DESIGN OF SOLAR TRACKING SYSTEM BASED ON SUN CONTOUR FOR PHOTO VOLTAIC (PV) SYSTEM IN KUWAIT

BY

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ABSTRACT

Renewable energy is the path for a sustainable future. The development in this field is progressing rapidly and solar energy is at the heart of this development. The performance and efficiency limitations are the main obstacles preventing solar energy from fulfilling its potential. This research intends to improve the performance of solar panels by identifying and optimizing the affecting factors. In this thesis, a top-down approach of solar PV planning and optimization methodology is developed to enable high-performance at minimum costs. This research aimed at analysing a photo voltaic (PV) solar tracker design based on the advantage of efficient power tracking. The research further proposed a photo voltaic (PV) solar tracker design based on the advantage of efficient power tracking Objective of this research is to design PV tracking system with a low-precision, low-cost and high-availability solar tracking mechanism and control system. The design methodology considers the installation location (latitude and azimuth) as a starting point for establishing an adequate angular range, simultaneity the aspects of available technology and the knowledge accords to developer. Finally, the design technique is experimentally validated by the implementation of a solar tracker at latitude of 28° longitude of 109° and evaluates the efficiency on a specific day. According to result (MPPT efficiency above 95%) the feasibility of this type of solar tracker for latitudes close to or greater than 30° is highlighted, given that this tracking system costs significantly less than traditional commercial systems as slew drive with its incorporation of lower-resolution azimuth tracking mechanisms. It also increases collection efficiency, just as continuous or time-based dual-axis solar trackers do, without the more complex controls and mechanisms of these designs. The results of this research demonstrate the success of the proposed extension in achieving the objectives of this study and for future research work.

ملخص البحث

إنّ الطاقة المتجددة هي الطريق إلى مستقبل قابل للاستمرارية، وإن التطور في هذا المجال يتقدم بسرعة، والطاقة الشمسية هي في صميم هذا التطور. إنّ محدودية الأداء والكفاءة هي العقبة الرئيسية التي تمنع تحقيق الاستفادة القصوى من إمكانات الطاقة الشمسية، لذلك يهدف هذا البحث إلى تحسين أداء الألواح الشمسية من خلال تحديد العوامل المؤثرة وتحسينها. في هذه الأطروحة، تم تطوير نهج تنازلي لتخطيط الطاقة الكهروضوئية الشمسية ومنهجية تحسين لتمكين الحصول على أداء عالٍ بأقل التكاليف، كما يهدف هذا البحث إلى تحليل تصميم متعقب الطاقة الشمسية الكهروضوئي بناءً على ميزة التعقب الفعال للطاقة، وقد اقترح البحث تصميماً لمتعقب الطاقة الشمسية الكهروضوئي استناداً إلى ميزة التعقب الفعال للطاقة. إن هدف هذا البحث هو تصميم نظام تعقب كهروضوئي مع نظام تحكم وتقنية تعقب للطاقة الشمسية منخفضة الدقة، ومنخفضة التكلفة، وعالية الوفرة. تأخذ منهجية التصميم بعير الاعتبار موقع التثبيت (خط العرض والسمت) كنقطة انطلاق لإنشاء مدى زاويّ ملائم، وتزامن جوانب التكنولوجيا المتاحة واتفاقات المعرفة للمطور. أخيراً، تم التحقق من صحة تقنية التصميم بشكل تجريبي من خلال تنفيذ تعقّب شمسي عند خط العرض 28 درجة، وخط الطول 109 درجات، وتقييم الكفاءة في يوم محدد. ووفقاً للنتيجة (كفاءة MPPT أعلى من 95%)، تم التركيز على جدوى هذا النوع من المتعقبات الشمسية لخطوط العرض القريبة من أو أكبر من 30 درجة، نظراً لأن نظام التتبع هذا يكلف أقل بكثير من الأنظمة التجارية التقليدية مثل محرك الدوران المدمج مع آليات تتبع مع سمت قليل الدقة. كما أن النظام المقترح يزيد من كفاءة التجميع، مثلما تفعل المتعقبات الشمسية ثنائية المحور، المستمرة أو القائمة على الوقت، دون استخدام أدوات التحكم والآليات الأكثر تعقيداً لهذه التصميمات. تظهر نتائج هذا البحث نجاح الإضافة المقترحة في تحقيق أهداف هذه الدراسة، ومقدمة لعمل بحثي مستقبلي.

APPROVAL PAGE

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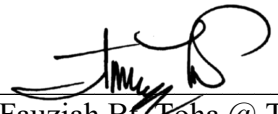

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LIST OF SYMBOLS

η	Efficiency of system
ϒ	Power temperature coefficient, °C-1
Ø	Glyph for the zero character
°C	Celsius
°F	Fahrenheit
I	Current through load, A
Id	Current through diode, A
Io	Reverse saturation current, V
Ipv	Current generated by PV, A
Isc	Short circuit current, A
Ish	Current through the shunt resistor, A
k	Boltzmann's constant ==(1.3806488×10−23), J.K-1
KW•h	Kilowatt-hour
Mpp	Current at maximum power,
n	Linearity factor (1 for ideal diode)
q	Elementary charge = (1.602176565×10−19), C
Rs	Equivalent circuit series resistance, Ω
Rsh	Equivalent circuit shunt resistance, Ω
T – p-n	Junction absolute temperature, K
U	Voltage applied to the load, V
Umpp	Voltage at maximum power
Uoc	Open circuit voltage, V
Ush	Shunt voltage, V
V Ema	Mean annual solar radiation, kWh/m2
VT	Thermal voltage, V
Wp	Peak energy of a single module, W

LIST OF ABREVIATIONS

ACELA	American Clean Energy Leadership Act,
ACES	American Clean Energy and
ACP	Alternative compliance payment (ACP) and
ARRA	American Recovery and Reinvestment Act,
ASES	American Solar Energy Society
BCSE	Business Council for Sustainable Energy
BIPV	Building Integrated Photo voltaic
CHP	Combined heat and power
CSP	Concentrated Solar Power
DG	Distributed generation,
DISCO	Distribution Company or Distribution Utility
EIS	Environmental impact statement
FERC	Federal Energy Regulatory Commission
KWatt	Kilowatt
MPPT	Maximum power tracker
MW	Megawatts (one million watts)
MWh	Megawatt hour
MWatt	Milliwatt
NEMS	National Energy Modeling System
NRDC	Natural Resources Defense
NREL	National Renewable Energy Laboratory
O&M	Operations & Maintenance
PAC	Political Action Committee.
PBI	Performance (or production) based incentives.
PHEV	Plug-in hybrid electric vehicle
PPA	Power Purchase Agreement
SACP	Solar alternative compliance payments
TWh	Terawatt-hour

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The relation between man and the sun is ancient. The sun has played a massive role in the history of mankind. Some old civilizations even had spiritual belief in the power of the sun. According to Hsieh (1986), the sun is a giant nuclear reaction that transforms four million tons of hydrogen to helium per second. The earth will receive only a tiny amount of the sun generated energy (Hsieh, 1986). The radiated energy from the sun must be equal to the energy it produces to ensure its structural stability (Sorensen, 2011). The evidence of this stability over the last 3 billion years can be seen by the relative stability of the temperature of the earth's surface (Sorensen, 2011). Oxidized sediments and fossil remains reveal that the water fluid phase has been presented through this time (Sorensen, 2011). The earth's orbit around the sun is slightly elliptical, making the distance between the two vary throughout the year. The earth and sun are 91.4 million miles apart in January compared to 94.5 million miles in July; this leads to an annual disparity of 3%–4% in the irradiance at the edge of the atmosphere (Shepherd & Shepherd, 2014). Although the earth receives just a tiny fraction of the Sun's generated energy, it is still a massive amount of energy.

The photo voltaic energy use dates back to seventh century B.C. Throughout the century the method of harnessing photo voltaic power had advanced such as having photo voltaic thermal energy, photo voltaic tower and photo voltaic technologies. Solar electricity is the most promising renewable energy as it is naturally handy and clean derived from the sun. Solar energy can be produced silently with minimal maintenance,

no pollution, and no depletion of resources. There are two techniques to produce electrical energy from the solar which are via concentrating solar thermal or through a photo voltaic (PV) cell. The most frequent technique is generating electrical energy through photo voltaic technology which will convert mild energy (photons) at once into electrical energy (voltage) via the aids of photo voltaic cell made up of silicon. It is extensively installed in the residential buildings usually at rooftop and open area the place availability of daylight is high.

However, the primary challenges of solar energy application are the low electricity density and the cycle of the sun. Thus, it requires long time to attain higher energy conversion to electricity. Consequently, exploring higher efficiency photo voltaic tracking technological know-how is blooming as is seen as necessary and realistic method to achieve excellent effectivity for solar-to-electric conversion.

Just like in different international locations in the world, the need of power in the developing countries such as Kuwait turns into foremost concern. The essential production of electricity in Kuwait comes from oil and gas. Nowadays, the use of oil and fuel is viewed as the lead contributor of the carbon emission which will lead to the greenhouse effect. Apart from that, the oil and gas reservoirs are depleting, and the recovery is decreasing.

Due to the pressure applied by the United Nation, all nations are forced to sign a treaty to reduce the impact of greenhouse impact which will lead to the global warming. One alternative of the power sources is solar energy. Comparing with the wind or tidal wave energy, Kuwait has a considerable supply of sun’s radiation. Kuwait has a longer summer season period which last for nine months of sunny session.

The uptake of the use of the renewable power assets in Kuwait has grown. Some initial solar electricity undertaking covers round 4500 photo voltaic panel have been

mounted in the infrastructure such as authorities' offices, faculties, and different small buildings. The expected generated electricity range between 100 KWatt to 350 MWatt.

A big undertaking on photo voltaic power is additionally being developed in Kuwait with a budget of USD 7.5 billion. The anticipated electricity output is 2000 MW. This is a bold authority's task to highlight how serious is the Kuwaiti authorities are engaged in this renewable energy field. With this additional alternative energy, it is hopped to assist to cover the high demand of the energy in Kuwait.

1.2 PROBLEM STATEMENT

As the global economy is continuously growing and the population is increasing rapidly, relying exclusively on fossil fuel to accommodate the potential demand for electricity generation is not a strategic plan. Undoubtedly, such augmentation in demand seeks extra energy resources to encounter this potential, which point-blank a result in increased utilization of finite fossil fuel, environmental pollutions and high lifecycle cost of traditional power systems. The hybrid electrical system (fossil fuel with RESs) could bring more advantageous environmental friendly system besides dominating the associated shortcomings of alternative energy including the intermittency and the disparity in energy density. The first problem is to investigates the design and analyses of solar PV system with different tracking systems configurations. The second problem deals with prioritization of RESs under different criteria including economic,

technical, socio-political and environmental.

The other issue is to align the need with the strategic direction, which was started by the ruler of the Kuwait, Sheikh Subah AlAhmad AlSubah. He pledged to increase

the use of the renewable energy from 2% of the country's power generated in 2015 to 15% by using 2030.

Solar power utility had started in Kuwait for some time now. The intention is to reduce the over dependence in fossil fuels and to undertake extra sustainable and clean approach to generate electricity. The solar science involved is the constructing of integrated photo voltaic and electricity plant with one axis tracking. However, the power output from solar electricity is still low and unable to gain the target on renewable electricity plan. The present application is regarded inefficient because it required long time to acquire significant solar-to-electric conversion. This is because, the application was established based on sun position, weather and high temperature distribution, and cloud cover. Therefore, a different mechanism is needed to increase the photo voltaic capturing capability.

1.3 RESEARCH OBJECTIVES

The goal of this research is to:

1. To analyze current energy consumed in Kuwait and its sources
2. To design and develop a solar tracker and control system
3. To optimize the maximum power from the solar cell and control sun tracker system
4. To validate experimental results in (3) with simulation results and connect the proposed solar power system to the grid.

1.4 RESEARCH SCOPE

A PV device can be chosen through a desire survey of the residents, performed by way of the Ministry of Water and Electricity of Kuwait, to have a look at the query "Which

renewable energy source is most suitable considering the environmental condition of the desert and the monetary feasibility and renovation aspects of the system?". Then the solar monitoring system is designed to optimize the PV system and the plan will be simulated and tested in Kuwait environment.

1.5 RESEARCH METHODOLOGY

The following research methodology will be followed in order to accomplish the research tasks:

1. Literature assessment on photo voltaic photo voltaic cells
2. Preparation and characterization of photo voltaic solar cells material
3. Construction of PV gadgets for sun monitoring machine
4. Characterization of device temperature, effectivity and LDR position
5. Characterize Photo voltaic system operation.
6. Mechanical properties and electrical energy producing assessment through one-of-a-kind sorts of testing.
7. Optimize electrical characterization for photo voltaic cells absorption efficiency.
8. The determination of equipment is primarily based on the circuit and the equation to see the efficiency.
9. Development and manipulate PV position primarily based on microcontroller for electrical power behavior and validate the model the usage of experimental work.

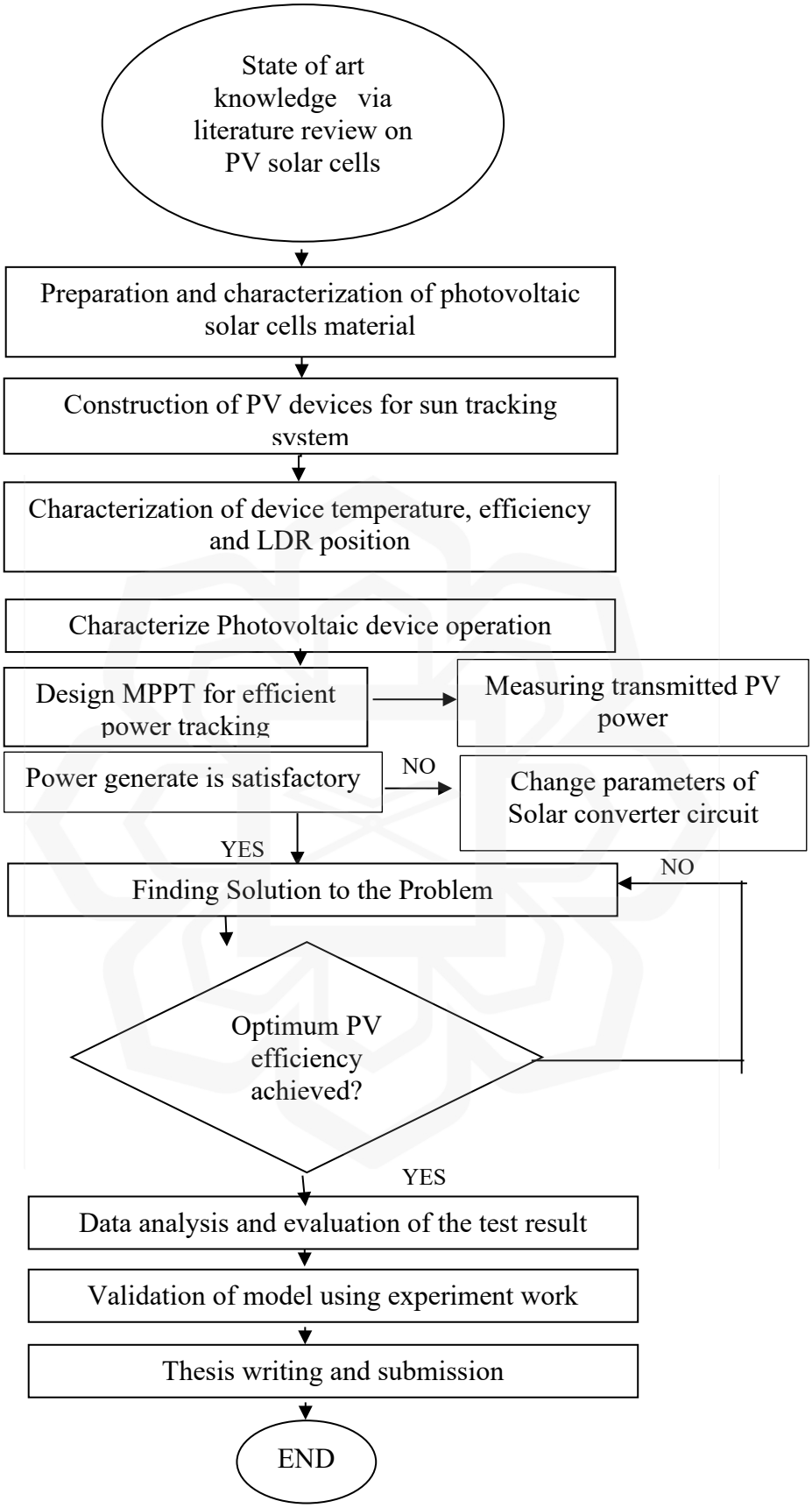

Figure 1.1: Schematic illustration of research flow diagram

1.6 SIGNIFICANCE OF THE STUDY

A successful outcome of this is study has many advantages. The first advantage is that the carbon emissions will be reduced. The carbon emissions produced by the traditional electricity generation to heat and provide electrical energy to houses. The usage of renewable electricity from the sun, will help to alleviate many environmental issues such as global warming phenomenon and local weather change. Therefore, this project will substantially contribute to carbon emissions reductions. The other gain is that it will reduce the real cost of producing electricity and create new economical resources that can be put to use in other development aspects. The ultimate advantage is it will optimize the energy harvesting for photo voltaic system.

1.7 THESIS ORGANISATION

This thesis is organized into five chapters. Chapter one briefly discusses the historical past of the research, trouble statement and magnitude of the study. Chapter two covers the literature assessment of the study. Chapter three go through the methodology and the design of the study. Chapter four compares the results and discusses them. Chapter five summarizes the main findings of the study, its contribution, and the end with the conclusions.

CHAPTER TWO

LITERATURE REVIEW

2.1 RENEWABLE ENERGY

Renewable electrical energy is booming, as innovation brings down fees and begins to provide on the promise of a handy energy destiny. American photo voltaic and wind technological grasp are breaking information and being blanketed into the USA, large electrical energy grid barring compromising reliability. This functionality that renewables are an increasing number of extra greater displacing “grimy” fossil fuels inner the electrical energy zone, imparting the achieve of restrict emissions of carbon and distinct sorts of pollution. On the exclusive hand no longer all sources of power marketed as “renewable” are helpful to the environment. Biomass and large hydroelectric dams create tough tradeoffs at the equal time as considering the have an impact on plant life and fauna, regional weather alternate and brilliant issues.

Renewable energy, oftentimes alluded to as clean vitality, comes from attribute sources or varieties that are consistently recharged. For case, daytime hours or wind maintains glowing and blowing, certainly, if their accessibility depends on time and weather. While renewable vitality is generally idea of as a modern-day innovation, tackling natures manipulation has been utilized for some time for warming, transportation, lighting, and more. Wind has fueled vessels to cruise the oceans and windmills to crush grain. The solar has given warmth amid the day and made a large difference motivate fires to ultimate into the evening. However, over the previous 500 years or so, human beings have opted to utilize no renewable and dirtier energy sources such as coal and fracked gas.

At present day we invent and establish affordable processes to trap and keep wind and photo voltaic energy, renewables are turning into a larger imperative electrical energy source, accounting for higher than one-eighth of U.S. generation. The growth in renewables is additionally occurring at massive and small scales alike, from rooftop photo voltaic panels on residences that can send electricity again to the grid to giant offshore wind farms. Even some complete rural communities take note on renewable electrical energy for heating and lighting.

This electricity consumption mix is up as 8.9% coming from ordinary biomass, 4.2% as warmth energy (contemporary biomass, geothermal and photo voltaic warmness), 3.9% from hydroelectricity and the closing 2.2% is electricity from wind, solar, geothermal, and one-of-a-kind patterns of biomass. International investments in renewable applied sciences amounted to more than US$286 billion in 2015. In 2017, international investments in renewable electricity amounted to US$279 billion, with China accounting for US$126.6 billion or 45% of the world investments, while the US accounts US$40.5 billion and Europe for US$40.9 billion. Renewable electrical energy constructions are quickly turning into giant facilities and much less expensive and their share of total electricity consumption is increasing. As of 2019, higher than -thirds of world newly mounted power performance used to be renewable. The consumption of coal and oil have for power generation has decreased and there is an acceleration of uptake of renewables and biofuel.

Many leading countries have made the shift for renewable energy, as a minimum forty-seven world locations are already producing over 50 percent of their electricity from renewable sources. Renewable electricity resources exist over massive geographical areas, in contrast to fossil fuel's locations, which are restricted in a small number of nations. Currently renewable energy and efficient energy utilization sciences

is pursuing different aspects of stable electricity, local weather alternate mitigation, and economic advantages. In world public opinion surveys there is sturdy useful resource for advertising renewable property inclusive of photo voltaic electricity and wind energy. Even as many renewable electrical energy initiatives are huge-scale, renewable technological knowledge also are magnificent to rural and a long way off areas and developing global locations, whereby electricity is regularly crucial in the development humanity. As most of renewable electrical energy utilized sciences furnish energy, renewable electricity deployment is commonly utilized along with in a comparable way electrification, which has a range of advantages: electrical energy can be modified to warmness (where necessary producing higher temperatures than fossil fuels), can be converted into mechanical energy with excessive performance, and is easily accessible. Similarly, electricity from renewable electrical energy contribute to a sustainable environment and save the bills that must paid by other sources of electrical energy.

When discussing about easy technologies, there are two essential ideas of energy technology: electricity furnishes technologies, which refers to probability assets of renewable energy (e.g., wind and solar energy), and energy efficiency technology, or the ones applied sciences which can be hired to increase energy efficiency, (e.g., blended warmness and electricity (CHP), digital electrical energy plant lifestyles (VPP) and smart meters). It is worth mentioning that remodeling the electrical energy generation and replacing traditional power generation with renewable energy is evolving as new technology transformations and new markets form. Jacobsson and Bergek (2004) mean that the redesigning manner for extremely good types of renewable energy, such as wind and sun, will appear after 2020, even if has a higher price tag of consumption and will strongly grow over the subsequent decade. Additionally,