INFLUENCE OF SOCIO-TECHNICAL FACTORS ON THE PERFORMANCE OF SOLAR ENERGY INTEGRATION PROGRAMMES: A CASE OF COAST REGION OF KENYA

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DECLARATION

This project is entirely my work and it has not been submitted to any faculty or university for degree considerations

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DEDICATION

I dedicate my study research to my brother Clinton Shilisia Wanjira and am especially grateful for his immense support during my academic journey.

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I would especially like to thank my supervisor, Prof. Harriet Kidombo, for providing me with invaluable support, advice, insight, and encouragement that is helping me in this research proposal. Many thanks to all of my lecturers for their assistance throughout my studies.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABREVIATIONS

IHL – Institutions of Higher Learning

SEI- Solar Energy Integration

IS – Information Systems

TAM - Technology Acceptance Model

EPRA- Energy and Petroleum Regulatory Authority

KEREA- Kenya Renewable Energy Association

IEA- International Energy Agency

ABSTRACT

solar energy integration" refers to the process of seamlessly incorporating solar energy systems into various aspects of energy infrastructure, buildings, and technologies. This involves designing, installing, and optimizing solar panels and related components to generate electricity or heat from sunlight, and effectively integrating this energy into existing power grids, buildings, industrial processes, and transportation systems. This research sought to establish how technical factors like research and development in installation cost improvement and energy storage solutions as well as social factors like consumer awareness, household needs and regulatory framework affected the performance of solar energy integration programs at the coast region. The descriptive research design was used in this investigation. This study's target demographic included businesses and individuals such as firm leaders, sales managers, and sales engineers, as well as a sample of customers in the Coast region who were impacted or impacted by solar energy integration initiatives. Census sampling was employed. The researcher carried out a survey using a questionnaire survey in which respondents read the survey queries and then provided their responses. The researcher conducted a pilot survey with five individuals from the solar energy integration business, whose feedback was critical in developing the final questionnaire that was distributed to participants. The questionnaires were examined by experts in solar industry and from the project management field, with feedback utilized to modify the surveys before mailing them to respondents. Data was analysed by the use of SPSS. The researcher explored how the independent variables i.e. consumer awareness, household needs, research and development, installation costs and technological advancements influenced performance of solar energy integration programs in Coast region. From the findings, all the independent variables greatly affected performance of solar energy integration programs in Coast region. All the variables had positive correlations with installation costs having the highest correlation of 77%. The study recommended that the Coast region county governments should introduce financial incentives such as tax credits, subsidies, and rebates for solar installations. These incentives can make solar energy systems more affordable and attractive to a wider range of individuals and businesses. Another study can be conducted to evaluate the effectiveness of various policies and incentives aimed at promoting solar energy adoption, with a focus on understanding their impact on market growth and technology innovation.

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

Photovoltaics, a technology that utilizes semiconductors generally referred to as solar cells to change the sun's rays into electric power, is used to generate solar energy. According to Scheer (2001), the sun provides significantly more energy in one hour than human life can use in a year. This explains why the sun has an energy potential that is far more than human requirements while being 150 million kilometers away and transmitting only a part of that energy to the Earth. Although most customers believe that the national electrical grid is the most practical way to obtain electricity, Mollie (2014) points out that most legislators and governments around the world are under pressure to focus more on environmentally friendly sources of power, thus the push for clean energy. This is a result of the growing concern about the depletion of petroleum and gas, which supply more than 80% of the world's energy needs.

Due to the fact that solar energy is a free, limitless resource that is present everywhere on Earth, albeit to varying degrees in various regions of the planet, this has led to solar power harvesting becoming an increasingly commercially popular renewable energy source. Contrarily, solar energy is environmentally friendly and has extended cell life expectancies of over 20 years. It also has cheap production costs compared to other renewable energy sources and low operating and maintenance costs. According to Deambi (2011), important members of the European Union, who by 2009 represented over 78% of solar power installation, are at the top of the list for solar PV power installations. Japan, Italy, the United States, Spain, and Germany are the top five solar PV producers globally, according to Prieto (2013). The five nations produce more than 80% of the solar energy used worldwide.

While acknowledging Germany's top ranking worldwide and its control of 69% of the EU energy sector by 2009, Deambi (2011) states that the primary factors contributing to Germany's top ranking are primarily the strong financing options available, widespread public awareness of PV technology, and the tried-and-true FIT scheme. Due to these factors, solar PV installations increased and produced 3.8 GW in 2010, from 1.8 GW in 2009. However, Jordan (2013) notes that Germans are thirty percent more effective than Americans, the Solar PV business in Germany employs around a hundred thousand people compared to 120,000 in the USA, and Germany produces about twice as much solar power as the US.

As per Simelane (2011), just 34% of the population of Africa has access to electricity, making it one of the continents with a significant power shortfall. However, there are many inequalities, particularly between rural-urban areas and also between nations, with countries in Africa frequently suffering from blackouts. In essence, Africa still remains behind many other industrialized continents despite having plenty of potential for renewable sources of energy. Sanoh et al. (2014) estimated that Africa will need to produce 5.2 GW of additional electricity by 2015, which is a 65% increase from the amount required in 2010. Although South Africa and Kenya have the largest deployed solar PV system statistics (11,000 and 3600KWP, respectively), little is known about the utilization of solar energy in Africa. Scholvin (Ed 2015) points out that one of the key obstacles to the widespread use of solar PV systems in South Africa is a lack of adequate storage capacity, although acknowledging the promise of solar PV in South Africa, particularly with the anticipated 5,000MW solar park in Upington by 2020.

According to Bundschuh et al. (2014), one of the key rural power supply efforts that has allowed the installation of more than 13,000 solar photovoltaic (PV) panels over 10,000 km2 in Kwazulu-Natal is the South African government's concessions program for rural solar power systems. However, it's been reported that Egypt plans to construct a 300MW solar power facility by 2020.Shanahan et al. (2013) offer confidence for the solar PV industry in Africa amidst all of these challenges, stating that the sector is growing as a result of the construction of a 15 MW plant in Mauritania, comprehensive plans for a 155 MW in Ghana, and two 50 MW solar farms in South Africa. According to Kempener et al. (2013). However, despite its success, the country has encountered problems with solar PV system quality. Due to their inability to distinguish between high-performing brands and low-performing ones and the fact that the bulk of market customers come from rural regions, this issue has caused a great deal of fear among them.

The failing brands, however, have lately been isolated by the two tests, which has led to their elimination from the market. Paron et al. (2013) note that small photovoltaic systems between 12 and 15Wp, largely composed of amorphous silicon solar cells, are extensively dispersed and even widely utilized, which agrees with Kempener et al. (2013). But as technology has advanced, monocrystalline and polycrystalline silicon have become more and more common. Bundschuh et al. (2014) assert that Kenya has made a significant effort to streamline institutions like KEREA and EPRA as well as the rules regulating solar PV projects. To establish large-scale solar PV system projects, however, like the 600KW Strathmore University project started in 2014, significant capacity expansion is necessary.

1.2 Research Problem:

Access to a reliable and sustainable energy supply is essential for having the necessary resources to support innovative growth and market competitiveness in Kenya's coast region in the current highly competitive and global context. In many homes and institutions, solar energy integration is contributing to this realization, which is dependent on socio-technical factors like consumer awareness, household needs, energy storage options, and installation costs as a result of research and development levels, whether it is competitive in business or education.

The coast region has the authorization needed to participate in this rapidly expanding growth tool of harnessing and exploiting solar in everyday life to preserve a competitive edge thanks to careful planning and awareness measures on socio-technical variables affecting solar energy integration programs.

According to Patwardhan et al. (2012), the worldwide energy consumption rises by 2% year, with a sizable percentage coming from fossil fuels. Given the alarming rise in emissions of greenhouse gases and air pollution from fossil fuels as well as the rapidly depleting fossil fuel resources, this paints a troubling picture. But according to a study by Iarossi (2009), one of the main barriers to economic growth in Kenya is the cost of power. The paper broadly presents the viewpoint that more public investment in energy production is necessary, but it makes no particular recommendations for how the price of electricity may be reduced. Anadon et al. (2013) focused more on the quality issues brought on by inferior amorphous silicon elements that first appeared on retail shelves in the 1990s while attempting to clarify what could be learned from the historical achievements and failures of solar energy integration in Kenya. They neglected to address other factors that might have tipped off the efficacy of solar energy integration initiatives generally in the Coast Region.

The most significant sociotechnical factors influencing the integration of solar energy in the African market, according to Ondraczek (2013), who compared the solar energy markets in Kenya and Tanzania, have more to do with cost-effectiveness, consciousness, and accessibility, leaving out other significant factors like research and development aimed at lowering installation costs and energy storage solutions, as well as meeting household needs and governmental regulations. Similar studies on renewable energy in the energy transition conducted in Kenya by Lay et al. (2013) attempt to shed light on the fuel options made by Kenyan households for lighting. They go on to say that adoption of solar electricity for household illumination is mostly influenced by knowledge and schooling, and financial levels. The relevance of solar energy for the general population, especially those living in rural areas lacking access to the grid, is not acknowledged in this, which gives the impression that operating solar energy integration is a wealthy activity.

Currently, Kenya's installed electricity capacity as of 2021 stood at 2,990 MW, an improvement from 1,800 MW in 2014, but still less for a country with an estimated population of more than fifty million and only one company producing local assets. According to Simiyu, Waita, Musembi, Ogacho, and Aduda (2014), overall Kenyan power amount stands at approximately 1191 MW against need of 1490 MW, which shot up to 2500 MW. Currently, there are more than 100 MW of solar installations, with Garissa Solar being the largest facility with a 55 MW installed capacity. It is astounding that Kenya, which is in the tropics and has a massive 15,000 MW solar energy potential is still far behind in terms of solar uptake.

According to the IEA (2009), only around 55% of urban population and about 1.8% of rural persons really are connected to grid supply. Furthermore, according to Kiplagat (2011), the ongoing droughts that decrease the flow of water in power dams have a significant impact on the market and have led to serious power outages in Kenya. These system losses, which are believed to be around 20%, as well as the market's overreliance on hydropower are the main causes of these shortages. Therefore, this study aimed at identifying the sociotechnical factors influencing the effectiveness of solar energy integration in Kenya's Coast region in order to give fundamental understanding that will support the development of the solar energy industry in the area while supporting the economy with a variety of renewable energy sources. Since solar energy integration is a relatively young business in Kenya and the Coast area, there wasn't a lot of literature on the subject. Contrarily, while considerable study on the key variables, socio-technical factors impacting its performance, notably in the coast region, had not been addressed. This research sought to establish how technical factors like research and development in installation cost improvement and energy storage solutions as well as social factors like consumer awareness, household needs and regulatory framework affected the performance of solar energy integration programs at the coast region.

Research questions

The following research questions guided this study:

1. How does research and development into solar energy storage and installation costs affect its program integration performance in the Coast Region?
2. How does government regulation affect performance of solar energy integration programs in the Coast region?
3. How does consumer awareness affect performance of solar energy integration in the Coast region?
4. How does meshing with household needs affect solar energy integration programs in the Coast region?

1.3 Research Objectives: -The specific objectives were as follows-

- **i.** To assess the influence of consumer awareness on performance of solar energy integration programs in the coast region.
- **ii.** To establish the influence of household needs on the performance of solar energy integration programs in the coast region.
- **iii.** To establish the influence of research and development on performance of solar energy integration programs in the coast region.
- **iv.** To establish the influence of installation costs on performance of solar energy integration programs in the coast region.
- **v.** To assess the influence of technological advancements in energy storage solutions on performance of solar energy integration programs in the coast.

1.4 **VALUE OF THE STUDY**

The study of the influence of sociotechnical factors on the performance of solar energy integration programs in Kenya's coast region has grown in recent years because it has become important in providing insight into solar energy popularity and responses to its integration in which organizations invest a lot of resources. This study adopted this methodology to shed light on how clients of solar energy integration projects have embraced and are using the project, as well as any difficulties or barriers to its utilization. No similar study had been conducted at the University of Nairobi to determine how sociotechnical factors influenced the use of solar energy integration, and none had been conducted on such projects in Kenya's coast region. Sociotechnical aspects are only now becoming an important influencing component in the country's solar energy integration projects, and it was hoped that they were to serve as a foundation for future and further research. The current study examined many areas of livelihood development in Kenya's coast region using solar energy distribution and integration initiatives. The study was significant in the regional context because it identified the strategic trend of the success of solar energy integration initiatives in the coast region to improve livelihoods against the backdrop of independent socio-technical factors such as research and development in improving energy storage solutions and installation costs on the technical side while also focusing on consumer awareness and household needs impact from a social standpoint.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, many key components that decide how sociotechnical aspects affect the effectiveness of solar energy integration initiatives were covered. The performance of SEI in the coastal region was influenced by a variety of social and technological factors, including the regulatory environment created by the government, consumer awareness, household needs, and energy storage and installation procedures. Theories that guided this study and conceptual framework were also highlighted.

2.2 Concept of Solar Energy Integration Programs

Boxwell (2012) describes solar energy as a remarkable concept that uses the sun's beams to illuminate photovoltaic panels in order to produce power. Solar power systems employ pv solar cells, which convert protons from the sun's rays into electricity. This electricity may be used for a variety of things, including lighting, battery charging, smartphone charging, and running other electrical equipment. In contrast, solar thermal systems generate heat energy from sunshine to warm fluids. A number of photovoltaic cells, either stacked in series or parallel, are included in each solar module. Power generation grows along with cell density.

According to Castellano (2010), photovoltaics come in three generations: In the first, a thin film semiconductor deposit, a single layer P-N junction diode with a large area, and semiconductors that do not require the antiquated P-N junction technology to separate photogenerated charge carriers are employed. Devices like polymer solar cells and nanocrystal solar cells are examples of this. However, Carl (2014) emphasizes that there are currently primarily three varieties of panels available: Polycrystalline silicon panels are less effective than monocrystalline silicon cells, with a power return of between 12% and 14%. The least effective panels are made of conventional amorphous silicon, although they are still quite affordable. Monocrystalline silicon modules are the most effective but also the most expensive variety, with a return electrical of between 14% and 18%. Since the energy produced by the solar panels is direct current, it can either be used immediately by devices that can run on this type of current (DC loads) or it can be stored in batteries. However, the voltage of the generated electricity is increased by using an energy inverter to convert the direct current to alternating current. According to Carl (2014), the main advantages of using sunlight, especially for residential use, are that it is a very quiet source of energy, requires little maintenance, boosts a home's value, solar panels have an average lifespan of more than 20 years, saves money, and most importantly, provides clean, renewable energy.

This study aims to investigate the survival theory, commonly known as the idea of adaptation, as it was first put forth by Charles Darwin in 1830. According to Charles' theory of adaptation, all living things must adapt to their surroundings in order to exist or perish. Given this, it is abundantly evident that the existence of the globe is seriously threatened by the global warming, which is mostly linked to the greenhouse gasses produced as a result of fossil fuel emissions, among other things. It is crucial that the globe devises solutions to adapt to the environment by looking for alternative energy sources that do not endanger life on Earth.

2.3 Theoretical framework

The study aimed at investigating Charles Darwin's famous idea of adaptation. According to Charles' theory of adaptation, all living things must adapt to their surroundings in order to exist or perish. Given this, the planet is in grave danger from the effects of global warming, which are mostly ascribed to greenhouse gas emissions from fossil fuels. It is crucial that the globe devises solutions to adapt to the environment by looking for alternative energy sources that do not endanger life on Earth. According to Scheer (2001), some of the sun's energy should be used to power the coastal region's economy because it has a greater power potential than the planet requires. This would not only lessen the severe damage caused by fossil fuel pollution, but it will additionally give the region the power to boost its economy by lowering its crippling poverty rate. Charles Darwin asserted that organisms will eventually perish and go extinct if they fail to adapt to their continuously changing environment. The region must thus make every effort to capture or adapt the sun's abundant energy in order to keep it from facing extinction. However, the regional transition to clean energy, such as solar, is expected to be difficult, given the quasi-institutionalized culture of humans of the major fossil fuel players, who are currently moving forward on a straightforward path created through many years of expenditures on infrastructure and are adamant about protecting their interests by making a difficult transition for renewable energy sources.

2.3.1 Consumer awareness and integration of solar energy programs in the Coast region

Despite the fact that the technology has been available for many years, Diouf (2011) states that solar energy integration innovations are still viewed as a new technology due to a lack of understanding about the use of solar PV systems. Leggett (2014) attributes this to humanity's quasi-institutionalized culture, which is supported by significant utility and fossil energy people to undermine cutting-edge innovations which pose a risk to their businesses by affirming the major energy industries and gas frequently overshadow the voice of renewables, reducing mass awareness, particularly of the advantages that mitigate risk. According to Patwardhan (2012), Kenya had a setback in the 1990s and 2004 due to negative publicity around the proliferation of subpar solar PV panels. This negatively impacted people's perceptions of solar power as a main grid alternative and caused many to lose interest in the sector. However, a large portion of the local population, particularly those who live in rural areas, hold the mistaken belief that solar power is primarily used for drying products, rather than for the generation of electricity that can be stored in the grid, due to poor exposure and lack of awareness of the PV panels' ability to convert sunlight into power generation. Simiyu (2013) points out that many cultures in the nation are accustomed to using modest utilities like firewood to generate heat energy and kerosene to light their homes.

The government should explore providing tax breaks to those who want to start local businesses manufacturing and installing solar energy systems. However, KEREA members have petitioned for the authorities to get involved in the PPA rate review so that it might be increased. Otherwise, investors who are ready to engage in the business will receive a limited return at the present $0.12 per kWh pricing. Additionally, there has been significant pressure for the regulator to embrace net metering, which is anticipated to revolutionize the sector by introducing renewable energy credits, particularly to modest residential users. This will dramatically boost solar energy efficiency. Because many Kenyans, particularly in remote regions, regard solar PV as strange and lack confidence in it to handle the amount of electricity they use in their homes, lamps have contributed to the formation of rural culture.

According to Kenyan energy policies, one of the issues that must be addressed within the framework of efforts and strategies to promote greater utilization of renewable energy sources in Kenya is a lack of awareness about the possibility, potential clients, and economic benefits offered by solar power. According to Hankins (1995), in order to increase the public's understanding of the solar energy integration industry, collaboration between the public and private sectors, which sell supplies and build the infrastructure required for the widespread adoption of solar energy integration systems, should be developed. According to Bhandari (2010), this, together with media marketing, training, and technical help, would significantly raise awareness in the otherwise ground-breaking solar energy integration business.

2.3.2 Household needs and integration of solar energy programs in the Coast region

Solar energy can be used for a variety of purposes in daily life, including power plants, business applications, ventilation systems, swimming pools, solar cars, and more. Overpopulation puts more strain on conventional fuels. Alternative energy is now more important and in demand. Home appliances can use solar power to generate electricity, according to solar energy applications. In the meanwhile, households with operating solar heaters can provide hot water. The primary device is the solar panel that is mounted on the home's roof and uses batteries to store solar energy. Evaluation of a home solar electric system's suitability for your home is the first step in contemplating the usage of solar energy in households. The following four factors should be considered: your home's solar resource availability; the size of your roof to determine whether you can install solar cells on it; your budget; and the local permits and rules.

There is always a chance when using solar energy that the solar panels will produce more electricity than a home actually requires. However, one benefit of solar panels is that they may store excess energy for later use. Due to technological limitations, solar energy has been a novel energy that has been challenging to use for the past ten years. As time goes on, solar-generated electricity becomes more stable and is able to meet everyday home needs. Only 16% of Kenyans, or more than 33 million people, have access to electricity, according to the IEA (2010), which means that only 16% of Kenyans are connected to the grid. According to the IEA (2009), just 1.8% of rural inhabitants have access to grid power, compared to around 55% of urban dwellers.

Wilkins (2010) estimates that seventy percent of Kenya's population lives in rural regions with no or little connection to grid energy. Simiyu (2014) appears to concur with the IEA (2010) that just 15% of Kenyans have access to grid power, meaning that the vast majority do not. According to Bhattacharyya (2012), who cites Abdullah (2011) study, rural communities are more willing to pay more for grid connection than for solar PV deployment and prefer to pay monthly for the units utilized rather than in one lump sum for the installation of a solar PV system.

Despite frequent power outages from the national grid, it appears that most Kenyans, due to a lack of knowledge about the prospective and actual cost of solar photovoltaic (PV) panels, regard the national grid as a more trustworthy source of power and would prefer to pay a premium to access electricity from the grid, regardless of the cost of solar PV power. In reality, it seems that no one ever thinks about using alternative energy sources after a residence has access to grid electricity. Halff (2014), on the other hand, believes that with increased knowledge and support of net metering, the people having access to grid electricity will be more likely to adopt solar PV systems.

2.3.3 Installation costs and integration of solar energy programs in the Coast region

The earth's crust is rich in silicon, a benign substance that is frequently used in the manufacture of solar cells. This shows that not only is it readily available, but also that it is almost endless. Palz (2014). According to Onyeji (2014), recent improvements in solar energy integration technologies have resulted in a substantial drop in the costs involved with the fabrication of solar energy equipment, allowing the area to enjoy affordable pricing on this equipment. According to Ondraczek (2014), it is fairly unexpected that there is a widespread belief in African nations, particularly Kenya, that solar PV power is significantly more expensive than grid generating. This suggests that policymakers may be incorrect in viewing solar power as an expensive venture as opposed to a feasible strategy to diversify electricity sources for growing economies such as the coastal area. The average cost of electricity in grid-connected solar photovoltaic (PV) systems may be much lower compared to that of traditional power stations.

Boxwell, 2012. Observes that solar energy will likely be the least expensive form of electricity generation by 2015 due to the rapidly falling cost of solar power brought on by improving technologies. In a similar vein, Seba (2010) contends that the notion of grid parity is one of the major fallacies in the discussion of solar PV. It is believed that grid equality with current solar technology may be attainable in locations with large insolation and comparatively high grid electricity costs, particularly the tropics surrounding the equator. According to Seba (2010), most defenders of this argument fail to recognize that sunshine has a substantial influence on solar energy costs and that grid equality has been reached in countries such as Hawaii. Deambi

(2011) notes that costly batteries must be developed to store the solar energy generated during the day. As a result, innovative and low-cost technologies are needed to reduce the cost of battery storage, such as super capacitors for electromagnetic storage systems or light-weight electrochemical batteries. The value of solar energy systems has been steadily lowering over time, with BIPV costs falling by fifty percent between the years 2005 and 2010, and other fifty percent expected by 2020 (Deambi, 2011). Crystalline silicon cells' efficiency has also greatly improved, rising from 14.5% in 2004 to 17.5% in 2010, with lots of room for additional development.

2.3.4 Research and development and integration of solar energy programs in the Coast region

The fact that costs are anticipated to continue falling in the near future, fueling the global solar revolution, has been the most optimistic finding in the majority of studies. This is due to improved economies of scale and ongoing advancements in solar technology. In reality, Jacobs (2014) predicts that by 2015, solar power costs in most major cities, involving setup, setting up, and panels, will be equivalent to those of fossil fuels, and by 2025, solar energy costs will be much lower and more cost-effective than fossil fuels. In reality, the sector is excited as a result of Kenya's recent passage of the PPP Act, which permitted FIT with a PPA at $0.12 per kWh for solar energy. Research and development influences installation costs and solar energy storage solutions influencing SEI in the Coast region.

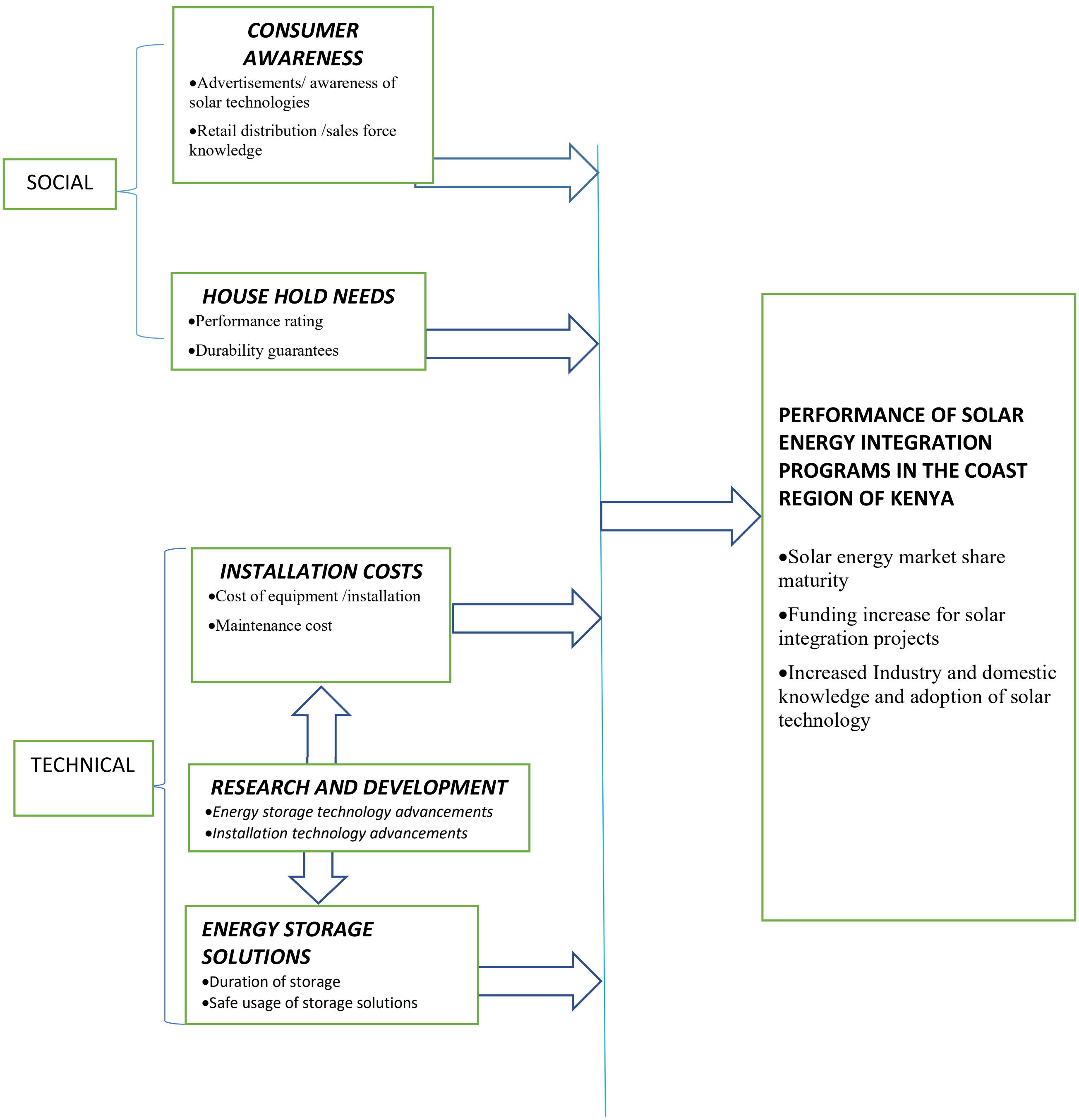
2.3.5 Solar Energy storage solutions and integration of solar energy programs in the Coast region

The potential of solar PV has attracted the attention of entrepreneurs and investors, leading to a rise in investment in the solar PV sector. This is due to advancements in solar energy storage technologies. The lack of a net metering policy in Kenya, on the other hand, tends to discourage small home users, such as inhabitants in the coast region, who could see it as a significant benefit to forego costly batteries for storage in exchange for some credits. According to Akhil (2013), lead-acid batteries are the most conventional and regularly utilized rechargeable electrochemical devices among energy storage systems. According to Akbari (2018), they were developed in 1859 primarily for home usage as well as a variety of commercial purposes, including motor starters. Lead dioxide serves as the cathode and a lead sponge metal anode serves as the anode in this type of battery (Mahlia, 2014). The technology is not only simple to construct but also reasonably affordable when compared to other batteries, has a reasonable life cycle in regulated environments, and has rapid electrochemical reaction kinetics.

It does, however, have some drawbacks associated to its use, including as performance degradation at high temperatures that shorten its lifetime. (2014) Kousksou. Due to its poor energy density, frequent water maintenance requirements, and the presence of ecologically toxic heavy metals, this technology is also inappropriate for a number of applications (Luo, 2015). Some of the technical improvements made possible by the development of lead-acid ultra-batteries are highlighted by Mahlia (2014). This invention is a brand-new continuous partial state of charge hybrid device (Luo, 2015). The gadget is faster, has a deeper charge range, and has the best stability and lifespan for charge/discharge operation. Additionally, it is effective and does not need charging or maintenance cycles. In comparison to typical lead-acid batteries, it has a life cycle that is nearly three times longer, and the process of loading and unloading it takes around 50% longer (Ecoult, 2019).

2.4 Conceptual Framework

This diagrammatic presentation shows the connection between performance of solar energy integration programs in the coastal region, and the independent variables, which include consumer awareness, the regulatory environment, household needs, and research and development that affects storage options and installation costs.



INDEPENDENT VARIABLE DEPENDENT VARIABLE

Figure 1.

2.10 Summary of literature review

The literature study showed that further research was needed to fully understand the factors that influenced the Coast region's solar energy integration projects. Misconceptions about research and development in implementation and storage of energy as well as the regulatory environment for SEI in the Coast area were, in fact, widely held, as the literature study amply demonstrated. On the other side, it was evident that there was a lack of knowledge regarding the potential and ability of solar energy systems to satisfy everyday demands, and more resources need to be devoted to fostering this knowledge and lining up of needs. More study was thus required to identify the essential drivers because no author had claimed that the factors influencing the efficacy of solar energy integration initiatives in the Coast area were fully understood. This is especially true considering the growing interest in renewable energy in Kenya.

Table 1

Objectives	**Variables**	**Type of variable**	**Indicators**	**Method of data collection**	**Data collection tools**	**Data Analysis Technique**
To assess the influence of consumer awareness on performance of solar energy integration programs in the coast region of Kenya	Awareness	Independent	•Advertisements/ awareness of technologies •Retail distribution / sales force knowledge	Administering questionnaires	Questionnaire	Descriptive

To establish the influence of household needs on the performance of solar energy integration programs in the coast region of Kenya	Household needs met by SEI programs	Independent	•Performance rating •Durability guarantees	Administering questionnaires	Questionnaire	Descriptive
To establish the influence of research and development on performance of solar energy integration programs in the coast region of Kenya	Research and Development	Independent	• Energy storage technology advancements • Installation technology advancements	Administering questionnaires	Questionnaire	Descriptive
To assess the influence of technological advancements in energy storage solutions on performance of solar energy integration programs in the coast region of Kenya	Research and Development into solar energy storage solutions	Independent	•Duration of storage •Safe usage of storage solutions	Administering questionnaires	Questionnaire	Descriptive

To establish the influence of installation costs on performance of solar energy integration programs in the coast region of Kenya.	Research and Development into solar energy installation costs improvements	Independent	• Cost of equipment/installation •Maintenance cost	Administering questionnaires	Questionnaire	Descriptive
To evaluate performance of solar energy integration programs in the Coast region of Kenya	Performance of Solar Energy Integration Programs	Dependent	•Solar energy market share maturity •Funding increase for solar integration projects •Increased Industry and domestic knowledge and adoption of solar technology	Administering questionnaires	Questionnaire	Descriptive

CHAPTER THREE
RESEARCH METHODOLOGY

Introduction

The methodology that was used to accomplish the study's goals is presented in this chapter. The topics covered included research design, the target population, sample data gathering tools and techniques, data analysis, and ethical considerations.

3.1 Research Design

The descriptive research design was used in this investigation. According to Kothari (2009), descriptive research design incorporates the use of several types of surveys and fact-finding methodologies. The purpose of descriptive survey research, according to Williamson and Johanson (2017), is to characterize phenomena and the researcher while also attempting to explain how particular behaviors or occurrences take place. However, it can report on recent or ongoing events without having any impact on the variables being examined.

3.2 Target Population

The term "target population" refers to the total group of people, things, or things that share certain traits as determined by the sample criteria used for the study (Stokes & Wall, 2017). This study's target demographic included businesses and individuals such as firm leaders, sales managers, and sales engineers, as well as a sample of customers of the sampled business and organizations in the Coast region who impact or are impacted by solar energy integration initiatives. The sampling frame or source list for this study was obtained from the EPRA website and KNBS Basic Report Kenya Integrated Household Budget Survey ,2015/2016. Because only licensed firms were surveyed using the census approach, this assisted the researcher to obtain credible information.

Table 3.1: Target Population

Groupings	Targeted Population
Solar Energy Contractors in the Coast Region licensed by EPRA	22
Solar Energy Technicians in the Coast Region licensed by EPRA	22
Direct consumers of Solar energy in the Coast Region	83,317
Total	83,361

Source: EPRA website, 2021 and KNBS Basic Report Kenya Integrated Household Budget Survey ,2015/2016

3.3.1 Sample Design

Sampling procedure refers to the process of drawing sample size in a research inquiry (Ogula, 2005). In drawing the 384-sample size, Krejci & Morgan (1970) sampling table was utilized. Purposive sampling is used in situations whereby the researcher may decide to choose research participant based on their potentials to answer specialized questions. According to Krejci and Morgan (1970) table of sample determination, a sample size of 384 was drawn from the population of 6,825. Sample size depends on many factors including type of data analysis and expected return rate. The sample size of 384 was adequate for higher statistical computation like correlational analysis (Alshibly, 2018).

The information was readily available on the EPRA website and KNBS Basic Report Kenya Integrated Household Budget Survey ,2015/2016, which included a complete list and contact details for all registered companies involved with solar integration projects in the Coast region, the number of respondents for this study was not too high and therefore was easily accessible. Respondents included engineers, sales managers, and heads of companies from solar energy integration program organizations in Kenya's Coast region, as well as customers.

Table 3.2: Sample Size.

Category	Sampling Technique	Sample Size
Solar Energy Contractors in the Coast Region licensed by EPRA	Purposive	22
Solar Energy Technicians in the Coast Region licensed by EPRA	Purposive	22
Direct consumers of Solar energy in the Coast Region	Krejcie & Morgan (1970) sampling table	384
Total		**428**

3.3.2 Data Collection

The researcher carried out survey using a questionnaire survey and interview guides in which respondents underwent through the survey queries and then provided their responses. This is especially true when there is a sizable and dispersed population. It is free of biases on the side of the interviewer and allows respondents enough time to reply thoughtfully. It may be straightforward to reach out to difficult-to-reach respondents, and it employs huge samples with ease, boosting the research's credibility and reliability. After emailing out the surveys, the researcher contacted the businesses and the population that was being researched by phone and email for the interview guide and questionnaire respectively.

3.3.3 Piloting the instruments

The researcher carried out a pilot test on the data gathering instruments before employing them. This ensured that the tools were genuine since any loose ends was resolved before the collecting instruments were distributed to respondents. This aided in the removal of ambiguity and unneeded material or questions from the surveys. The questions were reviewed by peers as part of the piloting process. It was critical to ensure that any devices used for factual data collection performed properly before employing them. As stated by Phakiti (2010), after the questionnaire had been piloted, several adjustments were made to fix particular areas that needed attention utilizing the piloting data to boost the questionnaire's accuracy in capturing the relevant information.

3.3.4 Validity of the instruments

According to Mugenda (1999), validity is the accuracy and significance of the inferences made from the study's research findings. Validity is consequently defined as the extent to which findings from data analysis properly depict the subject of the study. The information gathered must be accurate and reasonable. Before mailing the surveys, colleagues and specialists in the research business checked their validity and clarity. The researcher, on the other hand, conducted a pilot survey with five individuals from the solar energy integration business, whose feedback was critical in developing the final questionnaire that was distributed to participants.

3.3.5 Reliability of the instruments

The reliability of tools is an essential component of any inquiry. The results of a study are regarded reliable if they are repeatable using comparable methodologies (Nahid, 2003). Therefore, the questionnaires were examined by experts in solar industry and from the project management field, with feedback being utilized to modify the surveys before mailing them to respondents. This reduced doubt and ensured that elements that were conflicting with the study were removed following peer review.

3.4 Data Analysis

Before being coded for ease of analysis, the data generated by the questionnaire questions must be properly reviewed for completeness, accuracy, and consistency. For this analysis, means were utilized to assess enterprises' and customers' reactions to each of the assessed objectives. The mean is calculated by dividing the total number of items by the frequency with which they appear (Osborn, 2005). Standard deviation was also utilized to analyze the variation in replies offered by each respondent. The square root of the variance is the standard deviation (Black, 2011). Link between the Dependent and Independent variables was investigated using a multiple regression model as indicated beneath.

$Y_1=a + b_1X_1 + \varepsilon$: influence of consumer awareness on SEI programs in the Coast region

$Y_2=a + b_2X_2 + \varepsilon$: influence of household needs on SEI programs in the Coast region

$Y_3=a + b_3X_3 + \varepsilon$: influence of research and development in solar energy storage solutions on SEI programs in the Coast region

$Y_4 = a + b_4X_4 + \varepsilon$: influence of installation costs in installation costs on SEI programs in the Coast region

Data was analyzed using SPSS for computation and mining the data this is due to its ability to perform many complex statistical tests and easy interpretation of result is relatively easy.

3.4.1 Significance Tests

Non-parametric test for inferential statistics was conducted and thus analysis of variance was used to analyze variance and test overall significance at 95%. Correlation Coefficient (r) governed the degree of connection between the research variables while R^2 indicated independent variable percentage both combined and individually in elaborating dependent variable changes

CHAPTER FOUR
DATA ANALYSIS, PRESENTATION, DISCUSSIONS AND INTERPRETATION OF THE FINDINGS

4.1 Introduction

The study results are presented throughout the chapter as tables, which are subsequently interpreted. The information was arranged in accordance with the objectives stated in Chapter One. The presentation followed the questionnaire's question order and was arranged chronologically.

4.2 Questionnaire return rate

The proper responders in the Coast region were given the questionnaires. according to Table 4.1 From the distributed surveys, 372 were properly returned, or 87 percent. This return rate was high because the researcher personally called every member of the studied community to ask them to complete the surveys and return them.

Table 4.1 Response Rate

Category	Frequency	Percentage
Returned	372	87
Not returned	56	13
Total	**428**	**100**

4.2 Reliability Results

The Cronbach Alpha Coefficients were calculated by the researcher using the completed questionnaire. Table 4.2 shows the results that were determined and summarized.

Table 4.2: Reliability Results

	No. of Items	Cronbach Alpha Coefficient
Consumer awareness	5	.843
Household needs	5	.881
Research and development	2	.863
Technological advancements	4	.763
Installation costs	4	.713
Performance of SEI Programs	6	.837

Table 4.1 shows that all of the variables had Cronbach Alpha Coefficients over 0.7, demonstrating the reliability of the scale used in the questionnaire's design. The overall internal consistency and reliability of the questionnaire questions varied across several variables. Research and development, consumer awareness, household requirements, and SEI program success all have quite high Cronbach Alpha coefficients, which indicate great internal consistency. Technology improvements and installation costs, for example, have significantly lower coefficients than other constructs, implying a little lower level of consistency but still adequate reliability. This is consistent with Yin's (2017) advice to use a reliability threshold of 0.7 or higher.

4.3 Demographic characteristics of respondents

In order to assess the respondents' personalities in relation to how well they understood the veracity and dependability of the information they supplied, the research collected personal information about the people who participated. The researcher was interested in learning more about the respondents' age, education level, gender, time spent working in the energy sector, and job title.

4.3.1 Age of the respondents.

Age-related groups of individuals were asked to fill in their ages. This is crucial since it made it possible for the study's investigator to establish if the respondents were evenly dispersed.

Table 4.3: Distribution of respondents by age

Age	Frequency	Percent
20-29	67	18
30-39	137	36.8
40-50	123	33
Above 50	45	12.2
Total	372	100

The age distribution of the participants shown by the data analysis to be varied. The age group of 30 to 39 years represented the majority of those surveyed, accounting for 36.8% of the total. The majority of those involved appear to be in this age bracket.

Additionally, 33% of the people who responded were participants between the ages of 40 and 50, demonstrating a sizable presence in the study. About 18% of participants were between the ages of 20 and 29, which indicates a somewhat lower representation compared to the other two age groups. Finally, 12.2% of the total respondents were beyond the age of 50. This group doesn't seem to have as many participants as the others. The distribution of participants across different age groups sheds light on the demographics of the study's respondents and raises the possibility that age-related variables like experience, viewpoint, and life stage might affect how respondents answer.

4.3.2 Gender of the respondents

The gender of the subjects was considered in the study. This was required to calculate the ratio of male to female participants. This insight on the significance of gender balance was crucial. A table showing replies by gender is shown.

Table 4.4: Distribution of respondents by gender

Gender	Frequency	Percentage (%)
Female	138	37
Male	234	63
Total	372	100.0

The table shows that 37% of respondents were women and 63% of respondents were men. This demonstrates that survey participants of both genders took part. Gender has an impact on how people perceive their surroundings in social and biological ways. Men and women view the world and their lives from different angles. The researcher was better able to comprehend how gender differences affected the respondents' responses to the questions by knowing the respondents' gender. In summary, the survey on gender representation in solar energy research has shed important light on the current state of the discipline. The results show a significant gender gap among participants, with more men responding than women, which is in stark contrast to the findings.

While the precise reasons behind this gender imbalance are not fully explored within the scope of this survey, potential factors could include historical gender biases in STEM fields, lack of female role models, and societal expectations. It is essential to acknowledge that this skewed representation may lead to a lack of diverse perspectives and hinder the holistic advancement of solar energy research.

4.3.3 Time Duration.

Respondents were asked to choose the appropriate category based on the cumulative years of experience as consumers or facilitators of solar energy.

Table 4.5: Time duration

	Frequency	Percent
Less than a year	167	44.8
1-5 years	122	32.8
More than 5years	83	22.4
Total	372	100

Table 4.5 shows that the time length analysis reveals a wide variety of expertise levels in regard to solar energy among the respondents. 44.8% of the respondents, or a sizable number, stated that they had less than a year's worth of solar energy experience. This might indicate a high rate of turnover or a sudden rise in interest in the industry. This may be linked to elements like rising environmental consciousness and regulatory incentives that have encouraged people to

investigate solar energy options. 32.8% of those polled said they have experience with solar energy ranging from 1 to 5 years. This mid-range group represents a cohort that has over the course of a few years acquired some practical exposure to and knowledge of solar energy systems. This group may include those who have transitioned from being novices to becoming more informed and possibly active participants in the solar energy domain. About 22.4% of the respondents claimed to possess more than 5 years of experience in solar energy. This group likely includes seasoned professionals, experts, and enthusiasts who have been engaged with solar energy for a substantial period. Their extensive experience could contribute to a deeper understanding of the field's intricacies and a more nuanced perspective on its challenges and opportunities.

These findings underscore the dynamic nature of the solar energy sector, with a diverse range of experience levels represented among the respondents. The distribution across different time categories signifies both the growing interest in renewable energy solutions and the presence of a core group of individuals who have sustained their involvement over an extended period.

4.3.4 Designation.

Respondents were asked to indicate which position or specific role they hold in the solar energy industry.

Table 4.6: Position

Category	Frequency	Percent
Contractors	16	4.3
Technicians	20	5.3
Energy consumers	336	90.4
Total	372	100

The following conclusions on the distribution of designations may be inferred from the analysis of respondents' positions or particular tasks within the solar energy sector, as shown in Table 4.6: An overwhelming majority of respondents—90.4%—identified as energy users in the solar energy sector.This shows that a sizable majority of individuals polled primarily function as solar energy system end users, using them for domestic, commercial, or industrial uses.The large number of energy users highlights the expanding use of solar energy solutions across a range of industries as people and organizations look to harness renewable sources for their energy requirements.5.3% of those surveyed said that they were technicians. This group probably consists of experts who are in charge of installing, maintaining, and troubleshooting solar energy installations. The presence of technicians in the survey indicates the importance of skilled technical personnel in ensuring the efficient operation and longevity of solar energy infrastructure.

A smaller proportion, comprising 4.3%, identified themselves as contractors. This category likely includes individuals or companies that provide specialized services related to solar energy project development, construction, or installation. Contractors play a crucial role in translating solar energy concepts into practical implementations, making their contribution vital to the growth of the industry.

The dominance of energy consumers among the respondents underscores the significance of catering to their needs and preferences in the solar energy sector. Moreover, the presence of technicians and contractors highlights the multidisciplinary nature of the industry, where technical expertise and project management skills are essential for the successful deployment of solar energy solutions.

4.4 Performance of solar energy integration programs in Coast region

Those who participated were asked to rank how closely the ideas in Table 4.7 correspond to the effectiveness of the plans for integrating solar energy in the Coast area.

Table: 4.7: Performance of solar energy integration programs

STATEMENTS	5	4	3	2	1	Mean	SD
There is increased Solar energy market share maturity.	23.7%	33.6%	14.7%	17.7%	10.3%	3.53	0.712
There is increased number of industries adopting solar energy integration.	20.3%	35%	15%	17.3%	12.4%	3.66	0.771
There is increased NGO funding for solar integration projects.	25.6%	38.3%	11.3%	14.1	10.7%	3.84	0.744
There is increased number of inquiries on solar installation.	24%	42%	15.3%	10.4%	8.3%	4.1	0.736
There is increased industry and domestic knowledge on solar energy.	20%	38.4%	15.3%	16%	10.3%	3.61	0.746
There is increased government funding of solar assisted social programs like schools and community income projects	10%	16%	15.3%	38.4%	20.3%	2.31	0.706
Composite mean						3.50	0.740

N=372

The following conclusions about various assertions about solar energy integration may be inferred from the examination of respondents' assessments of the effectiveness of solar energy integration initiatives, as shown in Table 4.7: First, a statement concerning the rising maturity of the solar energy market share was given to the responders. According to the replies, 10.3% highly disagree (rating 1), 17.7% disagree (rating 2), 23.7% strongly agree (rating 5), 33.6% agree (rating 4), 14.7% are neutral (rating 3), and 10.3% dissent (rating 2). The average response was 3.53, indicating that most people generally agreed with this statement.

On increased number of industries adopting Solar Energy Integration: The responses for this statement show that 20.3% strongly agree (rating 5), 35% agree (rating 4), 15% are neutral (rating 3), 17.3% disagree (rating 2), and 12.4% strongly disagree (rating 1). The mean rating for this statement is 3.66, indicating a slightly stronger agreement for the construct. On whether there was increased NGO funding for solar integration projects, respondents' ratings for this statement were as follows: 25.6% strongly agreed (rating 5), 38.3% agreed (rating 4), 11.3% are neutral (rating 3), 14.1% disagreed (rating 2), and 10.7% strongly disagreed (rating 1). The mean rating for this statement was 3.84, suggesting a relatively strong agreement regarding increased NGO funding for solar integration projects. On whether there was increased number of inquiries on Solar installation: The responses show that 24% strongly agreed (rating 5), 42%

agreed (rating 4), 15.3% are neutral (rating 3), 10.4% disagreed (rating 2), and 8.3% strongly disagreed (rating 1). The mean rating for this statement is 4.1, indicating a strong agreement with the idea of an increased number of inquiries on solar installation.

On increased industry and domestic knowledge on solar energy: Respondents' ratings for this statement were as follows: 20% strongly agreed (rating 5), 38.4% agreed (rating 4), 15.3% are neutral (rating 3), 16% disagreed (rating 2), and 10.3% strongly disagreed (rating 1). The mean rating for this statement is 3.61, suggesting a moderate level of agreement.

Lastly, on whether there was increased government funding of solar assisted social programs: 10% strongly agreed (rating 5), 16% agreed (rating 4), 15.3% are neutral (rating 3), 38.4% disagreed (rating 2), and 20.3% strongly disagreed (rating 1). The mean rating for this statement is 2.31, indicating a stronger disagreement with the idea of increased government funding for solar-assisted social programs.

In conclusion, respondents generally express agreement or moderate agreement with statements related to the positive outcomes of solar energy integration programs. These outcomes include increased market share maturity, adoption by industries, NGO funding, inquiries on solar installation, and knowledge improvement. However, there is stronger disagreement with the idea of increased government funding for solar-assisted social programs. The composite mean reflects a moderate level of agreement on these statements collectively.

4.6 Consumer awareness and Performance of solar energy integration programs in Coast region

Investigating how consumer knowledge affects the effectiveness of solar energy integration projects in the Coast area was the goal of this aim. The responses evaluated how well the claims about consumer awareness matched the effectiveness of solar energy integration projects in the Coast area.

Table 4.7: Consumer awareness

STATEMENTS	5	4	3	2	1	Mean	Std. Dev.
There is effective advertisement of solar energy	26.7%	37.6%	13.4%	15.7%	6.6%	3.82	0.767
There is increased retail distribution of solar merchandise	20%	35%	18%	17.3%	9.7%	3.43	0.751
There is increased awareness of solar technologies.	14.1%	24.3%	23.3%	20.3%	18%	2.98	0.745
There is increased sales force knowledge on solar energy	24%	35%	14%	17.3%	9.7%	3.63	0.781
There are increased number of skilled solar installers.	17.7%	30.3%	15.3%	22.7%	14%	3.01	0.701
Composite/Average mean						3.37	0.749

N=372

The results are presented in Table 4.7. Regarding the promotion of solar energy, 26.7% of respondents highly agreed (rating 5), 37.6% of respondents agreed (rating 4), 13.4% are indifferent (rating 3), 15.7% disagreed (rating 2), and 6.6% strongly disagreed (rating 1). The average score for this claim was 3.82, showing a fair amount of agreement that solar energy is effectively promoted in the Coast area. Second, when asked if there was an increase in the retail distribution of solar products, the respondents gave the following responses: 20% highly agreed (rating 5), 35% agreed (rating 4), 18% are neutral (rating 3), 17.3% disagreed (rating 2), and 9.7% strongly disagreed (rating 1). The average score for this claim was 3.43, showing a modest level of agreement that the Coast area is seeing an increase in the retail distribution of solar goods. On whether there was increased awareness of solar technologies, the mean rating for the statement was 2.98, reflecting a slightly lower level of agreement among respondents. averagely 38.4% of respondents combined percentage of those who strongly agree and agree feel that there is increased awareness of solar technologies. The fourth construct sought to investigate whether there was increased sales force knowledge on solar energy, 24% of respondents strongly agree that there is increased sales force knowledge on solar energy, while 35% agree. 31.3% of respondents have neutral (3) opinions, and 26% disagree to some extent. The mean rating of 3.63 suggests a moderate level of agreement among respondents. Lastly, the last construct sought to investigate whether there was increased number of skilled solar installers: 17.7% of respondents strongly agree that there are an increased number of skilled solar installers, while 30.3% agree. 37.3% of respondents have neutral (3) opinions, and 36.7% disagree to some extent. The mean rating of 3.01 suggests that respondents were not so sure whether there were increased number of solar installers.

The overall average mean across all constructs is 3.37, indicating a moderate level of agreement on average among respondents regarding consumer awareness and program performance.

The standard deviation of 0.749 suggests that there is some variability in respondents' perceptions across the different constructs.

4.6.2 Correlation between Consumer awareness and Performance of solar energy integration programs in Coast region

The Pearson Moment correlation coefficient, which gauges the strength of the link between two variables, was used to investigate the relationship between consumer awareness and the effectiveness of solar energy integration projects in the Coast area.

Table 4.7.1 Correlation for Consumer awareness and Performance of solar energy integration programs in Coast region

		Performance of solar energy integration programs in Coast region
Consumer awareness	Pearson Correlation	.662**
	Sig. (2-tailed)	.000
	N	372

**Correlation is significant at 0.01 level (2 tailed) r = 0.662, N = 372, P<.01

From Table 4.7.1, The correlation coefficient of 0.662 suggests a strong positive correlation between consumer awareness and solar energy performance in Coast region. This means that as the effectiveness of consumer awareness improves, the performance of solar energy integration programs in Coast region tends to improve as well. The significance level being less than 0.01 indicates that this relationship is highly unlikely to be due to random chance. Many studies have explored the relationship between consumer awareness and solar energy uptake. For example, Heiskanen and Matschoss (2017) concentrated on deploying renewable energy technologies (RETs) in residential buildings to attain net-zero-carbon buildings in

Europe. Consumer awareness had a significant influence on families' readiness to participate in large-scale RETs, according to the study. Li et al. (2020) studied Australia's transition to renewable energy. According to the authors, Australia aggressively employs renewable energy resources, which benefit the environment (due to fewer carbon emissions). Australia is fulfilling 6% of its energy consumption with renewables because to strong government policies, public-private partnerships, increased consumer awareness, waste-to-energy integration, and geothermal energy utilization.

This conclusion is also consistent with the findings of other research, for example. Mosly and Makki (2018) investigated the societal propensity to embrace renewable energy technologies (RETs). They discovered that as one's degree of schooling rises, so does one's awareness of RETs. Similarly, age and economic circumstances are important factors in the use of sustainable solar energy. Yuan et al. (2015) carried out a questionnaire study in China's Shandong region to assess social acceptability of wind power. The survey findings indicated that locals support wind energy due to improved understanding of the benefits of solar energy. However, their level of acceptability for acts such as building wind turbines in their backyards or tolerating higher power rates declines. Low willingness impedes solar energy penetration and limits achievement of national objectives, emphasizing the importance of customer willingness in solar energy deployment.

4.6.3 Regression Analysis for Consumer awareness and Performance of solar energy integration programs in Coast region

The study employed a coefficient of determination (R2) using regression analysis to ascertain if consumer awareness was an important indicator of performance of solar energy integration initiatives in the Coast area.

Table 4.7.2 Regression analysis for Consumer awareness and Performance of solar energy integration programs in Coast region

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.662[a]	.654	.611	.565

Predictors: (*Constant*), consumer awareness, Dependent variable: Performance of solar energy integration programs in Coast region

Based on Table 4.7.2 R has a value of 0.662. This shows a significant positive association between consumer knowledge of solar energy integration projects and their effectiveness in the Coast area. The R Square value is 0.654, which indicates that a variance in consumer knowledge may account for around 65.4% of the variation in how well solar energy integration projects function in the Coast area. This suggests a significant level of effect. Relative R Square: R Square after adjustment is 0.611. This number changes the R Square to consider the number of predictors in the model. It offers a more precise assessment of how well the model fits the data while taking complexity into account.

An ANOVA test was also carried out to see if consumer awareness was a significant predictor of the effectiveness of solar energy integration projects in the Coast area. Table 4.7.3 presents a summary of the findings.

Table 4.7.3 ANOVA of Consumer awareness and Performance of solar energy integration programs in Coast region

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	100.887	1	100.887	122.625	.000[b]
	Residual	132.545	102	.734		
	Total	233.432	372			

a. Dependent Variable: Performance of solar energy integration programs in Coast region

b. Predictors: (Constant), Consumer awareness

It is clear from Table 4.10 that consumer awareness affects the effectiveness of solar energy integration projects in the Coast area and is therefore a significant predictor (F (1, 102) =122.625, P .05. The regression model's associated squares total 100. 887.This is a representation of how the predictor, consumer awareness, explains variation in the dependent variable, solar energy performance.

According to the ANOVA results, consumer awareness is a substantial predictor of how well solar energy integration initiatives function in the Coast area. The extremely low p-value (p .000) indicates that it is highly improbable that the impact of customer knowledge on solar energy performance is the result of chance. This confirms past findings that the county's solar energy performance is strongly positively correlated with customer awareness.

4.7 Household needs and Performance of solar energy integration programs in Coast region

The purpose of the study was to examine if the success of solar energy integration initiatives in the Coast area is affected by the household demands of the county. Five assertions of view on the requirements of households in the Coast region are summarized in Table 4.11. The measure ranged from strongly agree (5) to strongly disagree (1) on a scale of five..

Table 4.8: Household needs and **Performance of solar energy integration programs in Coast region**

STATEMENTS	5	4	3	2	1	Mean	Std Dev
There are reliable warranties for solar energy uptake	27.7%	40.6%	10.4%	12.7%	8.6%	4.35	0.887
Solar energy performs efficiently to client's needs.	15%	16%	20%	31.3%	18.7%	2.43	0.732
Solar energy lasts for long durations.	17.1%	33.3%	14.3%	22.3%	12%	3.64	0.692
The solar energy lighting is of high quality.	25.7%	30.3%	16.3%	15.7%	12%	3.91	0.687
Composite/average mean						**3.58**	**0.749**

N=372

The demands of households and the effectiveness of solar energy integration initiatives in the Coast area are the main topics of this section. Regarding the existence of credible guarantees for solar energy uptake, 27.7% highly concur, 40.6% agree, 10.4% are indifferent, 12.7% disagree, and 8.6% severely disagree. The average rating for this claim is 4.35, showing a strong degree of agreement that trustworthy warranties are offered for the use of solar energy. Although the standard deviation of 0.887 indicates considerable variation in viewpoints, the attitude is usually in favor of agreement. On the question of whether solar energy meets customers' demands efficiently, 15% strongly agree, 16% agree, 20% are neutral, 31.3% disagree, and 18.7% strongly disagree. The mean rating for this statement is 2.43, indicating a mixed sentiment. On average, respondents are leaning towards disagreement about the efficiency of solar energy meeting clients' needs. The standard deviation of 0.732 suggests a notable amount of variability in responses. On whether Solar energy lasts for long durations, 17.1% strongly agree that solar energy lasts for long durations,

33.3% agree, 14.3% are neutral, 22.3% disagree and 12% strongly disagree. The mean rating for this statement is 3.64, suggesting a moderate level of agreement that solar energy lasts for long durations. The standard deviation of 0.692 indicates relatively consistent opinions around the mean. Lastly, on whether the solar energy lighting is of high quality, 25.7% strongly agree that solar energy lighting is of high quality, 30.3% agree, 16.3% are neutral, 15.7% disagree and 12% strongly disagree. The mean rating for this statement is 3.91, suggesting a relatively high level of agreement that solar energy lighting is of high quality.

The composite/average mean of 3.58 indicates a moderately positive overall perception of the influence of household needs on the integration of solar energy in Coast region.

4.7.2 Correlation for Household needs and Performance of solar energy integration programs in Coast region

In order to determine the scores for the success of solar energy integration initiatives in the Coast area as a dependent variable and household requirements as an independent variable, correlation analysis was utilized.

Table 4.8.1: Correlation for Household needs and Performance of solar energy integration programs in Coast region

		Performance of solar energy integration programs in Coast region
Household needs	Pearson Correlation	.662**
	Sig. (2-tailed)	.000
	N	372

**Correlation is significant at the 0.01 level (2-tailed). r = 0.662, N = 372, P<.01

The success of solar energy integration initiatives in the Coast area is positively correlated with household demands, according to the Pearson correlation coefficient of 0.662. The statistical significance of this link (p .01) indicates that it is statistically significant and unlikely to have happened by coincidence.

This finding is consistent with the findings of other studies on the impact of household requirements. Gichui (2016), for example, undertook a research to estimate the level of solar energy utilization in Kenya's Kiambu County. Researchers used a descriptive survey approach. The researchers next examined the collected data qualitatively and quantitatively. This increased our understanding of the factors influencing solar energy adoption, such as the role of family demands and money to the acceptability of solar energy consumption. The findings indicate that individuals in Kiambu County have accepted solar energy technology to a significant level, which might be attributed to greater understanding as well as rising household needs that would never be met by limited power. The amount of persons who had installed solar energy systems in their houses, saw solar lamps or solar power in operation, were aware of solar technology producers, and had received some informal training affected the level of adoption of the technology.

The findings are similarly consistent to another study done by William Philip Wall 1(2021) to evaluate the factors influencing renewable energy uptake in Thailand. An sophisticated theory of planned behavior was applied in the study. To acquire primary data, the researcher used a quantitative study approach and performed a survey of customers in five major Thai cities. According to the results and conclusions drawn from the research, consumers' perceptions of solar energy efficacy, durability, environmentally friendly energy knowledge, environmental concern, and attitudes toward its benefits impact their intent to use it favorably and significantly. Consumers' adoption of renewable energy sources was shown to be favorably impacted, but not significantly, by risk or trust perception, whereas the cost of renewable energy sources was found to be negatively but non-significantly influenced.

According to Mwihaki (2021), households may need to look for alternate energy sources to satisfy these expectations when their energy needs rise as a result of variables including expanding families, more technological gadgets, and greater energy consumption habits.
Solar energy systems act as a supplement and sustainable source of electricity, bridging the gap between rising energy demands and the capacity of the current grid. Energy costs grow along with residential energy requirements. By using the sun to generate power, solar energy offers a means to mitigate these rising costs and lessen dependency on pricey grid electricity.

4.7.3 Regression analysis for Household needs and performance of solar energy integration programs in Coast region

The study used a coefficient of determination (R2) with regression analysis to determine the degree of impact caused by household needs and performance of solar energy integration programs in the Coast region and whether household needs was an important predictor of performance of solar energy integration programs in the Coast region.

Table 4.8.2 Regression analysis for Household needs and Performance of solar energy integration programs in Coast region

Model Summary

Model	R	R Square	Adjusted R Square	Std.Error of the Estimate
1	.662[a]	.601	.582	.435

a. Predictors: (Constant), Household needs

The R value in Table 4.8.2 is 0.662, indicating that household demands have a significant impact on how well solar energy integration initiatives function in the Coast area. The R Square value is 0.601, meaning that household demands may account for around 60.1% of the variation in how well solar energy integration projects function in the Coast area.

This indicates that the performance of solar energy is significantly influenced by household demands, and the model is able to explain a sizable amount of the observed variability.

The complexity of the model, including the number of predictors, is considered by the adjusted R Square value of 0.582. It is marginally inferior to the R Square.

This number demonstrates that the impact of household demands on solar energy performance is still statistically significant even when the model's complexity is considered. The results of the regression analysis demonstrate a significant correlation between household demands and the effectiveness of solar energy integration projects in the Coast area.

Additionally, an ANOVA test was conducted to determine whether household demands in the Coast region were a significant predictor of the success of solar energy integration initiatives.

Table 4.8.3 ANOVA of Household needs and Performance of solar energy integration programs in Coast region

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	81.194	1	81.194	101.141	.000[b]
	Residual	152.238	102	.682		
	Total	233.432	372			

a. Dependent Variable: Performance of solar energy integration programs in Coast region

b. Predictors: (Constant), Household needs

It is evident from Table 4.8.3 that household demands impact the effectiveness of solar energy integration initiatives in the Coast region and are therefore a significant predictor [F (1, 102) = 101.141, P.05]. The variance in the dependent variable (Solar energy performance) explained by the predictor (Household demands) is shown by the sum of squares for the regression (81.194).

The residual's sum of squares (101.141) reflects the variability that the model is unable to explain. The predictor "Household needs" considerably contributes to explaining the difference in solar energy performance, according to the low p-value (p .000).

4.8 Influence of research and development on Performance of solar energy integration programs in Coast region

The study sought to investigate how research and development influences performance of solar energy integration programs in Coast region.

Table 4.9: Research and development and Performance of solar energy integration programs in Coast region

STATEMENTS	5	4	3	2	1	Mean	Std. Dev.
More research into solar energy has led to more efficient and aesthetic solar energy designs.	21.7%	38.6%	12.4%	16.7%	10.6%	3.71	0.725
There is improved product customization for the African market due to research and development	33%	37%	10%	13.3%	6.7%	4.11	0.801
Composite/Average mean						**3.91**	**0.752**

N=372

Research and development (R&D) activities and the effectiveness of solar energy integration projects in the Coast area are covered in Table 4.9, which is supplied. More people highly agree (21.7%), agree (38.6%), agree (12.4%), disagree (16.7%), and strongly disagree (10.6%) with the statement that research into solar energy has resulted in more efficient and attractive solar energy systems. The average response was 3.71, suggesting that respondents generally concur with the notion that advances in solar energy research have resulted in more attractive and functional solar energy designs. The replies appear to be rather consistent and are not widely dispersed around the mean, according to the comparatively low standard deviation of 0.725. Research and development have increased product customization for the African market, according to 33% of respondents who strongly agree with the statement, 37% of respondents who agree with it, 10% of respondents who are neutral on the matter, 13.3% of respondents who disagree with it, and 6.7% of respondents who severely disagree. The average grade for this claim is 4.11, showing a fair amount of agreement that increased product customization for the African market has resulted from research and development activities. The standard deviation of 0.801 indicates that this statement's replies have a little bit more variation than the first statement's responses. The estimated average of the mean scores from both statements yields a composite average mean of 3.91. This suggests that, on average, respondents agree with the positive impact of research and development on solar energy integration programs in the Coast region.

4.8.2 Correlation for Research and development and Performance of solar energy integration programs in Coast region

Correlation analysis was used to determine the scores for research and development as an independent variable and the performance of solar energy integration programs in the Coast region as a dependent variable in order to examine the relationship between these two variables. Table 4.16 demonstrates this connection.

Table 4.9.1: Correlation for Research and development and Performance of solar energy integration programs in Coast region

		Performance of solar energy integration programs in Coast region
Research and development	Pearson Correlation	.622**
	Sig. (2-tailed)	.001
	N	372

**Correlation is significant at the 0.002 level (2-tailed). r = 0.622, N = 372, P<.01

According to Table 4.9.1, there was a significant positive correlation between the success of solar energy integration initiatives in the Coast area and research and development (r=.622 N=372 p.01). A high value of 0.622 for the Pearson correlation coefficient (r) may be seen. This suggests a substantial positive association between solar energy performance and research and development. The correlation coefficient's related significance level (p-value) is.001, which is less than 0.01. This suggests that there is strong statistical significance. The findings of the correlation study show a strong and favorable link between the success of the Coast region's solar energy integration initiatives and the research and development activities. The significant correlation value indicates a close connection between research and development methods and solar energy output. This finding implies that the quality and effectiveness of research and development processes may have a direct impact on the performance of solar energy.

These findings are consistent with a research conducted by Bilal Khalid (2021) on the factors affecting technology adoption considering its importance for conserving the environment. The study was mostly quantitative, with primary data collected from 467 Polish families who employ renewable energy sources. The TAM model hypothesis was applied in the investigation. The study finds that using renewable energy is essential for maintaining the environment through minimizing global warming and, therefore, climate change. When compared to other energy sources, the expansion of research and development activities positively impacts the uptake and use of solar renewable energy. This study showed that increased research has a significant and advantageous impact on Poland's adoption of renewable energy. It also aligns with Patrick's (2021) research, which looked at current green energy plans and projects with the goal of assessing energy output and consumption in Oman. The vast majority of the data for the study came from government, academic, and international sources. According to the research findings, Oman has only produced renewable energy from solar sources since 2017, with alternate sources not being effectively researched or exploited. Furthermore, the country has stated that it has high aspirations for producing renewable energy, which has resulted in investments in offshore wind farms, solar farms, and biogas energy projects around the country totaling many megawatts (MW). Due to tremendous investment in research and development, all of these goals have been achieved.

Ntsoane (2017) claims that research and development in solar energy has led to continued attempts to improve the effectiveness, accessibility, and sustainability of solar technology. This covers investigation into novel materials, enhanced production techniques, and cutting-edge system architectures. Next-generation solar panels, such as thin-film, organic, and perovskite solar cells, are the subject of research because they have the potential to be more efficient and affordable than conventional silicon-based cells. Energy storage options, such as cutting-edge batteries, are another key area of R&D that has greatly advanced since they support solar energy systems by supplying electricity at night and during overcast conditions. As part of research and development efforts to maximize the use of solar electricity, new developments in solar tracking systems, smart grid integration, and grid management technologies are being made.

4.8.3 Regression analysis for Research and development and Performance of solar energy integration programs in Coast region

The study employed a coefficient of determination (R2) using regression analysis to determine the degree of effect of research and development and if it is a significant predictor of success of solar energy integration initiatives in Coast area.

Table 4.9.2 Regression analysis for Research and development and Performance of solar energy integration programs in Coast region

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.622[a]	.552	.503	.463

a. Predictors: (Constant), Research and development

Table 4.9.2's R value of.622 indicates that research and development has a significant positive impact on the effectiveness of solar energy integration initiatives in the Coast area. R2 indicates.552 on the variance in Coast area solar energy integration program performance brought on by R&D.0.552 is the R Square value. This number reflects the percentage of variation in the independent variable (research and development) that can be accounted for by variation in the dependent variable (solar energy performance). 0.503 is the corrected R Square value. This number changes the R Square to consider the number of predictors in the model. It offers a more precise assessment of how well the model fits the data while taking complexity into account.

An ANOVA test was also done to ascertain whether research and development was a significant predictor of performance of solar energy integration programs in Coast region.

Table 4.9.3 ANOVA of Research and development and Performance of solar energy integration programs in Coast region

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	122.21	1	122.21	123.372	.000[b]
	Residual	111.222	102	.689		
	Total	233.432	372			

a. Dependent Variable: Performance of solar energy integration programs in Coast region

b. Predictors: (Constant), Research and development

From Table 4.9.3 where [F (1, 102) = 103.133, P<.05] it is evident that research and development influences performance of solar energy integration programs in Coast region and thus a significant predictor.

4.9 Installation costs and Performance of solar energy integration programs in Coast region

To ascertain its impact on the effectiveness of solar energy integration initiatives in the Coast area, four installation cost opinion statements were used, with a five-point scale ranging from strongly agree (5) to strongly disagree (1).

STATEMENTS	5	4	3	2	1	Mean	Std. Dev.
The cost of additional components such as wiring, connectors, mounting structures is affordable.	25.6%	36.7%	14.4%	14.6%	10.7%	3.72	0.687
The expenses associated with labor, installation, and setup of solar panels and related equipment are cheaper.	27%	35%	10%	17.3%	10.7%	3.60	0.701
The cost of the solar panels, inverters, batteries, and other hardware required for the system is affordable.	10%	12.3%	15.3%	37.3%	25.1%	2.35	0.735
The maintenance costs solar energy systems are low	24.7%	40.7%	10.3%	14.4%	10.9%	4.14	0.726
Composite/Average mean						**3.45**	**0.72**

N=372

This section focused on the performance and installation costs of solar energy integration in the Coast area. The study results are shown in Table 4.10. Additional parts including wire, connections, and mounting framework are reasonably priced: The affordability of these extra components was acknowledged by a sizeable portion of respondents (62.3%), who either agreed (36.7%) or strongly agreed (25.6%). The average score for agreement on the affordability of these components is 3.72, which indicates a reasonable level of agreement. The replies exhibit remarkably little variation, as indicated by the 0.687 standard deviation.

The expenses associated with labor, installation, and setup of solar panels and related equipment are cheaper: More than half of the respondents (62%) indicated agreement (35%) or strong agreement (27%) that these expenses are cheaper. The mean agreement score is 3.60, suggesting a moderate level of agreement on the cost-effectiveness of installation. The standard deviation of 0.701 indicates moderate variability in responses.

The solar panels, inverters, batteries, and other system gear are reasonably priced: The majority of respondents (52.4%) disagreed (37.3%) or strongly disagreed (25.1%) with the cost of these necessary components. The average agreement score is 2.35, showing a trend toward disagreement with hardware component affordability. The standard deviation of 0.735 indicates that responses are very variable, indicating various perspectives.

Solar energy systems have minimal maintenance costs: A large proportion of respondents (65.4%) agreed (40.7%) or strongly agreed (24.7%) that maintenance expenses are minimal. The average agreement score is 4.14, indicating that respondents strongly agree with the concept of reduced maintenance expenses. The standard deviation of 0.726 indicates that responses vary somewhat.

The average mean of all statements is 3.45, indicating a moderate level of agreement across all the statements. The relatively low standard deviation of 0.72 suggests that the responses have a moderate level of consistency around the average mean.

4.9.2 Correlation for Installation costs and Performance of solar energy integration programs in Coast region

Correlation analysis was used to determine the scores for installation costs as an independent variable and performance of solar energy integration programs in the Coast region in order to evaluate the relationship between those two variables.

Table 4.10.1: Correlation for Installation costs and Performance of solar energy integration programs in Coast region

	Performance of solar energy integration programs in Coast region

Installation costs	Pearson Correlation	.770**
	Sig. (2-tailed)	.000
	N	372

**Correlation is significant at the 0.01 level (2-tailed). r = 0.770, N = 372, P<.01

According to Table 4.10.1, there was a significant positive correlation between the effectiveness of solar energy integration projects in the Coast area and the influence of installation costs (r=.770 N=372 p.01). The findings of the correlation research show a strong and favorable link between the Coast region's solar energy integration initiatives' performance and installation costs. The high correlation coefficient shows a link between lower installation costs and higher solar energy output. These results corroborate those of Hemsing and Baker, who in 2020 performed research on the factors impacting the adoption of solar energy in low-income housing zones. According to the data, lower installation costs led to a better market uptake of solar energy technologies. A larger spectrum of customers and industries are more likely to embrace affordable systems. Government incentives, subsidies, or financing alternatives aimed at lowering installation costs can also help to promote solar energy adoption.

These findings concur with those of a 2017 research by D. Abdullahi and associates. According to their analysis, Nigeria has a lot of potential and chances for the installation of solar photovoltaic (PV) systems. This potential is due to factors like the year-round high solar irradiance, a sizable population that could be a market for solar-related goods, affordable solar installation options, and a problem with widespread low electricity access caused by frequent power outages (D. Abdullahi et al., 2017). Another analysis has also discovered a recent increase in Sub-Saharan Africa's use of renewable energy sources. The fight against climate change, attempts to increase access to power in Africa, and the low cost of solar installation are major forces behind this trend (UNEP, 2011; AfDB, 2010). The implementation of Feed-in Tariffs (FiT) and net metering in a few African countries has attracted the attention of international investors in renewable energy. Setting national targets for renewable energy, implementing quota systems, and directing funding toward clean development mechanisms (CDM) funds, including carbon pricing, all represent significant drivers and opportunities for the adoption of renewable energy in Sub-Saharan Africa (SSA) (Jenny Lopez et al, 2011).

Low solar installation costs are crucial to the success of solar energy integration initiatives, according to Mwihaki (2021) findings. They boost solar energy's accessibility, affordability, and economic feasibility, which promotes more adoption, better program performance, and a larger contribution to sustainability and renewable energy objectives. More affordable options have emerged as a result of improvements in solar panel production and installation methods. Governmental subsidies, tax credits, and other incentives have reduced the up-front costs of solar systems.

4.9.3 Regression analysis for Installation costs and Performance of solar energy integration programs in Coast region

The study used a coefficient of determination (R2) using regression analysis as shown in Table 4.10.2 to establish the level of influence of installation costs and to ascertain whether installation costs was a significant predictor of performance of solar energy integration programs in Coast region.

Table 4.10.2: Regression analysis for Installation costs and Performance of solar energy integration programs in Coast region

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.770[a]	.693	.532	.481

a. Predictors: (Constant), Installation costs

The efficacy of solar energy integration initiatives in the Coast region is strongly influenced by installation costs, as shown by Table 4.10.2's R value of.770. R2 indicates.693 on the variance in Coast area solar energy integration schemes' performance due to installation costs.

The effectiveness of solar energy integration initiatives in the Coast region was also tested using an ANOVA to see whether installation costs were a significant predictor of performance.

Table 4.10.3: ANOVA of Installation costs and Performance of solar energy integration programs in Coast region

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	105.11	1	105.11	131.140	.000[b]

	Residual	128.322	102	.686
	Total	233.432	372	

a. Dependent Variable: Performance of solar energy integration programs in Coast region

b. Predictors: (Constant), Installation costs

From Table 4.10.3 where [F (1, 102) = 131.140, P<.05] it is evident that installation costs influence performance of solar energy integration programs in Coast region and thus a significant predictor.

4.10 Technological advancements and Solar energy integration programs in Coast region

This objective's goal was to look at how technology developments affected the Coast region's solar energy integration efforts. The responses evaluated how well the claims about technical developments matched up with the use of solar energy in the Coast region.

Table 4.11: Technological advancements

STATEMENTS	5	4	3	2	1	Mean	Std. Dev.

The solar energy technologies can retain energy over a long duration.	20.7%	37.6%	14.4%	16.7%	10.6%	3.92	0.737
The solar energy technologies are safe to operate and handle.	27%	35%	18%	10.3%	9.7%	3.98	0.781
The physical size and space requirements of the energy storage system is small.	14.1%	23.3%	14.3%	30.3%	18%	2.82	0.725
The financial investment required for procuring and implementing the energy storage technology is low.	20.7%	34.3%	19.3%	15.7%	10%	3.71	0.721
Composite/Average mean						3.60	0.741

N=372

The results are shown in Table 4.11. Regarding the question of whether solar energy technologies can sustain energy for a long time A sizable majority of respondents (58.3%) agreed that solar energy technologies had the capacity to store energy for a long time (37.6%), or strongly agreed (20.7%). The average score for agreement is 3.92, which indicates that there is moderate to great agreement about how well solar systems can store energy. The replies have a standard deviation of 0.737, which indicates a rather low degree of variability.

Regarding the safety of using and handling solar energy technologies: Solar energy technologies are safe to use and handle, according to the majority of respondents (62%) who agreed (35%) or strongly agreed (27%) with this statement. The average score for agreement on the safety of these technologies is 3.98, suggesting a moderate to good degree of agreement. The standard deviation of 0.781 suggests a moderate level of variability in responses.

On whether the physical size and space requirements of the energy storage system are small: A substantial percentage of respondents (37.4%) disagreed (30.3%) or strongly disagreed (18%) with the idea that the energy storage systems have small physical size and space requirements. The mean agreement score is 2.82, indicating a tendency toward disagreement on the compactness of storage systems. The standard deviation of 0.725 suggests moderate variability in responses, reflecting differing opinions.

Lastly, the financial investment required for procuring and implementing the energy storage technology is low: A notable portion of respondents (55%) agreed (34.3%) or strongly agreed (20.7%) that the financial investment for energy storage technology is low. The mean agreement score is 3.71, indicating a moderate level of agreement on the affordability of these technologies. The standard deviation of 0.721 indicates moderate variability in responses.

The average mean of all statements is 3.60, indicating a moderate level of agreement across all constructs related to technological advancements. The relatively higher standard deviation of 0.741 suggests a moderate variability in responses around the average mean.

4.10.2 Correlation between Technological advancements and Solar energy integration in Coast region

Correlation analysis was carried out to gauge the strength of the link between two variables, was used to investigate the relationship between technical improvements and the integration of solar energy in the Coast region. The scores for technical improvements were used as the primary variable, while the dependent variable was the integration of solar energy in the Coast region.

Table 4.11.1 Correlation for Technological advancements and Solar energy integration in Coast region

		Solar energy integration in Coast region
Technological advancements	Pearson Correlation	.672**
	Sig. (2-tailed)	.000
	N	372

**Correlation is significant at 0.01 level (2 tailed) r = 0.672, N = 372, P<.01

Table 4.11.1 provides The integration of solar energy in the Coast region appears to be strongly positively correlated with technical improvements, according to the correlation value of 0.672. As a result, the Coast region's plans for integrating solar energy tend to get better as technology advances. Given that this relationship's significance level is less than 0.01, it is very improbable that it is the result of chance.

This result agrees with the outcomes of numerous other investigations as well. For instance, according to Kalmetova and Zhussupova (2021), solar energy has lately seen significant growth as a consequence of both cost-cutting technology developments and governmental initiatives that support the creation and use of renewable energy sources. These results are also consistent with those of M. Bruce and P. Szuster (2015), who found that the three main factors driving massive solar PV deployment in Australia were subsidies through capital subsidies attained through certificates schemes and production subsidies through FiT, as well as recent technological advancements in solar PV. The researchers also found that the three main drivers of solar PV deployment in Australia were rising electricity costs, which led households to use solar energy from their roofs to help offset their cost of electricity. As a result of these reasons, the number of PV systems installed increased from 8500 to 1.6 million between 2007 and 2018.The study's key drivers included regulatory policy frameworks, technological breakthroughs in renewables, particularly solar, market developments and models, and a FiT structure that favored rooftop solar (Mountain & Szuster, 2015).

4.10.3 Regression Analysis for Technological advancements and Solar energy integration in Coast region

The study employed a coefficient of determination (R2) using regression analysis to assess if technical developments was a major predictor of solar energy integration in Coast area.

Table 4.11.2 Regression analysis for Technological advancements and Solar energy integration in Coast region

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.672[a]	.624	.601	.565

Predictors: (*Constant*), technological advancements, Dependent variable: Solar energy integration in Coast region

based on Table 4.11.2 R has a value of 0.672. This suggests a significant positive relationship between technical development and the use of solar energy in the Coast area. The R Square score is 0.624, which indicates that 62.4% of the variance in the Coast region's use of solar energy can be attributed to changes in technical improvements. This suggests a significant level of effect.

Relative R Square: R Square after adjustment is 0.601. This number changes the R Square to consider the number of predictors in the model. It offers a more precise assessment of how well the model fits the data while taking complexity into account.

To determine whether technological advancements was a significant predictor of solar energy integration in Coast region, an ANOVA test was also conducted. The results were summarized as shown in Table 4.11.3.

Table 4.11.3 ANOVA of Technological advancements and Solar energy integration in Coast region

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	133.315	1	133.315	114.625	.000[b]
	Residual	100.117	102	.644		
	Total	233.432	372			

a. Dependent Variable: Solar energy integration in Coast region

b. Predictors: (Constant), Technological advancements

From Table 4.11.3 where [F (1, 102) = 114.625, P<.05] it is evident that technological advancements influence solar energy integration in Coast region and thus a significant predictor. The sum of squares related to the regression model is 133.315.

4.11 The Regression Model

This study employed a multivariate regression model to assess the significance of the independent factors in connection to the dependent variable—performance of solar energy integration initiatives in the Coast area. This is helpful in determining the statistical significance of the predicted factors in this study. The effectiveness of the predictor factors in predicting the performance of solar energy integration schemes in the Coast area was examined in the study. The regression model in use seemed like this;

$$Y= \beta_0 +\beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+\mathcal{E}$$

Where:

Y = performance of solar energy integration programs in Coast region

β_0 =Y intercept

β_1, β_2, β_3, β_4 = the slope of the regression line for each independent variable

X_1 = Consumer awareness

X_2= household needs

X_3 = Research and development

X_4 = Installation costs

X_5 = Technological advancements

Ɛ = Error term.

Table 4.12: Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.702[a]	.639	.633	.513

a. Predictors: (Constant), consumer awareness, household needs, Research and development, installation costs, Technological advancements
b. Dependent variable: performance of solar energy integration programs in Coast region

R value, which measures the correlation between the predictors and the dependent variable, was.702 according to Table 4.12. The results indicated that the effectiveness of solar energy integration initiatives in the Coast area was significantly influenced by consumer awareness, household demands, research and development, installation prices, and technical improvements. The coefficient of determination (R2) for our sample data, which was 639, or 63.9% of the variance in the effectiveness of solar energy integration programs in the Coast region as a result of the independent variables, demonstrated the proportion of variance in the dependent variable that was accounted for by the predictor(s) in the data. Because R2 is always between 0 and 100%, with a level of 0 indicating no variability in the response data and a level of 100% suggesting that the model explains all variability of the response data around its mean, 63.9% is a higher result, indicating that the model fits the data well.

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

5.1 Introduction

This chapter includes a summary of the findings, conclusions reached after the study was complete, and suggestions the author felt were essential.

5.2 Summary of the study

The focus was on evaluating the impact of socio-technical elements on the effectiveness of solar energy integration programs: A case study of Kenya's Coast area. Among the goals were: To ascertain the impact of technology improvements on the effectiveness of solar energy integration programs in the Coast, including the effects of consumer awareness, household demands, research and development, installation prices, and so on.

5.2.1 Performance of solar energy integration programs in Coast region

The effectiveness of solar energy integration projects in the Coast area served as the study's dependent variable. The following factors were taken into consideration when setting this goal: The maturity of the solar energy market, the number of industries integrating solar energy, the increase in NGO funding for solar integration projects, the number of inquiries about solar installation, the increase in industry and domestic knowledge, the increase in government funding of solar-assisted social programs like schools and community income projects, and the uptake of solar technical courses in regional vocational schools. A favorable evaluation of the effectiveness of solar energy integration initiatives in the Coast region is shown by the average of the means of all the remarks, which is 3.50. The entire variation in the respondents' assessments for all statements is represented by the composite SD of 0.740.

The respondents generally expressed agreement or moderate agreement with statements related to the positive outcomes of solar energy integration programs. These outcomes included increased market share maturity, adoption by industries, NGO funding, inquiries on solar installation, and knowledge improvement. However, there was a stronger disagreement with the idea of increased government funding for solar-assisted social programs.

5.2.2 Consumer awareness and the influence on Performance of solar energy integration programs in Coast region.

The first goal examined how consumer knowledge impacts the effectiveness of solar energy integration projects in the Coast area. The total average mean across all dimensions for all components is 3.37, showing that respondents generally had a modest level of agreement about consumer awareness and program performance.

According to the standard deviation of 0.749, there was some variation in the respondents' assessments of the various notions. This shows that consumer knowledge was sufficient, which enabled the Coast region's solar energy integration projects function better. The Coast region's solar energy integration projects performed well, and a correlation of 0.662 revealed a good link between consumer awareness and performance. This means that as the effectiveness of consumer awareness improves, the solar energy performance of the county tends to improve as well.

5.2.3 Influence of Household needs on Performance of solar energy integration programs in Coast region

The study also looked at the impact that household needs have on the effectiveness of projects in the Coast area that integrate solar energy. The general view of the impact of household demands on the integration of solar energy in the Coast region is fairly favorable, as indicated by the composite/average mean of 3.58. The standard deviations between the assertions indicate that respondents' degrees of agreement varied. A substantial positive correlation of 0.662 was established for this target. The correlation study indicates that there is a propensity for consumers to embrace solar energy technology when household demands rise in the Coast area.

5.2.4 Influence of Research and development on Performance of solar energy integration programs in Coast region

This demonstrated how success of solar energy integration initiatives in the Coast area is influenced by research and development. The estimated average of the mean scores from both statements results in a composite average mean of 3.91. This indicates that, generally speaking, respondents concur that research and development has positively impacted initiatives to integrate solar energy in the Coast area. The correlation analysis results indicate a significant and positive relationship between the research and development practices and the performance of solar energy integration programs in Coast region.

5.2.5 Installation costs and Performance of solar energy integration programs in Coast region

The fourth goal investigated how installation prices affected the efficacy of solar energy integration initiatives in the Coast area. The average mean across all assertions is 3.45, showing a modest level of agreement. The low standard deviation of 0.72 indicates that the responses are moderately consistent around the average mean. A correlation of 0.770 was found. The findings of the correlation study show a substantial and positive association between installation costs and the success of solar energy integration initiatives in the Coast area. According to the relatively strong association coefficient, reduced installation costs are connected with greater solar energy performance.

5.2.6 Technological advancements and Performance of solar energy integration programs in Coast region

The final purpose was to investigate how technology improvements affected the efficacy of solar energy integration initiatives in the Coast area. The average mean of all assertions is 3.60, demonstrating a reasonable level of agreement across all technological development frameworks. The significantly greater standard deviation of 0.741 indicates that answers around the typical mean vary moderately. A correlation of 0.672 was found. The findings of the correlation study show a strong and favorable association between technical improvements and the success of solar energy integration initiatives in the Coast area. The high correlation value indicates that advancements in solar technology are linked to enhanced solar energy performance.

5.3 Conclusion

The researcher investigated how independent variables such as consumer awareness, household demands, R&D, installation prices, and technical improvements impacted the efficacy of solar energy integration projects in the Coast area. As per the results, all of the independent factors had a significant impact on the effectiveness of solar energy integration initiatives in the Coast area. All of the factors correlated positively, with installation costs having the greatest correlation (77%).

According to the findings of the study, consumer awareness has a major impact on the performance of solar energy integration initiatives in the Coast area. The majority of the notions in the questionnaire were agreed upon by the participants. For example, 64.3% agreed (26.7% strongly agreed, 37.6% agreed) on successful solar energy advertising in the Coast area, with a mean rating of 3.82. 55% agreed (20% strongly agreed, 35% agreed) on greater retail distribution of solar items, earning a mean rating of 3.43. The mean grade for increased awareness of solar technology was 2.98, suggesting less agreement. Notably, 38.4% reported enhanced awareness (strongly agree + agree). Examining sales force knowledge on solar energy, 59% agreed (24% strongly agreed, 35% agreed), with a mean rating of 3.63. Lastly, on increased skilled solar installers, 47.7% agreed (17.7% strongly agreed, 30.3% agreed), and the mean rating of 3.01 implies uncertainty about the rise of solar installers. The findings highlight that consumer awareness play a significant role in improving the performance of solar integration programs, with a mean score of 3.37 out of 5.

The study also discovered that household demands influenced the efficacy of solar energy integration initiatives in the Coast area. According to the data, 68.3% (27.7% strongly agree, 40.6% agree) indicated agreement on the availability of dependable warranties, with a mean value of 4.35, indicating good consensus. The effectiveness of solar energy in satisfying the demands of clients was split, with a mean rating of 2.43. Respondents were somewhat more likely to disagree. In terms of the durability of solar energy, 50.4% (17.1% strongly agree, 33.3% agree) agreed, earning a mean value of 3.64, indicating moderate agreement. Lastly, on the quality of solar energy lighting, 55.7% (25.7% strongly agree, 30.3% agree) indicate agreement, with a mean rating of 3.91, reflecting substantial consensus on high lighting quality.

Furthermore, the study shows that R&D has a significant influence on the success of solar energy integration initiatives in the Coast area. According to the data, agreement on the premise that increasing solar energy research resulted in more efficient and visually appealing designs was significant: 60.3% (21.7% strongly agreed, 38.6% agreed), with a mean rating of 3.71. This indicated that respondents were mostly in favor of research to improve solar designs. Agreement was much greater on the subject of improved product customisation for the African market as a result of R&D: 70% (33% strongly agreed, 37% agreed), with a 4.11 average rating. The composite average mean of 3.91 underscored respondents' overall agreement on the favorable influence of R&D on solar energy integration programs in the Coast region.

The research also concluded that installation costs had a major impact on the performance of solar energy integration programs in Coast region. Respondents agreed with most of the constructs. For instance, most respondents agreed that the cost of additional components such as wiring, connectors, mounting structures was affordable. They also agreed that the expenses associated with labor, installation, and setup of solar panels and related equipment are cheaper. However, majority of the respondents disagreed that the cost of the solar panels, inverters, batteries, and other hardware required for the system was affordable.

Finally, the study discovered that performance of solar energy integration programs in Coast region is significantly influenced by technological advancements. Majority of the respondents agreed that solar energy technologies can retain energy over a long duration. They also agreed that solar energy technologies are safe to operate and handle and that the financial investment required for procuring and implementing the energy storage technology is low. However, they disagreed that the physical size and space requirements of the energy storage system is small.

5.4 Recommendations

1. The Coast region county governments should introduce financial incentives such as tax credits, subsidies, and rebates for solar installations. These incentives can make solar energy systems more affordable and attractive to a wider range of individuals and businesses.
2. County governments should develop and implement educational programs that target both consumers and businesses, focusing on the benefits, cost savings, and environmental advantages of solar energy. These campaigns should be designed to dispel misconceptions and increase public awareness.
3. Coast region foster collaboration between research institutions, universities, industry stakeholders, and government agencies to promote knowledge sharing, interdisciplinary research on initiatives focused on advancing solar energy integration technologies, such as improved solar panels, energy storage solutions, and grid integration systems.
4. Solar energy companies should establish bulk purchasing programs that allow communities or groups of consumers to purchase solar systems and installation services collectively. This can lead to cost savings through economies of scale.

5.5 Recommendations for further studies

Another study can be conducted to evaluate the effectiveness of various policies and incentives aimed at promoting solar energy adoption, with a focus on understanding their impact on market growth and technology innovation.

Another study can investigate the technical challenges and solutions related to integrating high levels of solar energy into existing energy grids, including issues like voltage fluctuations, system stability, and grid resilience.

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APPENDICES

APPENDIX I: LETTER OF INTRODUCTION

26th July, 2023.

ASTLEY MUNIALO WINJIRA

P.O. Box 8945 -80100

Mombasa.

Dear Sir/Madam,

DATA COLLECTION REQUEST

My name is ASTLEY MUNIALO WINJIRA, and I am pursuing a Master of project management at the University of Nairobi's Department of Management Science and Project Planning. I am undertaking a study named "INFLUENCE OF SOCIOTECHNICAL FACTORS ON PERFORMANCE OF SOLAR ENERGY INTEGRATION PROGRAMMES CASE OF COAST REGION OF KENYA**".** In order to conduct a thorough analysis of this study, I hereby seek your aid in completely and accurately completing the questionnaire that is attached. Any information provided will be held in strict secrecy and used solely for this academic study. It is encouraged not to provide your name or any personal information on the questionnaire.

I highly appreciate your corporation to this end.

Yours faithfully,

……………………………………..

ASTLEY MUNIALO WINJIRA

APPENDIX II: QUESTIONNAIRE

This research purposed to establish impact of sociotechnical factors on performance of solar energy integration programs: case of Coast region of Kenya.

Choose among the options given by ticking appropriately while completing blanks for queries that require opinions.

PART 1: Introductory Information

1. Kindly tick appropriately your main role in Solar energy integration Programs

Scope of operation	**Tick**
Consumer	
Implementer/ Installer	
Distributor/seller	

2. Designation in the company/ organization/ or homestead:

   Director ☐

   Sales ☐

   Technical ☐

   Guardian (if homestead) ☐

   Dependent (if homestead) ☐

3. Time duration of being a consumer or facilitator in solar energy integration programs

   Less than a year ☐

   1-5 years ☐

   More than 5years ☐

PART 2:

Outlined here are sociotechnical factors influencing solar energy integration programs in the Coast region of Kenya. Choose a number to represent the increasing influence of the sociotechnical factors affecting solar energy integration programs in the Coast region of Kenya with 1 having least influence and 5 having the most influence. Also evaluate the performance of solar energy integration programs in the Coast region of Kenya.

1. Consumer awareness on performance of solar energy integration programs in the coast region of Kenya

How the below elements consumer awareness influence performance of solar energy integration programs	**1**	**2**	**3**	**4**	**5**
Advertisements					
Retail distribution					
Awareness of solar technologies					
Number of skilled installers					
Sales force knowledge					

2. Household needs on the performance of solar energy integration programs in the coast region of Kenya

How the below elements of household needs influence performance of solar energy integration programs	**1**	**2**	**3**	**4**	**5**
Warranty reliability					
Performance rating					
Aesthetics judgment					
Durability guarantees					
Perceived Quality					

3. Research and development on performance of solar energy integration programs in the coast region of Kenya

How the below elements of research and development influence performance of solar energy integration programs	**1**	**2**	**3**	**4**	**5**

Investments into more efficient and aesthetical designs					
Improved product customization for the African market					

4. Technological advancements in energy storage solutions on performance of solar energy integration programs in the coast region of Kenya

How the below elements of energy storage solutions influence performance of solar energy integration programs	**1**	**2**	**3**	**4**	**5**
Duration of storage					
Safe usage of storage solutions					
Volume/Bulkiness of storage solution					
Cost of storage solution					

5. Installation costs on performance of solar energy integration programs in the coast region of Kenya.

How the below elements of installation costs influence performance of solar energy integration programs	**1**	**2**	**3**	**4**	**5**
Accessories price					
Installation price					
Equipment price					
Cost of maintenance					

6. **Evaluation** of the performance of solar energy integration programs in the Coast region of Kenya

Evaluate the performance of solar energy integration programs in the Coast region of Kenya based on its constituents elements outlined	**1**	**2**	**3**	**4**	**5**
Solar energy market share maturity					
Number industries adopting solar energy integration					
NGO funding increase for solar integration projects					
Number of inquiries on solar installation					
Increased Industry and domestic knowledge					

Increased government funding of solar assisted social programs like schools and community income projects					
Increased uptake of solar technical courses in local vocational institutions					