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Determinants of Uptake of Industrial Solar in Nairobi Metropolitan

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Abstract
Sub-Saharan Africa countries have abundant solar energy estimated in terawatts which can be harnessed to meet ever rising energy needs. Yet there are barriers affecting uptake of industrial solar by industries. This research aimed to establish determinants and how they effect of uptake of industrial solar mini grids in Nairobi Metropolitan area. The study objectives were; to explore the effect of financial capability, influence of Energy Act (2019), effect of business model and influence of public policy awareness on uptake of industrial solar. Descriptive research design was used. Target population was 30 industrial consumers in Nairobi Metropolitan area and three officials; a representative from Ministry of Energy, Kenya Association of Manufactures and one of the developers. The study established that energy regulations had a significant relationship with uptake of industrial solar resulting to delays, corruption and bureaucracy in implementation of energy regulations. Business model had also a significant effect towards uptake of industrial solar due to reliability and investment cost involved. Public policy awareness had a significant effect towards uptake of industrial solar and that promotion of the policy awareness was largely done by developers. The study recommends adoption of net metering, central publicly available database for industrial solar for planning purposes and need to offer affordable interest rates to investors in industrial solar with favourable loan application terms.
Keywords: Uptake of Industrial solar, Financial capacity, Business model, Public Policy awareness, Net Metering.
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1. Introduction

1.1 Background of the Study

Sustainable Development Goal (SDG 7) calls for availability of affordable, consistent, sustainable and modernized energy for citizens (UN, 2016). Globally, energy mixes include solar energy resources as a major plan in meeting energy deficits. The model of energy supply across the globe remains a centralized grid where large-scale generation of electricity occurs at centralized facilities. Mini-grids, on the other hand, ensures availability of electricity to homes, public institutions, and businesses using decentralized technologies that are electricity generated. These are run by institutions of government, private businesses, or community cooperatives. However, determinants of upkeep of new technologies are not always known. Global contribution of renewables in overall electricity matrix is approximated at 19%, 16% from hydro sources and 3% from new renewables (Ranjit, Juan & Ashwin, 2013). According to Day & Kurdziel (2019) embracement of mini-grids has risen globally in recent times. This has been triggered by reduced costs of renewable energy appliances, making it the most cost-effective options for mini-grid establishment in majority of countries.

China became second highest after Germany to use RE in 2014. In 2005 China was solely reliant on coal with it making a contribution of over 68% of electricity. Energy from solar was being mostly used for electricity in remote areas and tele-communication installations due to cost being high. The government introduced the '*Renewable Energy Law*' in 2005 to enhance generation of renewable energy with introduction of a number of new promoting guidelines and regulations. Emphasis was given to Research & development, manpower skills training and public engagement. The growth of SPV sector in China has been quicker than other countries. The revenue of Chinese PV did increase in the range between1%- 35% within 8 years. The government did establish a chain of PV industry to ensure supply of materials and products, in 2014 with sustained increment. Rooftop Subsidy program of $2.4/W and Golden Sun Demonstration (GSD) programmes were started. China had attained 28.33 GW SPV capability by March 2015 (Goel,2016).

In 2009, gross metering was started aimed at supporting development of solar project from captive load to the consumers. Owners of households get income from preferential tariff. The RTPV share was 26% commercial, 9% residential, 24 % industrial capability and about 1% out of building envelop, the rest at 40 % capacity from the ones installed on the ground. In 2013, the government decided to back up the batteries in all homes to improve storage and further increase RTPV usage. In addition to financial incentives, regulatory initiatives included recommendations on renewable resource legislation for associations with low-voltage networks on a priority basis (Goel, 2016).

In India, according to Bhattacharyya *et al* (2019), financial support is needed to ensure the profitability of the project through support channels such as one of these. For African countries, disconnections from main power is regular, with recurrent black- or brown-outs experienced on a daily or weekly basis. Unreliability of a grid could be as a result of various causes, such as problems arising from generation of power, weak infrastructure or unfavourable weather. However, challenges experienced by Commercial and Industrial (C&I) firms arises from unreliable grid are generally similar; productivity loss, lowered workforce productivity and likelihood of breakdown of machines. On various occasions power failure on essential producing power lines also negatively impact on work-in-progress, thereby affecting cost of operation (Mehta, 2019).

In Southern Nigeria according to Eronini (2014) there are insufficient policies to boost subsidies, high cost, challenge to access finances, high rates of interest of about 20% - 22% and limited period of payback of three (3) years for loans involving renewable technology.

Within the East Africa Community (EAC), countries that have drafted regulations for private mini-grid operators, such as Tanzania and Kenya, the process of obtaining licenses is often bureaucratic, tedious and unclear. Rwanda doesn't have a net metering guideline that permits providers associated with the lattice to criticism excess secretly produced capacity to the framework (CEADIR, 2020). This private venture centered investigation discovered that there are still difficulties in persuading possible business and institutional clients in Rwanda to take out a PV framework advance.

Kenya’s Vision 2030, focusses on transforming Kenya into a middle-income country which is industrialized by ensuring improved quality of life to all its nationalities. Vision 2030 is being attained through successive five-year medium-term plans with recognition of energy as a promoter in the Third Medium-Term Plan 2018–2022. One of the Kenyan government's development agendas is to improve manufacturing with the goal of increasing its contribution to gross domestic product (GDP) from 9.2% to 20% of GDP by 2020 (President's Big 4 Agenda, 2018).

In Kenya, Kenya's World Bank Enterprise Survey Report (2019) identified 1001 companies, of which nearly 4.3% reported loss of sales due to power outages (Bhamidipati & Gregersen, 2020). These companies are forced to rely on emergency diesel generators that use expensive fuel in the event of a breakdown or associated supply bottleneck. This unreliability of power supply, high grid tariffs and high cost of diesel-based emergency power supply lead to reduced competition and efficiency for these industrial companies. Poor grid quality was cited as a reason companies use onsite solar energy. This includes consideration of storage (battery installation). Sensitive machines can be destroyed and missed orders (Bloomberg New Energy Finance, 2019). Mburugu and Gikonyo (2019) stated that government policy had the greatest impact on the use of solar energy at tea processing plants in Mel County, Kenya. This is compared to the perception of socio-technical factors, environmental management, economic fluctuations and solar energy.

1.2 Statement of the Problem

While studies exist on industrial solar adoption, there is little that is known on the determinants of uptake of industrial solar mini grids. This area is attracting more analysis from scholars. This study adds to the growing body of knowledge on minigrids. The main contribution of the study is elucidating on the determinants of solar grid update. In the current literature, there is no detailed review on what determines uptake of solar energy minigrids in industrial facilities.

Many countries in Africa don’t have specific policies for mini-grids in their national electrification agenda, which makes it hard to plan especially by industrial enterprises. Although renewable mini-grids such as solar have many benefits, there are few installations in the industrial sector. Might the challenges faced by renewable mini-grid developers be related to uncertain or underdeveloped policies as well as financing and public awareness issues? This is what this study intended to find out.

It is hoped that this review will be resourceful to industrial energy users, policy makers, research, development and environmental organizations.

1.3 Objectives of the Study

i)To assess the effect of financial capacity on uptake of industrial solar
ii) To find out the impact of Energy Act, 2019 on uptake of industrial solar
iii) To explore the effect of business models on uptake of industrial solar
iv) To investigate the impact of public policy awareness on uptake of industrial solar

2 Literature Review

The main objective of the study carried out by Dutta and Das (2020) was to establish uptake of grid-connected solar rooftop systems in Jammu and Kashmir State in India. Snowball testing strategy was taken on. The findings gotten from the research stress that all the projects and programs affiliated to the uptake of a solar rooftop system should focus on awareness building.

Irfan et al., (2019) carried out a study on development of solar energy in Pakistan with regard to barriers and policy recommendations. The scholars did collect data for radiation of solar radiation and speed of wind for a duration of a year in four big cities of Pakistan i.e. Karachi, Lahore, Bahawalpur and Faisalabad. Results did suggest that energy from solar is the greatest renewable energy alternative for Pakistan when looking at price, life span, operation and maintenance cost. The study did propose important policy recommendations for government and institutions to counter these challenges and use maximum energy from solar in the country.

Ranjit et al., (2013) probed what capability, needs to be expanded from various players to ease development of the industry. These are specific capabilities required to put up, run, finance or control decentralized projects. This is taking into account a system majorly depends on the main grid extension and operation as the key method for ensuring access to power. It examined different strategies that have been adopted in sampled countries-Sri Lanka, Nepal and China. They did find out that in Sri Lanka, the World Bank did sponsor empowerment initiative in the 1990s to educate micro-hydro users. The majority are usually involved in project development, culminating in community competitive markets, peer-to-peer learning and auditing, resulting in 95% of the country's micro-hydro potential (Ariyabandu, 2005).

Abdullahi et al., (2017) did carry out a study on Solar Energy Development and Implementation in Nigeria: Barriers and Drivers. The desk study method was the one adopted for this investigation, otherwise known as literature-based from peered-reviews. The literature findings indicated that Nigeria has high capacity for solar energy throughout the year especially the North-East zone of the country. According to literature findings, the factors accelerating the solar energy technology consist; a demand for a sustainable environment to attain the SDGs, increment in energy demand due to increasing population, Power sector reforms Act, which advocated for energy mix, problems of energy access and security, creation of jobs, market and financing potential, building of energy research centers and stakeholders in the public private partnership agreements.

Mburugu and Gikonyo (2019) reviewed the factors that influence the use of solar energy in Kenya. These factors focus on the tea processing line in Meru County. The review included an attractive overview plan that included delimited irregular inspection and test parameters from five tea processing plants. Research showed that the government's need for solar-powered roof heating for entrepreneurship and enacted legislation will have a significant impact on the use of solar-based energy at tea processing plants in Meru County.

2.1 Theoretical Review

The study was guided by Diffusion of Innovations Theory

2.1.1 Diffusion of Innovation Theory (DIT)

DIT is a hypothesis that tracks the spread of new ideas, goals, or innovations among individuals of a particular culture (Rogers, 2010). The means of characterizing users are carried out through further development. This, in contrast to other social frameworks, is represented as a level at which a person is slightly ahead of schedule when embracing groundbreaking ideas. Ingenuity is considered "relative" in that some have a greater part of the social environment than others (Rogers, 2010).

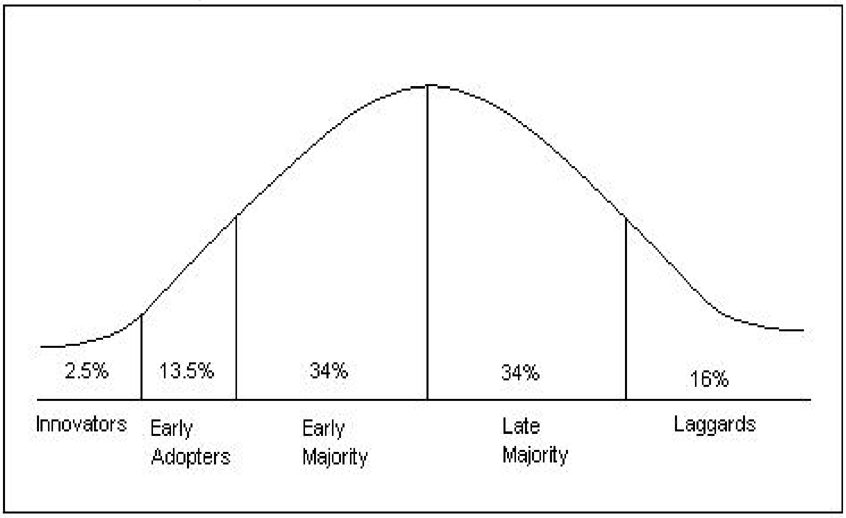

Fig 1.1 - Adopter categorization on the basis of innovativeness

This arrangement is commonly used. Figure 1.1 shows the distribution in five classes: trendsetters, early adopters, early major parts, late major parts, and loafers. 2.5% of pioneers first adopted another idea. Next are 13.5% early adopters. The next 34% of employers are marked as the majority of the early days. The remaining 34% is called the late big part and the remaining 16% is called slow pork.

According to Rogers (2010), innovators yearn to experiment, to the level where their interest in venturing obsesses them. Innovators' interest in new concepts sets them apart from their peers and into social relationships of higher level.

Early adopters seem to be more incorporated into local environment than innovators. Individuals of the early majority group adopt new ideas prior to average individual in the society. They interact regularly with friends, and not seen occupying positions of leadership.

The late majority are the hesitant category, embracing new concepts after the average individual in the society. Their adoption may culminate out of economic need geared towards increasing social pressure. Laggards are conservatives and embrace an innovation last. They have no opinion leadership, laggards are native to the level of being isolated in comparison with other adopter categories. They hold on the past, and all decisions must be based on the previous generations. This study will thus adopt DIT to enable explain on the real determinants of uptake of industrial solar system by industries despite the many economic benefits associated with installing industrial solar in the industries.

3 Research Methodology

3.1 Research Design

Descriptive research design would help explain the current situation with regard to uptake of industrial solar mini- grids in Nairobi Metropolitan.

3.2 Site of the Study

The commercial industries targeted under study were located at the outskirts of Nairobi city Central Business District (CBD) mainly in industrial area and satellite towns such as Kiambu, Ruiru, Thika and Juja. Business and modern purchasers represent the biggest portion of power deals at 55%, trailed by homegrown at 29% (Kivuva, 2021) subsequently the requirement for business enterprises to search for elective wellsprings of modest power.

3.3 Target Population

They consisted of all industries that have installed industrial solar and use it for production purposes in Nairobi Metropolitan. Industries using industrial solar for other uses and not solely for production were excluded in this study. Thus, there were thirty industrial consumers located within the Nairobi Metropolitan area who have installed industrial solar and use it for production purpose as listed in table 2.1

Further the target population also included three officials as follows; a representative from Ministry of Energy (MoE), Kenya Association of Manufactures (KAM) and an official from one of the developers and in this case Ofgen solar.

Table 2.1 List of industrial firms utilizing industrial solar for production purpose in Nairobi Metropolitan area

No.	*Name of Industrial Firm utilizing industrial solar or production purpose in Nairobi metropolitan area*	*No.*	*Name of Industrial Firm utilizing industrial solar for production purpose in Nairobi metropolitan area*
1	African Steel Pipes (ASP)	16	London Distillers, Athi River
2	Insteel	17	Africa Logistics Properties
3	Doshi	18	GSK Kenya
4	BidCo Africa	19	Kenya Sweets Limited (KSL)
5	Ashut	20	Sky Foods - Juja
6	Mabati Rolling Mills	21	Siginon Aviation
7	KenRub Limited	22	Spinners & Spinners
8	Sfal Group	23	Tatu City Industrial Park
9	Afya Fresh Produce Ltd.	24	Burn Manufacturing
10	Kapa Oil Refineries Ltd	25	Penta Flowers, Thika
11	Exotic EPZ	26	Thika Coconut Grill
12	Tropical Heat	27	Ponty Pridd Holdings
13	Large warehouse, Tatu City	28	Danco Plastics
14	Nairobi Plastics	29	Blue Nile Group (Thika)
15	Capitol Printers	30	C & P Shoe Industries

3.4 Sampling Techniques and Sample size

A complete census study was deployed to the industrial consumers since the target population was less than thirty and thus small. Officials from MoE, KAM and Ofgen Solar were the key informants who participated in this study.

3.5 Research Instruments
The primary data collection instruments utilized were the questionnaire and interviews. The questionnaire used was both open and close ended. It was distributed to the participants by the researcher and research assistant and then collected at agreed upon date. This was useful in collecting primary quantitative data.

Interviewing is a technique whereby the researcher interacts socially with one or more participants. The three officials from MoE, KAM and Ofgen solar were thus interviewed using designed questions. The researcher booked an appointment with the officials and then administered the interview.

3,6 Data Analysis and Presentation
Data analysis began by examining the questionnaires collected to confirm completeness and consistency through pre-processing. The collected data was then coded to facilitate the classification of the data into groups. The essence of coding was to ensure efficiency and to minimize the feedback gotten from participants to a small number of classes. After coding the researcher then stored the data in electronic form for data analysis.

Quantitative information was investigated with the assistance of electronic bookkeeping page SPSS programming where recurrence circulations and proportions of focal inclination were assessed. Subjective information was coordinated in topics according to the exploration goals. The broke down information was then introduced in recurrence appropriation tables. Relapse Analysis was done by the analyst to set up the idea of connection between the factors under study. The reason for utilizing relapse investigation was to clarify the variety of the reliant variable at whatever point the autonomous factors is changed.

$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$

Where: Y=Uptake of industrial solar mini-grid, β_0 = constant, β_i = Coefficients of regression for the independent variables Xi (for i = 1, 2, 3, 4)

X_1= Financial access, X_2 = policies, X3 = business model, X_4 = public awareness and ε= Error term.

4 Results and Discussions

4.1 Demographic Data

4.1.1 Gender

The participants were asked to indicate their gender in order to establish the gender composition of the participants who participated in this study and the results are indicated in
figure 3.1

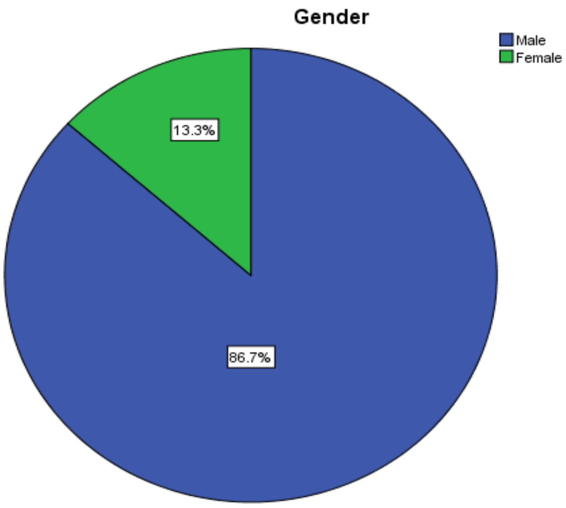

Figure 3.1 Gender

4.1.2 Age

The study sought to establish the age categories of the participants and the responses are indicated in figure 3.2.

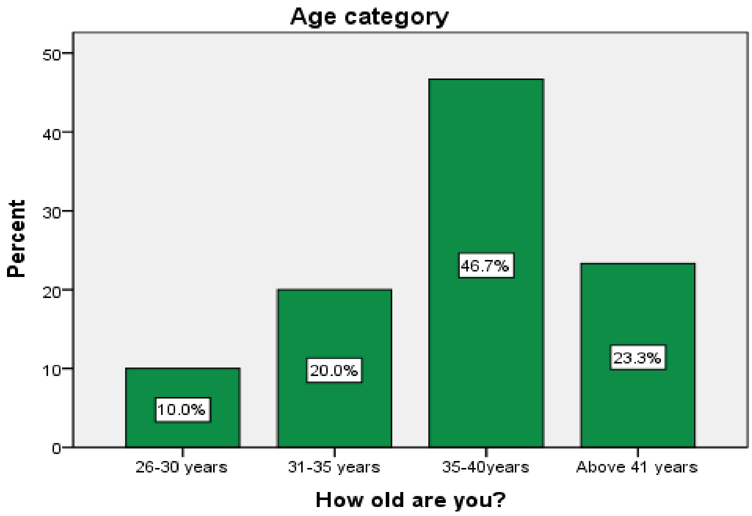

Figure 3.2 Age

4.1.3 Level of Education

The participants were asked to indicate the level of education and the study results are shown in in figure 3.3

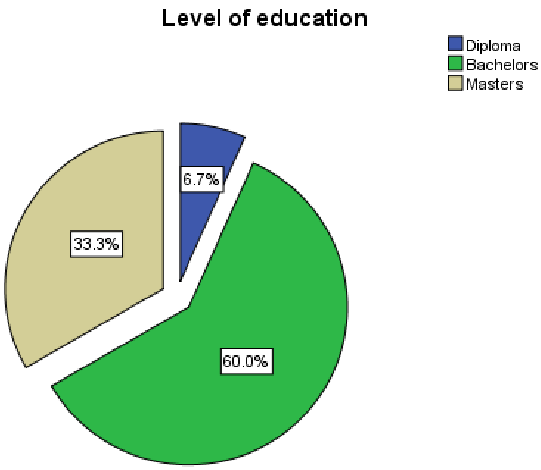

Figure 3.3 Level of Education

4.2 Descriptive Statistical Analysis

Descriptive Statistical Analysis was carried out in terms of mean and standard deviation.

Table 3.2 Financial Capacity

Descriptive Statistics							
(f)	1	2	3	4	5	Mean	Std. Dev.
Availability of capital was NOT required in order to set up Industrial solar	15	15	0	0	0	1.50	0.509
Availability of working capital was NOT required in operating and maintenance of Industrial solar	14	16	0	0	0	1.53	0.507

N=30

The participants stated that they disagreed (M=2) on the statements "*Availability of capital was NOT required in order to set up Industrial solar* " and "*Availability of working capital was NOT required in operating and maintenance of Industrial solar* ".

Table 3.3 Energy Act 2019

Descriptive Statistics							
(f)	1	2	3	4	5	Mean	Std. Dev.
The tariff approval process was NOT tedious and challenging	2	4	0	16	2	3.50	1.142
The construction permit and licensing approval was NOT tedious and challenging	8	15	0	5	0	2.07	1.016

N=30

The participants stated "agree" (M=4) on the statement "*The tariff approval process was not tedious and challenging*". However, the participants disagreed (M=2) with the statement "*The construction permit and licensing approval was not tedious and challenging*".

Table 3.4 Business Model

Descriptive Statistics							
(f)	1	2	3	4	5	Mean	Std. Dev.
Outright purchase of industrial solar is NOT an option in setting up and running the industrial solar	7	6	0	6	10	3.21	1.677
The leasing and Power Purchase Agreement method is NOT an option in setting up and running the industrial solar	7	0	0	13	8	3.54	1.551

N=30

The participants indicated that they were undecided (M=3) on the statement "*Outright purchase of industrial solar not an option in setting up and running the industrial solar*". The participants however agreed (M=4) with the statement" *The leasing and Power Purchase Agreement method is not an option in setting up and running the industrial solar* ".

Table 3.5 Public Policy Awareness

Descriptive Statistics							
(f)	1	2	3	4	5	Mean	Std. Dev.
There is NO public awareness on policies and incentives of adoption of solar mini-grids	0	0	4	12	13	4.31	0.712
There is NO public awareness on benefits of usage of solar energy power	0	2	2	15	10	4.14	0.833

N=30

The participants agreed (M=4) with the statements "*There is no public awareness on policies and incentives of adoption of solar mini-grids*" and "*There is no public awareness on benefits of usage of solar energy power*".

Table 3.6 Power Generation

Descriptive Statistics							
(f)	1	2	3	4	5	Mean	Std. Dev.
The amount of energy we produce is not sufficient for our production process	7	11	0	6	6	2.77	1.524
The number of industrial solar in our industry is not sufficient for our production process	5	14	0	7	4	2.70	1.368

N=30

The participants were undecided (M=3) on the statements "*The amount of energy we produce is not sufficient for our production process*" and "*The number of industrial solar in our industry is not sufficient for our production process*".

4.3 Relationship between financial capacity, energy regulations, business model and public policy awareness on uptake of industrial solar

In order to establish the relationship between financial capacity, energy regulations, business model and public policy awareness on uptake of industrial solar, regression analysis was carried out and the results are shown in table 3.7, 3.8 and 3.9.

Table 3.7 Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.422[a]	.178	.046	2.45180

a. Predictors: (Constant), Financial Capacity, Energy Regulations, Business Model, Public Policy Awareness.

From the table of model summary, it shows that the strength of relationship between dependent Uptake of Industrial solar) and the independent variables (Financial capacity, Energy Regulations, Business Model and Public Policy Awareness) is almost moderate (R= 0.422). Further the table indicates that independent variables explained 17.8% (R square) of the change in uptake of industrial solar.

Table 3.8 Analysis of Variance Table

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32.517	4	8.129	1.352	.0279[b]
	Residual	150.283	25	6.011		
	Total	182.800	29			

a. Dependent Variable: Uptake of Industrial solar

b. Predictors: (Constant), Financial Capacity, Energy Regulations, Business Model, Public Policy Awareness

As shown in Analysis of Variance table there was statistically significant differences between group means of dependent and independent variables since ($F(4,25) = 1.352$, $p = 0.\ 0279 < 0.05$)

Table 3.9 Regression Coefficients table

Co-efficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	6.764	5.097		1.327	.196	-3.733	17.261
	Financial Capacity	.133	.313	.081	.425	.0174	-.511	.777
	Energy Regulations	.635	.626	.217	1.014	.0320	-.655	1.925
	Business Model	-.492	.252	-.359	-1.952	.0462	-1.011	.027
	Public Policy Awareness	-.136	.429	-.069	-.316	.0355	-1.020	.748

a. Dependent Variable: Uptake of Industrial Solar

Relationship of the dependent and independent variables was determined using regression model given as

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$

Where: Y is Uptake of industrial solar, β_0 is the constant or the intercept of the regression line; β_1, β_2, β_3 and β_4 are regression coefficients for predictor variables; X_1 is Financial Capacity, X_2 is Energy regulations, X_3 is Business Model and X_4 is Public Policy Awareness.

$Y = 6.764 + 0.133X_1 + 0.635X_2 - 0.492X_3 - 0.136X_4 + \varepsilon$

This means that any unit increase in financial capacity and energy regulations leads to increase in uptake of industrial solar by 0.133 and 0.635 units respectively. Further any unit increase in business model and public policy awareness leads to a decrease in uptake of industrial solar by 0.492 and 0.136 units respectively.

From table 3.9 the significance level corresponding to financial capacity is 0.0174< 0.05. This implies that financial capacity has a significant relationship with uptake of industrial solar. Further the significance level corresponding to energy regulations is 0.0320< 0.05 which means that energy regulations has a significant relationship with uptake of industrial solar. The significance level associated with business model is 0.0462< 0.05 and this indicates that there is a significant relationship between business model and uptake of industrial solar. The research results further indicate that the significance level linked to public policy awareness is 0.0355<0.05 which implies that there exists a significant relationship between public policy awareness and uptake of industrial solar.

5 Conclusions and Recommendations

5.1 Conclusions

The exploration remarks that financial capacity affects uptake of industrial solar. Lack of capital and lack of capacity by some financing institutions and developers were cited as impediments to adoption of solar energy by industries. Another challenge cited was stringent approval requirements by financiers.

The study further concludes that energy regulations affects uptake of industrial solar. Delays, corruption and bureaucracy were cited as challenges in getting permits and approvals. These challenges can hinder growth and uptake of industrial solar.

Concerning effect of business model on uptake of industrial solar, the study concludes that indeed the business model is positively correlated with uptake of industrial solar. The choice of business model was mainly determined by reliability and the investment cost involved.

With regard to public policy awareness on uptake of industrial solar, the study concludes that it has an effect towards uptake of industrial solar. Public policy awareness was largely done by developers according to this study results.

5.2 Recommendations

Net metering is beneficial and can be applied across all the consumers who produce excess Energy especially from the industrial sector. Energy Act of 2019 proposed that consumers who own an electric power generator of capacity not exceeding 1MW may apply to enter into Net Metering system agreement with a distribution licensee or retailer if the consumer has a generation facility located within the area of supply. This will enable industrialists to invest heavily in solar in general to save on rising electricity and at the same time sell excess electricity to the national grid.

Delays and uncertainty experienced during permit application and approval processes should be addressed by making the portal interactive and with strict adherence to timelines. Timeframe for each stage should be well defined and if delays occur, an update of the reasons behind given and a penalty applied if the reasons given are not satisfactory.

Access to capital to install industrial solar system from the participant's perspective is challenging due to high interest rates and stringent loan terms. Therefore, this study recommends financial institutions to offer affordable interest rates to investors in industrial solar with favourable loan application terms.

Despite solar energy use in Kenya growing each day, no reliable data that can be used as reference for future use. Most of solar energy projects have been invested by private sector hence need for central data base for future use and planning that can be easily accessed by other members of the public for proper decision making.

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