Motives for solar photovoltaic (PV) adoption in urban Nigeria

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Abstract. Microgeneration technologies like residential solar photovoltaic (PV) systems have been shown to have immense potential for energy security and climate change mitigation. At over 50% private power systems ownership, the majority of urban Nigerian households rely on conventional self-generation utilising expensive petrol and diesel-powered generators. Despite the high upfront costs of a sizeable PV module, some households are choosing such sustainable alternative power. This paper investigates the motives for PV adoption in urban Nigeria following innovation diffusion and adoption theories. Using interviews, PV adopter data were collected on key drivers for uptake and results analysed. Field survey analysis established the key motives for uptake as power outages, energy cost-savings, including generator use fuel fraud, awareness and access to finance while key barriers include high capital costs and lack of finance. The results point to the need for regulatory and political intervention. Effective PV awareness creation campaigns and promotional strategies would also be necessary in the changing face of electricity supply in Nigeria.

1. Introduction

One of the most urgent societal challenges today is how to increase electricity and energy access while reducing atmospheric emissions. Over-reliance on unsustainable combustible fuels in energy supply especially for electricity generation is a major contributor to climate change and global warming [1]. A UN report estimates that globally 66% of aggregate electricity production comes from fossil fuels contributing to approximately 60% of GHG emissions which is responsible for climate change [2]. The bulk of this electricity and total energy demand takes place in buildings particularly during its operational life. Since buildings account for up to 40% of energy use as well as 30% of the share of CO\(_2\) worldwide [2], most green energy policies and initiatives focus on improving energy use in buildings especially dwellings.

In Nigeria, the bulk of total energy demand comes from the domestic sector representing about 57% in 2014. A large proportion of this is used to meet household demand for electricity. Clearly, the sector is an important one in relation to electricity supply, demand and for the promotion of micro-generation technologies (MGTs). MGTs refer to the off-grid generation of electricity of <50kWp and/or heat of <45kWp using low-carbon sources such as solar hot water (SHW), solar photovoltaic systems and micro-wind turbines [3]. Such renewable off-grid applications have huge prospects particularly in developing countries like Nigeria where the operational grid network capacity at 6GW [4], is underdeveloped and unable to meet consumer demand. As the Nigerian government desperately seeks to improve power supply, PV present opportunities that could be taken advantage of. Although Nigeria
has a favourable solar radiation resource that ranges between 3.5-7kWh/day [5], there are presently no
government monetary or fiscal incentives for PV promotion. But, there has been clear interest in this
technology for over 3 decades [5]. However, there is a renewed interest in diversifying the energy
portfolio in Nigeria and the government have now set target of 1GW of power to be generated from
solar by the year 2020 [4].
This paper investigates the motives for PV uptake by households and private consumers in urban
Nigeria. It does this to reveal the key determinants and identify suitable avenues to promote increased
adoption and thereby improve supply. This paper adopts the following structure. The next section
discusses innovation diffusion theory. This is followed by the data and methods used. Next is a
discussion of the results. Finally, the conclusions, implications and recommendations are presented.

2. Innovation diffusion theory
Different theories have been used to explain the determinants of PV adoption and MGTs in general.
The most common theories that have found application in literature include the innovation diffusion
theories, consumer attitudes or response theories and socio-technical systems [6]. The diffusion of
innovations model is a social psychological perspective developed by Rogers [7]. Under this model,
diffusion is defined as the process through which an innovation is communicated via certain channels
over time through a social system [8]. This innovation may be an idea, product, process (or a
combination of these) but does not necessarily have to be new, as long as it is new to the adopting
community [9]. The innovation diffusion concept can be examined from various perspectives
including product attributes, time and speed of uptake and characteristics of adopting population.
Diffusion is the relative speed with which an individual adopts a product or service compared to other
members of the same social system or society. Because of this time dimension, the speed of adoption
is taken to be a function of certain attributes that the innovation possesses. These include: relative
advantage, perceived risk, complexity, compatibility, trialability and observability [6]. Because every
individual does not adopt the innovation at the same time, Rogers’ [7] divided the stages of adoption
into five categorises according to consumer personalities, values and behaviour [10]. Within this five-
stage category and in ranking order are the innovators, early adopters, early majority, late majority and
laggards. The first two stages i.e. innovators and early adopters are considered crucial as they indicate
consumers who show the most initiative in the adoption process. See Figure 1. However, they are
often smaller in number. Their innovativeness in the adoption process is attributed to their level of
awareness and higher education [10]. As the cost of purchasing a sizeable PV is still relatively high,
this paper investigates the motives for PV uptake by consumers, mainly households in urban Nigeria.

![Figure 1. Adapted Rogers’ Innovation Diffusion S-Curve](image-url)
3. Data and methods
Unlike the traditional method largely deployed in engineering and the built environment studies, this paper adopts an approach that takes into cognisance the impact of human factor in energy production and consumption in buildings. This multidisciplinary approach treats electric power technology as socio-cultural and therefore includes the effects building occupant behaviours and decisions can have on energy demand and supply. This paper therefore applies a qualitative method of enquiry encompassing all the socio-cultural and technical aspects of a MGT.

Based largely on grounded theory, a qualitative research method was used in the form of interviews. As a deductive method, grounded theory is useful where there is lack of theory and concepts and when data collection, analysis and theory development and testing are intermingled [11]. Dearth of empirical research and literatures on urban PV adoption (both residential and commercial) in Africa as a whole supported grounded theory [12].

3.1. Purposive Sampling
Sample size decisions should be based on the nature of the topic under investigation, scope of the data and research methods [13]. Purposive sampling a generally acceptable technique in qualitative studies [11] was used. Here, the researcher’s judgment is relied upon based on study interest and rationale. Three of the PV adopters were identified from the questionnaire survey from a different but related study. Others were selected via referral, which is a situation whereby an interviewed adopter refers the researcher to other adopters. In most cases, adopters knew someone else using solar PV and may have had their panels installed by the same technician. Because PV is one of the most popular MGT, its appeal and acceptance has meant that it is a topic that many people are somewhat familiar with due to its high visibility. 14 adopters were interviewed. Experiential data requires fewer participants [11]. Bahaj and James did a similar study in Southampton UK using 9 households [14].

3.2. Interviews, questions and data
Open-ended semi-structured interviews were carried out and the interviews recorded using an MP3 recorder. The interview questions format took the order of the opening questions, the intermediate and the final questions. The opening questions enquired of the adopting households’ PV capacity and duration of use. It was very important to establish duration of PV use, as a very recent installation would not have been of great benefit to the study. The intermediate questions largely examined the role of feedback mechanisms such as PV monitor. The final questions covered maintenance issues, challenges and likelihood of recommending PV for other households.

Interviews can be useful when the investigation as to the rationale for a decision is sought. Research has shown that interviews are good strategies in consumer attitudes to green power [15] and adoption promotion studies [16]. For added clarity the recorded interviews were transcribed using a data analysis software. The human factor questions asked during the data analysis included:

- What led to the adopters’ decision?
- What were the PV households’ experiences from using the device?
- Based on their experience, would they recommend PV to other households?

Respondents were primarily drawn from Lagos State, Nigeria. Due to the small number of PV usage in Lagos, respondents were taken from other states i.e. cities in Nigeria such as Abuja (Federal Capital City) Delta, and Edo.

4. Results and analysis
The motives for PV adoption in Nigeria were broadly found to be socio-economic and environmental. The most significant motive was households’ need for reliable electricity supply. In other words,
frequent power outages were driving the demand. Others are energy cost savings and familiarity with PV generated power. They are explained accordingly.

4.1. Reliable supply
Power outages and the need for a more reliable supply source represented 80% of motives for PV adoption as Figure 2 indicates. All the interviewed found PV to be very reliable and better than grid electricity and petrol and diesel-generated electricity. The innovative adopters described PV as rugged, regular, uninterruptible, efficient and the most rational source of power supply.

![Motives for PV adoption](https://example.com/motives.png)

**Figure 2.** Motives for PV adoption in Nigeria

What was even more remarkable was that adopters whose systems eventually failed after a short time held this same optimistic view. Two of the interviewed adopters had systems that lasted for 3 and 6 months respectively as can be seen here in Figure 3. Overall, the opinions were positive.

![Total duration of adopters’ PV ownership prior to survey](https://example.com/total_duration.png)

**Figure 3.** Total duration of adopters’ PV ownership prior to survey
The short lifespan did not create a dislike for or disapproval of PV as would be expected. The adopters instead believed that the issues arose from not having sufficient funds to pay for a fully functional PV system. They also attributed the early PV breakdown to having installed an undersized inverter commensurate to the panels’ capacity.

4.2. Energy cost savings
Representing about 60%, energy cost savings was the second most important motive for PV uptake. This finding was surprising because of the widely acknowledged high initial cost of PV modules. Most of the adopters clearly thought that in the long-run, PV generated electricity was more economical than private generators and grid distributed electricity, with some specifically given a breakdown of the cost-savings. A notable point made in the interview regarding PV was that its installation turned out to be a mechanical solution to the problem of generator-use fuel fraud. An adopter narrated how his PV installation helped curb being defrauded by his employees. They said:

“I tell you something. In my shops when I am away, I have been having this issue where my staff members do not buy fuel for generator use but tell me that they did buy fuel. There might have been central electricity supply and they will say oh there was no light; that they bought fuel when they didn’t buy fuel. So, I have used my PV installation to cut them off. It is actually saving me a lot of money. They can tell you that they bought fuel and they used generator from morning to night when they didn’t use it.” -F. I.

The above described scenario was made possible because the PV adopter made use of a switchover connection allowing the system to switch automatically to grid electricity when central power was restored and vice versa. Therefore, depending on how the connections are made, PV can help safeguard adopters and users from being defrauded by employees and family members.

4.3. Familiarity and technical knowledge
As identified in studies, awareness precedes uptake in the adoption decision. Not only the awareness of the technology but also some basic technical knowledge about electricity. Sovacool [17] pointed out how basic electricity literacy was very low even in the United States. Familiarity represented about 30% of views. Many adopters said that they deliberately made certain electrical connections in their dwellings to accommodate such modern energy systems like PV. Awareness and familiarity also meant that some adopters were able to question the quality and number of modules, batteries and general work before deciding whether to go ahead with the installation. While the role of marketers influenced PV uptake as well as perceived overbilling from grid supplied electricity distributors was a driver of the change, they were less significant. Understandably, payback time was the least of the motives. This is expected for consumers who suffer frequent power outages and its associated inconvenience.

Lastly, studies reveal that tenancy can negatively affect MGT adoption decisions [18]. In this study, views about PV reliability, energy cost-savings and familiarity were relatively the same across tenant groups. This means that there was no significant difference between home owners and those that were renting. Figure 4 below illustrates. It is reasonable to expect that home owners would not object to their tenants installing PV on their property. This signals that the tenant or renter is willing to stay in the property for a long period of time hence guaranteeing rental income for the property owner.

1 Note that in Nigeria and most of Africa, electricity is generally referred to as “light.”
5. Conclusions and some recommendation
This paper has shed light on the motivations for urban household-level PV uptake in Nigeria. The key factors identified as driving adoption are national power outages and the need for regular power and households’ intention to reduce energy costs. The rise in fuel and electricity prices in Nigeria following the recent removal of subsidies has led the self-generating households to seek alternative power. In terms of reliability, the adopters found PV to be the best power supply technology and would recommend PV. There is also evidence that the cost of PV has been steadily declining in the last 10 years.

The identified motives for PV uptake in this paper provide evidence of the vital role of the private sector towards transforming the power sector in Nigeria and similar countries. Like Adhekpukoli, [4] rightly pointed out in his paper on the democratisation of power, meaningful change can only come in the Nigerian power sector only when it is decentralised and handed back to the people. Until, the end-users are seen as a key part of the power supply and demand process, the power access, affordability, sufficiency and efficiency challenge will remain unsolved. Developed nations have realised the power of prosumers\(^2\). So, should Nigeria, as it considers grid expansion and renewables with the intent to increase grid access to 75% of the population by 2020. Some of the hindrances to PV adoption include lack of finance, low product quality and poor technical know-how.

There is a need to regulate the nascent PV industry so that only quality modules are imported and used in Nigeria. The presence of monetary and non-fiscal incentives would encourage potential adopters who by their actions are contributing to CO\(_2\) reduction. This would also help support businesses as well as grow the economy as new markets are created. As a public good with net environmental benefits, PV will be instrumental for transforming the Nigerian power sector while contributing towards resolving the twin challenge of ensuring energy efficiency and reduced emissions.

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\(^2\)These are self-generators or investors who produce own power for own use or for export from a combination of micro-generation technologies.
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