UNIVERSITY OF NAIROBI

COLLEGE OF BIOLOGICAL & PHYSICAL SCIENCES

SCHOOL OF COMPUTING & INFORMATICS

Solar Panel Data Intelligence

by

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A project report submitted in partial fulfillment of the requirements for the award of Degree in Computer Science of the University of Nairobi

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Declaration

This project is my original work and, to the best of my knowledge, this research work has not been submitted for any other award in any University.

Gichira Alvin Kaburu: ___________________________________ Date: _____________________

P15/1553/2015

This project report has been submitted in partial fulfillment of the requirements for the Degree in Computer Science of the University of Nairobi with my approval as the University supervisor.

Dr Wanjiku Ng'ang'a: ___________________________________Date: _____________________

School of Computing and Informatics

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1. Introduction

1.1 Background Information

Since early time history, renewable sources of energy have slowly gained supreme levels of importance not only to the environment, but to the society at large. They have become the most fundamental sources of energy in comparison to non-renewable sources. Consequently, demand for these sources has been on the rise exerting immense pressure on to them. Like any other commodity usable by man, demand pressures lead to higher prices. This pressure has seen these sources slowly become more expensive thus unaffordable to the common mwananchi.

One of the most important and increasingly popular sources of renewable energy is solar energy. This energy source is promising because of its clean and reliable nature. Not only is this energy free to acquire – the sun is offered freely and widely – but it is also readily available all over the world at almost equal measure. This has led to huge investments in solar harnessing technology with the most common being photo voltaic cells packaged in a unit to form solar panels. A solar panel is a device that is designed to absorb light using photo voltaic cells converting this form of energy to electric energy. As a result, solar panels have found use in lighting, heating and powering of devices.

Solar panels as solar harnessing devices sit at a direct angle to the sun at maximum efficiency. This position mostly manifests itself as building rooftops and other supportive structures. With an increase in the demand of this technology, many companies and organizations have widely invested in it building simple yet very powerful and innovative solar harnessing devices. Energy collected from the sun is now used both as a primary and secondary device power source at homes and institutions worldwide.

Time has seen the development of solar technology. In 1964, typical solar panels could only produce 12 watts of electricity at maximum efficiency. This put into context could only power one fifth of a 60w bulb at that time. This has drastically improved over the years. Currently, a typical solar panel produces around 265w to 330w of energy. These panels are said to be 20% efficient and can power up to four and a half 60w electric bulbs. Also, at the moment, solar energy has become a contributor to the national grid of many developing and developed countries. This in itself is a major advancement of the technology.

1.2 Problem Definition

Solar panels should be intelligent enough to collect data from the environment so as to provide information that can be used by panel manufacturers, energy generators and panel owners in decision making.

With little or no intelligence embodied on the current solar panel design, currently no specific way to harness more value -other than energy- from them has been recommended. Solar Panel manufacturers and distributors rely solely on market research to influence decisions on market uptake strategies and solar panel design. They are therefore unable to collect usage, technical and geographical data from solar panels they manufacture to eventually make more founded and concrete business decisions and strategies. Solar energy users also need to accurately monitor data regarding its collection and usage. This therefore calls for a need to develop efficient ways to ensure that solar panels become and remain highly intelligent in the course of their usage.

In order to capture as much solar energy as possible, solar panels are positioned on top of buildings and other high facing structures. Unfortunately, many panels are stationary and rely on the assumption that the sun retains constant positioning during the day. This is inaccurate as the sun in always in movement along a vertical 180-degree axis between east and west. On average, the solar energy harnessed from the sun is at its maximum at a particular region for 4hrs. These maximum conditions are observed and gradually decrease 2hrs before and after the sun's point of direct perpendicularity with the solar panel. A solar panel positioned in stationarity at one angle is only at the maximum efficiency point for a maximum of 4hrs in a day. It slowly loses this efficiency as soon as the sun takes an unsuitable angle.

1.3 Research objectives

The goal of this project is to develop an intelligent single axis solar panel with the ability to collect data to be used by solar panel manufacturers, value adding companies, distributors and owners.

1.4 Development Objectives

The following are the development objectives:

a) To develop a solar panel with the ability to collect data from its owners for the sake of decision making.

b) To analyze the collected data and come up with information that can be used to improve business processes.

c) To develop a solar panel that is able to follow the sun along its east to west axis.

1.5 Project Justification

The information industry is one of the fastest growing global industries. It is a significant component of the Internet of things as inter device communication involves transfer of data as a core. In solar panels, data collected can mainly be used in decision making, analysis of consumption and streamlining of business processes. Implementing this solution lies in attaching some data collection intelligence onto existing solar panels. An intelligent single axis solar panel will be in operation by using several mechanisms. These mechanisms include solar tracking and data collection mechanisms. This data collected will manifest in the following forms:

a) **Power and Energy Information** – This is the amount of power and energy collected by the solar devices for lighting, heating and powering devices. This information can be used to align the solar panels at maximum efficiency as the device will always be able to attract the position at which collection of these entities are at a maximum.

Average Daily Production					
City	**1 kW system**	**1.5 kW system**	**2.0 kW system**	**3.0 kW system**	**4.0 kW system**
Adelaide	4.2 kWh	6.3 kWh	8.4 kWh	12.6 kWh	16.8 kWh
Alice Springs	5.0 kWh	7.5 kWh	10.0 kWh	15.0 kWh	20.0 kWh
Brisbane	4.2 kWh	6.3 kWh	8.4 kWh	12.6 kWh	16.8 kWh
Cairns	4.2 kWh	6.3 kWh	8.4 kWh	12.6 kWh	16.8 kWh
Canberra	4.3 kWh	6.45 kWh	8.6 kWh	12.9 kWh	17.2 kWh
Darwin	4.4 kWh	6.6 kWh	8.8 kWh	13.2 kWh	17.6 kWh
Hobart	3.5 kWh	5.25 kWh	7.0 kWh	10.5 kWh	14.0 kWh
Melbourne	3.6 kWh	5.4 kWh	7.2 kWh	10.8 kWh	14.4 kWh
Perth	4.4 kWh	6.6 kWh	8.8 kWh	13.2 kWh	17.6 kWh
Sydney	3.9 kWh	5.85 kWh	7.8 kWh	11.7 kWh	15.6 kWh

Power Generated from Solar Panel plants In Australia

b) **Solar intensity, humidity, temperature and geographical positioning information** - This information is important as it can be used to determine if there is a direct correlation between the amount of energy collected by the solar panels and the environmental conditions around the solar panel. Panel manufacturers and distributors will hence be at a more credible and sound position to make decisions regarding design of solar panels and geographical distribution of marketing strategies.

Parties that will benefit from the data collected will include panel manufacturers, energy generation companies, solar panel distributors and primary solar panel owners. These parties will use information from consumers as grounds for:

a) Decision making processes

b) Strategy and control

c) Appraisal and evaluation

<u>Justification of Solar data collection strategies to manufacturers, energy generation companies and distributors</u>

Manufacturers, energy generation companies and distributors often rely on scientific research while in the process of manufacturing and setting up distribution strategies. This leads to blanket decisions while coming up with panel designs in relation to their demand and use in a specific region. Embedding some data intelligence onto solar panels will ensure that these parties can make more sound decisions. This will be made possible using data collected from individual consumption and the environment conditions around a solar panel. In places where there is prolonged use of electrical energy from the sun, panel distributors will be able to create unique and specific marketing plans customized for these regions. Places where use of solar energy is on the contrary, could call for increased marketing and sensitization to encourage investments in solar energy.

Usage data collected from solar panels could also facilitate real time maintenance of solar panels as less productive faulty solar panels will be monitored and specific action taken. This will further improve customer service leading to happier customers. Diagnostic information could also be used to repair these panels and eventually used to prevent future faults.

This eventually will create a grounded opportunity for subscription-based plans for solar based companies leading to increased revenues.

Justification of Solar data collection strategies to panel owners

In addition to increased energy collection, solar panels owners shall be able to benefit from data collected from these devices. This will ensure that solar panel owners remain informed and in control. Data regarding power harnessed from solar panels can be used in the following ways:

a) To determine how much money is saved from self-generation of electricity using a solar tracker.

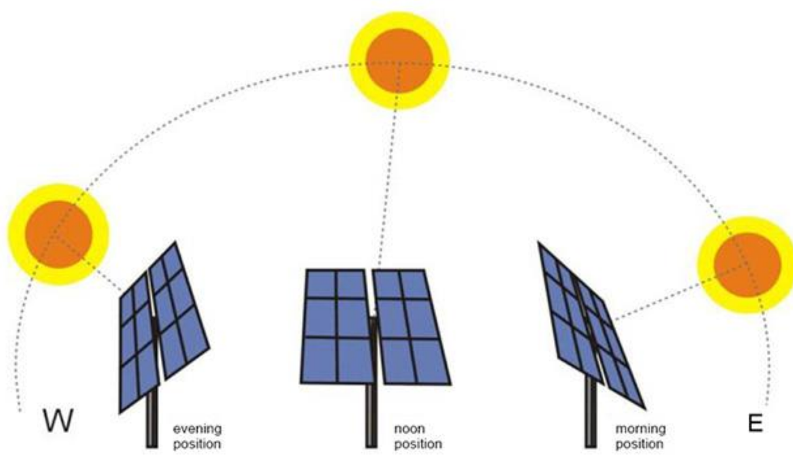
b) To determine the best type of home and industrial devices to purchase in order to maximize use of solar power.

c) To decide on different energy conservation strategies around the premise.

d) To understand the ideal conditions necessary for the collection of the optimum amount of solar energy.

Justification of Solar tracking technologies

The light gathering process is totally dependent on the angle of incidence of the light source provider to the solar panel's surface. The greater the levels of perpendicularity, the more the energy that will be harnessed. As the sun finds its way across the sky during the day, it therefore is very advantageous to have solar panels that can keep track of the sun's position throughout the day. This will ensure that the panels are always aligned at an angle of 90 degrees in relation to the sun thus maintaining high levels of perpendicularity. As a result of this additional feature, the amount of energy harnessed will always remain at a maximum, improving efficiency by over 30%. This in itself is viable enough to make solar tracking an important solution despite any additional costs that may arise during implementation.



7hrs	1750w	30%
Up to 7hrs of solar energy harnessed by solar trackers	Assuming one solar panel is 250w, this results to 1750wh of electric power generated	30% of more energy collected, with around 20% of energy lost

1.6 Proposed Solutions

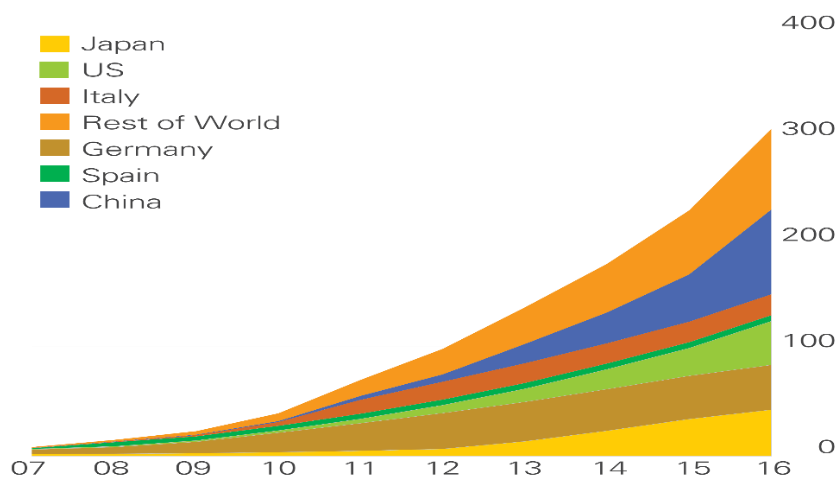
To satisfy the justification above, an intelligent solar panel will be able to collect environmental data as well as track the energy harnessed from the panel. This information shall be transmitted to solar panel distributors and manufacturers as well as the solar panel owner to facilitate decision making.

2. Literature Review

2.1 Evolution of Solar Panel Power Generation

Solar panels have greatly evolved over the ages. Photovoltaic technology was discovered by Alexandre Becquerel, in 1839. He placed an electrode in a conductive solution and when it was hit by sunlight, current was generated. This opened up research in the field. In the 1950s, solar panels designed were 6% efficient yielding 20 watts of electrical power. By 2012, this had drastically improved to 15% efficiency yielding an average of 200 watts. 2015, saw 20% efficient solar panels, yielding 265 watts of electricity. This is enough to power 4 and 2 fifth -60 watts bulbs.

Currently, 7% of renewable energy generation is solar energy. Glenn (2017). This is projected to grow to around 36% by 2055. China is the leading solar power generator in the world producing 100 GW of electrical power. South Africa is the leader in solar power in Africa yielding around 1329MW of electricity every year. However, solar generation is Africa is still considered very low and efforts are being made to improve generation of this form of energy.



World Distribution of Solar generation in Megawatts

2.2 Need for Intelligent Solar Trackers

<u>Importance of data collected by solar panels</u>

Ferman et al. (2016) examined that, like all non-renewable power sources, it is essential to collect and analyze quality solar data to determine feasibility and the future reliability of the energy source. With solar energy, the supply of sunlight varies, which can result in the uncertainty of a solar power site's performance. And so, the solar energy industry must collect and efficiently communicate data for success. Resource forecasting is also becoming increasingly more important as more solar power is being used throughout electric grids across the world. By collecting data, an accurate forecast can be created in favor of panel manufactures and used to increase profits by optimizing device dispatch according to time periods and geographical locations of greatest value.

<u>Use of solar trackers to improve on the amount of energy collected</u>

Rogers (2016) was able to conclude that a solar panel in a fixed orientation will lose almost 75% of energy during the dawn and dusk times of the day. Rotating the panels to the east and west can help recapture those losses. Due to the tilt of the earth's axis, the sun also moves around 46 degrees north and south. These movements are called seasonal motions. Rotating the panel to the north and south can further help recapture more loses. A tracker that only attempts to compensate for the east-west movement of the Sun is known as a single-axis tracker while a tracker that attempts to compensate for both the east-west movement of the sun and seasonal motions is called a dual axis solar tracker.

2.3 Exiting Intelligent Solar Data and Tracking Technologies

All over the world, many stake holders have attempted to implement the technology. However, most of these plants concentrate more on solar tracking aspect than data collection which is equally as important.

Existing projects and plants are as follows:

a) The largest single axis tracker project in Asia, generating 172MW of energy. The project is controlled and managed by Arctech Solar company.

b) An 8MW photovoltaic plant in Greece that utilizes single axis trackers adjusted every season.

c) NEXTracker company projects to install solar trackers on behalf of customers on demand. The company also manages and maintains the solar trackers to ensure they remain efficient and effective.

2.4 Challenges with solar panel data intelligence

Like any other technology, there are several challenges that could hinder perfect performance. To start with, collection of data by manufactures could result to privacy issues. Despite the fact that the data can be utilized to solar panel owners advantage, geographical and usage information could result to security breaches.

Hardware device get faulty from time to time. They therefore require maintenance which could result to extra pains. Trackers add cost and maintenance to the system - if they add the cost, and improve the output by an equal amount, then it could be argued that the same performance can be obtained by making the system larger. However, this could easily attract a counter argument.

Making panel systems larger will occupy more space. Space is considerably a more expensive resource.

3. System Analysis

3.1 Development Methodology

Development of an intelligent single axis solar panel will require a development model that will take into consideration the following fundamental attributes:

a) The budget constraint of implementing the panel technology and its risk evaluation is very important to manufacturers, distributors and panel owners.

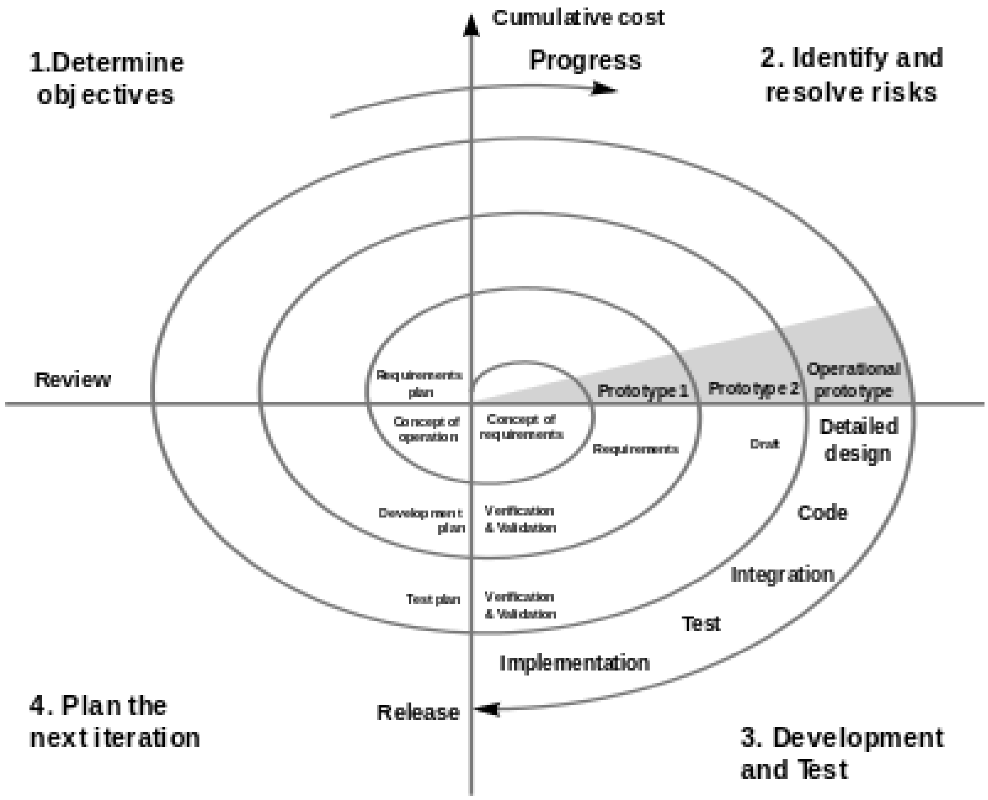
b) The project is a medium to high-risk project.

c) Manufacture, sale, distribution and maintenance shall be long-term in nature due to potential changes in economic priorities as the requirements change with time.

d) Intelligent panels are uncommon and their uptake is uncertain. They shall be dispatched in phases to get significant and ample customer feedback.

e) Significant changes are expected in the product during the development cycle.

Based on the above attributes, a spiral model of development will be most appropriate. This is because this model allows for incremental releases of a specific product and its incremental refinement through each iteration around the spiral. From its identification, design, construct and evaluation phases as well as their iterations, the project will evolve from a simple concept to a practical use case that will find use in homes, schools, industries and other institutions.



3.2 Schedule: Project Gannt Chart

ID	Task Name	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1	Research											
2	Planning											
3	Testing of Alternatives											
4	Choice Implementation plan and Design											

5	Assembling of Hardware Components											
6	Testing of Hardware components											
7	Software components design											
8	Testing of Software components											
9	Overall Testing											
10	Review											
11	Documentation											

3.3 Budget Analysis

	KSH	KSH
Income		
Total Income		0
Expenses		
Simple 6V 2A Solar Panel	1000	
2M PPR Pipes	250	
24 x 24 Inches Wood Board	250	
Arduino Mega 2560 Rev3	2500	
ESP8266 Node MCU	800	
DHT22 Sensor	200	

20 Pieces Resistors	80	
5 Pieces Light Dependent Resistors	15	
50 Pieces Male to Male Jumper Wires	200	
50 pieces Male to Female Jumper Wires	200	
I2C LCD Display	500	
10 Pieces LEDs	30	
Active and Passive Buzzer	100	
Total Expenses		6125

List of Appendices

1. Bibliography

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