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Performance Evaluation of Solar Pump for Landscape Irrigation System

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Abstract

Experiments were performed at a private garden in Al-Qaddbah, Al-Gharbia Governorate, Egypt. The latitude and longitude of the experiment site are 30°56'37"N and 30°47'01" E, respectively, and the altitude equals 30 m, at the 2019 season, the total landscape area (13.5m x 9m) was divided into 6 treatments each of an area (20.25 m^2), three plots were operated using solar system while the other three plots were operated using electric system. The irrigation systems were similar, 4 multi-stream sprayers, (90◦) and the distance between the sprayers was (4.5*4.5 m), different operating times were applied on each plot, under local climatic and working conditions. All the plots were planted with turfgrass (Passpalm10). The obtained results show, at solar energy powered system, uniformity coefficient increased from (65% - 75%) at operating time (10 – 30 min), then it decreased during operating time (40 - 60 min), while at electric energy powered system the averages of the uniformity coefficient were (76% - 80%), at operating time (10 - 40 min), while at operating time (45 - 60 min) the uniformity coefficient decreased to (75%), due to the silt clogging in the sprayers' filters. The energy saving reached (63%) with solar energy operation rather than electric energy operation in the summer season. The least total cost was (351 L.E/m^2/year) at the landscape area (A$_3$ 60.75m^2), which was irrigated on 3 cycles per day to give the highest uniformity coefficient (75%). When operating the solar batteries at full charge 3 - 4 times for a plot area of (20.25 m^2). The hydraulic power obtained was (17.86 – 26.74 W), the sprayer radius was (5.3 – 5.8 m), at an average pressure of (1.9 – 2.5 bar) which gave the best uniformity coefficient. The turf quality index was higher using electric motor rather than solar motor.

Keywords: Solar energy; Electric energy; Unite area; landscape irrigation; Battery cycle.

1 Introduction

According to U.S. Energy Information Administration (USEIA). The averages of solar radiation in Egypt are 5 and more than 8 kWh/m^2 of annual daily direct solar radiation, while the annual direct normal solar irradiance ranges between (2,300 - 4,000) kWh/m^2, with 9-11 hr/day of sunlight, and few cloudy days throughout the year, (USEIA 2014).

For renewable energy, Egypt is treated as a country of a suitable environment to meet a huge amount of its energy requirements by using wind and solar power. Due to its location, topography, and climate, Egypt is one of the world's best which is suitable for setting up wind and solar energy systems. But, the possibility of using renewable energy is limited by Egypt's energy mix, African Development Bank (AfDB 2012) and (Bahgat 2013).

In Egypt, photovoltaic systems are suitable for remote areas. According to New and Renewable Energy Authority (NREA), photovoltaic technologies are used for irrigation water pumping in recently reclaimed lands. The capacity of Egypt's photovoltaic systems placed presently is close to 5 MW peak, (Comsan 2010).

The advantages of the solar pumps are being capable of functioning under imperfect sunlight radiation conditions. The use of solar water pumps operate on varying voltage and current. However, pumps that operate using electric power need enough power to pump a large quantity of water in a short time. Solar pumps on the other hand pump less quantities of water for a longer operation time and would require less energy, (Malak 2016).

In Egypt, solar photovoltaic water pumping systems (SPWPSs) are used for water pumping in the agriculture sector. The price of the water pumped by solar systems is much less than that of water pumped using conventional diesel or traditional electrical pumps. SPWPSs are more effective than other irrigation systems during daylight, (Gopal et al 2013).

Because of the frequent electricity cut, also the solar radiation is at its peak during the summer season, which means there is unutilized solar power, the solar powered system needs a power of 24 volts which is acquired by a photovoltaic cell, the longrun cost is inexpensive, so the experiment is carried out. The objectives of this study are calibrating solar and electric pumps (Q-H), identifying the best irrigated landscape area to match the solar powered system per day, specifying the best operation time of irrigation to match the turf irrigation requirements, determining the best operation time for DC battery charging to give full power to operate the landscape irrigation system, calculating the annual cost for the solar and electric powered system, and indicating the quality index (color, density, and ground cover %) for turfgrass (Paspalum 10) under the solar and electric powered system.

2 Materials and Methods

2.1 Experiment location

Experiments were performed at a backyard area (private garden) in Al-Qaddbah, Al-Gharbia Governorate, Egypt. The latitude and longitude of the experiment site were 30°56'37"N, 30°47'01" E, respectively with altitude equals 30 m, to evaluate the best utilization of solar and electric pump for irrigating landscape area, during 2019 season.

2.2 Field experiment layout and design

The area of the experiment was (121.5 m²), divided into 6 plots, each plot (4.5m×4.5 m) for spray irrigation. The 6 plots were planted with turfgrass (Passpalm 10). Three plots were irrigated using solar pump, while the three other plots were irrigated using electric pump under local climatic and working conditions as shown in **Figs 1, 2, and 3.**

2.3 Storage tank

A 500- liters tank made of plastic was used to store water as the inlet source for the irrigation system which provided stable zero pressure.

2.4 Irrigation systems

Spray Irrigation (SI): 4 multi-stream sprayers, (90◦) for each plot. Sprayers used in this experiment for landscape with nozzle discharge of 0.071 m^3/h, at the head of 20 m, average precipitation rate of 12 mm/h, and radius of 4.5 m, the sprayers' filters of 150 µ to irrigate turfgrass (Paspalum 10), as shown in **Figs 4, 5, 6 and 7.**

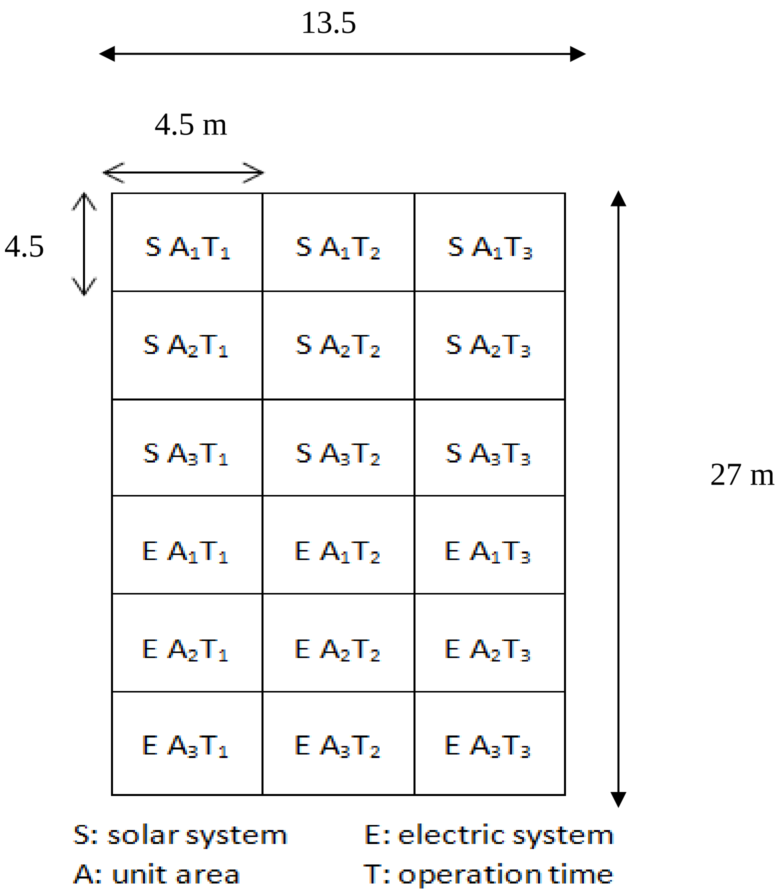


Fig 1. Layout of irrigated plot area by solar and electric pumps by random sectors

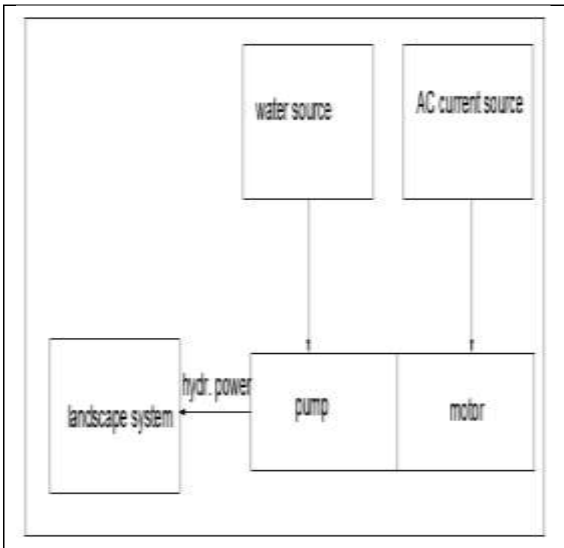


Fig 2. Layout of the electric system

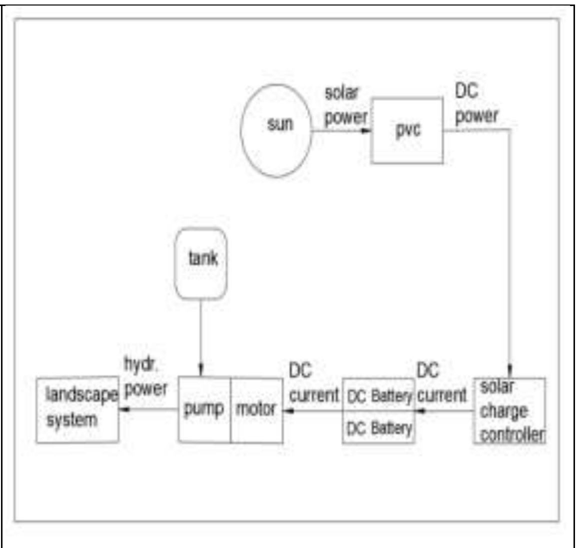
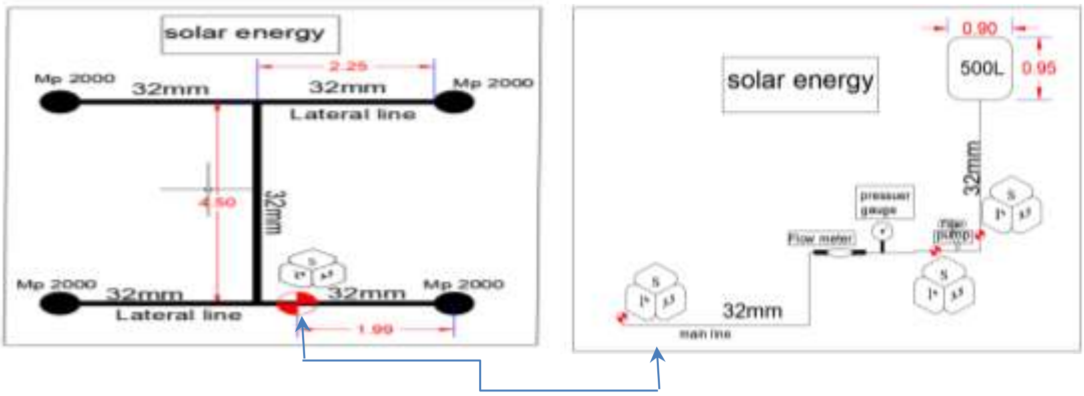
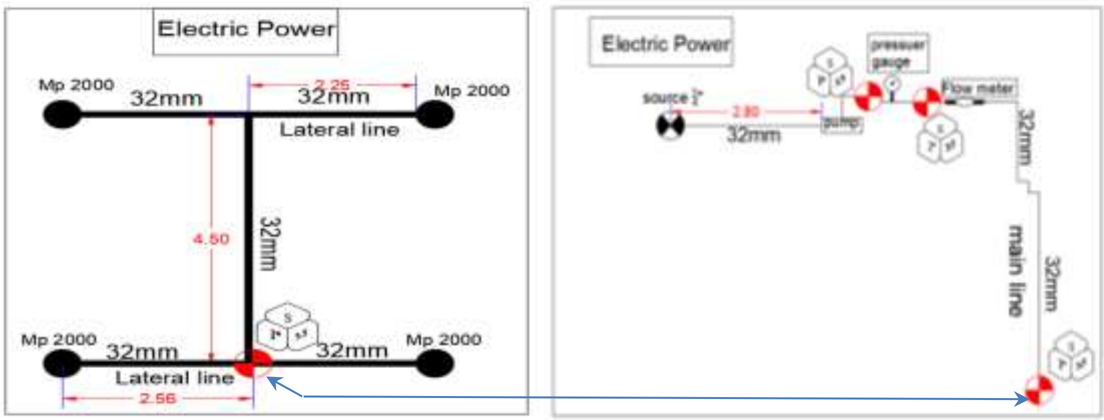


Fig 3. Layout of the solar system



Figs 4 and 5. Layout of the irrigation system for the solar-powered plot



Figs 6 and 7. Layout of the irrigation system for the electric-powered plot

The specifications of the multi-stream sprayers are presented in **Table 1.**

2.5 Treatments

2.5.1 Photovoltaic cell, charge controller and the solar system specifications

The specifications of the photovoltaic module and electrical data (STC) are presented in **Table 2**.

While the charge controller was used to adjust the voltage and current from the solar arrays to the battery to prevent overcharging and also overdischarging.

The specifications of the charge controller used in this experiment are presented in **Table 3**.

2.5.2 Dc batteries

Two batteries were used to operate the system connected parallel, (24 Volt – 12 Ampere). The specifications of the batteries are presented in **Table 4**.

2.5.3 Dc motor and pump

24 volt, 4.5GPM/17.0LPM. The pump supplies high volume water flow with lower pump cycling. It can be used with a tank water system. It can supply up to 1022 L/h. It has a built-in pressure switch, which automatically switches on/off the pump when the valve is opened and closed.

The specifications of both the Dc pump and motor are presented in **Table 5**.

Table1. Specifications of the multi-stream sprayers

Pressure Bar	1.7	2.0	2.5	2.8	3.0	3.5	3.8
Radius m	5.2	5.5	5.8	6.1	6.4	6.4	6.4
Flow m^3/hr	0.07	0.07	0.09	0.09	0.09	0.10	0.11
Precip ▲mm/hr	12	11	12	11	10	11	12

Table 2. Technical specifications of the photovoltaic module and electric data

Length x width x height [mm]	**1650*990*50mm**
Number of cells	60 poly cells
Cell material	Polycrystalline
Nominal Peak Power (P_{mpp})	240W
Open-Circuit Voltage (V_{oc})	36.2Volt
Short-Circuit Current (I_{sc})	8.88Ampere
Temperature Range	-40°C : +90°C

Table 3. Specification of the charge controller

Category	**12V-20Ampere**
To adapt to the battery voltage	12V/24Volt Automatically identify
The maximum output current	20Ampere

Table 4. Specifications of the Dc batteries

Nominal Voltage	**12Volt**
Nominal Capacity (20HR)	12.0AH
Terminal	T2
Self Discharge	It can be stored for up to 6 months at 250 C(770F). For higher temperatures, the time interval will be shorter.

Table 5. Specification of the Dc pump and motor

Motor	
Max.Amp Draw	15.0 Ampere
power	144 Watts/h
Pump	
Type	4 Chamber positive displacement diaphragm pump, self-priming, able of being run dry
Control Type	Pressure switch & By-pass control
Re-start Pressure	Shut-off Pressure 2.8 bar : 2 bar (± 0.3 bar)
Inlet/Outlet Ports	3/4" QUICK ATTACH

2.5.4 The electrical system, AC motor and pump specifications

The pump was not self-priming, so on the system, it is loaded directly to the entrance pipe of water, the valve was switched on before starting the motor to replace all the air in the pipe before the pump, the pressure was stabilized by loading a valve after the pump to get rid of the excess pressure.

The specifications of both the AC pump and motor are presented in **Table 6**.

2.6 Measurements and calculations

Calibrate solar and electric pumps in the site by measuring different flow and pressure of solar and electric pumps, was done to find the best operating point for solar and electric operating systems.

2.6.1 Determine pump discharge and uniformity coefficient spray at different operation times for solar and electric energy.

2.6.2 Calculate evapotranspiration at different months through the year 2019, from the Central Laboratory for Agricultural Climate, to achieve the best water requirements and low power usage for the landscape plot area.

Table 6. Specifications of Ac motor and pump

Model	Maximum Capacity l/min	Maximum Head (m)	Maximum Suc. Lift (m)	Power (HP)
QB60	26	30	9	0.5

2.6.3 Determine the best total water usage and power usage for landscape plot areas for every season under solar and electric energy sources.

2.6.4 Determine the effect of the different running times of solar pump on the uniformity coefficient of the sprayers for the landscape plot area.

2.6.5 Determine the best uniformity coefficient of sprayres, maximum plot area and the best operating time at different battery cycles.

2.6.6 Determine the turf quality index including (color, density, and ground cover %), which was affected by the power source used to operate the landscape area, as the variance of the operating pressure influenced the uniformity coefficient of water, which affected the quality index.

2.7 Coefficient of water uniformity

Christiansen’s uniformity coefficient was first used to present a uniformity coefficient to the sprinkler system (Karmeli 1978). It was used by researchers worldwide as a proven standard to represent water distribution uniformity (Karmeli 1978; Topak et al 2005):

$$CU = 100 * \left\{1 - \frac{\sum|x - x^{-}|}{n\, x^{-}}\right\} \text{-----(1)}$$

Where:

CU= The Christiansen's uniformity coefficient in %;
x = Numerical deviation of individual observation from average application rate, mm;
x^{-} = Mean of collectors amount in mm; and
n = Number of catch cans.

2.8 Plant water requirement

Plant water requirement was calculated according to the climate data (Costello et al 1993):

$$PWR = ET_o \times K_L \text{ -----(2)}$$

Where:
PWR = Plant water requirement (mm /season).
ET_o = Reference ET based on cool-season grass (mm /season).
K_L = Landscape coefficient (dimensionless).

Climatic data at Al-Gharbia governorate sites

The average ET_o during the months of the experiments in 2019 from the Central Laboratory for Agricultural Climate (CLAC) for Al-Gharbia Governorate sites, shown in **Table 7**.

A landscape coefficient KL was suggested by (Awady et al 2003; IA 2009), it was calculated by the following formula:

$$K_L = K_s \times K_{mc} \times K_d \text{ -----(3)}$$

Where:
K_L = Landscape coefficient (dimensionless);
K_s = Adjustment factor representing characteristics for a particular plant species (dimensionless);
K_{mc} = Adjustment factor for microclimate influences upon the planting (dimensionless); and
K_d= Adjustment factor for plant density (dimensionless), **Table 8**.

Table 7. The average ET_o in the 2019 season for Al-Gharbia Governorate

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T°_{max}	26.2	29.5	40.5	40	46.6	47.4	43.2	46.1	42.1	37.9	30.2	28.4
Average ET_o (mm)	1.4	2.2	3.3	4.1	5.4	5.8	6	8	7.2	6.5	3.5	2

Table 8. Species factor (K_s, $K_{mc,}$ and K_d) for different plant types. Density factor (Kd) for different plant types.

Vegetation	High	Average	Low
Turfgrass	1	1	0.6

Vegetation	High	Average	Low
Species factor (Ks)			
Warm season turfgrass	0	0.6	0
Cool Season Turfgrass	0	0.8	0
Microclimate factor (Kmc)			
Turfgrass	1.2	1	0.8
Density factor (Kd)			
Turfgrass	1	1	0.6

(Awady et al 2003; IA 2009).

2.9 Irrigation Run Time for the operation

Irrigation run time is the period that a zone valve is activated as required to achieve the water requirement for an irrigation operation time. It is usually defined in minutes. The base run time for the operation time (RT base) relies on the base irrigation water requirement for the operation time (IWR base) and the precipitation rate (PR) of the station/zone in applying the water:

$$RT= IWR \times (60/PR) \text{ -----(4)}$$

Where:
RT= Base run time (minutes) for the operation;
IWR= Base irrigation water requirement (mm) for the operation; and
PR = Precipitation rate of station/zone (mm/h).

2.10 Hydraulic horsepower (water HP)

The mechanical power of a hydraulic flow is the product of the fluid flow rate, by the head at which it is transferred. The water horse power was calculated according to (El-Gindy 2007) as follows:

$$\text{Water HP} = (QH/75)* 0.746 \text{ -----(5)}$$

Where:
Water HP = Water horse power (kW) ;
Q= Discharge (Lps) ; and
H= Pressure head (m).

$$\text{Break Hp} = \text{Water HP} / E \text{ -----(6)}$$

Where:
E= Motor Efficiency, (%).

2.11 Quality index

Turf quality index represents color, density, and ground cover percent for lawn plant (Paspalum 10) as shown in **Table 9**, according to (Khaseeva 2013).

Table 9. Turf quality index

Type of turf	Color	Density (pcs/m^2)	Ground cover%
Paspalum 10	0-9	0-9	1-9

Where,
1. Color: a 0-to-9 scale, where 0 = brown, (dead turf); 6 =acceptable quality for home lawn; and 9 = optimum color (dark green).

2. Density (pcs/m^2): summer density (1=low, 9=high), turf density was measured instrumentally and expressed in the number of tillers per unit area (pcs/m^2), high ratings (> 10000 shoots /m^2), 9 provided moderate density (6000 to 10000 shoots /m^2) and 4 demonstrated low ratings (<6000 shoots /m^2).
3. Ground cover%: ground cover (1=0%, 9= 100% cover).

2.12 Cost analysis

Annual total cost = Total initial costs + Total operational costs
Where,
Total initial costs, L.E./year = [a] + [b].
i.e., Pumps and installation, L.E [a] + additional infrastructure, L.E [b].
Total operational costs, L.E./year = [h] + [i] +[s].
i.e., Energy costs per year, L.E/year [h] + water consumption costs per year, L.E/year [i] + maintenance per year [s].
Where,
[a]: Pumping cost (L.E./m^3).
[i]: Water consumption (m^3/m^2/year).
[a] + [b]: Initial cost (L.E.), for the present value of the equipment irrigation system.
[s]: Maintenance costs, taken as 10% of its initial cost (L.E./year).
Years of working life expectancy (20 years).

3 Results and Discussion

3.1 Performance of solar and electric pumps in site

Results illustrated in **Fig 8** showed that the operation head increased when the discharge decreased for both solar and electric pumps for a plot area of (20.25 m^2). The optimum operation point for the solar pump which gives the maximum efficiency resulted from the relation between the flow and the head at the point of head of (17m) and a discharge of (800 L/h), the optimum operating point for the electric pump gives the maximum efficiency at the point of (17 m) and a discharge of (1200 L/h).

3.2 The capacity of water requirement landscape plot area at different interval times

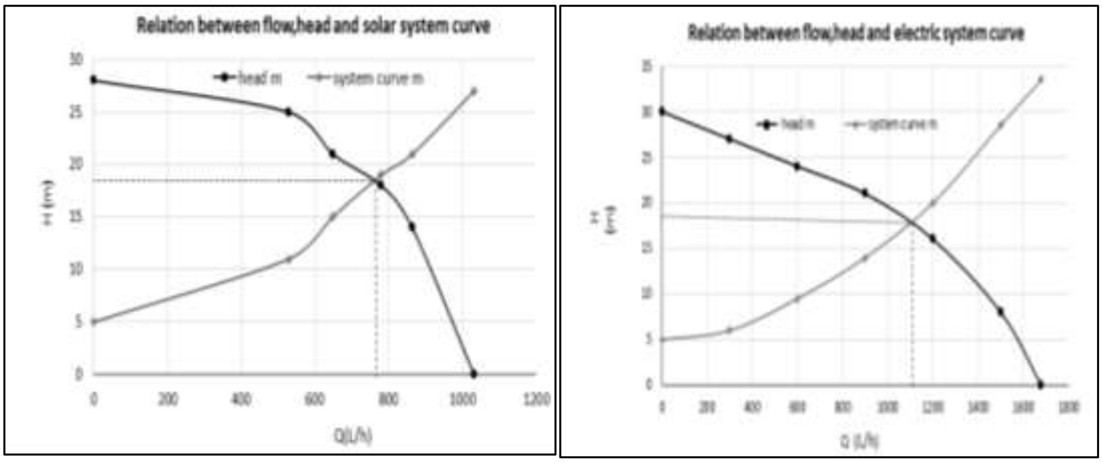
Fig 9, represents that the maximum discharge value for the solar pump was (0.29 m^3/h) at an operation time of irrigation 60 min, while the minimum discharge value was (0.06 m^3/h) at an operation time of irrigation of 10 min to provide the water required for the landscape plot, the system should be operated for 45 min, at the discharge of solar pump of (0.23 m^3/h). Also, the maximum discharge value for the electric pump was (0.32 m^3/h) at an operation time of irrigation of 60 min, while the minimum discharge value was (0.05 m^3/h) at an operation time of irrigation of 10 min, to provide the water required for landscape plot, the system should be operated for 45min, at the discharge of electric pump of (0.24 m^3/h).

3.3 The relation between the uniformity coefficient at different operation irrigation times

Data illustrated in **Fig 10** indicated that using the solar pump, the uniformity coefficient increased from (65 to 75 %) by increasing the operation time of irrigation from 10 to 30 min. Then it decreased after that by increasing the operation time of irrigation from 40 to 60 min as a result of the decrease of the power in the batteries. Also, the coefficient of the uniformity increased from (76 to 80%) by increasing the irrigation time from 10 to 40 min. Then it decreased to (75 %) when the irrigation time increase from 45 to 60 min, using an electric pump, due to the silt clogging in the filters of the sprayers.

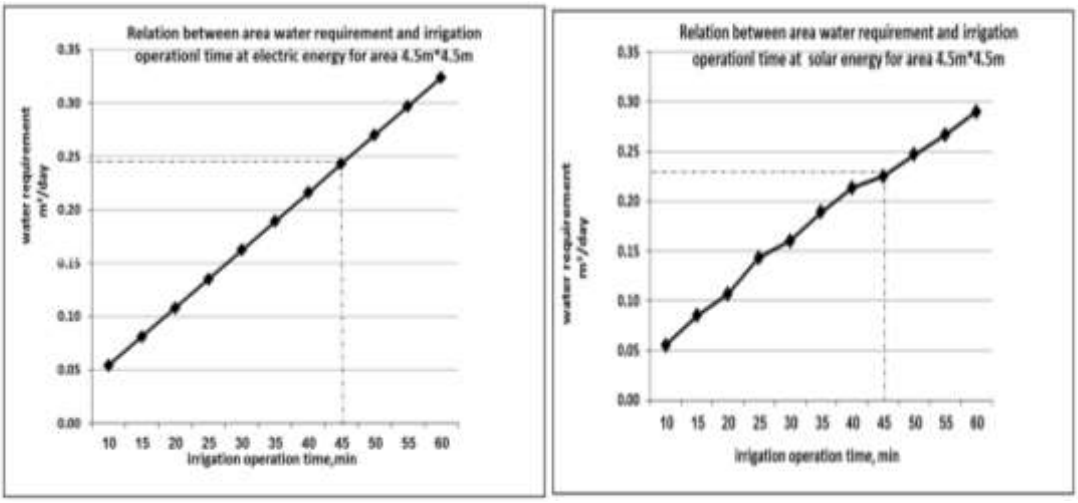
3.4 The relation between consumptive total power usages for a landscape plot area per season under solar and electric energy

Data illustrated in **Fig 11** showed that the highest power usage for the solar pump was during summer at a value of (9.90 kW/season), while the lowest power usage was during winter at a value of (1.83 kW/season). Also, the highest power usage for the electric pump was during summer at a value of (27 kW/season),



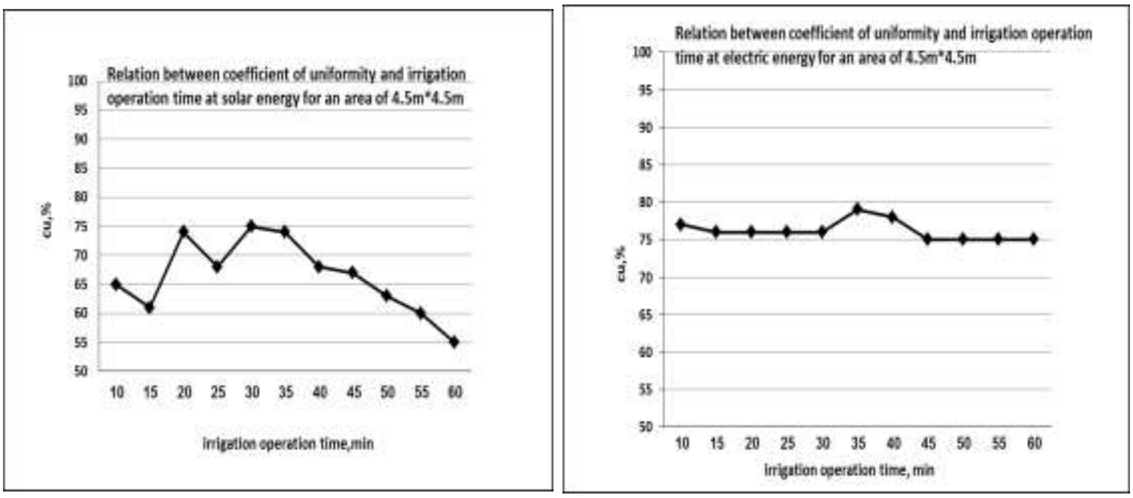
Solar pump Electric pump

Fig 8. (Q-H) for Solar and electric Pumps in site



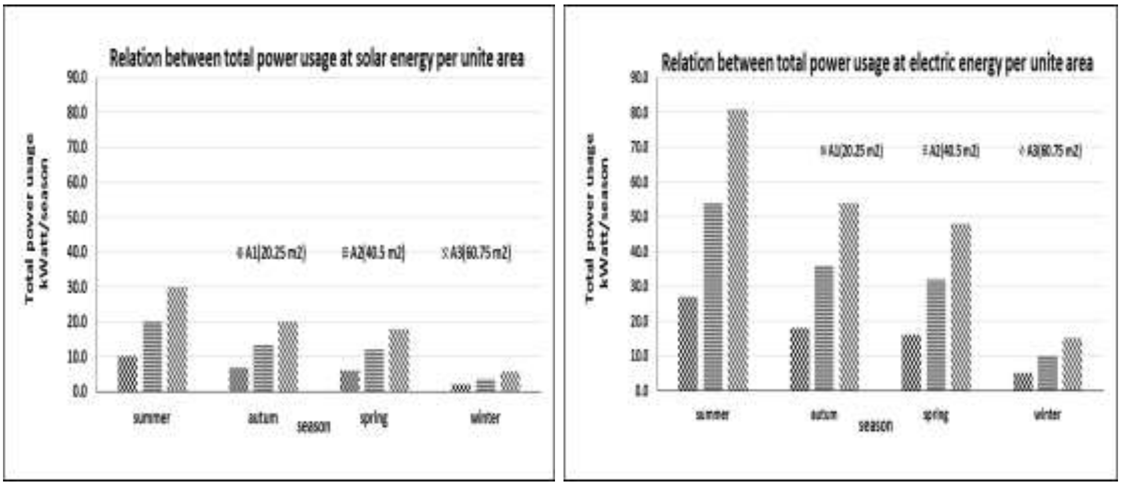
Solar pump Electric pump

Fig 9. The capacity of water requirement landscape plot area at different operation times



Solar pump Electric pump

Fig 10. The relation between the uniformity coefficient at different operation irrigation times



Solar pump Electric pump

Fig 11. The relation between consumptive total power usages for a landscaped plot area per season under solar and electric energy while the lowest power usage was during winter at a value of (5 kW/season), the change in the readings was because of the difference of water discharge during different seasons, as the water requirements increase at summer and decrease during winter.

After relating the results of each system to the other, the energy-saving reached (63%) at solar energy operation rather than the electric energy operation, at summer season, as the operating power for the solar pump motor was 144 W/h, while the operating power for the electric pump motor was 375 W/h.

3.5 The relation between consumptive total water usages for a landscape plot area per season under solar and electric energy

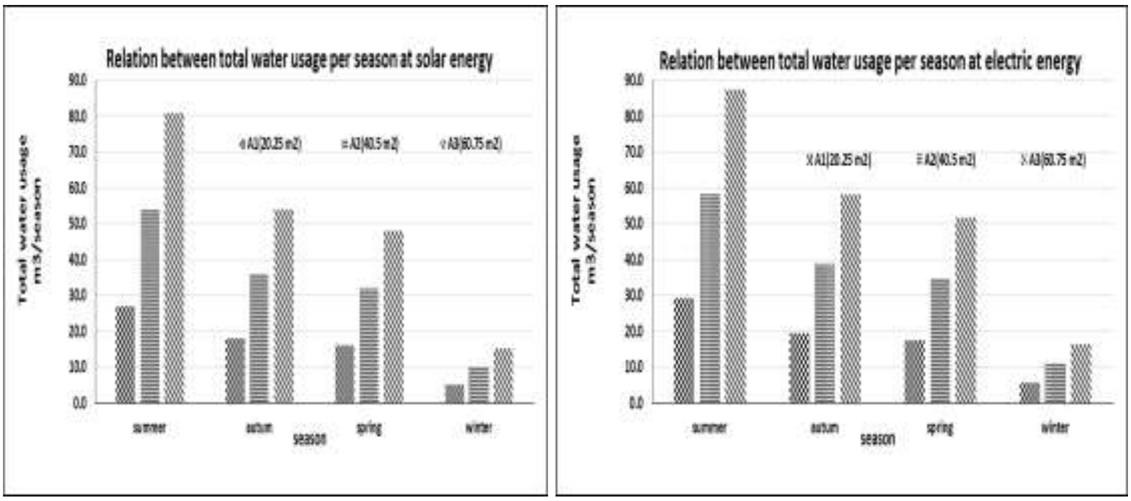
Data illustrated in **Fig 12** showed that the highest water consumption for the solar pump was during summer at a value of (27 m^3/season), while the lowest water consumption was during winter at a value of (5 m^3/season).

Also, the highest water consumption for the electric pump was during summer at a value of (29.2 m^3/season), while the lowest water consumption was during winter at a value of (5.4 m^3/season), the change in the readings was because of the difference in water discharge during different seasons for a plot area of (20.25 m^2), as the water requirements increase at summer and decrease during winter.

After relating the results of each system to the other, the water-saving reached (7%) at solar energy operation rather than the electric energy operation, during the summer season.

3.6 The relation between water consumption used for turf per month in site

Fig 13 represents the relation of water consumption in m^3/season for the turf per month, depending on the average ET_o (mm/day) readings during the months of the experiments which were obtained from Central Laboratory for Agricultural Climate (CLAC), The minimum value was on January at a value of (972 L/m^2/month) at ET_o value of (1.4 mm/day), while the maximum value was on August at a value of (5554 L/m^2/month) at ET_o value of (8 mm/day).



Solar pump Electric pump

Fig 12. The relation between consumptive total water usages for a landscape plot area per season under solar and electric energy

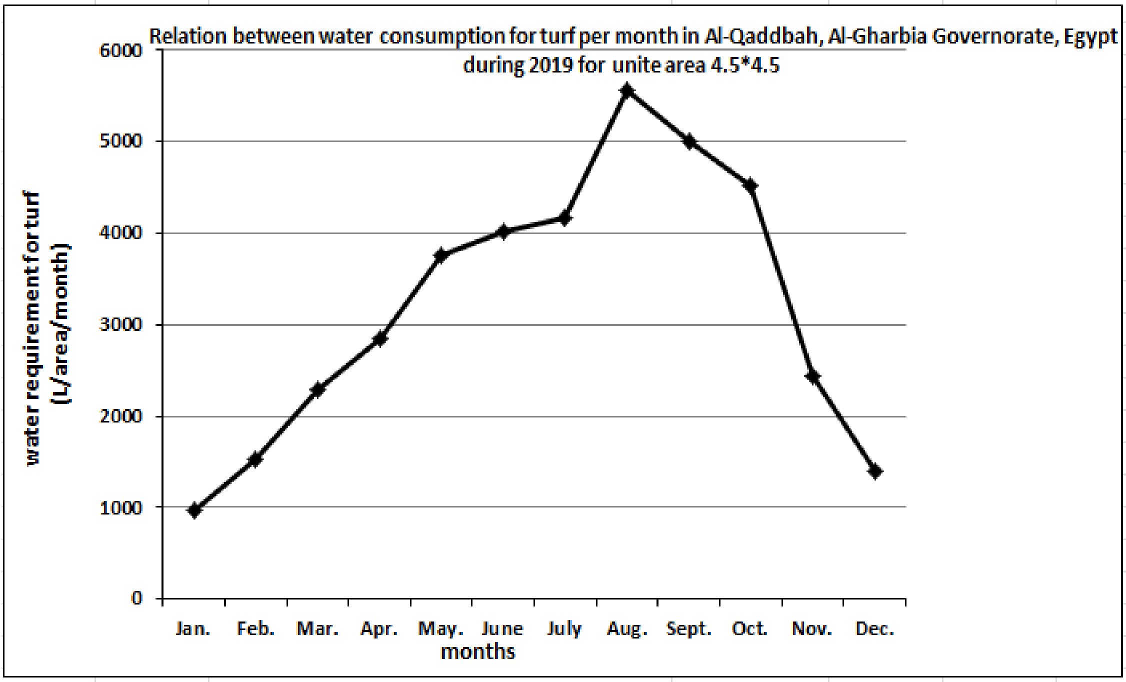


Fig 13. The relation between water consumption used for turf per month in site

3.7 Effect of the solar and electric energy system on the quality index for the landscape area

Fig 14 represents the turf quality index for the solar powered zone and electric powered zone, the best quality index including appearance and density were at electric system operation, as the solar-powered system had a variation in the operating pressure, which affected the uniformity coefficient of water on landscape area, so the landscape area was affected, while the electric powered system gave good quality index for plot area landscape it was stable in pressure.

3.8 Effect of the solar energy system on the total cost for the irrigated landscape area

Fig 15 showed that the least total cost per unite square meter for the landscape area was 351 L.E/m^2/year at A_3 (60.75m^2) each of a plot area equals (20.25m^2), which was irrigated on 3 cycles per day to obtain the optimum uniformity coefficient (75%). Because of utilizing the optimum power operating from the photovoltaic cells per day.

Landscape area A_3 (60.75m^2) was less than A_1 (20.25m^2), A_2(40.5m^2), in annual total cost by (47.6% -12.5%), respectively.

Landscape area A_4 (81m^2) had less in annual total cost than A_3 by 5%, but it was less in the uniformity coefficient for turf as it reached 45%. The annual total cost decreased and the uniformity coefficient decreased as well which was reflected on the quality of the landscape area.

3.9 Effect of battery operating cycle on the uniformity coefficient spray for the landscape plot area

Fig 16 showed that when operating the solar batteries at full charge 3 - 4 times for a plot area of (20.25 m^2), the hydraulic power obtained was (17.86 – 26.74 Watt) and the sprayer radius was (5.3 – 5.8 m), at an average pressure of (1.9 – 2.5 bar), which gave the best uniformity coefficient irrigating the landscape area, meanwhile operating the same unite area (20.25m^2) with partially charged solar batteries, the hydraulic power obtained was (34.97 – 43.75 W) with sprayer radius of (3 – 5.2 m), at an average pressure of (1.3 – 1.8 bar), giving the least uniformity coefficient irrigating the landscape area, so it was preferred to operate the solar batteries for the 3 cycles per day for (A_3 60.75 m^2) where each plot area was (20.25 m^2) to achieve the optimum uniformity coefficient.

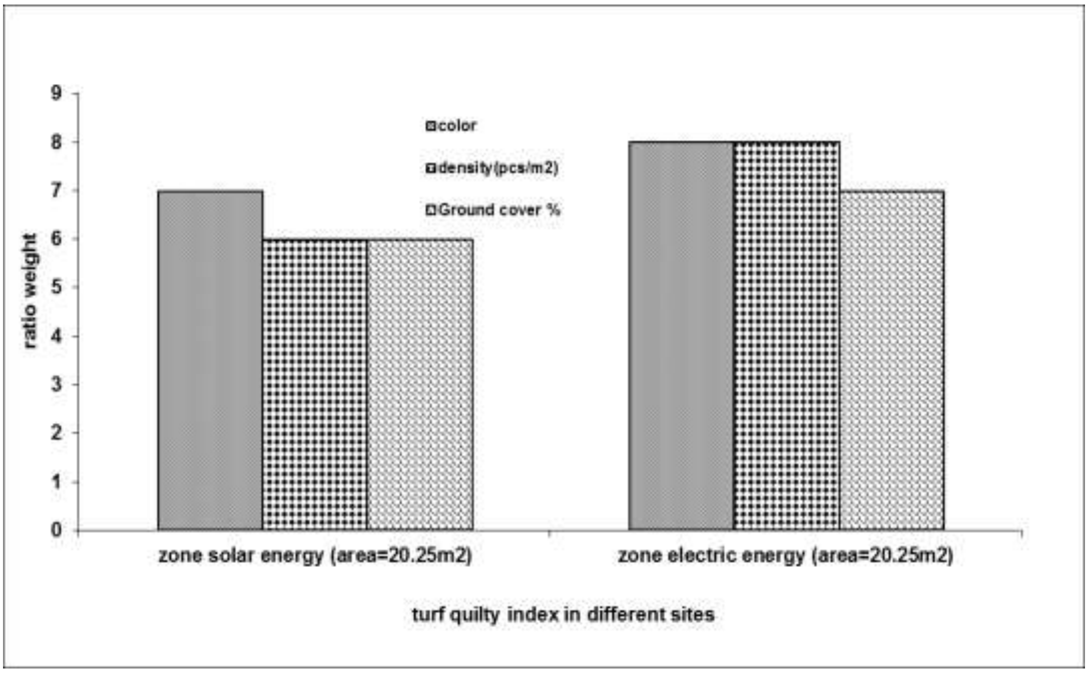


Fig 14. Effect of the solar and electric energy system on the quality index

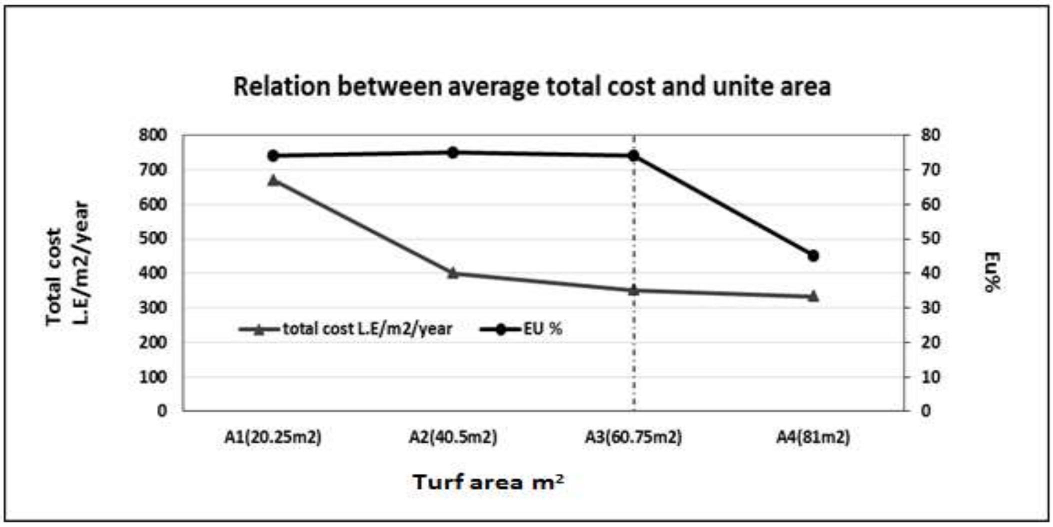


Fig 15. Effect of the solar and electric energy system on the total cost

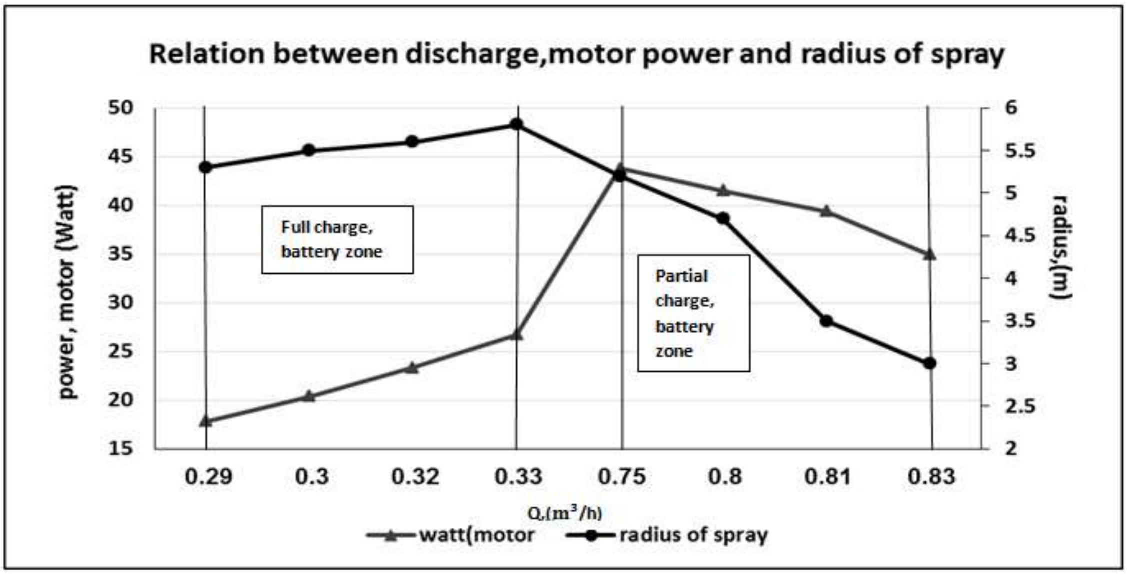


Fig. 16. Effect of battery operating cycle on the uniformity coefficient spray

4 Conclusion

Depending on the circumstances of this research. At solar energy powered system, it should be operated for a time interval of (10 – 30 min) to achieve the optimum uniformity coefficient, while at electric energy powered system it should be operated for a time interval of (10 - 40 min) to achieve the optimum coefficient, it is preferred to operate using solar energy in the summer season rather than the electric system as it helps with the energy saving up to (63%), while it is recommended to operate an area of (A_3 60.75m^2) each of a plot area equals (20.25m^2) on three cycles per day depending on operating the solar batteries at full charge 3 - 4 times to achieve the optimum uniformity coefficient (75%), and to achieve the least total cost per unit square meter for the landscape area which was 351 L.E/m^2/year. The turf quality index (color, density, ground cover) gave a high degree, using electric motor compared with solar motor, this was a result of the pressure stability in electric motors.

5 References

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تقييم أداء مضخة شمسية لنظام ري المسطحات خضراء

[13]

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أجريت التجارب العملية فى مزرعه خاصه بالقضابة – محافظة الغربية – جمهورية مصر العربيه، عند خطوط عرض وطول "37'56°30 شمالاً و"01'47°30 شرقاً والإرتفاع 30 متر عن سطح البحر في عام 2019، تم تقسيم المساحة الكلية (13.5م *9 م) الى 6 معاملات ، مساحة كلاً منهم (20.25 م^2)، حيث تم تشغيل مساحة ثلاث مربعات بإستخدام نظام الطاقة الشمسية بينما تم تشغيل الثلاث مربعات الأخرى بإستخدام نظام الطاقة الكهربائية, وكانت أنظمة الري متماثلة (4 رشاشات (90º) , علي مسافات 4.5 *4.5 م)، تم تشغيل أنظمة الري عند أوقات مختلفة لكل مربع تحت ظروف المناخ و العمل المحليه، وتم زراعة كل المعاملات بالنجيله (صنف باسبالم 10). أوضحت النتائج أن، عند إستخدام نظام الطاقة الشمسية، عند زمن تشغيل (10 – 30 دقيقة) إرتفع معامل إنتظامية توزيع المياه من (65%- 75%)، وعند زمن تشغيل (40 – 60 دقيقة) إنخفض معامل إنتظامية توزيع المياه، بينما في نظام الطاقة الكهربائية عند زمن تشغيل (10 – 40 دقيقه) إرتفع معامل إنتظامية توزيع المياه من (75%- 80%) ولكن عند زمن تشغيل (45 – 60 دقيقة) قل معامل إنتظامية توزيع المياه إلى (75%). وتم توفير الطاقة المستهلكة بقيمة (63%) عند إستخدام نظام الطاقة الشمسية بالمقارنة مع إستخدام نظام الطاقة الكهربائية في فصل الصيف.كانت أقل تكاليف كلية سنوية هي (351 ج/سنة) وذلك عند مساحة (60.75 م^2)، وتروي هذه المساحة على 3 دورات تشغيل لتعطي أفضل معامل لإنتظامية التوزيع للمياه (75%). عند تشغيل بطاريات الخلايا الشمسية في حاله الشحن التام من 3-4 مرات وذلك لوحدة المساحة (20.25 م^2) التي تعطي قدرة للمضخة (17.86 – 26.74 وات) ونصف قطر الرشاش (5.3 – 5.8 م) عند متوسط ضغط تشغيل (1.9 – 2.5 بار)، ليعطي أفضل معامل إنتظامية توزيع للمياه.و أفضل جودة للنجيله كانت عند إستخدام نظام الطاقة الكهربائية بالمقارنة مع نظام الطاقة الشمسية.