ISSN 2286-4822
www.euacademic.org

EUROPEAN ACADEMIC RESEARCH
Vol. XI, Issue 5/ August 2023

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Microeconomic Analysis of the Rebound effects of Solar Photovoltaic System Adoption in Kano State, Nigeria

GARBA IBRAHIM, PhD
MUHAMMAD ABDULAZIZ MUHAMMAD
FATIHU MAHMUD ALHASSAN
Department of Business Education
Kano State College of Education and Preliminary Studies, Kano Nigeria

Abstract

Societal acceptance of residential solar panels have sporadic increased due to population expulsion, progression in energy demand potentials and poor economic condition of the populace trigger the need in for solar adoption as an alternative source of energy. The study examines the solar rebound effect adoption in Kano state, Nigeria. Hence, this study conducted a survey using three hundred and eighty-five (385) residential buildings in Kano metropolitan, those who utilized 259 and those who do not adopt solar panel 126. The study employed Propensity Score Matching (PSM) using difference-in-difference model for the data analysis utilizing probit linear Regression. The study is revealed that the level of PV adoption in Kano has increased tremendously. The living standard of the household in terms of energy utilization for lighting, heating and cooling may change so many things.

Keywords: Rebound effects, Photovoltaic System & Households, energy, Kano

1. INTRODUCTION

Domestic energy consumption has being the contemporary issue of discussion in academia, business press and policy makers around the world (Gillingham et al., 2009). The new policy measures are introduced to cope with the outlook of draining energy resources and the detrimental effects of climate change that resulted from increasing carbon dioxide emissions for domestic and industrial consumption (Aydin et al., 2013, 2017; Scheer, 2005) The efficiency in energy pave ways for many opportunities and this could trigger innovation and development in technology. Less energy per unit of output may be used to increase production which gives room for comparative advantage in international markets. Secondly, energy saving could lead to new demand, new markets, promotes investment and leads to new job opportunities for the teaming populace. (Borger et al., 2016). The energy associated expenditure could be reduced due to efficiency in energy by the importing counties and channel the excess to priority sectors, and moreover it can lead to an increase in disposable income of the household and give room for other consumption (Goddard, 2022; Irandoust, 2019).The global demand for accessible and affordable energy can never be over-emphasized looking at population expulsion and the need to expand the existing economic activities around the world with particular emphasis on more environmentally friendly source of energy (Adom et al., 2017). Environmentalists and environmental economists argued that, electricity access receives a lot of emphasis (Ted Nordhaus, 2017). Access to power, the uptake of renewable energies (REs), and energy efficiency are prioritized in the seventh

Sustainable Development Goal (SDG). Energy efficiency (EE) as documented from (Human Development Index, & UNDP, 2018). The quest for nations in ameliorating energy demand to revamp the economy using advance technology, greener pasture energy was documented from the global energy demand trend from the time immemorial, in the year, 2000 the demand was 15,500 TWh and expanded to 25,000 TWh in the year, 2016 (Nordhaus, 2017) and (IEA, 2018). Nations can achieve global energy needed by investing in solar, wind and thermal power to meet the threshold and ensure that people have access to and meet the Sustainable Development Goal 7 by 2030 as proposed by the (UNDP, 2018) and (Boccard & Gautier, 2018).

Problem Statement/Justification

SDG 7, 2030, calls for the need to provides clean and efficient energy to support economic growth protect the environment, by investing in solar, wind, and thermal power, improve energy productivity, and make it affordable for various consumption (Corrado et al., 2016; Schettkat, 2009). The World Energy Council estimated that over three billion people are compelled to use fossil fuels for daily activities, whereas 1.4 billion people lack access to electricity. as in India, Southern Asia and Sub-Saharan Africa and Nigeria fall within this regions with limited energy supply as reported by (Abdullahi et al., 2017; Akorede et al., 2017; Insititute, 2014). Despite the significant role played by the energy in almost all economic ventures and all spectra of life to the surprise of this study one quarter of the world population lacked access to grid energy, but they do have access to sunshine on most days of the year. Since access to sunlight is common and in abundance why household choose to be using fossil fuel instead of solar energy. The country where the state is located is a high-sunshine region and solar radiation is evenly dispersed throughout the country. Total solar radiation in the country varies from around 12.6 MJ/m2/day (3.5 kWh/m2-day) along the coast to about 25.2 MJ/m2/day (7.0 kWh/m2-day) in the far north, (National Energy Policy Document, 2018). The global outburst in PV installation outpaced all other forms of energy in terms of cost reduction and environmental friendliness. The demand was 97 GW in 2017, increased to 400 GW in 2018 as reported by Global Solar Energy Outlook (2015). The giant economy like China will have surpassed all other nations in global PV installation and also India had incredible achievement in PV installation. These counties achieved this success using various programs like loan subsidy, feed-in tariffs, renewable energy certificates, tax breaks and refunds, and direct support, among others but implementing the success of the PV installation in Nigeria is something else despite the framework on ground. The proposed Vision 20:2020 envisaged an increase in the power output from 4000MW in 2007 to 35,000MW in 2020 to meet the country's energy needs, taking into account growing population growth and socioeconomic activity (Akorede et al., 2017). The Nigeria generating capacity as at 2017 was 7000 MW for a population of 180 million, despite the country's abundant sunlight, with a daily full sun of more than 7 hours, energy levels rise to more than 2300KWh each year in the northern part of the country. This provides a great potential for solar PV, and its location in the solar belt, is a great opportunity for harnessing renewable energies have remained limited and unpractical in comparison to conventional electricity (Abdullahi et al., 2017)**.**

Kano Electricity Distribution Company (KEDCO) is principal electricity supplier, serving Kano, Jigawa, Azare in Bauchi state and Gonzou in Niger Republic. The feeder daily electricity demand is roughly 600MW (though subjective as it may increase with steady supply of electricity). The Kano state electricity demand is currently over 400MW, however KEDCO are only receiving 180MW of power (KEDCO, 2016). Majority of houses in Nigeria use gasoline and diesel-powered generators as backup power as a result of decades of inconsistent national grid energy supplies. But the most recent modifications to the Multi-Year Tariff Order (MYTO), which resulted in higher electricity prices (Financial Times (FT), 2012) and the gradual elimination of fuel subsidies (BBC News, 2012); have prompted households and other private power consumers to look for better power supply alternatives.

The public adoption of domestic solar panels and their rebound effects have not been exhaustively investigated in Kano state. Hence the study has the following objectives

i. To determine whether the adoption of PV in residential homes could lead to improve energy efficiency.
ii. To quantify the rebound effects as a results of PV adoption in Kano state.

2. LITERATURE REVIEW

The atmospheric planet is a treasured and sensitive resource that needs to be protected. The quality of life depends on the availability and utilization of natural resources. Maintaining a balance in the ecosystem is a basic precondition for preserving life (Ntanos et al., 2018). Anthropogenic human activities degraded the ecosystem due to mass production of technological goods, rapid urbanization rate, intensity of agriculture searching for energy for consumption (Ntanos et al., 2018). Energy is germane for human survival and economic activities had drawn a global public concern about accessible and affordable energy for household consumption. Energy efficiency can decrease production cost using technological innovation and address conflict between demand and supply of energy for residential consumption (Wang et al., 2018). Many household are constantly demanding for efficient and affordable energy for daily usage, while the supply of energy is mostly constrain by other factors which make energy prices hike in most of the time (Finamore, 2020; Freire-Gonzalez, 2017). The demand for energy in heating, cooling, lighting and a host of other end-uses necessitate seeking for alternative and affordable prices of energy for household survival. Reducing home energy consumption, the economy's total energy intensity, and the elasticity of the growth of energy demand with regard to GDP growth are the objectives of energy efficiency (EE). It also aims to reduce household energy service costs, freeing up more money for other essential needs. (Guta & Börner, 2017). The EE is applicable to lighting, heating, and cooling systems. For example, in a home with classic incandescent lights and compact fluorescent light bulbs (CFLs), the former used less energy than the latter. Low income earners in Nigeria prefer to use energy saving bulbs than high consumption bulbs to save energy. Energy efficiency is regarded as a fundamental policy option dual for mitigating climate change and improving economic competitiveness (Corrado et al., 2016; Schettkat, 2009). The European Union's 2030 Energy Strategy acknowledge energy efficacy as fundamental in the transition towards an extra competitive, secured, and sustainable energy system. The efficient energy provides multiple opportunities for suppliers and increases the demand for energy usage in the economy. When there is efficiency in energy generated by a country the cost saving from the efficient energy usage could be used for other expenditure in the country. This energy saving may trigger innovation and development in technology.

Less energy per unit of output may be used which increase production and comparative advantage in global competitiveness. Secondly, energy saving could lead to new demand, new markets, promotes investment and leads to new job opportunities for our teaming populace The energy associated expenditure could be reduced due to efficiency in energy importing counties and channel the excess to priority sectors, and moreover energy saving in terms of efficiency increase disposable income of the household and give room for other consumption (Chitnis et al., 2012; Oliver et al., 2017).

Rebound effect

Rebound effect: is a behavioral reaction to enhanced energy efficiency in which Increased energy service demand somewhat offsets any potential energy savings from efficiency improvements, lowering the cost per unit of energy services (Hunsader & Dickens, 2014; Scheer, 2005). The flexibility of energy usage in response to changes in the energy efficiency of the user's appliances is known as the direct rebound effect, (Sembiring, 2022). Many hitherto empirical studies used energy price elasticity to estimate the rebound effect (Adom et al., 2017; Noreng, 2019; Rajat Gupta Laura Barnfield, 2014).

Solar Photovoltaic

Solar Photovoltaic in other words called solar electric is the direct conversion of sunlight to electricity via photocell in a centralized or decentralized style**.** It could be large or small scale, large may be connected to national grid, while small scale for a stand-alone systems (Insititute, 2014). It is extremely doable to reduce poverty in the vast Nigerian communities by providing alternative renewable energy, as the level of energy production in any community determines her rate of development. (Akorede et al., 2017; Finamore, 2020).

Empirical Review

Hitherto empirical studies documented different outcome across the globe with particular emphasis on solar photovoltaic adoption utilizing rebound effect, whether direct or indirect rebound effect and the hybrid of the two in Asia, Africa, Latin, US, UK, Europe as per as residential PV adoption and whether there is energy saving because of the effect using different modeling process, or the energy saving is eroded. (Finamore, 2020; Goddard, 2022; Guta & Börner, 2017; Hunsader & Dickens, 2014; Scheer, 2005). The gap between expectation and realization is the change in household behavior. The difference is attributed to ownership, tenants and income of the household. Tenants are mostly noticed this effect due to low energy budget while owners care about the retrofitted building with more energy consumption pattern (Corrado et al., 2016; Freire-Gonzalez, 2017; Schettkat, 2009; Winther & Wilhite, 2015). In addition, higher or lower rebound effect depends on the seasons and the geographical locations of the household. The radiance or irradiance solar availability (Adom et al., 2017; Aydin et al., 2017; Aydın et al., 2022; Rajat Gupta Laura Barnfield, 2014; N. Wang et al., 2019)**.**

3. METHODOLOGY

This study used survey research designs using Propensity Score Matching (PSM). The data were sourced from field survey of small and large scale household. The population of this study was unlimited but 385 household were taken. The study used simple random sampling technique and the unit of analysis was Kano Metropolis household. The study examined the electricity consumption behavior of the selected households in the metropolis of Kano state, Northwestern Nigeria. The data collected during the survey were 386 households out of which 259 have solar panel while 127 households do not.

3.1 Instruments Measurements

The questionnaire was adapted to source the data of the study. The microeconomic analysis of solar rebound effect is operationalized as the extent to which household in Kano Metropolitan adopt the solar usage and if there is any cost saving resulting from the adoption. The study adapted the analysis of solar rebound effect measurements from (Aydin et al., 2022 & Corrado et al., 2016). The study used household income; household location; household electricity consumption, and the electricity rate plans as the explanatory variables. While solar rebound effect is computed as calculated energy saving less real energy saving scaled by calculated energy saving as used by (Wang et al., 2018)**.** The study further used Propensity Score Matching (PSM) and probit linear regression model to analyze the before and after solar panel adoption energy consumption pattern of the households. Both are the two matching techniques employed as well as

3.2 Empirical model

The rebound effect is the decline in anticipated benefits from a more resource-efficient technology as a result of a systemic or behavioral change. To assess the rebound effect, the study used probit logistic regression analysis of panel data with the following empirical model:

$$e_{it}^{C} = \alpha + \beta 1\, ecit(-1) + \beta 2\, rbit + \beta 3\, rlit + \beta 4 mex + \beta 5 sop + \beta 6 hhi + \varepsilon it \quad (1)$$

e_{it}^{C}= household electricity consumption
(-1) = lag electricity consumption
RB = residential building
RL = residential location
MEX = monthly energy expenditure
SOP = source of power
HHI = household income

Solar-paneled homes may shift some of their use to days when there is a lot of solar electricity production. For instance, a person may opt to postpone a normal chore, like laundry, in anticipation of high power output, raising the electricity consumption for that future day. To address this issue, we introduce lagged electricity production variables ($ecit$ (-1) into our model. Aggregation of the β coefficients gives us the rebound effect. Individual and date fixed-effects δi and γt respectively) are also included in the model in order to control for household-variant and time-variant unobservable. Finally, εit denotes the error term.

Robustness checks

The researchers undertake a series of analysis to assess the robustness of our estimations. In order to establish a reliable estimate of the counterfactual for the solar homes, we first examine the comparability of solar and non-solar households on observable variables. As a result, we analyze the sample that took part in the home survey using propensity score matching (PSM).

Further test was conducted to validate the initial findings in regression table 5. The 386 study participants were found to satisfy the covariate common support assumption condition.The regressions of the new measures produced results that are substantively similar to those reported for the main analyses.

4. RESULTS

The demographic data for the respondents

Table 1 below, present the respondents' residential location, building type, and household income. It was shown from the table that 73.5% of the respondents live in high density areas, whereas just 26.5% live in low density areas. The respondents' main energy source, with 325 out of 386 respondents agreeing that KEDCO (national grid) is the main source of energy in their residential location, representing 84.4% of the total respondents, and only 61 out of the total respondents having other sources. This can be viewed in relation to the respective supply of power by the distribution company, which is relative among the residential areas.

Table 1 Respondents' Demographic information

Response	Frequency	Percentage
Residential location		
High density	283	73.5%
Low density	103	26.5%
Total	386	100
Type of building		
Flat	272	10.6%
Storey	114	29.4%
Duplex	-	-
Others	-	-
Total	386	100
House hold income		
0-50,000	252	65.5%
60,000-100,000	68	17.7%
Above 100,000	66	16.9%
Total	386	100
Source of power supply		
KEDCO	326	84.4%
Others	61	15.6%
Total	386	100%

Source: Researcher's field survey (2022) computations using STATA17.0

Alternative source of power supply

The table 2 below represent the alternative source of power used by the respondents where 259 out of the total number of respondents marking 67.23% are using inverters as alternative source of power in their respective residents while, 101 respondents 26.23% out the respondents use generator as alternative source of power and only 26, that is 6.49% use no any alternative source of power in their residence. This can be seen from the point of view that the choice alternative source of energy is relative to the income as well as choice of the house hold at times it relate to the nature of the household energy consumption.

Table 2. Alternative source of power supply

Response	Frequency	Percentage
Generator	101	26.23%
Solar panel (Inverter)	259	67.27%
None	26	6.49%
Total	386	100%

Source: Researcher's field survey (2022) computations using STATA17.0

Rate of energy consumption

The table 3 below presents the rate at which the respondents consume energy in their respective residence where 193 marking 50.12% out of the total respondents consume high energy rate while, 161 households 41.81 % consume moderate, and only 32 household 8.7% are consuming low energy.

Table 3. Rate of energy consumption

Response	Frequency	Percentage
High	193	50.12%
Moderate	161	41.81%
Low	32	8.7%
Total	386	100%

Source: Researcher's field survey (2022) computations using STATA17.0

Monthly Energy Spending

Table 4. below represent the monthly spending on power by the respondents in their respective residence 161 out of the total number of households 41.81% spend between N1000 to N 5000 monthly on energy while, 192 households 49.87% spend between N6000 to N10,000 and only 33 that is 8.31% spend above N10,000. As such this will also follow the rule of thumb that expenditure on energy is in relation to usage and this research is conducted among household not business or corporate energy users.

Table 4. Level of monthly spending on energy

Response	Frequency	Percentage
N1000- N5000	161	41.81%
N6000- N10,000	192	49.87%
Above N10,000	33	8.31%
Total	386	100%

Source: Researcher's field survey (2022) computations using STATA17 version

It is clearly indicated from the findings of this study that a large proportion of the population used alternative source of energy in their residents. The study revealed that large percentages of respondents are high energy consumers. This asserts the notion that rate of energy consumption is correlated to usage. Furthermore, the findings documented that large percentage of the respondents spend between N 1000 - N 5000, consistent with the current trend of epileptic power supply by the distribution companies.

Probit Linear estimation

The probit regression results show that the residential building has significantly influenced adoption of solar panels adoption. This signifies households adopt more solar panels contributing 37% to treatment. The study results also show that residential location has significantly affect adoption of solar panels. The result also shows that source of power has positive influence on adoption of solar panels, this implies that 65% of household that adopts solar panels consider their source of power.

Table 5. P /Linear estimation

Treatment	Coef.	Strd.err.	t-value	p-value	(95% conf. interval)	Sign.
Residential location	0.219	0.015	0.025	0.025	0.130	**
Type of building	0.378	0.037	2.13	0.034	0.151	**
Source of power supply	0.652	0.057	0.22	0.003	0.124	***
Mean dependent var	0.5				SD dependent var	0.488
R-squared	0.679				Number of Obs	386
F-test	2.7				Prob > F	0.015
Akaike crit. (AIC)	252.362				Bayesian crit. (BIC)	305.341

Source: Researcher's field survey (2022) computations using STATA17.0
*** p<0.01, ** p<0.05, * p<0.1

The Impact of solar panel adoption on Household monthly energy spending

The estimation in Table 6 illustrates that after matching using two period data i.e., the outcome variable of before and after adoption period and the all the matching yield result ranging from ₦4,293.563 to ₦5, 5261.736 Hence the households adopting solar panels have experienced energy efficiency by spending between ₦4,293.563 to ₦5, 5261.736 and this is an economically significant achievement secured by the households.

Table 6. Matching Estimation for Effects of Household Income

Estimation method	Difference in difference result	Std.Error	t-value
ATET Nearest Neighbor Matching	5485.232	6291.763	9.151
ATET Kernel Matching	6833.563	7968.787	9.681
ATET Radius Matching	5483.917	5973.170	12.521
ATET Stratification Matching	4239.563	6824.066	9.876
ATET Local Linear Matching	5526.736	5248.054	8.725

Source: Researcher's field survey (2022) computations using STATA17 version

Robustness of Model Estimate

To determine whether the common support assumption for covariates has been broken, the characteristic in the control group that reincarnated with the treated group underwent a balancing test. The results of this test for the five propensity score matching utilized in the study are shown in Table 7 Below, shows the inferior bound, the number of treated and the number of controls for each block.

Table 7. Balancing Test Result

Inferior of Block of Pscore	Treatment		
	Control	Treated	total
0.2	37	20	57
0.4	143	131	273
0.6	13	42	56
Total	193	193	386

Source: Researcher's field survey (2022) computations using STATA17.0

The STATA 14 program automatically constructed the four inferior blocks of propensity score matching for the balancing test from Table 7 among the treated and control groups, both of which have identical demographic features. So, among the 386 study participants, the covariate common support assumption property is satisfied.

5. CONCLUSION

The research communities, policy-makers are trying to tackle the energy crisis around the globe with particular emphasis on cost saving on one hand and decreasing the energy consumption using new energy saving gadget, bulbs for good service delivery and innovation in production. Inconsistent electricity supply to residential dwellings has led many household to source for alternative sources of energy and complement the National Grid. The sun energy is being wasted in county relying mostly on fossils fuels as the main source of energy. The sun which could have been converted to address both residential and industrial sectors through solar photovoltaic (PV) system. The apriori expectation of energy consumption of retrofitted buildings is assume to decrease, although the findings from hitherto studies documented mixed outcome ranging from real and estimated energy saving. Direct rebound effects result from increased demand for cheaper energy services, while indirect rebound effects result from increased demand for other goods and services that also require energy to provide. It is documented that, technological improvements change household behavior which change intensity of energy used and utilized for other usage. Although, the real controversy lies in the identification of the size of the rebound. This is of great importance, as energy conservation policies are mainly designed to increase the energy savings, not the energy efficiency. Despite the level of PV adoption in the state increase but still the level of awareness need to be higher so that residential building can keep using the solar for heating, lighting and cooling if possible. According to the study estimations, a household's electricity usage rises for every unit increase in solar PV electricity produced, this give the rebound impact. But we cannot quantify it because, most of the household cannot give estimates of their energy consumption in kwht(s). The study also discovers that the net power consumption from the grid is reduced by solar PV electricity output, however these are subject to change over time.

The likelihood of solar panel adoption is good because most owners/occupants are open to adopting it more as a substitute; it is hindered by the perceived high cost of solar Panel installation system and lack of awareness.

The need for government to provide a clear policy on solar energy market by providing incentives to individuals who are interested in the market, in order to grow it. Absence of which serves as a hindrance to the development of the renewable energy supply and also make the populace becoming more comfortable with the status quo of the country's energy provision challenges.

The study Further recommends further quantitative research on the area of study preferences of various household types) along with improved household consumption model could be useful in guiding policy and planning work in areas outside the purview of the study.

REFERENCES:

1. Abdullahi, S. B., Olawumi, T. O., & Omoboye, A. J. 2017. Solar Photovoltaic System : A Case Study of Akure ,. *World Scientific News*, *83*, 15–28.
2. Adom, P. K., Barnor, C., & Agradi, M. P. 2017. Road transport energy demand in West Africa : a test of the consumer-tolerable price hypothesis. *International Journal of Sustainable Energy*, *0*(0), 1–22. https://doi.org/10.1080/14786451.2017.1398161
3. Akorede, M. F., Ibrahim, O., Amuda, S. A., Otuoze, A. O., & Olufeagba, B. J. 2017. Current Status and Outlook of Renewable Energy Development in Nigeria. *Nigerian Journal of Technology*, *36*(1), 196–212.
4. Aydin, E., Brounen, D., & Kok, N. 2013. The Rebound Effect in Residential Heating. *Journal of Economic Literature*, 1–33.
5. Aydin, E., Kok, N., & Brounen, D. 2017. Energy efficiency and household behavior : the rebound effect in the residential sector. *The RAND Journal of Economics*, *48*(3), 749–782.
6. Aydın, E., Brounen, D., & Erg, A. 2022. The Rebound Effect of Solar Panel Adoption : Evidence from Dutch Households. *Journal of Ecoomic Literature*, 2–24.
7. Boccard, N., & Gautier, A. 2018. *Photovoltaic Power installation in Wallonia : Estimating the rebound effect* (Issue June).
8. Borger, B. De, Mulalic, I., & Rouwendal, J. 2016. Measuring the rebound effect with micro data : A first difference approach. *Journal of Environmental Economics and Management*, *79*, 1–17. https://doi.org/10.1016/j.jeem.2016.04.002
9. Chitnis, M., Sorrell, S., Druckman, A., Firth, S., & Jackson, T. 2012. Estimating direct and indirect rebound effects for UK households. *Centre for Environmental Strategy*, 1–37.
10. Corrado, V., Paduos, S., Primo, E., & Ballarini, I. 2016. The Rebound Effect after the Energy Refurbishment of Residential Buildings towards High Performances. *4th International High Performance Building Conference Purdue*, I–11.
11. Finamore, B. A. 2020. China ' s Quest for Global Clean Energy Leadership. *Istituto Affari Internazionali*, 4–18.
12. Freire-Gonzalez, J. 2017. A new way to estimate the direct and indirect rebound effect and other rebound indicators. *Journal of Energy*, *128*, 394–402. https://doi.org/10.1016/j.energy.2017.04.057
13. Gillingham, K., Newell, R. G., & Palmer, K. 2009. Energy Efficiency Economics and Policy. *Annual Review of Resource Economics*, *1*, 597–619.
14. Goddard, L. 2022. The Solar Panel Manufacturing Industry ' s Boom , Bust , and Future. *Business Economics*, *50*(3), 147–154.
15. Guta, D., & Börner, J. 2017. Energy Security, uncertainty and Energy resource use options in Ethiopia: A sector modelling approach. *International Journal of Energy Sector Management*, 1–29. https://doi.org/10.1108/IJESM-04-2015-0005
16. Hunsader, K. J., & Dickens, R. N. 2014. The oil industry ' s response to new avenues in futures trading. *Applied Financial Economics*, *December 2014*, 401–413. https://doi.org/10.1080/09603107.2010.532104
17. Insititute, G. E. N. 2014. *How is 100 % renewable energy possible for Nigeria ? March*.
18. Irandoust, M. 2019. On the causality between energy efficiency and technological innovations : limitations and implications. *International Journal of Green Energy*, *00*(00), 1–11. https://doi.org/10.1080/15435075.2019.1681430
19. National Energy Policy Document, 2015 & 2018. (n.d.). *National Renewable Energy and Eergy Efficiency Poiicy*.
20. Noreng, Ø. 2019. EU Energy Union: A Critical View. *The Journal of Energy and Development*, *44*(1), 197–236.
21. Ntanos, S., Kyriakopoulos, G., Chalikias, M., & Arabatzis, G. 2018. Public Perceptions and Willingness to Pay for Renewable Energy : A Case Study from Greece. *Sustainability Journal*, *10*(68), 2–16. https://doi.org/10.3390/su10030687
22. Ohunakin, O. S., Adaramola, M. S., Oyewola, O. M., & Fagbenle, R. O. (2014). Solar energy applications and development in Nigeria : Drivers and barriers. *Renewable and Sustainable Energy Reviews*, *32*, 294–301. https://doi.org/10.1016/j.rser.2014.01.014
23. Oliver, M. A. T. T. E., Moreno-cruz, J., & Toroghi, S. H. 2017. The Solar Rebound, Household Income, and Subsidization of Residential Photovoltaic Systems. *40th IAEE Internationa Festival Singapore*.
24. Rajat Gupta Laura Barnfield. 2014. Unravelling the unintended consequences of home energy improvements. *International Journal of Energy Sector Management Unravelling*, *8*(4), 506–526. https://doi.org/10.1108/IJESM-11-2013-0006
25. Scheer, H. 2005. *The Solar Economy Renewable Energy for a Sustainable Global Future*.
26. Schettkat, R. 2009. Analyzing Rebound Effects. *Journal of Economic Literature*, *177*, 1–38.
27. Sembiring, M. 2022. Decarbonisation on a Finite Planet : A Preliminary Assessment of Environmental and Social Impacts. *NTS Insight*, *2020*, 1–19.
28. Ted Nordhaus. 2017. The Energy Rebound Battle. *Issues in Science and Technology*, *33*(4), 51–58.
29. Wang, N., You, W., & Peng, C. 2019. Heterogeneous risk spillovers from crude oil to regional natural gas markets : the role of the shale gas revolution. *Energy Sources, Part B: Economics, Planning, and Policy*, *0*(0), 1–20. https://doi.org/10.1080/15567249.2019.1662519

30. Wang, Q., Gao, Z., Tang, H., Yuan, X., & Zuo, J. 2018. Exploring the Direct Rebound Effect of Energy Consumption : A Case Study. *Sustainability Journal*, *10*(299), 2–21. https://doi.org/10.3390/su10010259

31. Winther, T., & Wilhite, H. 2015. An analysis of the household energy rebound effect from a practice perspective : spatial and temporal dimensions. *Energy Efficiency*, 595–607. https://doi.org/10.1007/s12053-014-9311-5