# The Impact of Distributed Cloud Computing Initiatives (DCCI) on Green Energy Management Using Cronbach's Alpha Test

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**Abstract**

Distributed Cloud Computing (DCC) is a new paradigm which plays a vital role in addressing complex energy management issues at low cost. In this study, a statistical survey using primary data on the impact of Distributed Cloud Computing Initiatives (DCCI) on green Energy Management was carried out. Data was collected from the Energy Commission of Nigeria (ECN), the National Agency for Science and Engineering Infrastructure (NASENI), Nigeria and Power Holding Company of Nigeria (PHCN).This research was designed to assess the response of individuals and stakeholders towards decisions regarding renewable energy metering, cloud management of energy data (storage, backup &recovery, security, etc) and related cloud concepts. The intent was to ascertain how a new framework for green PV plants on the utility grid can improve the smart grid architecture of Nigeria. The Direct Data Capture Survey (DDCS) involved the collection of primary data (on Renewable/Green Energy Management in relation to Distributed Cloud Computing Initiatives in Nigeria) and the formulation of research questions and hypotheses. The hypotheses were tested using **t**-**T**est and ***A***nalysis ***o***f ***V***ariance (ANOVA). The Cronbach's alpha test showed good degree of internal consistency with a value of ***0.8555*** (*85.55%*). The findings also revealed that there is a positive correlation between DCCI and renewable energy management. Thus, we argue that it is feasible to re-brand green energy management strategies, fine tune decision-making and motivate the development of a functional framework for energy management which will allow consumer participation in the power generation value chain. Also, the results of this research will be taken into account in the proposed Cloud Energy Management Application on DCC (EETACP) architecture in the future work.

**Keywords:** Distributed Cloud, Energy Management, Framework, Architecture, Smart Grid, Survey, Hypothesis

## I. Introduction

Nigeria has a population of about 170million people [1], but the ever increasing demand and the meagre supply of energy in Nigeria has been a great challenge to her development [2, 3].The incessant power generation failure has grossly affected the economy, seriously slowing down development in rural and sub-rural settlements, with present energy policy mainly benefiting urban dwellers [2]. Global energy projections stipulate that between 2002 and 2025, global energy needs may rise by over 34%, with that of developing nations doubling this percentage. Hence, a robust energy management solution that is flexible must be leveraged to salvage the nation’s energy crises.

Considering solar energy alternative, Nigeria receives a huge amount of solar radiation, has abundant wind energy resources, and large deposits of fossil fuel, as well as enormous hydro-power resources from Niger and Benue Rivers. However, of all these, about 80% of hydro-power remains untapped, the total 5.5KW-hr/m2/day of solar radiation is not utilized and wind energy resources remain unexploited. The solution lies in creating a mixed supply of energy in which the yet untapped renewable resources are combined with abundant non-renewable fossil fuel, including the massive quantities of gas wasted from crude oil exploitation [2].

Evidently, power reform policies in Nigeria is yet profer the expected energy solutions. But, the problems or challenges which triggered the electricity power reforms as highlighted by the government have been outlined in [4], viz:

- Limited access to infrastructure,
- Inadequate power generating capacity
- Inefficient usage capacity
- Lack of capital for investment
- Ineffective regulation
- High technical losses and vandalism
- Insufficient transmission and distribution facilities.
- Inefficient use of electricity by consumers
- Inappropriate industries and market structure
- Unclear description of roles and responsibilities.

With the aforementioned problems identified, the Reform Bill sought solution by taking the following steps:

i. Unbundling the National Electric Power Authority (NEPA) through 18 separate successor companies incorporated into PHCN as outlined in table1
ii. Privatizing the unbundled entities.
iii. Establishing a regulatory Agency (The new Nigerian Electricity Regulating Commission (NERC)).
iv. Establishing a rural electrification agency and fund
v. Establishing the Electric Power Consumer Assistance Fund

Table 1: PHCN Plc Successor Companies [4]

| Generating Company (Genco) | Transmission Company (Transco) | Distribution Company (Disco) |
|---|---|---|
| * Kainji Power Plc<br>* Shiroro Power Plc<br>* Ughelli Power Plc<br>* Sapele Power Plc<br>* Afam Power Plc<br>* Geregu Power Plc | * Transmission Company of Nigeria; | * Eko Electricity Distribution Co. Plc<br>* Ikeja Electricity Distribution Co. Plc<br>* Ibadan Electricity Distribution Co. Plc<br>* Benin Electricity Distribution Co. Plc<br>* Abuja Electricity Distribution Co. Plc<br>* Port Harcourt Elect. Distrib. Co. Plc<br>* Enugu Electricity Distribution Co. Plc<br>* Kaduna Electricity Distribution Co. Plc<br>* Kano Electricity Distribution Co. Plc<br>* Jos Electricity Distribution Co. Plc<br>* Yola Electricity Distribution Co. Plc |

However, the current electricity reforms are still faced with the challenge of allowing for effective customer participation. Following the electricity generation, distribution and usage challenges in Nigeria, the focus of this research is to explore alternative energy initiatives that is environmentally sustainable and to derive ways of maximizing its gains for improving the Nigerian energy sector.
Existing works in literature made efforts to highlight the power challenges in Nigeria but not in the context of cloud energy management for renewable energy plants in Nigeria. Our previous research in [5] articulated the benefits of Solar Energy (Green Power). Building on that, our current research seeks to generate a scientific basis for developing a novel green energy management system. We aim to define the context, approach, objectives, controls and guidance necessary for the planning and execution of a novel cloud energy management for renewable energy plants in Nigeria. The framework which has been discussed in our previous works [5, 6, and 7] and shown in figure 1 must meter renewable energy sources when loaded, while using an RF Cloud Energy Meter (CEM) to transfer the energy data to the cloud data centre. Starting from the Solar satellite [5] or PV panel which generates AC output voltage via its 3phase inverter, the incident radiation which yields voltage (V) and Current (I) components is metered and the usage parameters communicated to the cloud datacenter. The functional features of the cloud datacenter (DCCI) include: Server consolidation, virtualization [9], fault tolerant load balancing [8], and data security encryption algorithms will be discussed in the future research outcomes.

However, in the next sections, we shall employ a Direct Data Capture Survey (DDCS) for data collection which servers as a means to investigate the impact of DCCI on green energy management. The results will be used to facilitate the development of the novel architecture of figure 1 into a production prototype for implementation in Nigeria.

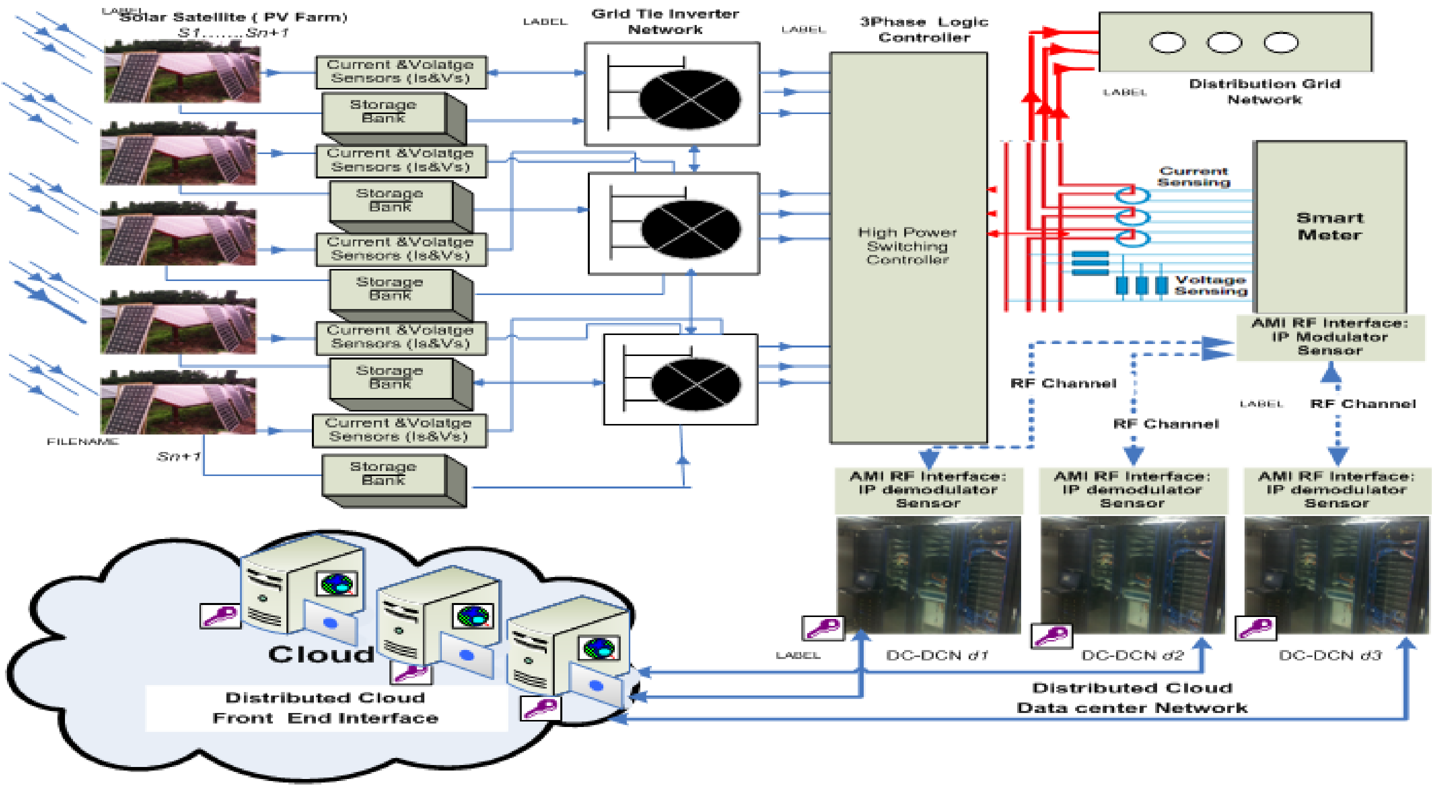


Figure 1: Proposed global system architecture for Smart Green Energy management system

## II. MATERIALS AND METHODS

### 2.1. Design Research Methodology (DRM)

DRM can be used for analysing projects, and in selecting suitable research methods to address specific research issues. The DRM framework was used in this research to identify possible research areas of DCCI and green energy management issues. Thus the need for formulating successful research questions as well as measurable criteria was addressed using the DRM model. The DRM framework is shown in figure 3. The Criteria Definition stage identified the aim that the research is expected to fulfil as well as the focus of the research hypotheses. The importance of descriptive studies was to increase understanding of design in order to inform the development of design support. The Descriptive Study I was used to identify the factors that contribute to or prohibit success of the proposed hypothesis and to provide a basis for the development of support to improve design. It provided more details that were used to evaluate the developed design support and resulted in a reference model/theory for the research. The developed support (Descriptive Study II) was carried out to enable evaluation of the research questions and hypothesis. The Prescriptive Study was undertaken to address those factors that were likely to have the most influence on a research hypothesis. The data collection approach as the Direct Data Capture Survey (DDCS) using questionnaires. At this stage, we developed an improved model/theory based on the reference model derived at the descriptive study stage. Drawing from the DRM framework, we made some deductions based on the empirical analysis which helped in explaining and predicting the relevance of DCCI on green energy management.

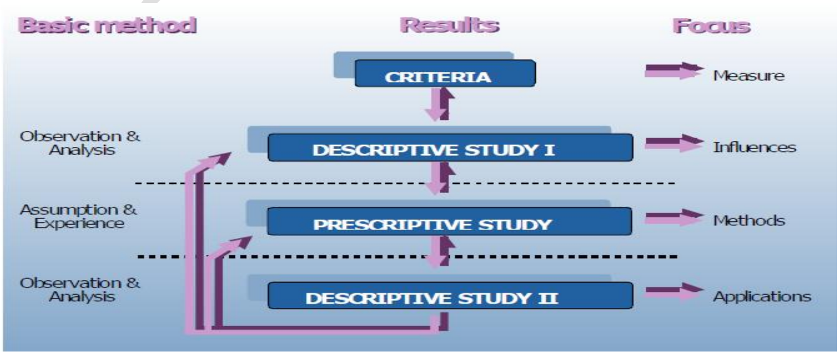


Figure 3: DRM framework [10]

### 2.2 Data Collection on Green Energy Management- Direct Data Capture Survey (DDCS)

To facilitate the DCCI, a DDCS design was developed as a means for data collection for this research. The survey structure was based on a 5-point likertscale namely: Strongly Agree, Agree, Undecided, Disagree, Strongly Disagree. The population of the study comprised of technical/expert workers in some selected service and Research &Development organizations in Nigeria which were: University of Nigeria (UNN) Energy Research Centre, Electronic Development Institute (ELDI) Awka and Science Equipment Development Institute (SEDI) Enugu, (both from NASENI). The hypothesis was tested using three major parameters namely: On-the field years of working experience, Educational qualification and Place of work. The survey was administered directly in order to ensure the accuracy of data and was collected immediately from respondents soon after answering the survey questions.
A total of 34 questionnaires were returned out of the 40 that were distributed. The Frequency Count was used in analysing *section A* of the instrument eliciting data on the working experience, educational qualification, name of organisation of the respondents and area of specialization while mean and standard deviation was used to answer the research questions $Q_1 - Q_6$ discussed in section 2.3. Also, in order to analyse hypothesis $H0_1$, $H0_2$ and $H0_3$, the mean ratings (X), standard Deviation (SD) of experts with work experience of *below* 5yrs and those a*bove* 5 yrs, Bachelors Degree/equivalent and Masters/equivalent, UNN Energy Research Centre, ELDI, Awka and SEDI, Enugu were used for the computation. The t-Test and ***A***nalysis Of ***V***ariance (ANOVA) tests were then used to test the hypothesis.

## 2.3 Research Questions

### *Q1* Research Question: What are the General Issues Relating to Renewable Energy Management.

In this research, IBM SPSS statistics Data editor was used to analyse the complete data. Table 1 shows the frequency and percentage distribution of respondents on working experience, educational qualification, name of organisation and area of specialisation respectively. The tables 1 below shows the analysis run of frequency and Percentage Distribution of Respondents on working experience, educational qualification, Organisation and area of specialisation.

**Tables 1:** Analysis of frequency and Percentage Distribution of Respondents on Organisation, area of specialisation, educational qualification, and working experience

organizations

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | UNN ENERGY CENTER | 12 | 35.3 | 35.3 | 35.3 |
| | ELDI AWKA | 12 | 35.3 | 35.3 | 70.6 |
| | SEDI ENUGU | 10 | 29.4 | 29.4 | 100.0 |
| | Total | 34 | 100.0 | 100.0 | |

specialisation

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Renewable energy | 12 | 35.3 | 35.3 | 35.3 |
| | Electronics | 9 | 26.5 | 26.5 | 61.8 |
| | ICT | 8 | 23.5 | 23.5 | 85.3 |
| | other | 5 | 14.7 | 14.7 | 100.0 |
| | Total | 34 | 100.0 | 100.0 | |

edu

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | ssce/equi | 4 | 11.8 | 11.8 | 11.8 |
| | NCE/equi | 2 | 5.9 | 5.9 | 17.6 |
| | B.Sc/ equi | 12 | 35.3 | 35.3 | 52.9 |
| | M.Eng/equi | 11 | 32.4 | 32.4 | 85.3 |
| | P.hD/equi | 5 | 14.7 | 14.7 | 100.0 |
| | Total | 34 | 100.0 | 100.0 | |

wrkexp

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Below 5yrs | 13 | 38.2 | 38.2 | 38.2 |
| | Above %yrs | 21 | 61.8 | 61.8 | 100.0 |
| | Total | 34 | 100.0 | 100.0 | |

**Table 2:** Mean and Standard Deviation of Respondents on the General Issues Relating to Renewable Energy Management.

| S/N | Item statement | Mean | Standard Deviation | Decision |
|---|---|---|---|---|
| 1 | Green energy sources have no significant environmental impacts and can be managed for low consumption by end users. | 3.71 | 1.488 | Agree |
| 2 | Renewable energy sources is good to be located at remote load centers where there is limited transmission capacity | 4.09 | 0.996 | Agree |
| 3 | Given the low capacity factors of renewable energy sources, it makes sense to build a smart meter with a capacity to the peak capacity for end users | 3.94 | 0.814 | Agree |
| 4 | An energy management system that allows utilities to remotely read and manage meters, communicate with final customers and provide final customers with accurate and detailed energy usage information will be gain wide acceptance. | 4.12 | 0.88 | Agree |
| 5 | Renewable energy deployments can be used and maintained by individuals, institutions, while selling to the grid, etc | 4.26 | 0.864 | Agree |
| 6 | Acceptability index of Solar PV systems as well as its associated technologies is still very low in Nigeria. | 3.91 | 1.138 | Agree |
| 7 | Policy shift and encouraging investment in solar technology is a major militating factor in smart energy management design framework. | 4 | 1.073 | Agree |
| 8 | The objectives of resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need are vital for an efficient energy management system | 4.26 | 0.931 | Agree |
| 9 | Green energy management using cloud computing solves the problem of planning and operation of energy-related production and consumption units | 3.62 | 0.739 | Agree |
| 10 | Smart meter for remote energy management is a widely accepted device. | 3.24 | 1.103 | Disagree |
| 11 | Using a large cloud storage system with many independent storage servers is considered as a large scale distributed storage system with higher cost and better efficiency. | 3.71 | 0.836 | Agree |
| 12 | An effective and flexible distributed scheme with explicit dynamic data support that ensures the correctness of users' data in the cloud will be widely accepted. | 3.94 | 1.013 | Agree |
| 13 | The existing meters in the market are single phase systems with no cloud transmission interface and supports | 4.06 | 0.736 | Agree |
| 14 | Choosing between capital expenditures and outsourcing is highly relevant in Smart meter/cloud computing designs. | 3.74 | 0.666 | Agree |
| 15 | Planning and system stability studies are needed to determine energy consumption patterns | 4.21 | 0.946 | Agree |
| 16 | Modular PV-based Inverters can be expanded incrementally as demand increases | 4.09 | 0.83 | Agree |
| 17 | Technology issues could affect Solar PV energy management using cloud computing designs. | 3.97 | 1 | Agree |
| 18 | Government policies on technology issues affect energy management. | 4.09 | 0.996 | Agree |
| 19 | Adoption of cloud computing smart meters permits significant savings in the area of supportive technologies-e.g. Smart grid | 4.26 | 0.828 | Agree |
| 20 | Adoption of cloud facilitates in a smart meter offers additional savings in terms of location independent energy access | 3.94 | 0.776 | Agree |
| 21 | Energy management with cloud smart cards can offer wide flexibility | 3.68 | 0.976 | Agree |
| 22 | Energy traffic (Video, data, Voice) can best be stored in cloud computing systems compared with other storage systems. | 3.59 | 1.019 | Agree |
| 23 | End users needs lots of orientation and awareness so as to evaluating cloud energy management initiatives. | 5 | 5.245 | Agree |
| 24 | Security challenges in solar PV cells can be avoided through the customization of solar system PV cells. | 3.65 | 1.07 | Agree |
| 25 | Advanced feedback control systems in energy management framework will facilitate zero downtime operations. | 3.65 | 0.884 | Agree |
| 26 | Remote collection of meter data should reduce the cost of data collection, eliminate estimated bills and provide accurate data for usage information on bills. | 4.32 | 0.684 | Agree |
| 27 | High Speed, highly available and fault tolerance processors for smart metering infrastructure will elongate the system lifespan. | 4.15 | 0.821 | Agree |
| 28 | Cloud metering systems and cloud computing applications in energy management is new in Nigeria | 4.21 | 0.77 | Agree |
| 29 | Adopting cloud energy management initiative will solve the challenges of careless energy users | 4.12 | 0.844 | Agree |
| 30 | Existing metering infrastructure have zero supports for alternative energy backup, and lacks interfaces for web based integrations | 4.18 | 0.834 | Agree |

Table 2 shows an agreement between all the elicited items on the general issues relating to renewable energy management except for item 10. In other words, among others, end users require a re-orientation and awareness creation in order to embrace cloud computing energy management initiatives. Security challenges in solar PV cells can be avoided through the customization of solar system PV cells. Advanced feedback control systems in the energy management framework will facilitate zero downtime operations; thereby addressing some of the general issues relating to renewable energy management.

**Q2-Research question 2: In Which Ways does Cloud Metering Energy Feedback Computing relate to Distributed Cloud Computing Initiatives in Nigeria?**

Table 3 shows that all the elicited items were agreed to be ways in which cloud metering energy feedback computing related to distributed cloud computing initiatives in Nigeria. In other words, among others, consumers need to be able to observe their energy consumption both instantaneously and continuously without having to first switch on an optional in-home feedback device. Additionally, energy feedback promises to be more effective when accompanied with goal setting for consumption planning.

**Table 3:** Mean and Standard Deviation of Respondents on Cloud Metering Energy Feedback Computing

| S/N | Item statement | Mean | Standard Deviation | Decision |
|---|---|---|---|---|
| 1 | Consumers need to be able to see instantaneously and continuously what is happening to their consumption, without having to switch on an optional in-home feedback device first | 4.41 | 0.657 | Agree |
| 2 | The internet promises to provide useful additional feedback through incorporation of further analysis and advice on a longer term basis. | 3.79 | 0.77 | Agree |
| 3 | Feedback through wireless communication into the internet cloud (cloud SaaS web page) promise to be a more preferred way of communication for consumers than Direct, in-house displays, in combination with convectional billing | 3.62 | 1.074 | Agree |
| 4 | Energy feedback promises to be more effective when accompanied with goal setting for consumption planning | 4.03 | 0.627 | Agree |

**Q3-Research Question 3: How does Data Location on the Cloud Provider's Data Center and the Client's Ability to Investigate the Stored Data, relate to distributed Cloud Computing initiatives in Nigeria?**

**Table 4:** Items on Data Location on the Cloud Provider's Data Center and the Client's Ability to Investigate the Stored Data.

| S/N | Item statement | Mean | Standard Deviation | Decision |
|---|---|---|---|---|
| 1 | It is important for end users to know where the cloud providers store their data. | 3.56 | 1.211 | Agree |
| 2 | There is the need for providers to obey local privacy (Service level Agreements) requirements on behalf of their client. | 4.68 | 0.475 | Agree |
| 3 | There is the need for providers to store their client data in design specification which are consistent with the client's data privacy and security requirements. | 4.35 | 0.646 | Agree |
| 4 | Itisimportant for clients to be able to investigate their energy data stored on the cloud. | 4.24 | 0.855 | Agree |
| 5 | In case a client can't investigate his stored data, the provider should do so but without any malicious operation on the data. | 4.18 | 0.968 | Agree |

Table 4 shows that all the elicited items were agreed to be ways in which data location on the cloud provider's data center and the client's ability to investigate the stored data influences the distributed cloud computing initiatives in Nigeria. This implies that when a client cannot investigate his stored data, the provider could do so but without any malicious operation on the data. It is also important for clients to be able to investigate their energy data stored on the cloud hence the need for providers to store their client data in accordance with specification which is consistent with the client's data privacy and security requirements. These are the identified ways in which data location on the cloud provider's data center and the client's ability to investigate the stored data relates to distributed cloud computing initiatives in Nigeria.

**_Q4_ Research Question 4: In what ways does Data Segregation on the Shared Environment of Cloud Providers' Data Center (and how much of Providers' Services would be available whenever needed) relate to Distributed Cloud Computing Initiatives in Nigeria?**

**Table 5:** Mean and Standard Deviation of Respondents on Segregation of Data on Shared Environment of Cloud Providers' Data Center and How Much the Providers' Services would be Available Whenever Needed.

| S/N | Item statement | Mean | Standard Deviation | Decision |
|---|---|---|---|---|
| 1 | Clients will not comfortable having their data stored on a shared environment on the cloud. | 3.59 | 1.019 | Agree |
| 2 | Data can be protected by the providers on the shared environment using encryption. | 4.15 | 0.857 | Agree |
| 3 | Encryption would solve data shared environment problems. | 4 | 0.921 | Agree |
| 4 | The providers must be available with acceptable rate. | 4.15 | 0.744 | Agree |
| 5 | The providers should be able to device mechanism to ensure availability of server in case one server goes down. | 4.5 | 0.707 | Agree |

Table 5 shows that all the elicited items were agreed to be ways in which segregation of data on shared environment of cloud providers' data center and of how much the providers' services would be available whenever needed related to distributed cloud computing initiatives in Nigeria. Thus we infer that among others, the providers should be able to device a mechanism to ensure uninterrupted server availability.

**_Q5_- Research Question 5: How does Business Continuity, Cloud Provider and Regulatory compliance relates to distributed cloud computing initiatives in Nigeria?**

**Table 6:** Mean and Standard Deviation of Respondents on Business Continuity, Cloud Provider and Regulatory compliance

| S/N | Item statement | Mean | Standard Deviation | Decision |
|---|---|---|---|---|
| 1 | The cloud providers must be able to have long-term viability for external data values. | 4.09 | 0.621 | Agree |
| 2 | In case the cloud provider is acquired by another company, the client data should still be available. | 4.38 | 0.652 | Agree |
| 3 | Data should be stored such that the client should still have access to his data even if he changes his cloud provider. | 4.44 | 0.66 | Agree |
| 4 | There are external audits and security certifications to confirm cloud provider's qualifications. | 4.06 | 0.919 | Agree |
| 5 | External auditing of cloud provider's qualifications and good service level agreement are essential for quality of service | 4.47 | 0.615 | Agree |
| 6 | If the cloud provider violates any agreements with the client or if it does any illegal thing against people's data, there are enough authorities to investigate it | 3.76 | 1.13 | Agree |

Table 6 shows that all the elicited items were agreed to be ways in which business continuity; cloud provider and regulatory compliance were related to distributed cloud computing initiatives in Nigeria. This however requires external audits and security certifications to confirm cloud provider's qualifications. Thus, data should be stored such that the client could still have access to his data even if he changes his cloud provider. Thus we surmise that external auditing of cloud provider's qualifications and good service level agreement are essential for quality of service with respect to business continuity, cloud provider and regulatory compliance and distributed cloud computing initiatives in Nigeria.

**Q6 Research Question 6: How does Backup, Recovery, Privileged User Access and User Trust in Cloud Computing relates to Distributed Cloud Computing Initiatives in Nigeria.**

Table 7 shows the Mean and Standard Deviation of Respondents on Backup, Recovery, Privileged User Access and User Trust in Cloud Computing. This explains the case of security vis-à-vis access control in a Distributed cloud.

**Table 7:** Mean and Standard Deviation of Respondents on Backup, Recovery, Privileged User Access and User Trust in Cloud Computing

| S/N | Item statement | Mean | Standard Deviation | Decision |
|---|---|---|---|---|
| 1 | In cloud computing, the cloud provider devises an adequate mechanism for backing up data. | 4.41 | 0.701 | Agree |
| 2 | If anything goes wrong and client data corrupts on a datacenter, the data could be recovered from backed up data. | 4.47 | 0.706 | Agree |
| 3 | The cloud provider hires trusted people for managing and accessing clients' data. | 4.06 | 0.983 | Agree |
| 4 | The providers must give adequate training to their personnel who manage the cloud datacenter. | 4.68 | 0.684 | Agree |
| 5 | The Cloud application on the web offers scalability and intrinsic security minimizing need additional IT resources | 3.79 | 0.914 | Agree |
| 6 | Cloud Computing platform for smart green energy management could support incremental addition of new smart grid applications with backup and recovery systems | 3.91 | 0.793 | Agree |
| 7 | Cloud Computing can facilitate Smart grid implementations while augmenting the existing utility capabilities with robust security fusion | 4.09 | 0.712 | Agree |
| 8 | Cloud computing initiative will allow the integration of data and capabilities from multiple, diverse sources to deliver powerful software as a service application over the web | 4.12 | 0.769 | Agree |
| 9 | Security and reliability are main challenges of cloud computing for energy management | 4.09 | 0.83 | Agree |

Table 7 shows that all the elicited items were agreed to be the relationship between Backup, Recovery, Privileged User Access and User Trust in Cloud Computing and distributed cloud computing initiatives in Nigeria. By this, it implies that, the providers must give adequate training to their personnel who manage the cloud data center, If anything goes wrong and client data corrupts on a data center, the data could be recovered from backed up data and Cloud computing initiative will allow the integration of data and capabilities from multiple, diverse sources to deliver powerful software as a service application over the web are all ways in which Backup, Recovery, Privileged User Access and User Trust in Cloud Computing related to distributed cloud computing initiatives in Nigeria.

## 2.4 Hypothesis

**Hypothesis 1:** $H0_1$: There is no statistical significant difference in the mean of the responses of the workers with above 5 years of working experience and those with below 5 years on how Cloud Metering Energy Feedback Computing Relates to Distributed Cloud Computing Initiatives in Nigeria.

**Table 8:** t-Test Analysis of Mean and Standard deviation of responses of the workers with above 5 years of working experience and those with below 5 years on how Cloud Metering Energy Feedback Computing Relates to Distributed Cloud Computing Initiatives in Nigeria.

| S/N | Below 5 yrs | | Above 5 yrs | | t-cal | Sig (2-tailed) |
|---|---|---|---|---|---|---|
| | $X_1$ | $S.D_1$ | $X_2$ | $S.D_2$ | | |
| 1 | 4.31 | 0.63 | 4.48 | 0.68 | -0.72 | 0.476 |
| 2 | 3.85 | 0.689 | 3.76 | 0.831 | 0.306 | 0.762 |
| 3 | 3.54 | 0.967 | 3.67 | 1.155 | -0.33 | 0.741 |
| 4 | 3.92 | 0.641 | 4.1 | 0.625 | -0.77 | 0.445 |

$N_1$ = 13; * = Significant at 0.05 (reject hypothesis), $N_2$ = 21; $X_1$= mean score for workers with below 5years of work experience, $X_2$=mean score for workers with above 5 years of work experience.$S.D_1$= standard deviation for workers with below 5years of work experience, $S.D_2$= standard deviation for workers with above 5yearsof work experience.

In the analysis, "sig (2-tailled)" are the figures showing the probability/significance level in which the calculated t-value will be significant. Null hypothesis will be rejected if calculated t-value is less than 0.05 otherwise accept the hypothesis. From the table above, the significance levels of all the items are more than the stated 0.05 level of significance therefore the null hypothesis is accepted.

**Hypothesis 2:** *$H0_2$: There is no statistical (significant) difference in the mean of the responses of workers with Degree/Equivalent and those with M.Sc/Equivalent on the ways in which Data Location on the Cloud Provider's Data Center and the Client's Ability to Investigate the Stored Data related to distributed cloud computing initiatives in Nigeria.*

**Table 9:** t-Test Analysis of Mean and Standard deviation of responses of workers with Degree/Equivalent and those with M.Sc/Equivalent on the ways in which Data Location on the Cloud Provider's Data Center and the Client's Ability to Investigate the Stored Data related to distributed cloud computing initiatives in Nigeria.

| S/N | Degree/Equiv. | | M.SC/ Equiv | | t-cal | Sig (2-tailed) |
|---|---|---|---|---|---|---|
| | $X_3$ | $S.D_3$ | $X_4$ | $S.D_4$ | | |
| 1 | 1.206 | 0.348 | 1.044 | 0.315 | -1.92 | 0.068 |
| 2 | 0.492 | 0.142 | 0.505 | 0.152 | 0.146 | 0.886 |
| 3 | 0.515 | 0.149 | 0.647 | 0.195 | 1.28 | 0.215 |
| 4 | 1.193 | 0.345 | 0.603 | 0.182 | -0.04 | 0.97 |
| 5 | 1.528 | 0.441 | 0.302 | 0.091 | 0.161 | 0.873 |

$N_3$ = 12 ; * = Significant at 0.05 (reject hypothesis) ; N4 = 11

Table 9 above shows that the significance levels of all the items are more than the stated 0.05 level of significance, therefore the null hypothesis is accepted for all the items. In the analysis, "sig (2-tailled)" are the figures showing the probability/significance level in which the calculated t-value will be significant.

**Hypothesis 3:** ***$H_4$**:There is no significant difference between the responses of the different organisations on the ways in which Segregation of Data on Shared Environment of Cloud Providers' Data Center and How Much the Providers' Services would be Available Whenever Needed related to DCCI in Nigeria.*

Table 10 shows that the F-ratio is significant at 0.05confience interval and at 3 and 30 degrees of freedom *(df)* for numerators and denominators respectively. The hypothesis is however rejected if the value of F-cal is greater than the critical value of *F*, otherwise, the hypothesis is accepted. In this case, table 10 therefore shows that the null hypothesis stated for items 2, 3 and 5 were acceptable while that for items 1 and 4 were rejected.
The implication of the rejected decisions is that providers of the computing infrastructure will work hard on their quality of service to restore confidence on the clients and also their must be a regulated price rate for end users to pay instead of providers arbitrarily fixing prices for the computing services.

**Table 10**: ***A**nalysis* **o***f* ***V**ariance* (ANOVA) on the mean responses of the different organisations (UNN Energy Research Centre, ELDI, Awka, and SEDI, Enugu) *on the ways in which Segregation of Data on Shared Environment of Cloud Providers' Data Center; and How Much the Providers' Services would be Available Whenever Needed are relates to DCCI in Nigeria.*

**ANOVA**

| S/N | ITEMS | | Sum of Squares | df | Mean Square | F-cal | Critical Value of F | Sig. | DECISION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Clients will not comfortable having their data stored on a shared environment on the cloud. | Between Groups | 6.605 | 3 | 2.202 | | | | Reject |
| | | Within Groups | 27.631 | 30 | 0.921 | 2.391 | 2.39 | 0.088 | |
| | | Total | 34.235 | 33 | | | | | |
| 2 | Data can be protected by the providers on the shared environment using encryption. | Between Groups | 4.051 | 3 | 1.35 | | | | Accept |
| | | Within Groups | 20.214 | 30 | 0.674 | 2.003 | 2.004 | 0.135 | |
| | | Total | 24.265 | 33 | | | | | |
| 3 | Encryption would solve data shared environment problems | Between Groups | 4.7 | 3 | 1.567 | | | | Accept |
| | | Within Groups | 23.3 | 30 | 0.777 | 2.017 | 2.017 | 0.133 | |
| | | Total | 28 | 33 | | | | | |
| 4 | The providers must be available with acceptable rate | Between Groups | 1.259 | 3 | 0.42 | | | | Reject |
| | | Within Groups | 17.006 | 30 | 0.567 | 7.41 | 0.74 | 0.536 | |
| | | Total | 18.265 | 33 | | | | | |
| 5 | The providers should be able to device mechanism to ensure availability of server in case one server goes down. | Between Groups | 0.758 | 3 | 0.253 | | | | Accept |
| | | Within Groups | 15.742 | 30 | 0.525 | 0.482 | 0.482 | 0.697 | |
| | | Total | 16.5 | 33 | | | | | |

## III. ANALYSIS AND EVALUATION

### A. Cronbach's Alpha Reliability Coefficient for Survey Likert-Type Scales

In statistics, Cronbach's (alpha) [14] is a coefficient of internal consistency and the measure is viewed as an extension of the Kuder–Richardson Formula 20 (KR-20), which is an equivalent measure for dichotomous items. While analysing the datafor the item questions (59), we ensured that these item questions ($q_1$ through $q_{59}$) all reliably measure the same latent variable (i.e., DCCI on Renewable Energy). A measure of the internal consistency was derived by running a reliability test using the Cronbach's alpha test.

**Table 11:**Cronbach's Alpha Reliability Coefficient [13],[14]

| Cronbach's alpha | Internal consistency |
|---|---|
| $\alpha \geq 0.9$ | Excellent (High-Stakes testing) |
| $0.7 \leq \alpha < 0.9$ | Good (Low-Stakes testing) |
| $0.6 \leq \alpha < 0.7$ | Acceptable |
| $0.5 \leq \alpha < 0.6$ | Poor |
| $\alpha < 0.5$ | Unacceptable |

The following valid deductions were obtained from table 11:

i. Cronbach's alpha reliability coefficient normally ranges between 0 and 1.
ii. The closer the coefficient is to 1.0, the greater the internal consistency of the items (variables) in the scale.
iii. Cronbach's alpha coefficient increases either as the number of items (variables) increases, or as the average inter-item correlations increase (i.e., when the number of items is held constant).

From tables 1 to 10, a total of fifty nine (59) items were investigated in order to validate the various research questions and hypotheses. To check for internal consistency, the Cronbach's alpha in SPSS was used and a screenshot of the result is shown in figure 4.
The first important table is the *Reliability Statistics* table that provides the actual value for *Cronbach's alpha*, as shown in figure 4. In our case, it was observed that the Cronbach's alpha test resulted in ***0.8555*** for the fifty nine items which indicates a high level of internal consistency for our chosen scale. Cronbach's alpha in this context simply provided us with an overall reliability coefficient for a set of variables (e.g., item questions). It could be deduced that Cronbach's alpha generally increase as the inter-correlations among test items increase resulting in internal consistency results. Also, mean scores were used to take decisions, thus, if *mean >3.5*, then agree else, disagree.

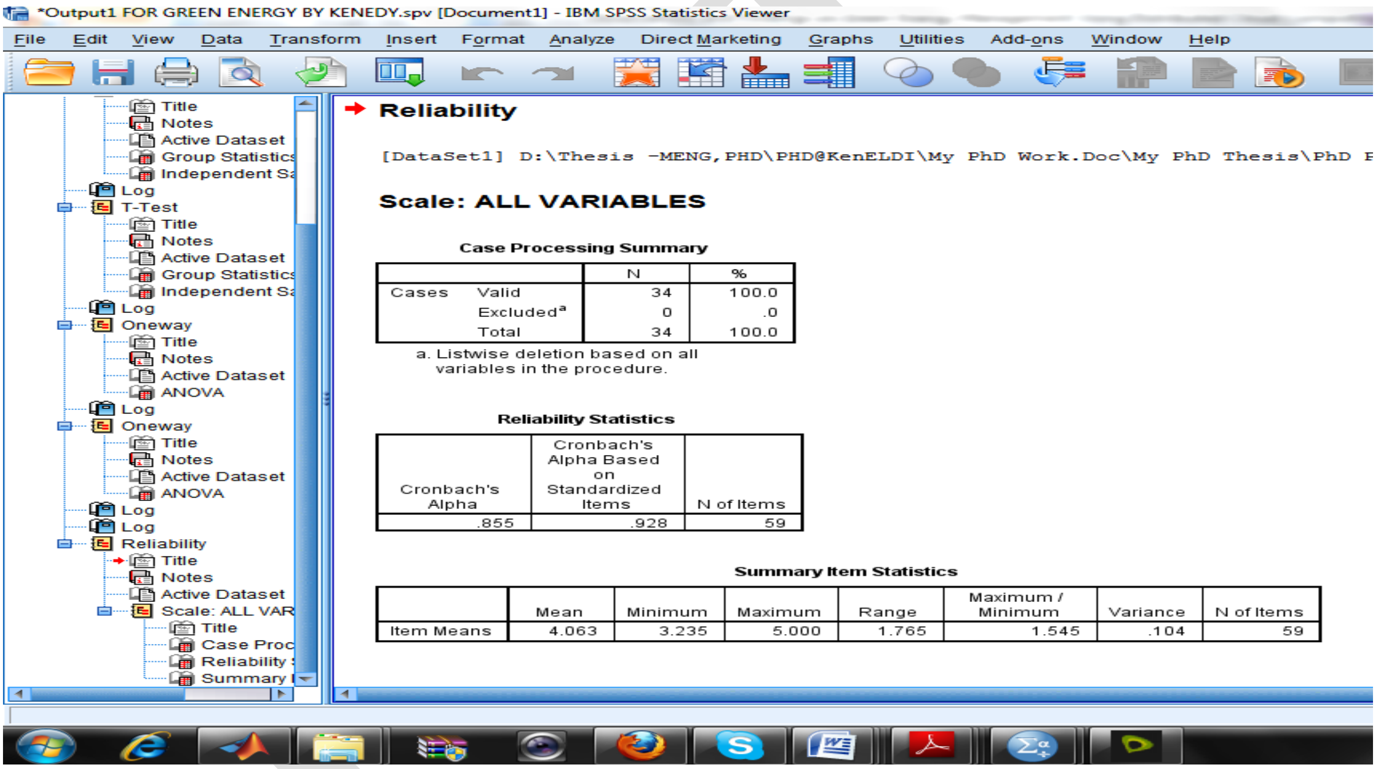

**Figure 4:** Reliability Analysis Snapshot from SPSS Viewer

## B. Survey Deductions

From the survey results documented in tables 1 – 10, we demonstrate that there is a significant relationship between DCCI and green energy management. Data centre consolidation is an element of Green IT Plan, with a key goal of the Sustainability Performance Plan [15]. The report of GSA's on Data Center Consolidation Initiative Planning Team reached consensus on the following goals having identified the importance of an efficient data centre design [15]:

i. Reduce the cost of data center hardware, software, and operations;
ii. Shift IT investments to more efficient computing platforms and technologies;
iii. Promote the use of Green IT by reducing the overall energy and real estate footprint of government data centers; and Increase the overall IT security posture of the government.
iv. Study life-cycle costing and reduce the expenditures of data center operations;
v. Reduce the physical footprint of GSA data centers;
vi. Identify and analyze federal office server rooms for regional consolidation;
vii. Increase overall IT physical posture by moving servers to secure facilities;

viii. Assess viability of multi-tenant (government and/or commercially operated) data centers;
ix. Outsource e-mail and collaboration tools to a cloud computing environment;
x. Serve as a federal shared service provider for financial management (FMLOB), payroll and human resources services (HRLOB);
xi. Achieve optimal virtualization and utilization levels (servers, storage, workstations);
xii. Establish and implement standardized data center processes and best practices;
xiii. Plan for data center business resiliency (disaster recovery/COOP); and Promote the use of Green IT to reduce overall energy consumption.

Consequently, this research opines that with DCCI, an energy management infrastructure can be effectively achieved with lost cost, yielding high Return on Investment, ROI, while incorporating features such as fault tolerance, load balancing, Modulation/demodulation, Security and real time communication with remote customers, etc.

**Table 12:** Target Focus for Federal Data Center Consolidation Initiative, [15]

| TARGET | FY 2010 BASELINE | FY 2015 TARGET | % CHANGE Realized From Baseline |
|---|---|---|---|
| Regional Computer Rooms/Data Centers (#) | 15 | 3 | 80% reduction |
| Regional Computer Rooms/Data Centers (Sq Ft) | 55,510 | 18,003 | 80% reduction |
| Servers (#) (Virtualized and Decommissioned) | 2,333 | 620 | 73% *improvement* |
| Server Utilization (%) | 45% | 60% | 15% *improvement* |
| PUE (#) | 2.4 | 1.8 | 25% *improvement* |

## IV. CONCLUSION

This research investigated six research questions and four hypotheses in order to ascertain the impact of DCCI on green energy management using a Direct Data Capture Survey in the research design approach. The result of the reliability analysis of Cronbach's alpha showed that the survey items were valid with a value of ***0.8555*** (85.55%). Hence, we surmise that the introduction of a Cloud Energy Meter, as well as the integration of the Cloud Energy Management portal, will positively impact on the perception of renewable energy usage and adoption by Nigerians. This will enable a very flexible system which allows for end user participation in the energy value chain. Thus, promoting the adoption of the Smart grid architecture currently advocated for in the world today. The smart grid architecture of Nigeria should therefore, leverage the advantages of our proposed framework.

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