marginal increase due to the project.

Table 2: Cost of installation for a 500KVA substation

S/N	Item Description	Quantity	Price (₦)
1	CT operated smart energy meter	1	50,000
2	800A contactor	1	258,000
3	10A, 250V AC relay	1	500
4	Cable lugs, bolts and nuts	lot	3,000
5	Plastic panel casing	1	5,000
6	Communication Cable	5M	1,000
7	CTs	3	7,500
8	Labour	-	-
	Total		325,000

From table 3, the costliest material in the project is the automatic breaker (contactor). Price of contactor depends on its capacity [6]. The table also shows various distribution substations' capacity (in KVA) that may be found in distribution network and their maximum attainable load (current). It also shows a recommended rating of contactor for each distribution capacity and market price of the contactor. Hence, table 4 gives cost of implementing this project for various capacities of our distribution substation.

Table 3: Distribution Capacity and Price of Recommended Contactor

Transformer Ratings (KVA)	Maximum Load (A) at 415V	Recommended Contactor Rating (A)	Manufacturer's Model ID	Amount (₦)
50	70	100	1SBL367001R1422, ABB	14,000
100	139	200	1SFL447101R1400, ABB	90,000
200	279	350	1SFL527102R1400, ABB	133,000
300	418	500	1SFL577001R7122, ABB	165,000
500	696	800	1SFL597001R7111, ABB	258,000

Table 4: Cost of Project Implementation for Various Distribution Capacity

Transformer Ratings (KVA)	Maximum Load (A) at 415V	Recommended Contactor Rating (A)	Investment Cost (₦)
50	70	100	81,000
100	139	200	157,000
200	279	350	200,000
300	418	500	232,000
500	696	800	325,000

B. Cost of Constructing a Spur of New Distribution Line

For a primary distribution line of 50 meters span length, a spur being ten spans of such line will be equal to 500 meters network length. The table 5 shows approximate cost of constructing a spur of 11KV distribution line.

Table 5: Cost of constructing a Spur of Standard 11KV Distribution Line

S/N	DESCRIPTION OF MATERIALS	UNIT	QTY	RATE (₦)	AMOUNT (₦)
1	100mm ² Bare Aluminium Conductor	Metres	1500	150	225,000
2	H.T Concrete Poles	No	11	25000	275,000
3	11KV Tie Strap	No	18	350	6,300
4	5 Feet Angle Iron/ Fibre Cross Arms	No	10	5, 500	55,000
5	5 Feet U-Channel Iron	No	4	5, 500	22,000
6	11KV Pot Insulator	No	33	1, 200	39,600
7	11KV Spindle	No	30	700	21,000
8	11KV Jumper Spindle	No	3	900	2,700
9	11KV Disc Insulator Complete	Set	6	5, 200	31,200
10	H.T. Stays Complete	No	4	5, 000	20,000
11	11KV Gang Isolator	Set	1	60, 000	60,000
12	Line Earthing Complete	No	3	4, 000	12,000
13	Various Bolts and Nuts	LS	LS	15, 000	15,000
	Total				784,800

6.0 CONCLUSION

One of the major issues confronting all DISCOs today is poor energy management, which this tool will greatly resolve if implemented. This presentation therefore will improve distribution network energy management structure in Nigeria for optimal electricity distribution by DISCOs. And with the concept of Automatic Meter Reading (AMR) schemes already been implemented by most Discos, this concept can be conveniently keyed in. This paper also draw the attention of DISCOs to other striking benefits (i.e Substation Remote Control and time of need supply concepts) that they may derive as they implement AMR projects, and also derived the double benefits of NERC metering requirement of metering all distribution substations; using same resources. This of course will help towards closing their loss gap and improving revenue [7].

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