A NEW PROPOSED DEMAND SIDE MANAGEMENT TECHNIQUE

Eze, C.U.[1], Agwu, D.D.[2], Uzoechi, L. O.[3]
[123]Department of Electrical and Electronic Engineering, School of Engineering and Engineering Technology,
[123]Federal University of Technology, Owerri (FUTO), Nigeria.
[1]ezecharlesugo1@gmail.com, [2]daviddaberechi@gmail.com,
[3]lazarus.uzoechi@futo.edu.ng

ABSTRACT

Demand Side Management (DSM) is considered a great tool in energy management because it enables utility companies satisfy the power needs of more customers with little or no increase in power supply generation. Though Nigerian electricity distribution companies (DISCOs) are aware of Nigerian electricity needs and supply lapses, they are yet to fully embrace and implement DSM as part of their operations. This paper discuses DSM concepts, challenges and proposes how it can be applied in solving power problem of Oda community, a residential settlement within the coverage area of Benin Electricity Distribution Company (BEDC). It also presents a systematic model that can be used to measure the impact of DSM when applied in the community. The DSM tools proposed in this paper will benefit not just the customer or the power utilities but the nation at large when properly implemented.

KEYWORDS: *Demand Side Management, Load Management, Energy Efficiency, DISCO, & Nigeria.*

I. INTRODUCTION

The ever increasing population and development needs has led to and increased gap between electricity demand and supply in many countries. Nigeria being the highest populated country in Africa with a population of about 148 million is not excluded from this challenge [1]. Due to the increasing population of Nigeria, there has been a corresponding increase in power demand without a reliable supply to meet such [2]. The political uncertainty, great risk, huge investments and complexities linked with new power plant constructions and industrial bypass forces the Nigeria electric power utilities to seek alternatives to mitigate their inadequate supplies. Therefore, they must review their traditional role as suppliers of electricity and forge closer ties with their consumers to help them control and shape electricity demand pattern and costs in a mutually beneficial way. One tool for achieving this is with Demand Side Management (DSM).

With electricity being a product that has great attributes of social interest, the power utility companies in Nigeria have a Hobson choice of making power supply available to each customer no matter how small the duration might be. Seeing that the rate of increase in demand does not equal the rate of supply increase in Nigeria, the questions are:

Should power utility companies stop accepting new customers in order to close the Demand-Supply gap?

Should they start rejecting existing customers in order to reduce demand an improve quality of supply?

As will be discussed in the subsequent sections, increasing number of distribution transformers in Oda feeder for Oda community will only end up increasing their consumption capacity. This will not really improve their power supply conditions as they wish. Most consumers do not know that their loads sum up at the injection substations. They feel that energy from national grid is unlimited and all they need is getting more distribution substation to increase their consumption capacity. Probably, this is why the Landlord association of Oda community is making this request. This paper seeks to address these landlords' problems.

In this paper, a detailed methodology of how DSM programs can be implemented and monitored are given. The Oda rural community in Akure, Ondo state of Nigeria was used as a case study and the proposed impacts of DSM technique on energy consumption are evaluated. The DSM techniques proposed in this paper when implemented, can go to a great length in improving utility power supplies and better customer relationships.

1.1 The Idea of Demand Side Management In Brief:

Demand-side management (DSM) is the traditionally method of lowering peak electricity demand so that utilities can delay building further capacity. The term DSM emerged after the energy crisis in 1973 USA [3]. DSM is also known as Energy Side Management or Energy Demand Management whose ultimate aim is to reduce the peak demand of power plant [3]. It entails the planning and implementation of utility activities designed to influence the time pattern and/or amount of electricity demand in ways that will increase customer satisfaction, and coincidentally produce desired changes in the utility's system load shape [4, 5]. DSM has different facets for different categories of peoples. As mentioned earlier, for Nigeria Distribution Companies (DISCOs), DSM means avoiding or delaying the need to construct new generating capacity by reduction or shift of consumer's energy use period [6]. For consumers, DSM means an opportunity to save money by reducing their electricity bill taking the advantage of financial incentive provided by utility.

When DSM technique is applied to the consumption of energy in general; not just electricity but fuels of all types, not only can it bring significant cost benefits to energy users but also corresponding reductions in emissions . Opportunities for reducing energy demand are numerous in all sectors and many are low-cost, or even no cost items that most enterprises or individuals could adopt in the short term. DSM targets to improve appliance consumption, trim down utilization, while maintaining an equivalent level of service and pleasure [6]. DSM has been recommended as a key solution to solving the problem of inadequate power supplies amidst growing consumer demands.

1.2 Why Propagate DSM In Nigeria?

The first utility company, the Nigerian Electricity Supply Company, was established in Nigeria in 1929 [8]. However, electricity generation in Nigeria had started over 30 years before the establishment of the first utility back in 1896 [7]. Despite the various efforts of the State-owned utility, (which operated as a monopoly) to manage the sector to provide electricity, it became clear by the late 1990s that the Nigerian electricity system was failing to meet Nigeria's power needs. Hence, the National Electric Power Policy of 2001 kicked off the power sector reform in Nigeria, leading to several other reforms over the last decade [7].

The Nigerian Power Sector Privatization is reputed to be one of the boldest privatization initiatives in the global power sector over the last decade, with transaction cost of about $3.0bn [7]. Over the past decade, the Federal Government has been able to complete the privatization process. The Federal Government retains the ownership of the transmission assets with the generation and distribution sectors fully privatized. In Table 1, the 6 different successor Generation companies (GENCOS) in Nigeria, their names and installed capacities [9] are listed. Table 2 presents the 11 electricity distribution companies (DISCOS) in Nigeria [10].

Table 1: 6 Successor GENCOs [9].

S/N	Generation Company	Plant type	Capacity (MW)
1	Afam Power Plc	Thermal	987.2
2	Egbin Power PLC	Thermal	1,320
3	Kainji/Jebba Hydro Electric Plc	Hydro	1,330
4	Sapele Power Plc	Thermal	1,020
5	Shiroro Hydro Electric Plc	Hydro	600
6	Ughelli Power Plc	Thermal	942

Table 2: 11 Nigeria DISCOs and percentage load allocation [10].

S/N	DISCOs	Percentage Load Allocation (%)
1	Abuja Electricity Distribution Company (AEDC)	11.5
2	***Benin Electricity Distribution Company (BEDC)***	9
3	Eko Electricity Distribution Company	11
4	Enugu Electricity Distribution Company (EEDC)	9
5	Ibadan Electricity Distribution Company (IEDC)	13
6	Ikeja Electricity Distribution Company	15
7	Jos Electricity Distribution Company	5.5
8	Kaduna Electricity Distribution Company	8
9	Kano Electricity Distribution Company	8
10	Port Harcourt Electricity Distribution Company (PHEDC)	6.5
11	Yola Electricity Distribution Company (YEDC)	11.5

Despite the above mentioned privatization and growth in electricity supply, Nigeria power system is struggling to overcome epileptic power shortages and poor power quality. With the demand exceeding supply, severe peak (around 18%) and energy (around 10%) shortage continue to plague the sector [6]. As stated earlier, considering that the construction of new Power plant and industrial bypass are associated with lots of great risks, huge capital investments and complex engineering tasks not to mention the political schemes in Nigeria. Thus, the need for the proposed technique; DSM. A major contribution to these energy shortages are the inefficiencies mainly at end-users. The inefficiencies in the end-user are due to one or combination of the following reasons [10];

Irrational tariffs, technology obsolescence of industrial processes and equipment, lack of awareness, emerging energy services industry and inadequate policy drivers.

The only value way in handling these inefficiencies is through Demand Side Management Strategy [10]. Recent studies have found that effective DSM programs can aid in reduction of the electricity use and peak demand by approximately 20-40% [3]. In Nigeria, great opportunities for reducing energy demand using DSM are available in all the sectors. Many are of low cost that even individuals can adopt them to help reduce the electricity demand and per unit generation cost, improving system reliability, environment and social improvement.

Furthermore, various reasons for propagating DSM can be geared towards obtaining the under listed mutual benefits between consumers and Nigeria Electric Power utilities [12];

- Reductions in customer energy bills,
- Reductions in the need for new power plant, transmission and distribution networks,
- Stimulation of economic development,
- Creation of long-term jobs due to new innovations and technologies,
- Increases in the competitiveness of local enterprises,
- Reduction in air pollution,
- Reduced dependency on foreign energy sources and
- Reductions in peak power prices for electricity.

1.3 Problem Definition

The Landlord Association of Oda community is requesting for two relief substation to assist an existing substation in their community to provide improved power supply condition in their area. This of course is a key indication of increasing energy demand and development in the area, which is laudable. However, approving two relief substations will only increase their consumption capacity without increasing their power supply duration, although the voltage level of their power supply might improve. It also requires huge financial capitals which is not immediately available. Hence, approving their request only, is not the best option as**.**

II. SUPPLY CAPACITY OF ALAGBAKA 7.5MVA 33/11KV SUBSTATION

Oda is a community in Akure capital of Ondo state, Nigeria. The Benin Distribution company (BEDC) is the Nigerian DISCO supplying this area. Oda feeder which feeds Oda community and Igbatoro feeder share Alagbaka 7.5MVA 33/11KV Substation. A study of BEDC Akure Business Unit (B.U.) load shedding schedule load reading on the 7.5MVA power transformer between March and April 2015 shows that Oda and Igbatoro feeders are rarely given power supply simultaneously in order to avoid system collapse due to overload. Table 3 is a day load reading of Alagbaka 7.5MVA 33/11KV Substation demonstrating load shedding style between that Oda and Igbatoro feeders.

Ideally, from figure 1, the maximum load Alagbaka 7.5MVA 33/11KV Substation can carry is 682A. From the Table 3, summation of Oda feeder and Igbatoro feeder load is never up to 300A, yet both feeders are rarely being supplied at once. Are you surprise to learn this? We know you might be wondering why it has to be so (Oda and Igbatoro feeder rarely been supplied simultaneously). Maybe, going through the pertinent part of Akure Business Unit (B U) distribution network in figure 1will help you understand why it is so and what we can do. Alagbaka 7.5MVA injection substation gets supply through REC Obaile 33KV line and shares this REC Obaile feeder with Elshedai 2.5MVA, 33/11KV substation and REC Obaile 15MVA 33/11KV substation. For the purpose of protecting T2C: 60MVA, 132/33KV transformer and supplying other places, the overload protection relays for REC Obaile feeder is set to trip at about 13MW maximum. The transmission station operators ensure the load on any feeder does not get to the set maximum. Whenever the load is approaching the maximum limit, they call BEDC dispatch or distribution substation operators to drop (load shed) one or two feeders to enable the system maintain its limits.

Table 3: Alagbaka 7.5MVA 33/11kV Substation Hourly Load Reading.

BENIN ELECTRICITY DISTRIBUTION COMPANY
LOAD READING OF POWER TRANSFORMER AND 11KV FEEDER (B)

District: Akure Date 08/04/2015
Injection S/s: Alagbaka 7.5MVA, 33/11kv INJ. S/S

Equipment		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Trf. #1 7.5MVA	R	93	136	132	132	132				60	68	74	75	75	140	160	180	186	188	192	82	86	88	91	99
	Y	90	130	130	130	136				62	69	75	74	81	148	162	178	182	184	188	81	89	86	90	98
	B	85	125	125	125	125				64	68	76	75	84	140	144	176	184	188	186	80	88	84	92	96
Peak Load																									
Feeder #1 Igbatoro	R	93								60	68	74	75	75							82	86	88	91	99
	Y	90								62	69	75	74	81							81	89	86	90	98
	B	85								64	68	76	75	84							80	88	84	92	96
Peak Load																									
Feeder #2 Oda	R		136	132	132	132									140	160	180	186	188	192					
	Y		130	130	130	136									148	162	178	182	184	188					
	B		125	125	125	125									140	144	176	184	188	186					
Peak Load																									

Period under load shedding; Period of No Supply to 7.5MVA 33/11KV Substation

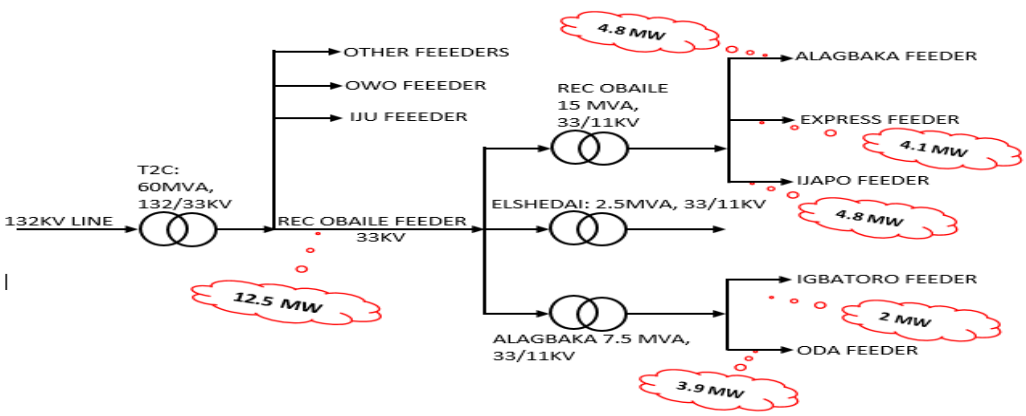

Fig. 1: Excerpts of BEDC Akure Distribution Network.

The peak load recorded so far on the REC Obaile 33kV feeder is 12.5MW. The peak load recorded on BEDC corresponding 11kV feeders as illustrated in the network diagram are as follows in Table 4:

Table 4: Peak load of 11kv feeders supplied by REC Obaile 33KV line.

Feeder (11KV)	**Alagbaka**	**Ijapo**	**Express feeder**	**Oda**	**Igbatoro**
Recorded Peak Load (MW)	4.8	4.8	4.1	3.9	2

As illustrated in figure 1, the Akure distribution network diagram and Table 4, all the 11kV feeders supplied by the REC Obaile line cannot be loaded onto the system at the same time. For now, Ijapo feeder has higher priority than the rest of the associated feeder and does not get load shed. Elahedai 2.5MVA 33/11KV substation is unmanned and cannot also be load shed. Hence, the rest of the feeders only share whatever energy remaining after Ijapo feeder and Elshedai substation have taken supply. These limitations create difficulties in drawing power supply schedules for Oda, Igbatoro, Alagbaka and Express. In the subsequent sections, proposed models for solving these power supply shortages are investigated.

III. METHODOLOGY

The technical and economic advantages of DSM are evaluated using two basic indices. They are namely, [13];

- Demand Side Management Quality Index (DSMQI), and
- Demand Side Management Appreciation Index (DSMAI) .

These indices will help stake holders such as engineers, economists, management personnel and consumers appreciate the rationale behind a particular DSM technique.

3.1 Demand Side Management Quality Index (DSMQI)

This is an index that quantifies the technical benefits attached to a particular DSM program [13]. Mathematically;

$$DSMQI = \frac{kVA_{WoDSM}}{kVA_{WDSM}} \qquad (1)$$

It is desired that the $DSMQI > 1$; the greater the ratio, the greater the benefits of DSM program.

kVA_{WoDSM} and kVA_{WDSM} are the kVA with (WDSM) and without (WoDSM) DSM respectively.

3.2 Demand Side Management Appreciation Index (DSMAI)

This is index that highlights the economical gain of DSM programs. DSMAI is defined as, [13];

$$DSMAI = \frac{CkWh_{WoDSM}}{CkWh_{WDSM}} \qquad (2)$$

$CkWh_{WDSM}$ and $CkWh_{WoDSM}$ are the cost of kWh with and without DSM, respectively.

In addition to the above indices, various techniques or categories of DSM can be adapted in solving the power supply shortages of Oda community. For effective implementation of demand side management in Oda community, the suitable DSM activities or tools or techniques for this community will generally be categorised into [14, 15 and 16]:

1. Techniques to be used by Benin Electricity Distribution Company (BEDC); which are activities to be carried peculiarly.
2. Techniques to be used by Consumers; which are activities that cannot be carried out without consent, support and participation of consumers.

It is pertinent to note that consumers being laymen in electrical technology are not expected to initiate and practice most of the techniques attributed to them. It is still the responsibility of the DISCOs (for example BEDC in this case), being professionals to initiate and guide the consumers towards effective participation in the DSM exercise. A flow chart for the proposed method is illustrated in Figure 2. The tools for BEDC are as follows [14, 15, and 16].

3.3 Tariff Incentives And Penalties:

BEDC should encourage certain pattern of use by tariff incentives where customers use energy at certain times to achieve a better-priced rate for their energy use. In this technique, BEDC should provide attractive prices to consumers, i.e. high unit rate during peak load time, average rate per unit during base load time and discounted rate per unit if consuming energy during low demand period. In addition to that, they should also provide the following;

- Public Awareness using various viable media.
- Provision for rewarding compliant customers just to encourage the customer and motivate others to practice it too.
- Provision of technical assistance to customers on demand
- Ensuring use of appropriate and standard materials in power distribution
- Discouraging of “rocking” and ensuring load balance on power equipment.

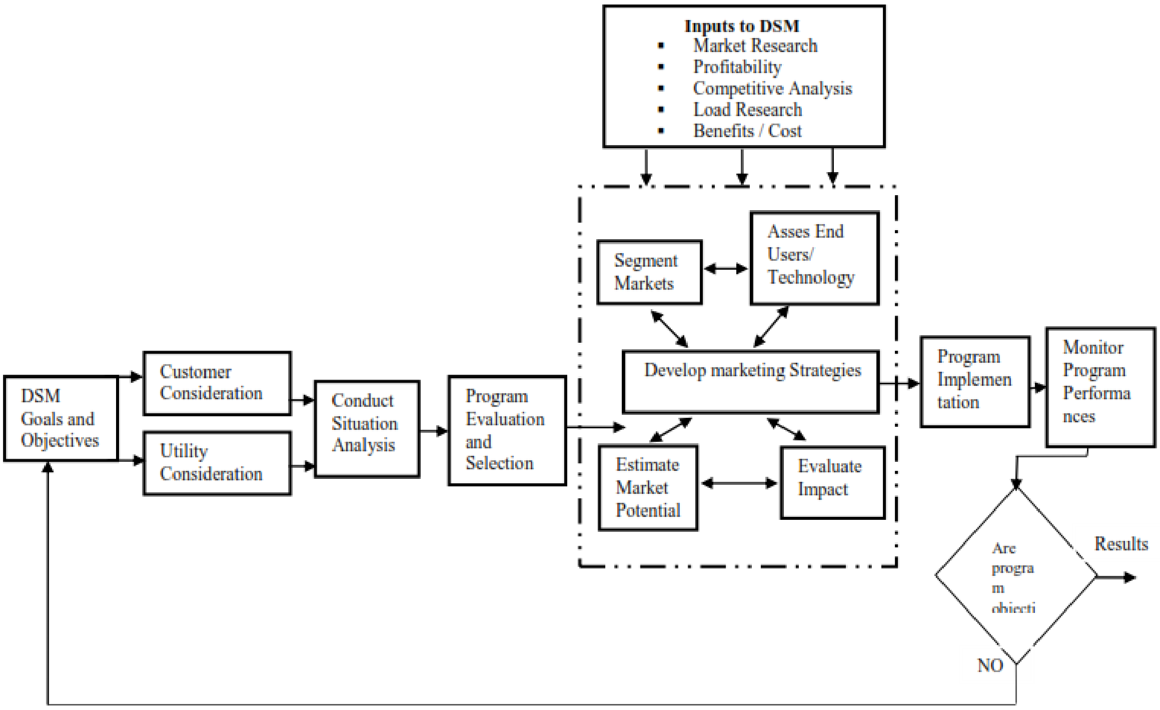

Figure 2: Flow chart for the proposed DSM Technique

- Engaging in Technical researches for Energy conservation and disseminating resulting knowledge to customers.
- Lobbying for favouring Government Policies.

The second category of technique are customer focused tools and as mentioned earlier are to be implemented in cooperation with the people of Oda community. However, these techniques are based on objectives of the DSM as briefly explained [17, 18]. They are divided into two categories;

- Energy reduction/conservation programs and

- Load shaping and scheduling.

3.4 Energy Reduction and Conservation Programs

Akure is the capital of Ondo State in Nigeria where the major consumers of electricity supplies are residential customers. Table 4 is a description of its electricity consumption patterns.

Table 5: Customer Energy Consumption.

Customers	Energy consumption (%)	Energy billed (%)
Residential	87.9	81
Commercial	10.8	11.4
Industrial	0.86	4.4
Special customers	0.35	2.4

It can be observed from the data in Table 5 that majority of the energy consumers in Akure are for residential purposes. Oda community in Akure also falls within this consumer consumption patterns. About six hundred and fifty- two houses (Oda community inclusive) are located in Akure. It was observed that most of the residential buildings in the community had so many combinations of inefficient lighting fixtures. Some of them includes; Halo lamps, incandescent bulbs and four ft fluorescent tubes. Approximately 87% of lighting fixtures of the community were using inefficient incandescent bulbs. Hence using energy reduction/conservation as a tool in DSM, recommendations are made with respect to residential areas. In summary, the following opportunities abound in application of DSM techniques for residential lighting in Oda community:

Lighting retrofitting: the replacement of existing lamps with more efficient light sources, sometimes in conjunction with new lighting fixtures (possibly high initial costs but long-term benefits);

Fixture de-lamping : removing selected lamps from existing light fixtures in a uniform pattern throughout specific areas to reduce overall lighting, or to remove selected lights entirely where they do not contribute to task or safety lighting;

Modifying switches, e.g. to allow selected areas of lighting to be switched off while adjacent areas remain on. Additional switches can be installed in large areas where selected parts are switched on or off rather than keeping the whole area illuminated when few people are present.

Measures needing investment

- Replace old outdated appliances (washing machines, refrigerators, air conditioners, etc.) with new more efficient ones;
- Install a solar water heater (but check payback period for the investment needed);
- Install double glazing windows (but check payback period).
- BEDC should make available some of these energy saving lights/appliances for their customers at subsidized prices.

3.3 Load Scheduling and Shaping

Load on the power plant is variable in nature [17]. There are large difference between peak demand and valley demand. However, the power plants are designed to meet the maximum demand, which results in high generation cost per unit and demand large installed capacity. It is not possible for developing countries such as Nigeria to meet the targeted capacity by installing new power plants [17]. Therefore, Benin Electricity Distribution Company (BEDC) should
encourage the redistribution of the demand and time of electricity usage in Oda community. Six generic load shape techniques can be encouraged here and are succinctly explained below [18].
Peak Clipping: this technique involves load reduction at peak times and at high demand periods, loads are “clipped”. The idea here is to reduce peak demand [18].

***Valley Filling (Including Seasonal and Daily)*:** here, when the load demands are low, the valleys created are "filled" by building off-peak capacities. This form of load management can be obtained by thermal energy storage that displaces fossil fuel loads [18].

***Load Shifting*:** here loads are "shifted" from peak to valley times, i.e. achieving both clipping and filling. Shifting is different to clipping in that the load is present in the overall demand whereas in clipping it is removed [18].

Strategic Conservation: Strategic conservation is the load shape change that results from utility-stimulated programs directed at end use consumption [18].

Strategic load Growth: Strategic load growth is the load shape change that refers to a general increase in sales beyond the valley filling described previously [18]. These are schematically shown in figure 3.

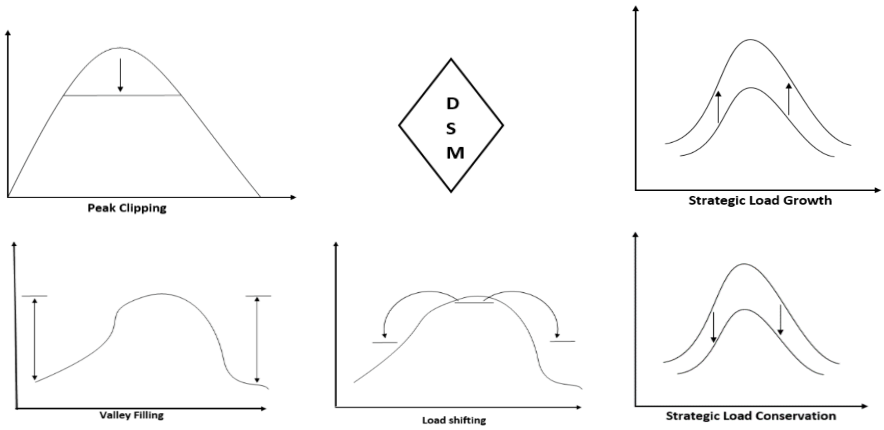

Fig. 3: DSM several load shape techniques, [15].

IV. DSM IMPLEMENTATION AND MONITORING

4.1 Implementation

The execution of DSM techniques after their objectives and financial effectiveness have been critically determined during DSM design phase is termed Implementation [5]. Implementation entails the daily decisions that must be made by the BEDC in order to see that the targets of DSM programs in Oda community are achieved. These can also be adopted by other Nigeria DISCOs. The four various methods of implementation proposed here are briefly explained; Program planning, program management, program marketing and program logistics.

Program Planning helps ensure program efficiency and effectiveness. It entails the setting of Specific, Measurable, Action oriented, Realistic and Timed (SMART) goals. The program implementation can be checked against the plan and variations can be immediately corrected.

Program management ensures that in DSM, quality assurance, cost accounting and monitoring employee productivity are all implemented. It guarantees efficient implementation.

Program marketing involves developing a realistic view of the opportunities in the utilities' service area and understanding the customers' decision making process.

Program logistics includes staffing, facilities, equipment and training requirements. Here, plans on how to reach out to customers are made. The use of mass media, advertising and promotional activities (such as bill inserts, door to door engagements) are suggested here.

4.2 Monitoring

The main goal of monitoring DSM program is to identify any deviations from the set out objectives. Just as there is a need to monitor the performance of supply-side alternatives, there is a need also to monitor demand-side management alternatives [5]. In monitoring the performance of the utility DSM program, two question need to be answered:

Did the program achieve its objectives? Was the program implemented as planned? If not, what are the opportunities for improvements?

V. CHALLENGES TO DSM IMPLEMENTATION IN ODA COMMUNITY

Notwithstanding the promise of efficient energy utilization and economic benefits brought about by the implementation of DSM techniques. There are challenges or obstacles to the implementation of DSM techniques. Some of these challenges are;

- Low awareness of energy efficiency and DSM programs.
- Most of customers are less literate, therefore, not able to understand the future problems.
- Since energy efficient appliances and control drives are costly than standard appliances, hence consumers are not showing interest to buy them.
- Lack of the communication and faith between utilities and consumers.
- Lack of energy audits hence companies fails to collect reliable information on their current operations and
- Finally, lack of available funds for research and experimental work.

VI. RESULTS AND BENEFITS OF THE PROPOSED DSM

Irrespective of the challenges in the implementation of DSM in Oda community, the positive impacts of the techniques when applied will yields very promising results. It will benefit not just the Oda community or the Utilities (BEDC in this case study), but the nation as well. Table 6 presents the benefits of the proposed DSM technique to the Customers, the Utilities and to the entire Nation at large.

VII. CONCLUSION

Oda and Igbatoro feeders are being load-shed because of limited energy (13MW) pegged for REC Obaile line and not because Alagbaka 33/11KV 7.5MVA substation cannot carry the two feeders at the same time. This indicates that increasing distribution capacity within the area via installation of two relief transformers will not be the best solution. Rather, while the relief substations are being awarded to improve power quality, DSM should be applied to reduce their energy consumption demand. This has probability of increasing their supply duration by if the same measure is applied to all the areas supplied by Alagbaka 33/11KV, 7.5MVA substation. Added to the benefits of practicing DSM in Oda community is the avoided capital involved in the two transformer installation which are currently unavailable.

Table 6: Proposed Benefits of DSM to the Customers, Utility and the Nation.

Benefactors	**Proposed Benefits**
Customers (Oda community)	Reduction in customers electricity bill, Improve value of service Reduce the no of blackouts, Maintain/improve lifestyle and productivity.
Utility (BEDC)	Improved customer service and relationship, Lower service cost Network reliability is improved, Mitigating electrical system emergencies and Deferring high investments to set up distribution networks
Nation (Nigeria)	Postpone the construction of new power plant, deferring high investments to setup transmission network, less stress on power plant reduces local air pollution, Reduced green gas emission and reduce dependency on expensive import of fuel Conserve resources

Generally, DSM has reformed the traditional mode of thinking to construct a new power plant or installation of relief transformers in order to meet the demand. The proposed DSM techniques are important tools for enabling a more efficient use of the energy resources available to a country. Its proposed benefits are listed in Table 6. When properly applied, DSM can offer significant economic and environmental benefits. The DSM model proposed in this paper can be implemented in any power distribution system.

REFERENCES

[1] Nigeria Over 167 Million Population. Implications and challenges. http://www.population.gov.ng/index.php/84-news/latest/106-nigeria-over-167-million-population-implications-and-challenges. Accessed 12 March, 2013.
[2] T. Givler, and P. Lilienthal, 'Using HOMER software, NREL's micro-power optimization model, to explore the role of gen-sets in small solar power systems case study: Sri Lanka', [Online] NREL/TP-710-36774 (2005), pp. 1–25. http://www.osti.gov/bridge
[3] www.upm.ro/proiecte/EEE/Conferences /papers/s335.pdf.
[4] C. W. Gellings, "The concept of demand-side management for electric utilities," *Proc. IEEE, vol. 73, no.10, pp.1468-1470, 1985.*
[5] A. Faruqui and C.W. Gellings, "Should demand-side management be a top-down of a bottom-up process?" *in Strategic Planning and Marketing for Demand-Side Management; selected Seminar Papers,* EPRI EA- 4308, Electric Power Research Institute, Palo Alto, CA, Nov. 1985.
[6] E. Bonneville and A. Rialhe, 'Demand side management for residential and commercial end-users', *Effic. Eco-Des. (2006).*
[7] A Guide to the Nigerian Power Sector, KPMG, December, 2013.
[8] Nigeria Electricity Regulatory Commission (NERC).
[9] Monthly Energy Balance Sheet, October, 2013, Transmission Company of Nigeria (TCN).
[10] C. C. A. Rajan, , 'Demand side management using expert system', *IEEE Conference on Convergent Technologies for Asia-Pacific Region TENCON 2003.*
[11] T. W. Keelin and C. W. Gellings, 'Impact of Demand-Side Management on Future Customer Electricity demand', *EPRI EM-4815-SR, Electric Power Research Institute, Palo Alto, CA, Oct. 1986.*
[12] S. Saini, 'The Growing Need of Demand-Side Management, Energy Programs', *Sanco Global, Jan., 2004.*
[13] A. Dharme and A. Ghatol, 'Demand-side management quality index for assessment of DSM programs', in Power systems conference and exposition, 2006, PSCE'06.
[14] F. Boshell and O. Veloza, "Review of developed demand-side management programs including different concepts and their results," *Proceedings of the IEEE Trans,ission and Distribution Conference, Latin America, PES, 2008, pp. 1–7.*
[15] J. Han and M. Piette, "Solutions for summer electric power shortages: Demand response and its applications in air conditioning and refrigerating systems," *Refrigeration, Air Conditioning, and Electric Power Machinery, vol. 29, no. 1, pp. 1–4, Jan. 2008.*
[16] M. Zhou, Y. Gao, and G. Li, "Study on improvement of available transfer capability by demand-side management," *in Proc. 3rd Int. Conf. Electric Utility Deregulation and Restructuring and Power Technologies, DRPT'08, 2008, pp. 545–550.*
[17] Yang Zhirong," Demand-side management and its application", *Beijing: China electric power press, pp 60-90, 2007.*
[18] www.cogeneration.net/Demand_Side_Management.htm Accessed 06, July 2006.

AUTHORS

Engr. Dr Uzoechi, Lazarus O.: is a senior lecturer in the Federal University of Technology Owerri, Nigeria. He is interested in the repositioning of the Nigerian power sector through system reforms, Power system planning and operations, stability studies, electricity deregulation and marketing, application of optimization to power systems, high voltage engineering, etc.

Eze, Charles U.: obtained his B.Eng degree in Electrical Engineering, from the University of Nigeria, Nsukka, 2012. He is currently an M.Eng student (Control Systems) of Electrical and Electronic Engineering, Federal University of Technology, Owerri in Nigeria. His areas of interest include; Efficient Energy Management Systems, Renewable Energy Resources, Satellite Control System Design, System Identification and Control.

Agwu, David D.: is currently an M.Sc student in department of Electrical and Electronic Engineering, Federal University of Technology, Owerri in Nigeria. He obtained his B.Eng degree in Electrical Engineering, from the University of Nigeria, Nsukka (2012). His research interests include: Efficient. Energy Management Systems, Electricity Distribution Automation, Renewable Energy Resources, Power Converters and Solid State Electronics.