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# A REVIEW STUDY OF THE RENEWABLE ENERGY PROSPECT IN HORN OF AFRICA AND MIDDLE EAST

## (Case of SOMALILAND, SAUDI ARABIA)

By

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A Thesis Submitted to the Academic Faculty in Partial Fulfillment of the Requirements for the Degree of

**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING**

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# CERTIFICATE OF RESEARCH:

The thesis title **" A REVIEW STUDY OF THE RENEWABLE ENERGY PROSPECT IN THE HORN OF AFRICA AND MIDDLE EAST (SOMALILAND, SAUDI ARABIA)"** submitted by
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# Declaration

We currently declare the thesis to become the result of review work under the supervision of Mr Safayat Bin Hakim (Assistant Professor of Electrical and Electronic Engineering, Department, at the Islamic University of Technology, Dhaka Bangladesh).
This thesis never was partially or completely submitted at any institution's degree.

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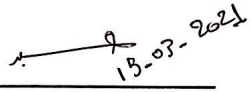

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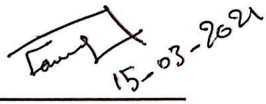

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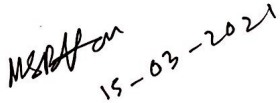

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# ABSTRACT

Saudi Arabia is one of the worlds largest extractor of petroleum in contrast of being one of the most prominent exporters of petroleum as well as its basis of products variant that concerns the utilities as well as the contents from petroleum. The country not only has an abundant supply of the natural oil that is stored within its barren sand of golden hue but of course has other attributes that compliments the brevity of the vocabulary that emphasizes economical energy especially in plain renewable terms such as solar power and wind ferocity. As these untapped forces are laid dormant throughout the vast, fathomless kingdom which can be prospectively connected by a grid, technologically smart enough to be precisely adaptive towards the ever nature of expansion of transmission facilities overlooked by the countries power station. By contrast the power grid or Smart Grid is an auto balancing, self-administered, monitored grid system that accepts any source of fuel from any non-renewable or renewable sources ranging from solar, wind water, biomass to uranium, gas, oil or coal etc, and delivers electricity directly to the suppliers in order to sell to consumers on demand, hence satisfying the market forces by just mere economic yet with a slight advancement in technological aptitude. It aids in the control of appliance management and perfects the modules of resource allocation to a perfection. Not only it promotes to appraise the saving percentage of energy and lowering energy expenditure cost but also it displays economical reliability towards the country's huge consumption of high-end electrical energy. This paper explains the true extensive utilities of Smart Grids as well shows prospects on how it could actually help in modernizing the use of grids throughout the designated regions. Moreover, the necessity of conservation of oil in KSA is often argued as the vast availability of renewable sources such as wind and solar lay idle before them will be soon depicted among the pages as one descends reading down these written pages. As both utilization as well as advantages are mentioned in this paper.

**Keywords:** Solar energy, wind energy, smart grid, conserving oil, megawatt

# PART 1: KINGDOM OF SAUDI ARABIA

## Chapter 1 Introduction

### 1.1 Kingdom of Saudi Arabia

This region of the country called Saudi Arabia is situated within the midland of the East, which clearly borders both the Red Sea and the Persian Gulf. Coastlines along its own extensive reaches provides significant leverage on the shipping press especially on the ones that harvests and harbors crude oil, through the Gulf and the Suez Canal towards neighboring countries that include Iraq Jordan to the borders of UAE and Yemen. The geography Arabia however is quite rugged and primarily deserted as the scenery is totally covered with a barren wasteland with little water and few rugged mountains that acts as jagged shadows which props the sunrise and sunset, overshadowing the concept of art that resides within its golden hue. The Government system that primarily rules the central region of KSA mandates the leadership under a monarch system [1]. Despite being in modern economic times, the country feels quite safe and comfortable in terms of ruling under the shade of dictatorship as much as following the old traditional customs with a twist of modern cultural as well as political aspects which legally promotes economic activity within the country as much as elevating the country development infrastructure. Hence only one person can be the leader and that person is the sole ruler of the country as Chief Of State which in macroeconomic terms states as Government, Prime Minister or in royal terms known to be King. KSA constitutes the vast majority of landscape that confines the entire parametric border of the Arabian Peninsula. With a land area that is estimated an approximate numerical parameter of 830000 Sqm, Saudi Arabia is considered by default, geographically, the largest sovereign state of western Asia. 2$^{nd}$ in the Arab world, 5$^{th}$ in Asia alone and 12$^{th}$ in enormity within the glimpse of the optic lenses that are eyes of global geographical prospectus [2][3]. Even those the country has both the gulf and the red sea and yet most of its terrain consist of only the dust of the barren deserts and the echoes of the wind that sighs along the way of the arid lowlands and the jagged edges of the rugged mountainsides. According to a journal that was issued back in 2018 state that Saudi Economy is one thriving nest of development as it's the largest within the abode of middle east and 12$^{th}$ in the global economic region [4]. It also stated that Saudi Arabia procures one

of the youngest Populus which consist of 50% of its 34.2million of its being is under 25 years old. Hence the unemployment rate is significantly lower, higher employment which is both good for the state as well as for the betterment for the economy to grow, prosper and blossom into the country it was meant to be.

## 1.2 The Climate of Saudi Arabia and Surface Meteorology

The climate of Saudi Arabia can be portrayed as a desert climate which can be often characterized by an extreme heat by day and an abrupt fluctuation of temperature by night. The seasonal change would vary temperatures from infernally hot or bitter cold by favours that are bestowed upon the seasonal changes that are brought on by summer or winter. However, the country's environmental aspects suffer no consequences from spring and monsoon however brings very little annual rainfall if luck often favours. The influence of this sub-Saharan which is often regulated to be a resultant of subtropical nature which results in high pressure systems. It was often seen in very silent observation that the temperature varies from 43 to 54 Degree C in terms of summer which is deemed quite normal in these sub Saharan counterpart regions and yet it only births from the break of dawn from the sunlight reaching its peak in high noon, and then slowly when the evening descends so does the sun while shutting down its eye during sun set chills of wind grown increasingly stronger while the temperature slowly drops even in some readings it has been reported to drop in less than zero degree C. Yet in the season of winter, there is absence of humidity, the nights seem more longer and there had been higher gust of wind with even stabbing bitter chill while the temperature is significantly less than zero, making it quite difficult to survive let alone adapt. Yet inhabitants do have quite the unique ways to making it quite bearable to live as much as the saying goes life is untamed and it will eventually find a way to live and survive even in the harshest condition's nature bestows upon them. Spring and autumn keep the temperature to a minimum of 29-degree C. Monsoon generally occurs in the month between October and march, usually from the

waters that are extracted from the Indian ocean along the western coast. During this period the region experiences barely 300millimeters of rainfall in about 60 percent of annual participation. For the rest of the country the rainfall is quite erratic making the rainwater more insufficient which act to be deficient. Annually the country can expect a couple of cloudbursts followed by a few thunderstorms to spook their spirits a little.

## 1.3 The Energy Situation in Saudi Arabia

The entire economy of KSA is energy centric which clearly means that the Kingdom is dependent on energy production as well as consumption simultaneously through out the entire time of the daily activities mandated within the particular region. In plain words energy is the backbone of the country. The kingdom not only possesses the legal deeds of having ownership of more than a quarter rights of the oil reserves but consequently they are the largest producers and exporters of oil in eyes of global concept. Yet Saudi Arabia is developing and structuring its extensive reaches towards additional forms of energy such as the LPG and natural gas that are once flared off oil wells and collected, then fractured lesser into LPGs. In another practicality aspect of one theology which clearly states that economically the kingdom is the sole producer of oil and other various petrochemicals such as Kerosene, diesel and gasoline. Despite having such amazing reputation in terms of oil they do have reserves for possessing concerns of deposits that consist of both precious and semi-precious metals which clearly seconds the favour of the country in becoming a legal as well as major exporter of minerals in economic anticipations in the near upcoming decades. To which Saudi Arabia did give a positive response to their glorious feedback that they indeed had taken certain solid steps in order to structure the energy pipeline and encourage more investment especially from foreign multinational companies. In one article it has been depicted that on the date of May 2000 the SCPM Supreme Court of Petroleum and minerals had indeed announced a crucial decision to unanimously allow foreign investments that concerns the monetary subsidies as well as financial leverage to fuel the production of gas and other downstream industries. All the while Saudi Arabia consistently yet persistently invest within the energy sector of the region. Hence in double ways economic growth can be fully achieved. The kingdom plans to invest

$70 Billion USD on Oil and Gas alone in various programs related to the project over a 5-year success plan that is similar to a sustainable development goal as constructed by the united nations, which derives the same goal of unity towards conserving energy which constantly yet victimizing suffers from scarcity which is indeed a development and a economic problem and needs to be addressed as swift as possible.

## 1.4 Renewable Energy

The Kingdom of KSA is very much blessed with the abundance of sunlight as well as heat energy especially during spring and summer seasons, due to the fact not only this is a sub-Saharan continent but it has sub-tropical means of the ratio if humidity endowed to it. Middle East and central African countries are very fortunate to be bestowed with the direct face of the sun hence they are extremely notorious for exploiting this free gifted resource to their pro card hence gaining a particular competitive advantage within the sub sector of the energy industry speaking from a complete fair economical point of view. Most continents such as Europe America, Latin America and even nations of Western Asia experience the radiation of the sun to be around 100-200 Max /m2 where as in Arab nations it can span up to more than 250+ W/m2 as stated by GCC (gulf Cooperation Council). Even from the western region of North Africa towards the eastern edge of Central Asia it has been reported that there's a particular area that gets around 6-7kWh/m2/day. Which is pretty considerable for the fact that it can cause the temperature to change over daylight into power at any place and its cost significantly less. Hence the demand of the expanding cost of oil can suddenly be rifted as the demand for fuel will suddenly change its orient towards solar energy while Saudi being its main both importer as well as distributer. Hence theres a huge hopeful anticipation for Saudi to harvest, invest as well as distribute this free natural source of renewable power. In a manner of speaking such power can eventually be sustained and control various pricing strategies that can be practiced in both micro as well as macro-economical regime. Hence such fare will be argued in more sun deprived areas where high energy intrigue and can tolerate paying good prices for the energy. Back in 1980 KACST King Abdul Aziz City for Science and technology, had issued a project for a sun-based town, to create solar-based enhancements for applications in far off areas as per issued by KSA government themselves. There few solar based experiments did take place which

led to the evident theorization as well as practical hypothesis as well as practice of demonstrating in harvesting outstanding potential for solar products in Arabian territory where the country can use this ideology to fuel the project of desalination of water. As predicted and pointed out by Saudi Arabia public science organization, the vision is presently wanting to implement as well as assemble sun powered desalination plants in aiding to save the energy expended by petroleum products. Even as of now roughly
**1.1** million barrels of oil are used daily to fuel the production of desalination plants. Hence by factors of production, cost increases so does inflates the price to ascend. Along side in driving the desalination plants the economy also expects to utilize the solar power to procure a framework limit to build a strong foundational aspect by using sharp developments within the framework.

## 1.5 Overview of Saudi Arabia's Renewable Energy Resources

Despite being an enormous country, it is a moderately a prosperous agricultural nation with a request for power management that's roughly increasing by 5% yearly. Throughout 2.5 decades it has been observed that USA would invest $117 USD on KSA in the country's core power region. The state power framework had provided energy around 80% of the population while increasing the mechanical forces, military advances, technological enhancements as well increasing the standards of living quite drastically so to speak. However, its quite unfair to expand too rapidly into the regions inadequately populated districts as such with great electrical matrix framework might be too unstable for them to handle. Thus several numerous little distant frameworks needs to be free placed acting as a well spring for electrical energy output. Hence these certain areas address a critical potential port for environmentally friendly applications. However even though Saudi Arabia is indeed taking part in becoming one of the lead oil distributers, its still has a huge interest in taking part on the making as well as developing the various growing innovations for abusing as well as exhausting the well springs of the energy. One of the most sustainable renewable energy sources are indeed wind and solar power. The force within the wind will be able to convert kinetic force into electricity while the heat radiation from the solar rays will be eventually be converted to electrical energy with the compliments of thermodynamic radiation modules. Hence such forces will be able to make useful ties with the Kingdom energy supply. Hence such branding

of environmentally friendly forces will be able to put KSA within the land mark for businesses hence attracting more foreign consumers to buy their products as well as foreign multinationals to invest on them.

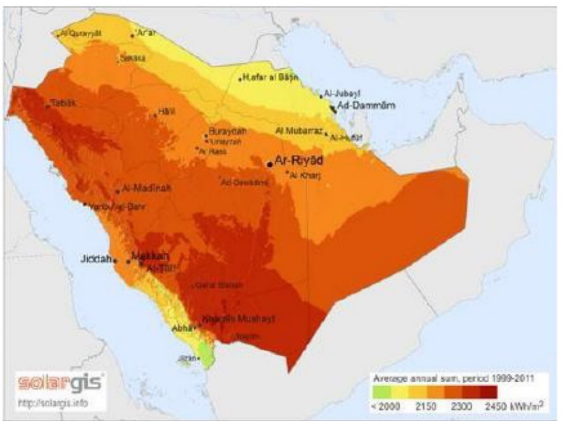



Figure 1: Average Annual Daily Solar Radiation in KSA [39]

## 1.6 Wind

There is a fast increment of force age overall using wind energy due to its higher transformation measure proficiency. For example, in 2016, the breeze energy sum was expanded by 12% (50 GW) from 2015 [1]. Wind energy arrived at 469 GW of total energy in 2016 overall [2]. That makes 4% of the all- out energy created worldwide, comparable to that delivered by Japan, the fifth biggest energy maker worldwide. In Europe, the portion of wind energy creation innovation was 12% of any remaining fuel sources. Ongoing information demonstrates that most Middle East nations aside from Iran and Israel represented practically 0% of this environmentally friendly power innovation [3]. The creation of energy from this inexhaustible source in these nations has not actualized for an assortment of reasons. Right off the bat, the accessibility of oil in enormous amounts in these nations and the absence of data and venture on examination remove energy from other environmentally friendly power sources[6][7]. In any case, Gulf Cooperation Council (GCC) part expresses: The United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar, and Kuwait have taken numerous measures to lessen their reliance on unrefined petroleum and intended to use other familiar sources, for example, flammable gas, wind, and sun- powered energy to deliver power and decrease fossil fuel byproduct regardless of the fast populace and mechanical development in these nations. Wind power innovation is required to rise quickly in numerous nations in the future, including KSA. As of late in Saudi Arabia, innovative work activities have been taken by a few government-supported tasks intended to decrease the utilization of unrefined petroleum and, consequently, control CO2 discharges. A few investigations [2-5] and tests progress in sunlight-based and atomic ability to create power. The Saudi Vision 2030 is zeroing in mostly on environmentally friendly power, including wind energy.

# Chapter 2 Wind Energy utilization in KSA

## 2.1 Current power generation scenario in KSA

Currently SEC Saudi Electric Company and SWCC Saline Water Conservation Corporation are the main producers of electricity within KSA which uses Gaseous petrol and diesel. SEC mandates and bears 79GW of power with a 36% success factor of effectiveness while SWCC gives 12% of all out power in KSA. However, the national electricity transmission company is an organization claimed by SEC is answerable to the company for the exchange of transmission of electrical energy from the age plans to the dissemination of company activity and support of the power transmission from 110 to 380kV[8]. The organization has roughly above 77000km power transmission line. Additionally, they possess over 3060 transformers and 990 stations to monitor the constant fluctuation and elevation of power. Saudi Arabia, Bahrain, the Arab Emirates, Qatar, Kuwait, and Oman decided in 2001 to form the Gulf Cooperation Council (GCC) and build an interconnecting power station. The Commission started its capacities with four-part states in 2009, until the rest of the nations were organized in 2014. . In 2017, GCC 2 handled a total of 142 instances of lack of age or loads greater than 100 MW, and for the 10th year in a row, the coherence of two defence of force networks was up to 100 percent. Figure 2 depicts the strength. of Saudi Arabia's electricity generation and unit cost (Riyals/KWh). In 2013 with the creation of the power age out of around 203 GWh, the absolute bottom of the creation was seen, while next year 2014 was the pinnacle. About 219 GWh. There was a downward trend from 2014 to 2017 in the production of the high-power value in Saudi Arabia.Amount in Fig. 2 shown.

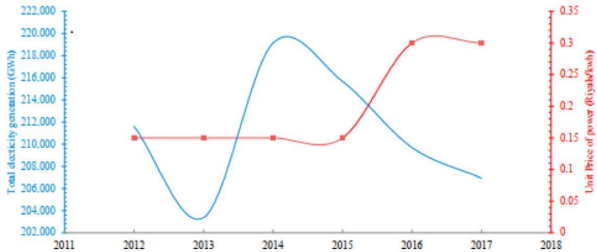



Fig. 2. Electricity production and change of unit price of power in Saudi Arabia, adapted from [8-9].

**Figure 2: Electric production and change of unit of power in SAUDI ARABIA [40]**

## 2.2 Wind energy in Saudi Arabia

Wind energy is significantly higher in the coastlines of Arabian Gulf and Red Sea. As indicated by the RRA Renewable Resource Atlas, it states the average wind speed along the Kingdom is around roughly 6 to 8m/s. Speed is an important factor when it comes to measuring the ferocity of wind. King Abduallah City of Atomic and Renewable Energy stated that they had Set up ten observing station all around the central as well as as outskirts of the kingdom. Namely Hafar Al Batin Aljof Tarif and 7 others etc. KA CARE plans to introduce 40 checking poles all under the obsewrving organization for further forecast[9].

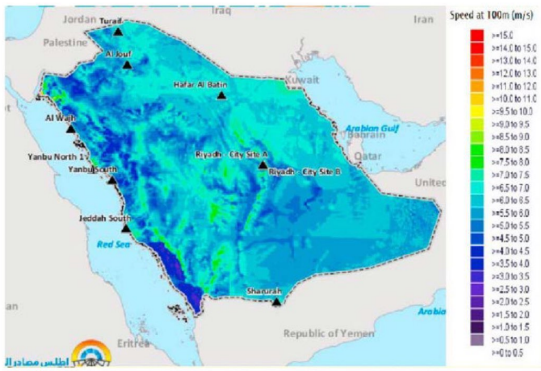



Figure 3: Saudi Arabia airspeed around the country

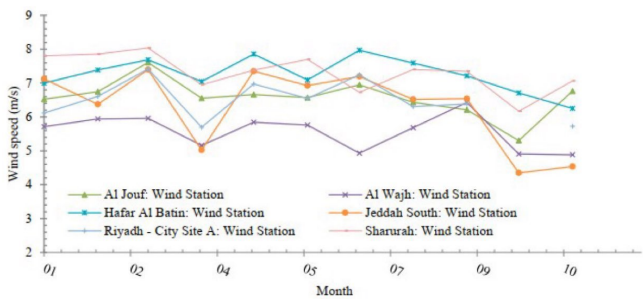



Figure 4: Monthly average wind speed in different location of Saudi Arabia in 2016

## 2.3 Selection of wind turbines for power generation in Saudi Arabia

Currently there are two windmills turbine manufacturers in the region called Goodwill and vestas who manufacture Turbines on a commercial scale. As proficient as they are they have installed many turbines globally[9][10]. The selection of proper turbine depends on the land they have to be set up with especially if that land has a particular windy atmosphere to catch the maximum air drift. The selction of proper wind characteristics as well as availability of wind in those sights can affect the results of the entire project. The vestas wind turbine is significant for this because its suitable and sustainable to invest. However more research needs to be done in order to find out proper ways to cut down costs while maintaining good turbines in a decent budget. Hence financial knowledge of capability capacity and quality is needed to be noted.

| Type | Vestas V136 | Goldwind 3.0MW(S) |
|---|---|---|
| Capacity | 4-4.2 MW | 3-3.4MW |
| Temperature | -20 +45 | -30 +50 |
| Frequency | 50/60 Hz | 50/60 Hz |
| Hub High | 91.5 m | 100m |
| wind speed | 6-9 m/s | 5.5-8.5 m/s |
| Price | $1.1 million/ MW | $1.01 million /MW |
| Annual Energy Production | 18 GWh | - |
| Design Lifetime | 25 Years | 25 Years |

Table 1: Comparison of two wind turbines with their specification

# Chapter 3 Use of Renewable Energy Sources in Saudi Arabia through Smart Grid

## 3.1 Smart Grid and Its Role

For the most part, a forced matrix sends power from a couple of focal force- producing stations to an enormous number of burdens or clients. Keen lattice innovations empower this framework to be fit for steering power in more ideal manners and the two ways. The conditions to which a splendid grid could respond happen wherever in the power age, transmission, scattering, and solicitation chain. A calculated graph of the shrewd matrix appears in Fig. 1. Brilliant matrix will probably have a control framework that examines its presentation utilizing self-sufficient fortification learning regulators with methodologies to deal with the lattice's conduct for truly changing climate because of some gear disappointments [12]. Without much of a stretch, disengage influenced regions and divert power streams around the harmed offices, keeping up force accessibility and expanding reliability. It energizes the shoppers for top interest shaving or requests touchy administration [10]. By empowering conveyed energy assets like private sunlight based boards, little wind generators, and other force sources, keen matrix persuades little players like individual homes and independent companies to offer their neighbors' capacity or back to the lattice [13]. It upholds conventional burdens; additionally, they likewise can, without much of a stretch, interconnect miniature turbines, renewables, energy units, and other dispersed age advances at nearby, provincial, public, and even worldwide levels. Critical expansions in mass bandwidth will require upgrades in the transmission matrix board. These upgrades are required to make an open business community where elective fuel sources from geographically blocked off zones can, without a very remarkable stretch, be offered to the customers any spot found. It can advance capital resources while limiting tasks and upkeep costs. Enhanced force streams amplify the utilization of least expense age assets and subsequently decrease the waste. The sustainable power assets are generally discontinuous. Keen matrix innovations can empower the force frameworks to work with an enormous number of such energy assets so that the two providers and customers can

make up for inconsistencies related to the fickle nature of most inexhaustible sources. Savvy framework advances can assist with interconnecting and control the progression of the copious sun-powered energy and wind energy all through the realm with the current fuel sources. The ideal and dependable force supply of such a framework will permit singular customers to create power nearby utilizing any suitable technique and to adjust their ages to their heaps. Subsequently, it will make them less influenced by the framework's force disappointment. It additionally permits a switch stream of surplus energy produced by a nearby sub-organization, in the wake of meeting its utilization needs, to the principle framework. The keen framework connects with generators and burdens in a robotized style progressively and organizes its presentation as per the interest. It oversees energy utilization in light of supply conditions or the market cost. One bit of leeway of brilliant framework applications is the time-sensitive valuing that can be applied. Buyers can screen the changing cost in a moment or two, and along these lines, electrical gear offered messages to respond to such value variety. A savvy matrix urges customers to lean toward affordable energy in collaboration with power lattice at the most appropriate time [10]. It helps load shaving by propelling customers to work just the most virtual machines at maximum interest periods and to move the activity of less essential apparatuses at off pinnacle hours when electrical energy duty might be lower.

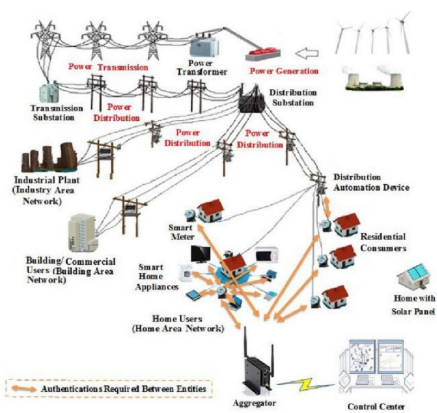



Figure 5: Conceptual diagram of smart grid[41].

## 3.2 The need for conserving oil

There is rising global concern about the organic oil industry. The global oil demand has risen far above the world production of oil in the last decade. Full development of unrefined oil and fire retardancy gas fluids are present in Figure 2. It reveals that OPEC nations perform almost 35% The world's oil is 45%. The most prominent oil is Saudi Arabia nation supplying and generating between OPEC selections. Approximately 30% of the entire stock of OPEC oil. The speed use and Saudi Arabia has oil-based goods fairly. Expanding. - Expanding. An immediate result of how everyone works spaces are developed, Market is expanding, the number of movement ventures completed and the power age is extraordinarily based on oil. The regular energy utilization per capita growth in the realm as seen in Fig. 3. From 2000 to 2008, it grew 6.5 percent and from 1990 to 2000 it grew 4.7 percent. Saudi Arabia, Russia, Norway, Iran and the UAE are the top five net oil exporters. Countries trade for a world net oil segment between 2000 and 2005, the combined expansion of local use of such countries stood at 3.7 percent per annum, stimulating development speed with such a use rate of 5.3 percent per annum from 2005 to 2006. Furthermore, the fare ratio declined by 3.3 percent per annum from 2005 to 2006[1]. Given the technology for linearization in Hubbert, Saudi Arabia should have 185 giga barrels [1] of a definitive restorative oil shop. The unrefined cost of growth and potential figure of oil in Saudi Arabia appears in Fig. 4. Per day (mbd) in 2005 it peaked at 9.5 million barrels. The unrefined oil output was respectively 9.3 and 8.1 mbd in 2008 and 2009. There is a steady decline since 2010. In those discussions, the preservation of oil products is unmistakable to meet the needs of the world; later, shrewd matrix innovation becomes adapted to use environmentally friendly power hotspots for the electric force age will prompt moderate oil.

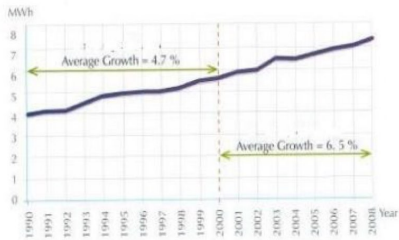



Figure 6: Energy consumption per capita

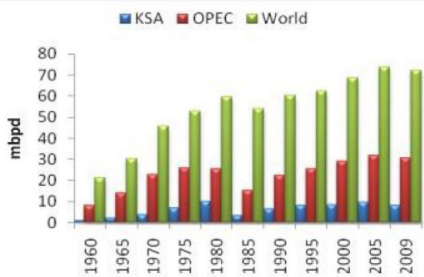



Figure 7: Statics of oil production with year

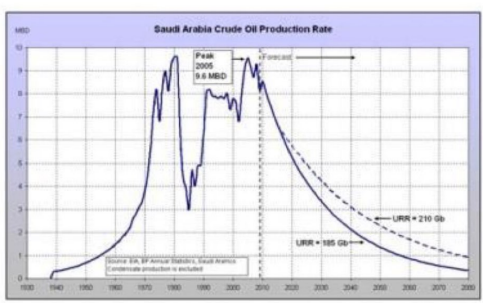



Figure 8: Saudi Arabia crude oil production rates
[38]

## 3.3 Saudi Arabia and Solar Energy

Saudi Arabia is the area with the greatest capacity for sun power collection. Fig. 5 observed that the best places for solar power are the Arab states. The average annual solar radiation intensity in most European countries in North America, in the majority of Latin American and Western Asian countries is from 100 - 200 W/m2 while it ranges about 250 W/m2 in the Arabs, including GCCs. There is a huge rainless area, covering about 6-7 kWh/m2 from the west end of Northern Africa to the eastern edge of Central Asia. Saudi Arabia/day. It can also be exported to other countries where the potential of solar energy is smaller but strong energy demand and energy is able to afford. A "solar village" program was started in 1980 by Saudi Arabia Photovoltaic technology for remote areas. energy .KACST (King Abdul Aziz City of Science) Research Institute[13]. Multiple solar energy- related science and technology) ventures projects. Studies showed relevant prospect regarding the Solar energy utilization as well as appliance in Arabia. Another area where KSA can use their solar applications in desalination of water. According to KCAST the kingdom now plans to implement solar based desalination plants in order to harvest and conserve fossil fuels. Yet a significant amount of money does goes in to these plans which equals the amount of 1.5 million drums of oil each day. Causing the price of the desalinated water to shoot up along with the inflation of oil prices. Along with the powering of it with the grid will eventually energises the desalination plants which the country aims to use solar power to further strengthen and expand the grid capacity[19].

## CONCLUSIONS AND PERSPECTIVES

Even though KSA is largely dependent on fossil fuel, renewable energy can also be used as a second source of energy, energy from the wind would be the main one for electricity generation. Numerous locations of Saudi Arabia can be used for wind power generation on a large scale. Saudi authority can take action to build in multiple wind turbines in those locations by some pilot programs to examine the usefulness of wind power generation further. Thus, the kingdom will get 20% of its power output from renewable energy sources that are communicated in the Saudi vision 2030. it argued that smart grid technology could be play an imp important role incorporating renewable technology in the electric power field. Therefore, the oil consumption would be less, which is mainly used for power generation in Saudi Arabia. Saudi Arabia uses 1.5 barrels of oil each day for no renewable energy sources, so incorporating a sunlight based energy source would massively decrease overall costs and the reliance on oil [16]. The advancement of a renewable energy plant with a limit of 20 MW will generate around 200-300 GWh/year, with an expected force plant region of 1.25 km2. 500,000 barrels of oil will be saved and 200,000 tons of carbon dioxide will be avoided each year [8]. The use of AC (constrained air framework) units increase in the pre-summer time span (april-september) in the domain in light of high sun radiation and temperature rise.

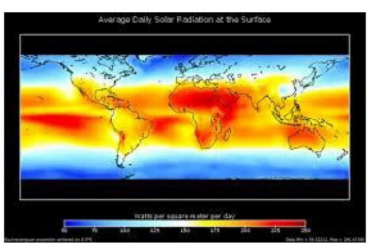



**Figure 9: Distribution of solar radiation in Saudi Arabia and neighboring countries[37].**

## PART 2: THE REPUBLIC OF SOMALILAND


# Abstract

Dhagax Dheer is situated within the southern region of Somaliland which has a duly population of over 25000 residents. The average monthly solar consumed at a daily scale is around $5.5 to $7.3 a day and the velocity varies from 4.2 to 8.2 m/s. Hence this expense of creating energy is above the cross breed framework. Hence never the less for diesel the only option would be to negotiate in an existing agreement levelled the cost of energy for Dhagax Deer. However if the cost of diesel remains lower then the cost of the hybrid systems energy would be kiwer than the diesel only system. Hence optimum system requirement changes with the price change of diesel. The most economical decision that would be feasible would be to agree to go with the diesel only system.



Figure 10: Republic of Somaliland map [34]

# PART 2: THE REPUBLIC OF SOMALILAND

## Chapter 1 Republic of Somaliland

### 1.1 The Republic of Somaliland

For Somalia and the broader district of the Horn of Africa, Somaliland is vital. The Gulf of Aden is many miles north of the coastline, neighbouring Ethiopia south and west, and Djibouti north-west. it crosses Ethiopia. Somaliland's regional cases are challenged by Puntland, the semi- autonomous territory of Somalia that lay east. Somaliland is located in the Gulf of Aden, near the entrance to Bab al-Mandeb, a vital ocean route that takes over 33% of the world's supply. Its region has helped the government withdraw in trade and marketing agreements[21]. The Dubai company has reported in late 2016 that it is trying to adapt to and revise Berbera port and create a hallway to the Ethiopian border from that point. The Arrangement is made available to Ethiopia. The Horn of Africa has also attracted late security interests. Djibouti is also a base for the unfamiliar army installations, with all offices in China, France, Italy, Japan and the US[22].

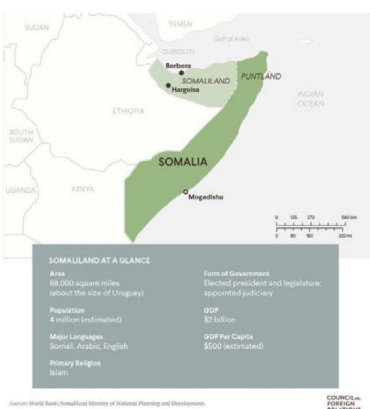



Figure 11: Republic of Somaliland map [35]

## 1.2 The Climate of Somaliland

Somaliland is located in the so-called Horn of Africa and its tropical climate, which is hot throughout the year, is also mostly dry. For the most part precipitation is scarce and occurs in vast regions across desert or semi- desert miles, while savannah involves west regions. The north coast is the driest of the areas, with annual rainfall dropping at about 50 mm and northeast, below 200 mm (8 in). The most rainy areas are then in the northwest, where the Ethiopian Highlands' intense offshoot and precipitation approaches an altitude of 500 mm (20 pounds) a year. The coastal plains Guban, "The watershed Mountainous area Golis" and the hi- altitude high plateau "Haud" can clearly be separated into three ecological areas. The natural resources of the area are described by these three different ecological zones. In these three areas, rangelands, forests and nature reserves are determined. Somaliland0 is further emphasized by its significance for poultry, which is Somaliland's key economic activities. The guban and golis offer the goat and camel good pastures, while the haut gives the camel, goat and sheep good weeding in some pockets at the same time (Borama, Gabiley, and Odwyene). The haud, also referred to as "Ogo" is good for cereal production. Pasture and water availability are dependent on the rains, which vary depending on the altitude of the region. Guban coastal plains have an average annual rainfall of 50 mm and annual golis ranges from 2483 m to 1900 m asl. Normal 550 mm precipitation, extending from the haud Hargeissa (1280 m asl) Sheik (1441) Borama (1454 m asl) in the north-east have annual Erigavo(1744 m asl). The average precipitation is
410 mm. The hair is covered by low pockets. Rainfall zones that are only suitable for Burao (1042 m asl). Las-anod (706 m asl), averaged nearly 130 mm annual rainfall. Washing occurs moderately every three to four years in the area and seriously every 7 to 9 years. The Face In pastoral areas, traditional production systems are implemented. Reflects weed variation and scarcity of water in the areas. During the many seasons. This system is conventional. Characterized by well-defined livestock and seasonal movement. Weeds and water availability pastoralists.

## 1.3 Current Energy Status

Three major problems have been reported in Somaliland at a broad charge: lack of connectivity, incredibly high cost, and poor reliability. Only a small minority of national families and organisations. Real, observable information on the energy situation in Somaliland is not present since not many studies in the country have been conducted over the last few years. While the World Bank reports that 29.1% of people in Somaliland are approaching power, the subsequent evaluation of the African Energy Outlook 2014 assesses that the power gain is not exactly one third of the population. This estimates obscure a wide metropolitan country void. Power is almost non-existent in nation territories. It shifts the country almost over in metropolitan areas. A new measure is 68 percent of Hargeisa's population, while the smaller cities, such as Sheikh, have just 23 per cent of electricity. The evaluations of the level of entry to power are probably exaggerated in the territories where more persons dislodge inside the territory that are more critically to be examined. Although these rates are higher than comparable urban areas in Somaliland, particularly in Hargeisa (the capital), the power of organizations and households to "access" which is Dangerous. The main question is that taxes on electricity are one of the most noteworthy on the planet. From .80 to $1.5 each Kw/Hr. comparatively ethopia and kenyas are adjoined nation that appreciates paces of 0.15 to 0.06. Not only Somalia are paying a significant chunk out of their hard earned money for power but they are also receiving less of it. The GDP per capita measure for Somaliland is $128 , a little bit of the GDP per capita of $454 in Ethiopia and $942 in Kenya . Somalilan citizen probably the least fortunate country on the planet and pay perhaps an essential duty for any country's power. The variety of power taxes is clarified by area and differential evaluation which are determined by the energy suppliers. Individual in areas are from a long way from metropolitan focus which is commonly to pay for energy costs. Within urban areas taxes change on demand towards their suppliers. Since they do not utilize a uniform rate among their clients the absence of straightforwardness and consistency make issue for both clients as well as providers who contend in that area. The other issue is with the electrical stockpile that causes a huge amount of untrustworthiness. Deficiencies and blackouts haunts the organizations because of the limits if the current foundation that resides within the transmission line grid or insufficient macroeconomic expenditure on the electrical energy. Answers for power transmission and conveyance have been ad-libbed without guidelines or principles, and is regulated faithfully

as well as in practice without any professional touch let alone preparation. These impromptu, frameworks have lead to failures which further adds misfortunes, as high as 40% during energy creation , conveyance as well as transmission towards the receiving clients, keeping both parties unsatisfied. Valuing inconsistency, and restricted admittance clarify why the utilization of power from Somalia is among the least within the planet. The guage net utilization of power from 2012 was 288.3 million kilo watt -hours , putting Somalia and in the base quintile on the planet . Give the participants direct picture. Somaliland ' s 2 8 . 7 kWh our utilization per capita is a simple 1 percent of the world average (2,798kWh), a large portion of that of Ethiopia's utilization (57kWh) , and just 19 percent of Kenya's use (153kWh).


Figure 11: Republic of Somaliland map [36]

## 1.4 Overview of Somaliland's Renewable Energy Resources

Environment friendly power harbours assets that are collected, assorted and differed, from country to country it varies. Somalialands known renewable energy resources are hydro, biomass, wind and solar.

### 1.4.1 Biomass

The country is pretty much known for their possession in bio mass energy in the Sub Saharan African region. Biomass reshapes the common wellspring if energy, that addresses 66.7% of the full scale public energy usage with wood fuel being the prevalent biomass structure to be used. Biomass can be both local and business usually gathers gas for cooking or other purposes.

### 1.4.2 Wind

The country have very mean winds that exceeds the nominal speed by 80% while the eastern region have a 60% chance of exceeding their previous record. Hence why the country have so muh wind hence building of turbines will do the trick of having a built in generator especially during windy days.

### 1.4.3 Solar

Being tropical country, they always had the upper hand in being the top country to have the abundance of the sun. And they are well endowed by the divine fruit of it which so they reap even till now. Receiving 3000 hours of sunlight per annum with an average solar intensity and radiation of 240w/m2. Some significant solar energy resources are scattered yet available in this country which are both discovered and undiscovered. During the sunny part of the day the average solar radiance have been estimated up to 5.8Kwh/m2 while being 4.9Lwh/m2 within the rest of the country as well as neighbouring nations. Henceforth the conditions seems rather insightful and ideal throughout the country for exploitation of cameroons solar energy resources through various diverse methods as well as utilizing the innovative technologies of conversion.

# Chapter 2 Metrology

## 2.1 The Weight of Energy Deficiencies in Somaliland

The energy shortfall trouble in Somaliland that comes from the significant expense and restricted admittance weighs intensely on the Economy, the climate, and the arrangement of essential administrations. While power can change Somaliland, without expeditious and considerable change or interest in the area, it will keep on being an obliging element for an additional turn of events and obstruct development openings.

## 2.2 Requirements to the Economy

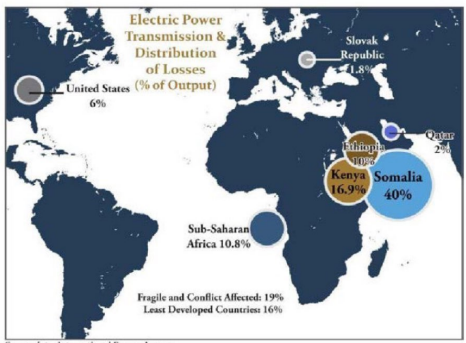
The significant expense of and restricted admittance to power have real monetary ramifications. Across non-industrial nations, the punishment of electrical blackouts and untrustworthy assistance on profitability prompts a considerable total impact on economies [10]. The problematic electrical stock in Africa can cost a normal of 1 to 2 percent of GDP each year, as organizations are compelled to close down activities when the force goes out. [11] As with numerous delicate and struggle influenced states, in Somaliland, power is given by private business people who use diesel- controlled age frameworks that are usually utilized or repaired—an impression of what is accessible as opposed to, in fact, ideal. Eventually, reliance on such diesel-run frameworks builds questionable administrations' financial cost to however much 4 percent of GDP.[12] The duties that Somaliland associations pay are among the most critical on earth, which makes the massive costs of force in Somaliland perhaps more veritable than issues starting from trustworthiness. This reality impedes the headway of new associations and bargains the thriving business improvement that has simply occurred. The tremendous cost of force eats up Somaliland business edges at an exceptionally high rate that remains genuine; creation expenses should be counteracted excessively lower rough material or work costs. Imports are conveyed even more economically basically because overhead.

## 2.3 Damage to the Environment

The citizens of Somaliland continue to rely on biomass for basic necessities without access towards any reliable let alone affordable source of electrical output. Hence this leads to severe catastrophic aftermath towards nature itself. Biomass is the primary fuel for cooking and other gaseous fuel related purposes that serve the utilities which its predecessor <Natural Gas> had once laid the foundations before becoming the victim of over exhaustion. However, Biomass can be over exhausted and yet still be sufficient for its ability to be renewably reproduced by means of decaying the carrion or cadavers of animals or natural biological excretion of healthy beings to a particular spot where the gas can be collected pressurized and thus developed, this too applies for the collection of rotten wood or charcoal or any biological immobile beings. Hence this too serves 96 percentiles of electrical appliances fuelled by electricity. However, charcoal itself is fossil fuel since it's overused for decades leading to devastating economic and environmental problems. Every year Somaliland is a victim to a devouring of 2million charcoal sacks. Which normally adds up to the annihilation of natural timberlands. Over exploitation from domestic charcoal use and illegal exports had reduced the forester landscape in the region which increasing in an alarming state. This systematic deforestation causes soil erosion which correlates to desertification, which is a process that cuts in depth of the economic prospects of agriculture and ranching industries in the country which has already related into recent onslaught of draughts and famines. Simultaneously the cost of charcoal had inflated by quads since 2007, which severs through most of the economic disposable income of the working-class families, hence eating up most of half of family's monthly income. More over charcoal does poses sever biological health hazards too when exposed towards near public, especially those who are of young age or old or those with pulmonary dysfunctional disabilities. Such mass exposure would cause an up rise in epidemics of the following pulmonary ailments such as bronchitis, pneumonia and tuberculosis and lung cancer. WHO had recently reported that Somaliland had suffered 11000 indoor pollution death cases per annum, primarily due to pulmonary problems.

## 2.4 The Landscape of Electricity Provision in Somaliland

The energy sector in Somaliland has many features and attributes that are quite matching with similarities in developing countries. Such as the electrical sector is decentralized and has private suppliers which are quite common in these uncharted regions, significantly energy supplied by larger generators are more stationed towards aiding the construction of economic infrastructure and military funding, however for consumption the electrical energy is completely let loose in the hands of the free market hence which results in fewer generators but large demand for it. Without government aided generators this would result in a catastrophic outcome. Hence many of these IPP that have emerged in the market because they needed electricity to run the businesses such as telecom and internet service. Now these generators installed, began providing electricity as a business for household. This nature of supplying electricity privately had led to a fully fragmented sector of energy in the grasp of the market forces of demand and supply. This sector is unregulated by the government since they lacked the technical skill capacity as well as resources to regulate energy service providers. Moreover, there is a negligence as well as lacking in supervision and legal intervention in matters of privately supplying energy. Hence this had led to the construction and distribution of multiple lines and poles across the nation. Hence due to lack of specifications and regulation from the government these unsupervised energy poles often pose as a physical threat towards common civilians.



*Source data: International Energy Agency*

**Figure 13: Electric power transmission & distribution of losses**

# Chapter 3 A case study "Dhagax Dheer Town."

Dhagax Dheer (8.4148098° N, 45.765953° e), is a town situated in the southern part of Somaliland. Dhagax Dheer lives in a nomadic way and is fully committed to Sheep and camels, for example. Only a few gas generators The fortunate are available to control and the remainder are energized. Demand from carbon and other biomass. Demand by Hunger is .This region of Somaliland is noted for its full dependence on.The wet season of both the season. for which Dhagax Dheer were picked This case study as a pre-crisis humanitarian plan.Can occur as identified in cases of further drought. Dhagax Dheer is a really good potential for the implementation of Solar PV. Global solar monthly average ray is between 5.5 and 7.03 kWh/m2/ day, while the average monthly wind speeds vary between 4.2 and 8.2 m/s. Homer Software is used to determine the best green energy-efficient hybrid systems with which a unit of 50 homes can be powered and water supplied by a water pump. The information to be provided effective delegation (vital energy interests), limitless assets (solar radiation, data on sustained winds), specialized subtleties, costs, imperatives and controls. The product is designed to be suitable for the electrical load. Conducts several reproductions per hour to prepare for Optimum atmosphere. It also carries out an internal examination while speculating results. Solar insulation effects, PV costs, wind speed and diesel investment impact. It cannot transient adjustments which are module on the fuel price of COE. Over 1 hour, smaller. Until downloading the business review, the power generation machine.

## 3.1 Load

Since hourly information cannot be accessed in this way, NASA collected broad radiation information month by month at the midpoint of the world. HOMER includes an accuracy and longitude data file from the site users had chosen. HOMER generates 8760 hourly qualities for the assessment analysis of the data using the Graham calculation.

## 3.2 Solar Energy

As hourly information is not accessible this way, month to month arrived at the midpoint of worldwide radiation information has been taken from NASA (National Aeronautics and Space Administration). [35] HOMER presents a clearness file from the scope and longitude data of the chose site. HOMER makes the incorporated 8760 hourly qualities for a year utilizing the Graham calculation. Figure 2 delineates that the sun-powered radiation is high between Februarys to April.

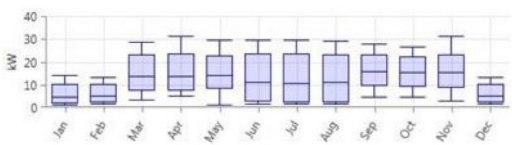



Figure 15: Shows the yearly load profile in Dhagax Dheer

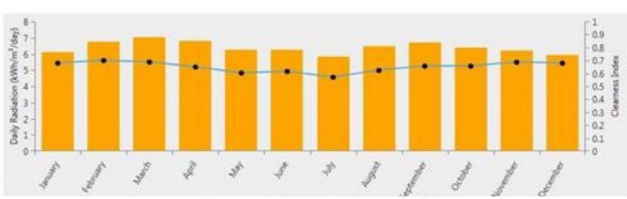



Figure 14: Annual solar radiation

## 3.3 Wind Energy

When no information is free from hourly information, hourly information can be artificially created from the mid-point, wind speed generator generated per annum since it requires four boundaries. The estimate of the Waybill: k value is a portion of wind speed distribution over the year. The k approximation is taken as 2 in this study. The factor of automotive correlation: The breathing irregularity is calculated by this factor. Higher qualities indicate that the brisk speed in 1h will usually strongly depend on the vigorous speed in the earlier hour. Inferior respect ensures that wind frequency generally wavers from hour to hour in a more distinctive manner. The prediction of the auto-correlation factor is 0.78. The magnitude of the diurnal example: how intensely the wind depends on time. 0.30 can be used for this review in action. The time of the pinnacle of winds: practically the hour of the day is reliably exceptionally windy. 14 being used for the pinnacle wind speed hour in this investigation.


Figure 16: Average wind speed

## 3.4 Emission analysis

The production of electricity from green fuels decreases CO2, SO2, NOX to the environment. A PV hybrid energy system emitting wind diesel 20,506 kg/an and 50,6 kg/an CO2 emissions', but the generator emits just 34.206 kg/yr of CO2. Fig. 11 Fig. 11 Show CO2 emissions for two related systems PV-diesel and wind, for instance. The battery of PV-diesel.

## 3.5 Results and discussion

In this product, the improved results are fully applied in order to determine particular limitations of effect, such as sunshine radiation, wind direction, diesel value and the most severe yearly limit deficiency. In order to prepare the perfect crossbreed system HOMER completes several recreations time and time again. Diverse qualities for sun based radiation, wind speed, less inexhaustible division and diesel costs were considered in the study, which improved adaptability. Statistics of overt pace 4,71m/s for sunlight 4,5486kWh/m.sq. The improvement results. It is seen that a PV, wind turbine, diesel generator, and battery cross breed framework is monetarily more plausible with a base COE of $0.477 KWh and an NPC of $613,935.

# Conclusion

Information of most sorts is scant for Somaliland, where even reliable GDP gauges have been hard to determine. This investigation incorporates a few factual realities that we refer to with however much perseverance about their legitimacy as could reasonably be expected given the country's absence of information. All insights referred to ought to in this manner be utilized carefully. Improving access to resources and rationality would help the country tackle poverty by can family incomes. While the scale of the power effect on the turn is difficult to determine. A variety of study developments in non-industrial countries. Keep the adage that influence increases the living standards of family groups. For the first time. In the Caribbean, or instance, the 2002 Bank Group focus. It was decided that the extended family pay $81 to $150 for power access. The number of family unit members and the number of jobs each month. Financial transaction degree at home. Likewise, a new Bangladesh study showed that 12.2 culminated in power access Increased family income percentage variable. In 2005, the UNDP finds that zap has caused a $0.32 increase in a day-to-day wage across Malian cities and average annual woman wage of $68,20 boosted which had Improved. Therefore, the neediness in traditional family pay affects the emergence of where access to information reduced that poverty of a community to Tanzania. Around 4 and 13 percent anywhere. The report was submitted. As the results. Posted from Dhagax Dheer town's situational review Achievable half framework execution, we can copy the concept to the most Somalia province districts. Scenes to avoid such pitying situations. Moreover, the general economy will be revived.

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