An Energy Efficiency and Management of Hybrid Solar Renewable Energy System for Farms: Engineering Economic Present Worth Analysis Approach

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ABSTRACT :

In most developed countries, oil and gas are the primary sources of energy. There are significant energy losses in residential and industrial sectors due to different factors. Remote areas such as farms use diesel generators to generate electricity with no energy efficiency control and no renewable energy alternative resources. There is no straightforward economic approach to control the energy cost over a specific period. The losses and inefficient use of energy resources are studies from an economic point of view. The paper represents a new approach to investigate two mutual projects based on power consumption, power sources, and initial and future costs. The engineering economic approach - present worth analysis- is implemented to select two alternatives applied to a farm project based on diesel and power consumption. The research's primary goal is to Decrease diesel dependency as the primary source for Diesel generator and diesel irrigation pumps. Measuring energy consumption, calculating costs, and considering the environment parameters are the critical performance parameters used for analysis and investigation. The results show that Hybrid solar renewable energy sources with energy efficiency management systems can decrease the cost over n periods. The cost decreased by 50%, and oil consumption was reduced by 40%. Besides, the research considered different periods and different interest rates.

KEYWORDS :

Energy Efficiency, Engineering Economic, Renewable Energy, Ha'il City.

1. INTRODUCTION :

Access to electricity has increased in the world due to the increase in population. Only 71% of the global population had access to energy resources. But this number reached over 87% in 2016. However, 13% (approximately 940 million) of people in that year had no energy support. In 2017, the number was dropped to 869 million in 2018 (Ritchie et al., 2020, Bank, 2019, IEA. SDG7, 2019). The challenge is to serve a population located in remote areas. The efficient solution to serve them is to implement renewable sources as individual or hybrid energy systems.

Oil and gas remain the most significant sources of the primary energy used to produce electricity in KSA (Ritchie et al., 2020). These two sources generate a total of 45000 MW. The residential sector is consuming about 41% of the generated energy. Unlike the industrial area, the residential consumers like houses, apartments, and governmental buildings need more control and energy conversion tools to monitor the energy-consuming process and what to decide regarding this issue (Bank, 2019).

There are significant energy losses in remote areas, where electricity generators and pumps supply farms due to different factors. Diesel usage as a source of energy, the absence of energy efficiency control, and the absence of any renewable energy alternative such as solar or wind energy systems cost energy losses. Most agricultural projects do not have a detailed economic study that helps make the right decision. Table1 shows the Saudi Arabia's basic energy indicators for year 2017.

Crude oil reserves	266.2 billion barrels
Natural gas reserves	8.04 trillion cubies meters
Oil production	11.95 million barrels/day*
Oil consumption	3.92 million barrels/day*
Natural gas production	111.4 billion cubic meters
Natural gas consumption	111.4 billion cubic meters
Coal consumption	0.09 million tonnes of oil equivalent
Electricity production	375.6 terrawatt-hours

Table 1. Saudi Arabia's basic energy indicators, 2017

Note: * includes natural gas liquids

Due to the considerable expenses in energy sources and the waste in energy, farmers suffer from significant losses that make it difficult for them to continue their projects or improve their farms. These expenses are Air conditioners, heaters, pumps, and Diesel Generators (DG) are the primary sources of energy losses that need control, replacement, or management (Bank et al., 2019, IEA. SDG7, 2019).

To help farmers making the right decision, the present worth approach compares two alternative projects. The first alternative is entirely traditional and based on diesel as the primary energy resource for DG and pumps without energy efficiency controllers. The second alternative is a hybrid solar-Diesel generator, electrical pumps, and energy efficiency controllers (Reggae, 2013)

In the vision 2030 of KSA, the investment in the energy efficiency measuring and power-saving technologies is one of the primary objectives "Business Environment, Restructure Our Economic Cities, Create Special Zones And Deregulate The Energy Market To Make It More Competitive" (Al-Qawasmi, 2017).

In this paper, an in-depth study of energy resources, devices, and power consumption analyses provided an engineering economic approach to calculate costs.

1.1 SOLAR ENERGY TECHNOLOGY :

The direct use of solar power is possible through PV panels that directly convert solar radiation to electrical energy (Al-Qawasmi and Tlili, 2018a). The essential PV module parameters are the open-circuit voltage, the short-circuit current, and the voltage and current at maximum power point (Vmp and Imp, respectively). The desired operating end of the PV module is defined by the full PowerPoint, determined by Vmp and Imp's product. There are different types of materials used for the design of PV cells (Al-Qawasmi and Tlili, 2018b). The organic thin-film PV cells are becoming of great interest for research and demonstration (Saudi Vision 2030). There has been a significant price decrease per watt peak for solar cells during recent decades. Figure 1 shows the price reduction history for silicon solar cells (International technology roadmap for photovoltaic, 2017).

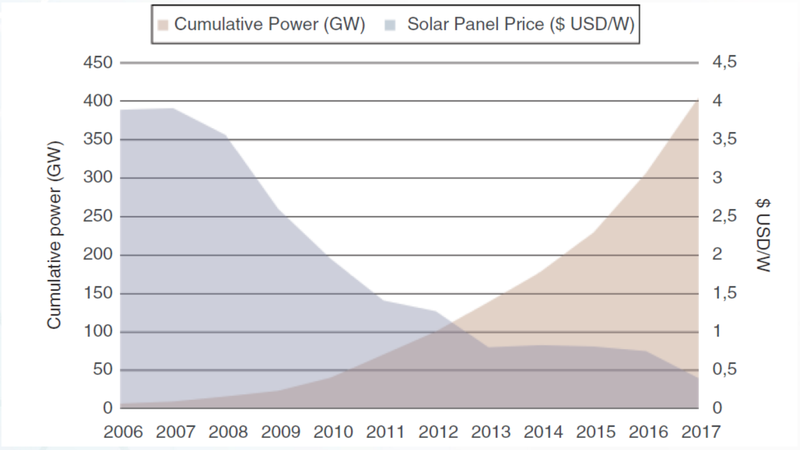

Fig. 1 Price history of silicon solar cells, 2006–2017 (International technology roadmap for photovoltaic, 2017).

Solar photovoltaic energy is the most attractive renewable source worldwide because of its abundance, safe conversion process, ease of transportation and installation, good visibility, long lifetime with little maintenance, and affordable price significantly decreasing (Trends 2016 in photovoltaic applications). The cost of PV systems has been dropping sharply (Sulaiman et al., 2013, Fu et al., 2017).

Ten years ago, several research types were published to calculate the economic factor of using Solar energy—all systems adapted to their region and residential building conditions. But obviously, the use of a PV solar system faced several technical and economic problems (Solar Energy Industries Association, 2011, International Energy Agency, 2015).

Specifying the case parameters and determining variables and constants for a specific project simplifies the research process and formulating the problem more straightforwardly. Farms and building-related applications have been an active part of recent PV developments worldwide (greentechmedia.com).

The Kingdom of Saudi Arabia (KSA) has a fast-growing building sector driven by burgeoning populations, economic and infrastructure development, and modernization. Due to their energy-intensive operation, buildings impose significant energy, environmental and financial burdens for the country (Khan and Hague, 2012).

In some areas in KSA, farms' location is away from the national grid power source. They use DG to generate electricity for personal use and irrigation purposes like pumps, air conditioners, heaters, lights, and other daily devices.

Solar or wind energy implementation is useful for commercial purposes over a specific period, not less than ten years (Khan and Hague, 2012).

The potential PV capacity for each lot can be estimated using each farm area plus an assumption regarding the area for solar modules. The installed PV system's size depends on the power rating of the modules used (i.e., Watts (W)/m^2) and the mounted angle. Because Saudi Arabia lies in the northern hemisphere, installed facing south at an angle of 25 degrees with the horizon.

The power to area ratio typically ranges from 0.15 to 0.2 kW/m^2. Assuming a separating distance of 1 meter between strings, the power to area ratio drops to the range of 0.10 to 0.12 kW/m^2 (Roy et al., 2018, Ismail et al., 2015).

Based on IRENA data, in 2018, the generated electricity using solar technology reached 65.04 GW (Krane, 2019). Figure 2 shows a significant growth in electricity using solar systems from 4 GW in 2010 up to 65.04 In 2018.

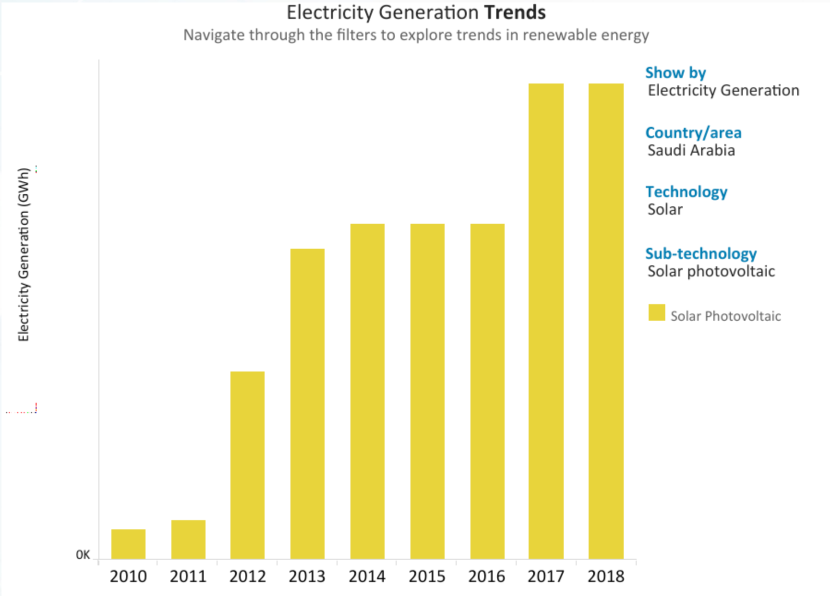

Fig. 2 Electricity Generation Trends in Saudi Arabia.

1.1 ENERGY EFFICIENCY CONTROLLERS USING WIRELESS SENSOR AND ACTUATORN NETWORK (WSAN) :

In addition to the solar energy system and to control energy consumption, the WSAN is used (Mumtaz et al, 2017, Elshurafa and Matar, 2017). WSAN is a promising technology implemented in different areas, such as environment monitoring for energy saving and energy controlling (Al-Ajlan, 2019). Combining a solar energy system with the WSAN increases energy efficiency significantly up to several rates. Using motion detectors and measured visual data using WSAN will give feedback to switch off extra energy resources or control the maximum energy consumption reference.

Today, organizations use IEEE802.15.4 and ZigBee to deliver practical solutions for various areas, including consumer electronic device control, energy management, and efficiency home and commercial building automation and industrial plant management (Muhsen and Elshurafa, 2019). Monthly records were provided and analyzed based on several monitored buildings' analyses In (Elshurafa and Matar, 2017, Hu et al., 2016, Akyildiz, 2004, Sabri et al, 2011).

1.2 HYBRID SOLAR RENEWABLE ENERGY SYSTEM :

Implementing a solar power system to replace or offset a portion of the diesel electricity generation is an option to consider for private residential homes and farms. Replacing the DG with the Solar system is not logical due to the winter season, where the sunshine is low. The hybrid system can prove reliable and cost-effective, given the right conditions (such as optimal sizing), especially for areas isolated from the grid (Neves et al., 2008).

The considered systemin this work is a hybrid solar renewable energy for farms, which consists of a renewable (photovoltaic) energy system integrated into a conventional (diesel) power generation system, energy storage in a battery, a DC/AC converter, and an AC/DC converter (a rectifier for the conversion of generated AC power to charge the battery). The bidirectional inverter is used to maintain energy flow between the AC and DC components (Sudha et al., 2011).

When the PV system and the connected battery could not serve the load, the generator supplies electricity directly to the load and charges the battery simultaneously using a rectifier (Michael, 2014).

1.3 PROBLEM FORMULATION :

Remote areas are not connected to the national electricity grid. Most of them and mainly in farms and implement a diesel generator for their essential applications. In KSA, this method is very cheap compared to Solar PV systems and the energy efficiency controllers' implementation for a short period or present worth.

Most of the current research concentrates on minimizing oil and gas dependency to protect the environment. Of course, the economic part is considered in every system explained earlier in this research. However, there is still no clear studies with an economic (Cost/energy consumption) relation that considers the three systems' implementation.

Some publications considered energy management strategies for Hybrid renewable energy systems and energy efficiency management solutions (Anayochukwu, 2016, NASA, 2012, Laxmi, 2018).

Making the right investments in capital assets, such as land, machinery, and buildings, are critical to long-term success. Energy consumption information shows the amount the farm can afford to pay for those assets. It is useful when conducting reviews of investments in enterprises that fail to meet total costs in the long run and determining where to redirect energy resources to more economical energy systems. Cost of production statistics considering energy saving and energy controlling provide farm owners with data to support their long-life investment, which helps evaluate an individual farm's management practice against energy waste. It also allows better targeting to the largest profit for their business, which, in turn, elevates productivity. The article proposes an engineering economic approach to calculate economic factors' effect on installing an Energy-Efficient-Hyper-Solar System (EEHSS) based on two main factors: The time and interest rate.

2 ENVIRONMENT AND EEHSS SPECIFICATIONS :

2.1 ENVIRONMENT SPECIFICATIONS :

The EEHSS is implemented in a dry, hot area in the north-east of Saudi Arabia.

The average temperature and daylight, and humidity are shown in Figures 3 and 4, consequently (Al-Qawasmi, 2018a).

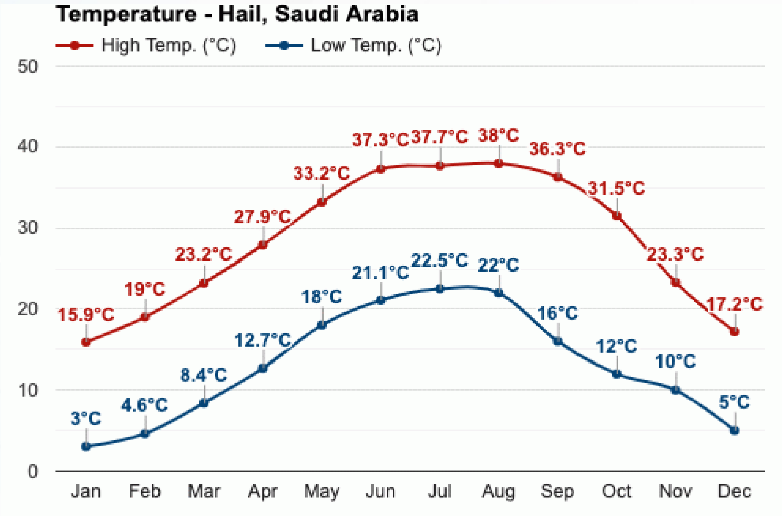

Fig. 3: Average temperature in Hail for one year (Al-Qawasmi, 2018a).

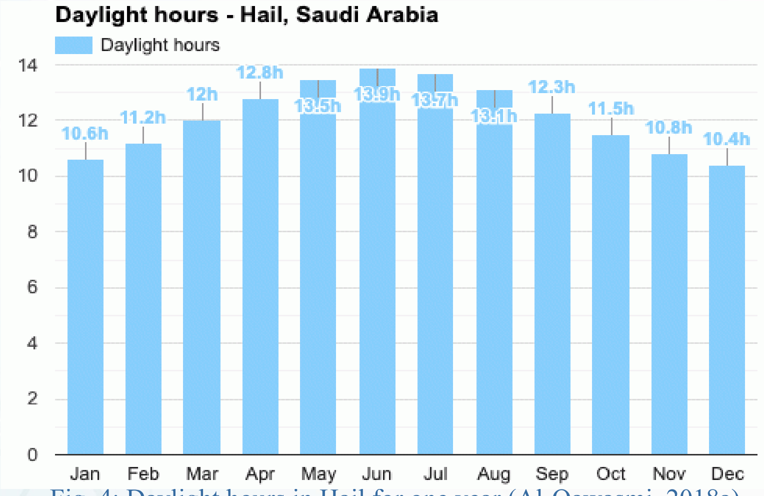

Fig. 4: Daylight hours in Hail for one year (Al-Qawasmi, 2018a).

2.2 LOAD SPECIFICATIONS :

The load specifications of EEHSS (Generators, PV solar system, energy efficiency controllers) depends on humidity, temperature, and daylight. Other parameters are not considered. Changing the farm's location for the desert climate to a wet-sea environment changes the effectiveness of the EEHSS. These changes are investigated in other articles.

The EEHSS applied to a farm. The farm has a one-floor building with four rooms (Kitchen, two bedrooms, and a Hosting room), one WC, and one bathroom. Around the building, there is a land with three bumps for irrigation. An extra load is added to accommodate different building sizes and the number of appliances on the farm.

That contains light, air-conditioners, water pumps, heaters, different size refrigerators, and malicious.

Item	Number	Power per unit kW	Total Power kW
Air conditioners	4	2.5	10 Kw
Heaters	2	2	4
Indoor Lights (average)	8	0.020 W	0.160
Outdoor Light	3	300	0.900
Extra (Malicious)	--	--	5
Total			20

Table. 3 ambient temperature, Co2 concentration and relative humidity at test days

2.3 DIESEL GENERATOR SPECIFICATIONS :

The DG specifications are listed in tables 3 and 4 below:

- Enclosed diesel generator sets with the given minimum kVA rating Prime rated at 240/415V, 1500/1800 rpm, comprising a diesel-fueled, reciprocating, inter-cooled, prime power rated engine which is direct coupled to a three-phase 400 V synchronous generator;
- The gen-set shall provide excellent power on variable loads for an unlimited number of hours per year, in island operation mode, providing 110% of prime power during a minimum of 1 hour per 12 hours cycle.

The Diesel Generator Units (DG Unit) shall consist of Diesel Generator Set, Fuel Tank, Exhaust System, outdoor Weather Protective and Sound Attenuating, Automatic Transfer Switch (ATS), and External Fuel Tank. The DG Unit is supplied as a complete pre-integrated and pre-assembled unit.

Ambient temperatures- Outdoor :	Up to 100 meters above sea-level
Maximum outdoor	$+55^{O}C$
Maximum outdoor daily average	$+40^{O}C$
Maximum outdoor yearly average	$+30^{O}C$
Minimum outdoor	$+10^{O}C$
Highest one day variation	$+25^{O}C$
Relative Humidity:	
Maximum	$+92^{O}C$
Minimum	$+12^{O}C$
Yearly average	$+44^{O}C$

Table 3: Service Conditions

Nominal System Voltage	400v/230v
Highest System Voltage	440v/253v
Number Of Phases	3 ph, 4 wire
Frequency	50 HZ
Neutral Point	Solidly Earthed

Table 4: System Conditions

When it comes to purchasing a generator, the commercial generator is quite different than the residential one. Usually, your home needs a light-to-moderate power back up, which can be covered by a smaller, portable generator.

On the other hand, a commercial farm requires a power backup system that ensures a minimal gap so that the electronic devices in your office don't stop working.

The generator must have an automatic operation and an automatic voltage regulator, making sure there's no interruption in the power supply and has a continuously controlled voltage to protect the equipment. The following factors can help you make decisions when it comes to sizing a commercial generator. A voltage sag or voltage dip is a temporary drop that occurs when there is a short circuit or overload of electric motors. In an industry, there are different tolerance levels of voltage dip for other devices.

The generator must have the ability to deal with the maximum allowable voltage sag as it reduces the available voltage, thus affecting its regulator system. Since there is so much heavy equipment on a farm, a high possibility of a frequency dip could be a huge problem due to the nominal frequency.

To solve this problem, you need to make sure that the generator can handle the maximum transient drop in both frequency and speed. It's essential to consider the humidity, temperature, and altitude of the building while installing a generator.

2.4 SOLAR SYSTEM SPECIFICATIONS :

Considering the KSA areas, the power to area ratio is 0.11 kW/m2. The farm's residential building area is calculated based on area sizes in table 5. These changes are investigated in other articles. The power required from the PV solar system is 13.42 kW.

Air conditioning systems accountable for a considerable amount of energy consumption, Referring to ASHRAE Standard 62.1-2007 specified. These standards are shown in Table 6.

Air Conditioner application type	Cooling capacity limit (cc) (Btu/h)	Mandatory EER (Btu/h)/watt Phase 1: 7 September 2013		Mandatory EER (Btu/h)/watt Phase 2: 1 September 2015	
	At testing Conditions T1 (35°C)	T1 (35°C)	T3 (46°C)	T1 (35°C)	T3 (46°C)
Window type	CC<18,000	8.5	6.12	9.8	7.06
	18,000 ≤CC< 24,000	8.5	6.12	9.7	6.98
	CC≥24,000	8.5	6.12	8.5	6.12
Split type and other type	All Capacities	9.5	6.84	11.5	8.28

Table 5: Energy classifications and concert requirements for air conditioners.

EER limits	Star Rating
EER > 10	6
9.5 < EER ≤ 10	5
9 < EER ≤ 9.5	4
8.5 < EER ≤ 9	3

Table 6: Star rating of air-conditioner quality.

2.5 THE ELECTRICAL BUMPS :

Compared to diesel pumps, electric pumps are more efficient, have lower maintenance requirements, and are easier to control via automated systems. The existing solar PV system can generate around 14,000kWh of electrical power per year (or around U2,500 per quarter in electricity savings as it is clearly seen in table 7.

Fuel Type	Purpose	Energy Used(GJ)
Diesel	Pumping	1.095
Diesel	Tractors	757
Electricity	Pumping	9
Electricity	Homestead and Other	43
LPG	Heating	10
Total		1.914

Table 7: Diesel and Electricity pumps.

3 ENGINEERING ECONOMY ANALYSIS: PRESENT WORTH ANALYSIS :

Engineering economics, previously known as the engineering economy, is a subset of economics concerned with applying economic principles to analyze engineering decisions. Fundamentally, engineering economics involves formulating, estimating, and evaluating the economic outcomes when alternatives to accomplish a defined purpose are available (Al-Qawasmi, 2018b).

Figure 5 shows a simple block diagram of the proposed system based on an economical and energy consumption relationship.

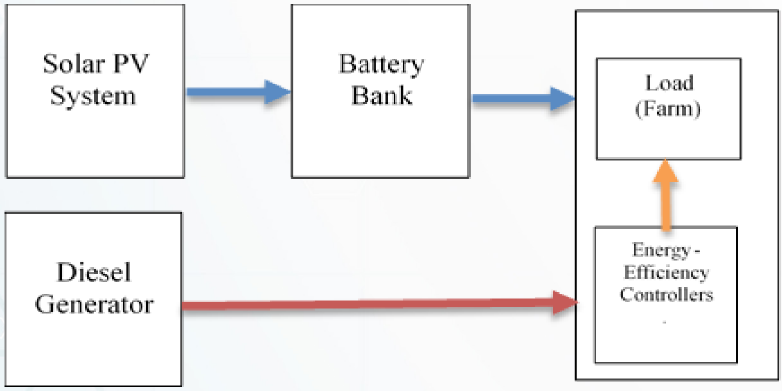

Figure 5: The proposed block diagram of the system

In this research, a particular software program designed to calculate the engineering economic factors that can be found in (weather-atlas.com). This software is developed by the author and published online to calculate all economic factors. A screenshot of this software is shown in Figure 6.

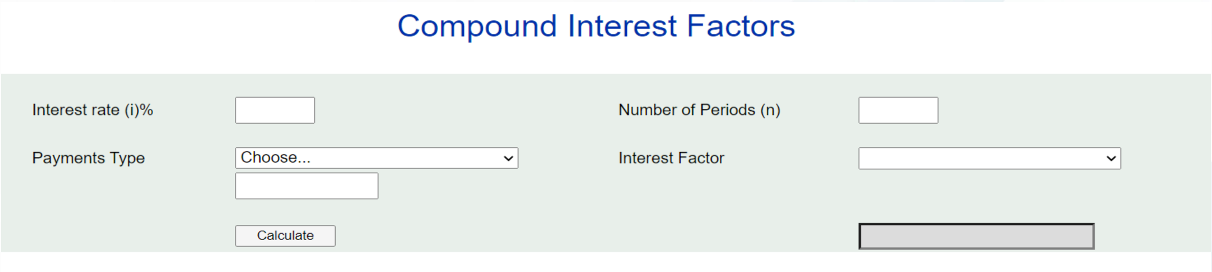

Fig. 6: Screenshot from the software

The proposed EEHSS contains the following Scenarios for ten years with an interest rate of 10%:

Diesel Generator for a house on the farm with three diesel pumps for irrigation. Hybrid Solar Diesel generator with Hybrid Solar Diesel irrigation pumps controlled by energy efficiency system. For the first Scenario, diesel is only the source of power for the farm, and in this case, the costs depend on three factors: Diesel generator initial cost. Future Diesel generator cost after ten years with an interest rate of 10%. Diesel consuming cost/liter multiplied by diesel consumption for one hour, 24 hours/day for ten years with an interest rate of 10% Initial cost of pumps. The future price of pumps with IR 10% for ten years. Diesel consuming cost/liter multiplied by diesel consumption for one hour, 24 hours/day for ten years with an interest rate of 10%. Maintenance yearly cost for generator and pumps for ten years with interest 10%. For the second Scenario, the diesel is only the source of power for the generator shared by the solar PV system. Electricity is the primary source of power for pumps. For the farm, and in this case, the costs depend on the Diesel electricity generator's initial cost. Future Diesel generator cost after ten years with an interest rate of 10%. Diesel consuming cost/liter multiplied by the consumption of diesel for one hour, 24 hours/day for ten years with interest rate 10%: Initial PV solar system cost, future PV solar system cost, the initial cost of electrical pumps, future cost of electrical pumps with IR 10% for ten years and maintenance yearly cost for generator and pumps for ten years with interest 10%.

In this paper, the two scenarios' results are generalized to apply to different farms and designs. Table 8 shows the terminology and symbols used in this research:

Item	Symbol
Diesel electricity initial cost	DEIC
Diesel electricity Future cost	DEFC
Overall Annual Diesel Consuming Cost 1	ODAC1
Overall Annual Diesel Consuming Cost 2	ODAC2
Diesel pumps initial cost	DPIC
Electrical Pumps Initial Cost	EPIC
Diesel pumps Future cost	DPFC
Electrical Pumps Future Cost	EPFC
Annual Overall Maintenance Cost 1	OMAC1
Annual Overall Maintenance Cost 2	OMAC2
PV solar system Initial cost	PVSIC
Future PV solar system cost	PVSFC
Interest rate	I
Interest Factor	IF
Number of periods (Project lives)	n

Table 7: Diesel and Electricity pumps.

From the above scenarios (alternatives), the Mutually Exclusive (ME) Alternative is selected: Only one is appointed; Compete against each other.

For ME alternatives, select one with the numerically largest Present Worth (PW) that is chosen.

For the first alternative, the PW analysis required the following input data:

- Initial cost: DEIC + DPIC (1)
- The annual cost: ODAC1 + OMAC1 (2)
- Salvage Value: DEFC + DPFC (3)
- Interest Rate (%): I
- Number of periods: The lives' period is the same for the two alternatives (n)

Then the present worth analysis for the first alternative can be calculated using equation (8):

PWA1=-(DEIC + DPIC) -(ODAC1 + OMAC1)(P/A,I,n)+(DEFC + DPFC) (P/F, I , n) (4)

For the second alternative, the PW analysis required the following input data:

- Initial cost: DEIC + EPIC + PVSIC (5)
- The annual cost: ODAC2 + OMAC2 (6)
- Salvage Value: PVSFC +EPFC + DEFC (7)
- Interest Rate (%): I
- Number of periods: The lives' period is the same for the two alternatives (n)

Then the present worth analysis for the second alternative can be calculated using the equation (8):

PWA2=-(DEIC + EPIC + PVSIC)-(ODAC2 + OMAC2)(P/A,I,n)+(PVSFC +EPFC + DEFC) (P/F, I , n) (8)

1 EXPERIMENTAL RESULTS AND ANALYSIS :

The costs are in units and estimated and related to real cases.

1.1 THE FIRST ALTERNATIVE:

- Initial cost:

DEIC + DPIC = 10000 + 3*700=12100 units

- The annual cost:

The diesel is consumed by one DG and three DIP. For DIP, the 10-kW engine generates 10 kW * 2,000 h/yr. = 20 MWh/yr. of electricity. Using a specific diesel consumption of 0.3 L/kWh (33% efficiency), the annual diesel consumption is 20,000 kWh/yr. * 0.3 L/kWh = 6,000 L/yr.

At a diesel price of U1.50 per liter, the annual running cost is 6,000L *U1.50/L = 9,000 units

Assume that the average operating hours per day 22%, the cost becomes 0.22*9,000

The 30 kW DG 30 kW * 4000 h/yr. = 120 MWh/yr. of electricity. Using a specific diesel consumption of 0.3 L/kWh, the annual diesel consumption is

120,000 kWh/yr. * 0.3 L/kWh = 36,000 L/yr.

At a diesel price of U1.50 per liter, the annual running cost is 36,000 L* U1.50/L = 54,000 U

The OMAC assumed to be 1000 Units annually

ODAC + OMAC = (54,000 +3*0.22*9000)+1000 = 60,940 Units

- Salvage Value:

  The Salvage value calculated based on number of periods by -10% from its yearly cost.

  DEFC + DPFC =4219 U

- Interest Rate: I%=10
- Number of periods: 10

  Then from eq (4)

  PWA1=-(12100) -(60,940) (P/A,10,10) +(4219) (P/F, 10, 10)= -12100-60,940(6.144567) + 4219(2.5937)=-12100-374,450.35+ 1626.607 = -384,923.4 Units

1.1 THE SECOND ALTERNATIVE :

- Initial cost:

  The electric irrigation pump (10 kWh) Electric costs around 1300 Units. The PV solar system with a 35kW commercial example is shown in table 9 (aginnovators.org.au):

35Kw Off Grid Solar Power System Components			
Item	Name	Description	Quantity
1	Solar Panel	Poly 325w Solar Panel	110pcs
2	Inverter	35kw Off grid Solar Inverter	1 set
3	PV Combiner Box	11 Inputs 3 output	1 pc
4	Charger Controller	240V 150A (MPPT /PWM)	1 pc
5	Battery	12V 200AH (Lead Acid/Gel)	20unit
6	Solar Mounting Structure	Roof/Ground Install (Customized)	1 set
7	PV Cable	4 mm2 DC PV Cable	1000m
8	MC4	MC4 Connector	40prs
9	Standard Wooded Package + System Connecting Drawings (Easy Installing)		
10	System Capacity could be adjustable according customer's situation		

Table 9: PV solar system with a 35kW commercial example.

  The average cost of such a system is 27000 Units.

  DEIC + EPIC + PVSIC = 10000 + 3*1300+27000=40900 units

- The annual cost:

  The 30 kW DG 30 kW * 4000 h/yr. = 120 MWh/yr. of electricity. Using a specific diesel consumption of 0.3 L/kWh, the annual diesel consumption is 120,000 kWh/yr. * 0.3 L/kWh = 36,000 L/yr.

Due to the PV solar system and energy efficiency controllers' implementation, Diesel consumption is reduced by 40%. The DG fuel consumption is decreased annually to be 21,600 Units.

At a diesel price of U1.50 per liter, the annual running cost is 21,000 L* U1.50/L = 32,400 U

ODAC2 + OMAC2 =21,600+1000=31,600

- Salvage Value:

The Salvage value is calculated based on the number of periods by -10% from its yearly cost.

PVSFC +EPFC + DEFC=14,261 U

- Interest Rate: I%=10

- Number of periods: 10

Then from eq (8)

PWA2=-(40,900) - (31,600) (6.144567) + (14,261) (2.5937) = -40,900 - 194,168.317 + 36,988.7557 = 198,079.56 Units

The cost presented in the first alternative PWA1 is higher than the price offered in the second alternative PWA2, due to the high annual cost and using DIP.

The following results in figure 7 below show the effect of different alternative lives for the same interest rate (10%)

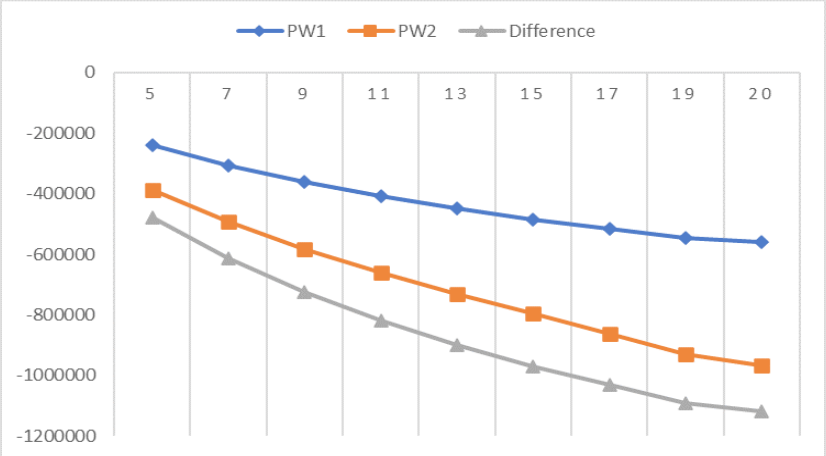

Fig. 7: the effect of different alternative lives for the same interest rate (I=10%)

The following results in figure 8 show the effect of different IR for the same life period (10).

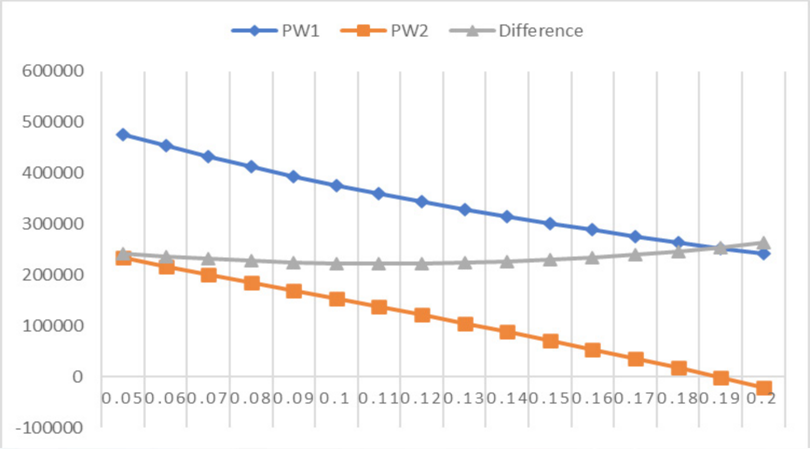

Fig. 8: effect of different IRs for the same life period (n=10)

It is clear from figure 8 that the cost difference is within limited ranges for an extended period, especially after ten years. It was changing the IR (Inflation) and complexed the situation. The IR>0.18 was raised due to the negative value (zero-crossing value) for PWA2.

2. CONCLUSION :

In this paper, an engineering economic approach is applied using present worth analysis for energy resources alternatives. The results show that implementing renewable energy sources and applying energy efficiency controlling decreased the energy cost over a specific period by 50%. Based on the interest rate and projects' lives, results still show the privilege of using solar renewable energy with primary electric devices (DG and IEP) over pure diesel energy sources.

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