A Comprehensive Economic and Environmental Analysis to Supply the Electricity Sector of the MED Desalination Unit Using Renewable Energies

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The main goal of the current research is to study the feasibility of using renewable hybrid systems and introducing the optimal configuration from a technical-economic and environmental point of view in supplying electrical energy for desalination plants (South of Iran). HOMER analyzer software is used to simulate the load and introduce renewable systems to provide part of the energy of this complex. The electrical energy required for this complex to produce approximately 300 cubic meters of fresh water per hour is estimated at approximately 5.5 kilowatt-hours per cubic meter. Currently, this energy is supplied only through the power grid, which has a cost equivalent to 0.088 dollars per kilowatt-hour. In the following, the possible scenarios are introduced and compared in two modes, grid-off and grid-connected. The optimal off-grid configuration with an initial cost of $65.8 million will have an electricity cost of 12 cents/kWh, with 37% of the energy needed coming from wind and solar energy. In the state connected to the grid, the optimal configuration provides 44% of the required electrical energy through renewable energy, which reduces the carbon dioxide emissions by 4527 tons per year, and by selling excess electricity to the grid, the cost of energy is decreased to $0.078/kWh, which means that the cost of electricity needed to supply each cubic meter of freshwater falls down about 11.4%. Also, 47% reduction in carbon dioxide emissions. The difference between this research and other manuscripts is that the MED desalination packages have been used and our electrical load is constant, which makes more appropriate decisions for the scenarios, and on the other hand, from two private sector sources (The unit supplies electricity and sells the excess to the grid) and the government sector (supply electricity and does not sell it to the grid) have been investigated.

keywords: *MED Desalination packages, Off-grid, Grid-connected, HOMER software, Renewable energy.*

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NOMENCLATURE

$C_{ann.tot}$ Total annualized cost ($)

$C_{ann.capitol}$ Total capital cost of components ($)

D Pipe diameter (m)

$E_{ann.tot}$ Served energy in a year (kWh)

$G_{T.STC}$ STC Solar irradiation at the Standard Test

I Annual real interest rate (%)

I_{max} battery's maximum charging current

I' Nominal interest rate (%)

$NBatt$ Number of batteries

n Number of year (-)

P_{rated} Rated power of wind turbine (kW)

V_{rated} Rated wind velocity (m/s)

V_{rated} Cut-off wind (m/s)

V_{batt} Voltage of single battery (V)

Y_{PV} Rated capacity of PV (kW)

P_W Output power of wind turbine (kW)

P_R Rated power of diesel generator (kW)

P_{PV} PV panel capacity (kW)

T_P Lifetime of project (year)

T_C PV module temperature at the operating conditions ()

V Wind speed (m/s)

V_{cutin} Cut - in wind velocity (m/s)

$T_{c.STC}$ PV cell temperature under Standard Test Conditions (kW/m^2)

COE Cost of Energy ($/kWh)

CRF Capital Recovery Factor (%)

CO Carbon Monoxide

CO_2 Carbon Dioxide

DG Diesel Generator

EL Electricity Loss (kWh/year)

NPC Net Present Cost ($)

OC Operating Cost ($)

WT Wind Turbine

RF Renewable Fraction (%)

1. INTRODUCTION

In the past 50 years, global energy demand has risen up due to the number of developing countries and increase technological innovation, and it is estimated that this demand will upheaval again in the next 30 years. Therefore, According to this increasing need and population growth, optimization of energy consumption and reduction of environmental pollution is important, in this research, designing a Power Supply System for MED Desalination packages with Off Grid and Grid Connected Configuration the design of a hybrid system for supplying energy to MED desalination packages with the approach of maximizing renewable energy Acceptable will be reviewed [1]. Using Non-renewable energy sources for water desalination will be more expensive, on the other hand, non-renewable energy sources are restricted. It has been calculated that to produce 22 million cubic meters of fresh water per day, 203 million tons of oil are consumed per year, so renewable energy such as solar energy, wind energy, etc. is preferred for water desalination because They are inexhaustible and available. They are also cost-free and environmentally friendly [2]. It will be possible to solve the problem of water shortage by desalination of sea water. However, separating salts from seawater requires a large amounts of energy can harm the environment when fossil fuels are used. Therefore, it will be useful to use renewable energy technologies to desalinate sea water to produce drinking water. A lot of research has been done to address the challenges of using renewable energy to meet the energy needs of desalination packages. Iran is one of the countries that periodically struggles with the lack of drinking water. In addition, forecasts indicate a significant increase in the need for water in the coming years [3].

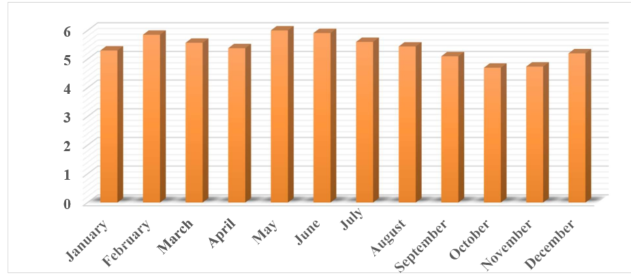


Fig. 1. Monthly average wind speed of the study area

2. METHODOLOGY

This section presents an overview of the geographical location of the unit, introduction of components, Annual conception schedule, Economic parameters formula, pollutant data, and principal analysis component.

A. The Geographical Location of Case Study

This branch presents of the geographical location of Asalouye, South of Iran near Khalije Fars gulf coast. The monthly average wind speed, global horizontal radiation (GHI), and temperature of this region were used from the reports of the National Aeronautics and Space Administration (NASA). The highest and lowest average wind speed in this region is in May (6 m/s) and October (4.7 m/s), respectively. Also, the annual average wind speed is 5.4 m/s. In June and December have the topmost (7.45 kWh/m^2) and the lowest (3.36 kWh/m^2) overall horizontal radiation, respectively. Also, the average annual GHI of this area is 5.51 kWh/m^2. Also the ultimateand minority monthly average temperatures are in July (33.85 C) and January (16.3 C), respectively. Finally, the yearly average temperature of this area is 25.97 C.

B. Introduction of components

In this research, various components have been used to simulate renewable hybrid systems, including grid, photovoltaic panels, inverter, wind turbine, diesel generator, and battery. In the following, the technical characteristics and formulas used to calculate the output power of each constituent for simulation are stated. The economic data of each constituent is prepared in Table 1.

C. Power grid

In the tariff form, timings are defined according to the average consumption of the country and taking into account the peak

Table 1. Technical and economic characteristics of the equipment

Constituent	Type	Nominal capacity (KW)	Initial cost ($)	Replacement Cost ($)	Maintenance cost($/yr)	Durability (yr)	Ref.
Photovoltaic panel (PV)	Sharp ND – 250 QCS	0.25	1000/kW	1000/kW	10	20	[4]
Inverter	Generic	1	600/kW	600/kW	10	10	[4]
Diesel Generator (DG)	Generic Large Genset	1600,1700,1900	1000/kW	900/kW	0.02 $/hr	15000 hr	[4]
Wind Turbine (WT)	Eocycle EO25 Class IIA	25	2000/kW	1800/kW	300	20	[4]
Battery (Bat)	Surrette 4 KS 25 P	7.55	1259	1100	10	10	[4]

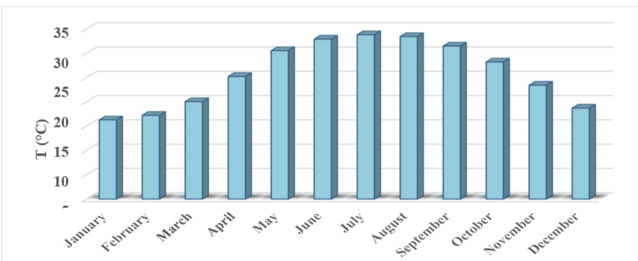


Fig. 2. Monthly average solar radiation of the studied area

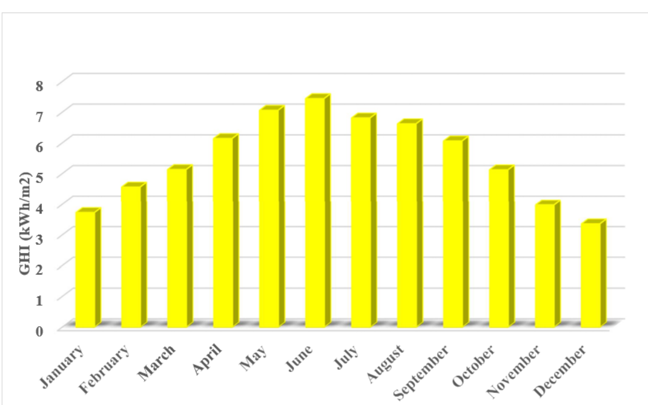


Fig. 3. Average monthly temperature of the studied area

Table 2. Electricity price of Iran's national grid

Hours of use	Price ($/kWh)	
	In non-summer seasons	In the summer season
Low consumption hours	0.05	0.60
Average consumption hours	0.07	0.80
Peak hours	0.10	0.21

Table 3. Emission content of Iran's power plants for main pollutants

Kind of emission	Value (g/kWh)
Carbon Dioxide	660.65
Carbon Monoxide	0.62
Unburned Hydrocarbons	180.18
Particulate Matter	0.12
Sulfur Dioxide	1.66
Nitrogen Oxides	2.38

with or low load or intermediate load in the hot and cold seasons. You can see the details of these tariffs in Figure 4 and Table 2. The price of selling electricity to the grid will be calculated at 8 cents per kilowatt hours [5].

D. Emissions calculation

Most of Iran's power plants use natural gas to generate electricity. contamination is a significant obstacle that brings extra costs to the government, mostly in medical management. According to the Iran national energy balance sheet, the emission content for some of the main contaminants is illustrated in Table 3, which leads the software to use more renewable energies [6, 7]. HOMER software performs the three basic functions of simulation, optimization, and sensitivity analysis in the modeling method. HOMER models the performance of a specific energy system sequence for each hour of the year by determining the possible methods of providing the desired energy and its life cycle cost. In the optimization process of this software, all the various power supply arrays that overcome the technical restrictions are searched to achieve the most main economical mode for the life cycle cost. HOMER uses the grid cost equation for the life cycle, which includes initial investment costs, replacement, maintenance, fuel, buying/selling electricity from/to the grid for revenue, and air pollution fines. HOMER evaluates all expenses and income at a constant interest rate throughout the year.

E. Economic parameters

After evaluating the technical possibility of the mixture energy system, HOMER calculates the net present cost (NPC). The NPC of the system is acquired as follows [8].

$$NPC = \frac{C_{ann.tot}}{CRF(i.T_p)} \tag{1}$$

In the mentioned relationship, C_{tot}, CRF, i, and T_p are the total annual cost of the system, the annual interest and investment return rates, and the lifetime of the project, respectively. In the present research, the life span of the project is considered to be 20 years [9]. The amount of annual interest (i) and the amount of return on investment (CRF) can also be calculated from relations 2 and 3 [10, 11].

$$i = \frac{i' - f}{1 + f} \tag{2}$$

$$[CRF(i.n) = \frac{1(1+i)^n}{(1+i)^n - 1} \tag{3}$$

where i' represents the nominal interest rate, f is the annual inflation rate, and n is the number of years. In this study, according to the report of the Central Bank of Iran, the nominal interest and real inflation rates are weighed to be 21% and 10%, respectively.

$$SC = C_{RC} \frac{T_{rem}}{T_{com}} \tag{4}$$

In the above formula, CRC, T_{rem}, and T_{com} are the equipment replacement value in dollars, remaining life and project life, respectively. The cost of energy (COE) for each equipment and the whole system is obtained from equation 5 [12].

$$COE = \frac{C_{tot}}{E_{tot}} \tag{5}$$

where E_{tot} kilowatt hours per year is the total annual energy demand. HOMER stands for Multi-Renewable Electric Energy Combination Optimization and is tasked with both off-grid and grid-connected power systems. By designing a power generation system, there are many decisions to be made about the arrangement of the system. Models are provided with inputs that describe technology options, component costs, and resource availability. HOMER displays the simulation results in a wide variety of tables and graphs, which helps to compare arrays and evaluate them from an economic and technical point of view. HOMER simulation simulates the performance of a system by performing energy balance calculations at each stage of the year. In this software, the energy balance for each system configuration and electrical demand under the specified conditions, and the cost of installing and operating over the life of the project and also system cost include capital cost, replacement, operation and maintenance, fuel cost, and interest rate is calculated [13].

F. Photovoltaic panels

In this study, Sharp ND-250 QCS photovoltaic panels with nominal capacity and efficiency of 0.25 kW and 15.3% were used. The lifespan of these panels is 20 years. DC power output from PV modules can be obtained from equation 6:

$$P_{pv} = Y_{pv} f_{pv} (\frac{G_T}{G_{T.STC}})[1 + \mu(T_c - T_{C.STC})] \tag{6}$$

In the above formula, YPV (kW) and fPV (%) refer to the nominal capacity and the loss coefficient, respectively. GT (kW/m^2) and G T.STC (kW/m^2) are respectively related to solar radiation and solar radiation under standard test conditions. μ represents the temperature coefficient that shows the effect of temperature increase on the produced electricity (-0.485%$/C$). T $(c.STC)$ (C) and Tc (C) refer to the temperature of the PV cell in the standard condition (298 K) and the temperature of the PV module in the working condition, respectively. The temperature T_c is determined using the following equation:

$$T_c = (\frac{T_a + (T_{c.NOCT} - T_{a.NOCT})(\frac{G_T}{G_{T.STC}})(\frac{[1 - \eta_{mp.STC}(1 - \mu T_{c.STC})}{\alpha T})}{1 + (T_{c.NOCT} - T_{a.NOCT})(\frac{G_T}{G_{T.STC}})(\frac{\mu.\eta_{mp.STC}}{\alpha T})}) \tag{7}$$

$Tc.NOCT(C)$ and $T\alpha.NOCT(C)$ refer respectively to the nominal operating temperature of the cell (NOCT) which is considered 20 degrees Celsius) and the ambient temperature. $\eta mp.STC$ (%) is associated to the efficiency at the point of ultimate electricity generation. α (%) and T (%) are related to the light imbibition and transmission coefficient of the cell, respectively [14].

G. Wind Turbine

In this research, EOcycle EO25 class IIA model wind turbine is selected for simulation. The capacity of each of these turbine models is 660 KW and their investment cost is equivalent to 2000 dollars for each kilowatt. The cost of maintenance and replacement is 1000 dollars per year and 1800 dollars per kilowatt, respectively. Also, the lifespan of each wind turbine is 20 years. The power output of wind turbines can be calculated as follows:

$$P_{WT} = \begin{cases} 0 \quad V \leq V_{cutin} \\ a.V^3 - b.P_{rated} \quad V_{cutin} \leq V \leq V_{rated} \\ P_{rated} \quad V_{rated} \leq V \leq V_{cutoff} \\ 0 \quad V > V_{cutoff} \end{cases} \tag{8}$$

The constants a and b are obtained from the following relations:

$$a = \frac{P_{rated}}{V^3{}_{rated} - V^3{}_{cutin}} \tag{9}$$

For above formulas, P_{rated} (kW) is connected to the rated power of the turbine. V_{cutin} (m/s) and V_{cutoff} (m/s) show the starting speed and the final limit of the turbine operating speed [15].

H. Inverter

An inverter or converter in any hybrid energy system is necessary to convert DC to AC to supply electricity to household devices and store it in the battery. The efficiency and lifespan of the converter used for this project are considered 100% and 10 years. To Compute the Power output of the converter, equation (11) can be used:

$$P_{out}(t) = \eta_{inv} \times P_{in}(t) \tag{10}$$

In this regard, η_{inv} (%) and P_{in} (kW) are converter efficiency and input.

Fig. 4. Annual electricity consumption schedule of Iran's national electricity grid

I. Battery

The main purpose is to use the battery to store excess electricity produced by other devices such as PV and WT Sometimes batteries are also used for grid peaking. The Surrette 4 KS 25P model is the battery of choice for this research.

$$P_{\max,b} = \frac{N_{batt}.V_{batt}.I_{\max}}{1000} \quad \textbf{(11)}$$

N_{batt}indicates the number of batteries used, $I_{\max}$ (A) belongs to the maximum charge current and V_{batt} (V) corresponds to the voltage of a battery [16].

J. Diesel Generator

A Diesel generator is used to meet the peak demand for electricity. In other words, if there is no access to other sources, the diesel generator acts as a backup mode in hybrid energy systems. The minimum load ratio and lifetime of DG are considered to be 25% and 15000 hours, respectively. The cost of each liter of diesel is $0.10. The consumption per hour of DG diesel can be expressed as follows [17].

$$F_D(t) = A.P_R + B.P(t) \quad \textbf{(12)}$$

$P(t)$ and $P_R$refer to the output power of the DG at the moment and the rated power of the diesel generator, respectively. A and B are constants with values of 0.081 and 0.246.

K. Data analysis

The electrical load of the electrical equipment of this complex is currently supplied by the national power grid, which is about 40 MWh/d on average. Almost the required load of this complex is constant at all hours of the day and night, but it changes during various months of the year. This amount reaches its highest amount in summer due to the need for more fresh water consumption and reaches its lowest amount in winter. The different forms of consumption of this collection can be seen below in Fig. 5 and 6.

For this work, the authors considered the results of the electric charge modeling of this water desalination complex in Asalouye will be investigated and analyzed. This analysis will be reviewed in three cases:

I. The current state where the electric charge of the set is supplied only through the grid.

II. In The off-grid mode, the electrical load of the complex will be provided independently by adding wind and solar energy to the system without considering the power grid.

III. The grid-connected mode, in which the electricity supply equipment will be added to the configuration using renewable energy and will supply the system with the required electricity at different times of the day through energy exchange with the grid.

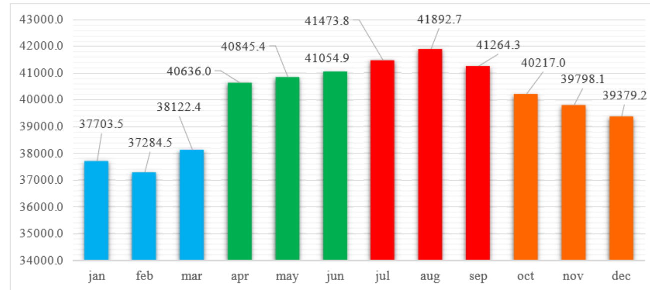


Fig. 5. Average daily electrical load in different months of the year (KWh)

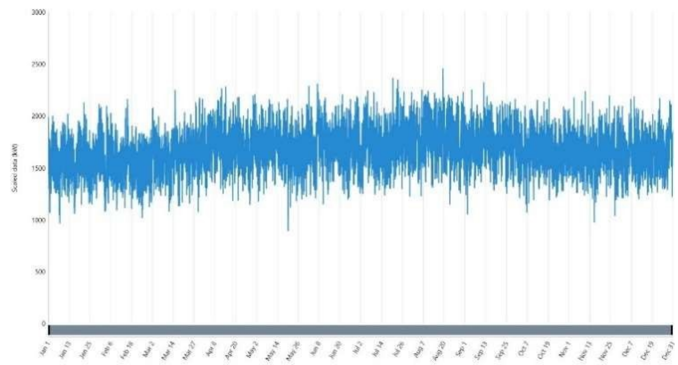


Fig. 6. Annual hourly electrical load of the studied area

3. RESULTS

In this section, the results of the three considered scenarios are described separately.

A. Current configuration (Power grid)

In this scenario, the electricity required by the system is supplied only through the power supply grid. The economic results of this scenario are illustrated in Table 4. In the scenario of electricity supply through the grid (S), the electricity cost is finally calculated as 0.088 dollars per kilowatt hour. The total required energy equal to 14,595,220 kilowatt hours per year is purchased from the grid, which will bring the current value of the costs to 19.8 million dollars during the 20-year life of the project with an inflation rate of 15%. delivered This scenario results in the amount of carbon dioxide emissions of 9642332 kg per year.

B. Off grid configuration

Table 5 shows the off-grid systems to supply the electrical load of the water desalination complex. 4 hybrid renewable systems have been proposed for this collection. The scenario with the lowest value of IC or initial cost is introduced, which only uses a diesel generator, but has high emission of pollutants. In the

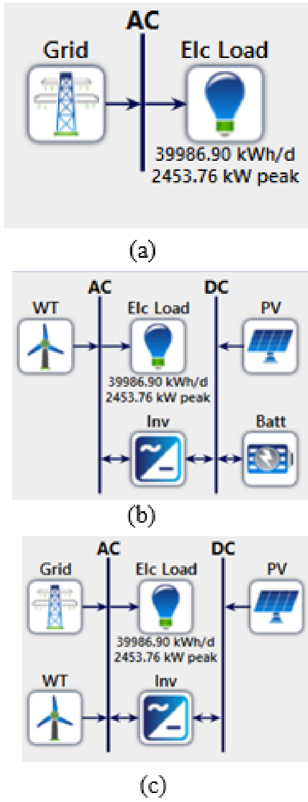


Fig. 7. (a), (b) and (c). Suggested configurations to supply the electrical load of the desalination unit

Table 4. Technical, economic, and environmental characteristics of the current configuration of electric load supply

Inflation (%)	15
configuration	S1:G
Net present value of costs ($M)	19.8
Electricity cost ($/kWh)	0.088
Share of renewables (%)	0
Carbon dioxide emission (kg/year)	9642332
Purchase of electricity from the grid (kWh/year)	14595220

second and third rows, another practical scenario has been introduced by adding solar panels or wind turbines with lower emissions but higher initial start-up costs than the previous system, and in the last row, the best configuration from an economic and environmental point of view. For this set, it is suggested that the largest share of renewables is also simulated in this scenario with 36.5 percent for inflation rates of 15 percent. For this system, the S5 hybrid configuration including diesel generator, solar panel, wind turbine, and battery has been chosen as the best off-grid system from the economic and environmental point of view. The NPC and COE of this hybrid system are calculated as 27 million dollars and 0.12 dollars per kilowatt, respectively. Figure 8 shows the unity of each portion in supplying electricity demand for the optimal scenario for off-grid. The largest share in meeting demand is related to diesel generators (58.4 percent). The second place belongs to photovoltaic panels (35.5%). Diesel generators can produce 9267064-kilowatt hours of electricity per year by consuming 2400 cubic meters of fuel per year. Photovoltaic panels can produce 5,638,212 kilowatt hours of energy per year with a balanced cost of 0.044 dollars per kilowatt hour. Also, the total production and working hours of wind turbines are calculated as 975065-kilowatt hours per year and 6008 hours per year, respectively. Scenario S4 including PV/DG is propounding as the second practical option for this complex. In this scenario, 312 the capacity of the diesel generator is reduced to 1700 kW. According to the increase in the amount of fuel, CO2 313 increases by 6% (377,269 kg per year) compared to the optimal scenario, and the start-up cost is reduced to 0.71 314 million dollars. 315 The practical scenario is similar to the previous scenario of the S3 system including WT/DG. Its start-up cost is 316 1.09 million dollars more than the optimal scenario, and also the cost of electricity and the current value of costs 317 increase. 318 And finally, the proposed scenario S2, which only uses diesel generators and requires the least amount of initial 319 investment. Due to the use of more fuel, this scenario produces more carbon dioxide and is in the last place from 320 an environmental issue, and the percentage of renewables in it is zero. 321 In general, off-grid scenarios can be effective for this type of load that does not change much throughout the 322 year, because the system is designed and planned for peak load, and the production capacity will not be unused 323 at all other hours of the day and night. In other words, excess electricity is not produced (less than 8% of excess 324 electricity).

4. RESULTS

A. Grid connected

Another solution to supply the required load of this desalination complex can be a combination of the grid and renewable systems (scenario connected to the grid). In this group of scenarios, 3 systems have been proposed. Table 6 shows the technical and economic characteristics of these hybrid systems. In all the scenarios of this part of the grid, the extra power is sold to the grid, and electricity is purchased from the grid. Of course, the S9 scenario is the most optimal configuration with the condition of not selling excess electricity to the grid, which will be discussed further. In the first row, the required load is supplied through the grid and wind turbine, and in the next row, instead of the wind turbine, photovoltaic panels are added to the grid finally, the combination of these three components forms the model of the most optimal system can be achieved from the economic and environmental points with the highest amount of renewable production. Also, the contribution of each of the renewables will

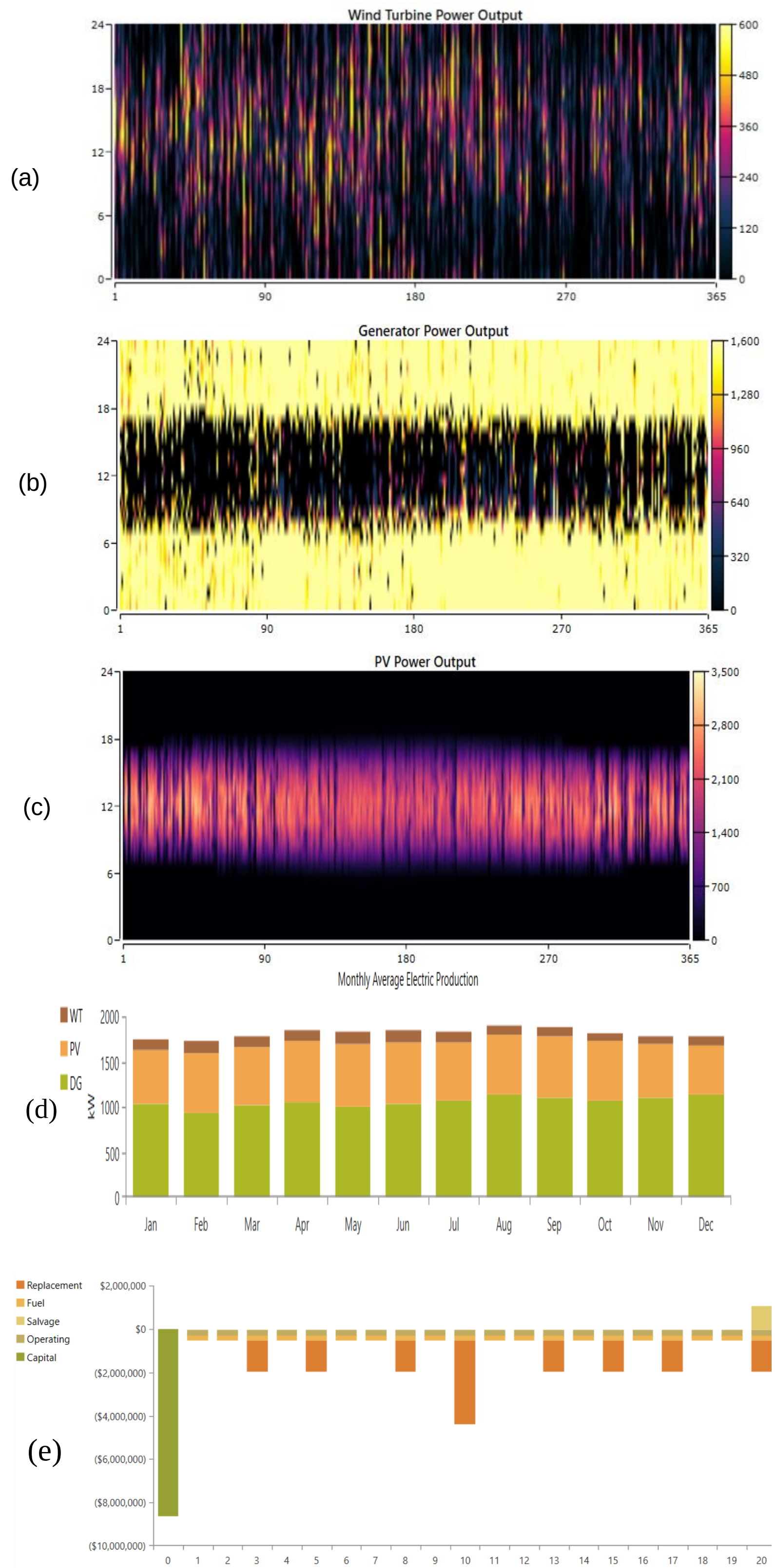


Fig. 8. The contribution of optimal system grid off components in supplying electricity demand with an inflation 347 rate of 15%: WT (a); GT (b); PV (c); monthly share (d); Project financial flow (e)

Table 5. Technical, economic, and environmental characteristics of off-grid configurations (inflation rate: 15%)

Off grid configurations	S2:DG/Batt	S3:WT/DG/Batt	S4:PV/DG/Batt	*S5:PV/WT/DG/Batt
Photovoltaic panel (kW)	0	0	3516	3308
Electric converter	518	1426	2220	2157
Wind Turbine	0	119	0	23
diesel generator	1900	1700	1700	1600
battery	317	977	1106	1029
Fuel consumption Diesel (m^3/year)	3803	2641	2544	2400
Net present value	29.2	29.2	27.1	27
Electricity cost ($/kWh)	0.13	0.13	0.12	0.12
Initial cost ($M)	2.61	9.74	7.94	8.65
share of renewables (%)	0	30.1	32.7	36.5
Carbon Dioxide Emission (kg/yr)	9972032	6924588	6670137	6292868

be investigated in more detail in the optimal scenario.

In scenario S6, by adding wind turbines to the power grid to supply electricity with a value of 25.6 million dollars, NPC is reduced by 0.5 million dollars. This work causes the cost of energy to decrease by 0.6 cents per kilowatt hour and reach 0.082 dollars per kilowatt hour. The share of renewables in this scenario will be 34.9 percent. In scenario S7, photovoltaic panels take the place of wind turbines and it has better conditions than the previous scenario because the situation of solar radiation in the studied area is better than the wind speed. By spending 5.54 million dollars, this scenario brings the current net value of costs and electricity costs to 18.7 million dollars and 0.0774 dollars per kilowatt hour, respectively. The amount of carbon dioxide released in this scenario is estimated at 5520536 kg per year. The most optimal configuration is introduced in the S8 scenario, which is a combination of the grid, 850 kW of wind turbines, and 3575 kW of photovoltaic panels. In this scenario, by spending the initial cost of 6.51 million dollars, NPC and COE will reach 18.69 47%. Figure 4-4 shows the contribution of each component of this configuration. The operating time of photovoltaic panels is 4382 hours per year, which will have a share of 37.5% of the electricity supply. These panels produce 6,091,729 kilowatt hours of electricity per year with a balanced cost of 0.044 dollars per kilowatt hour. Wind turbines with 6008 operating hours per year will have a share of 8.9 percent. These turbines will produce 1,441,401 kilowatt-hours of electricity every year with a balanced cost of 0.084 dollars per kilowatt-hour. The investment return in this scenario will be approximately 17 years considering the interest rate and 14 years without considering the interest rate, which can be seen as million dollars and 0.0778 dollars per kilowatt hour, respectively. The share of renewables in this scenario is calculated to be 44%, which reduces the amount of carbon dioxide emissions in Figure 10. The line that starts from zero initial cost shows the current system (base) and the other line is the proposed system that will be accompanied by the initial cost.

In the off-grid systems, carbon dioxide emission has decreased by 35% in contrast to the current system, and owing to the use of diesel fuel in the Diesel generator, the amount of CO has increased, and the amount of unburned carbon is almost negligible (almost 100% reduction) has been in the scenario connected to the grid, all publications have decreased by about 47%. This amount in terms of carbon dioxide emissions has been reduced by approximately 4527 tons per year compared to the current system.

The NPC and COE of the Current configuration (Power grid) are accounted to be 19.8 $\$M$ and 0.088 $\$/kWh$, respectively. The values of CO2 emissions of this system are obtained at 9642332 kg/year. In Off grid configuration S2: DG/Batt, S3: WT/DG/Batt, S4: PV/DG/Batt, S5: PV/WT/DG/Batt the NPC are 29.2,29.2,27.1,27.0 $\$M$, respectively. Also, for COE for the scenarios are 0.130,0.130,0.120 and 0.120 $\$/kWh$. For values of CO2 emissions, the results showed 9972032, 6924588, 6670137, and 6292868$kg/year$. Finally, for Grid-connected the configurations from S6 to S9 $(G/WT, G/PV, G/PV/WT, G/PV/WT$ for NPC indicated 19.3, 18.7, 18.7 and 18.9 $M.Moreover, forCOE$0.082, 0.077, 0.078, and0.084/kWh. The values of COW emission for the third category are 6141370, 5520536, 5115367 and 6808622 $kg/year$, respectively

5. CONCLUSION

In this Research, to supply the power demand for Desalination units in the south of Iran, various possible scenarios are suggested by using renewable systems with/without a power grid. In this research, three configurations were considered: Current configuration (Power grid), Off grid configuration, and Grid connected. The energy configurations are simulated and appraised by HOMER Pro software. Between all configurations hybrid renewable systems (grid-connected) are the best option. In this study, HOMER analyzer software is used to calculate the cost of electricity, Net present cost and CO_2 emissions to supply the 300 cubic meters of fresh water per hour. 40 MWh of electricity is needed. For this system, three configurations were considered. At the moment, the power supply is provided from the pure grid which has a cost equivalent to 0.088 dollars per kWh. According to Table 9, the optimal stand-alone configuration with an initial cost of $65.8 million will have an electricity cost of 12 $cents/kWh$, with 37% of the energy needed coming from wind and solar energy. In the grid-connected configuration, the best scenario composed from The results indicated 3575 kW photovoltaic panel and 850 kWWind Turbine and grid that provides

Table 6. Technical, economic, and environmental characteristics of grid-connected configurations for the Desalination complexes

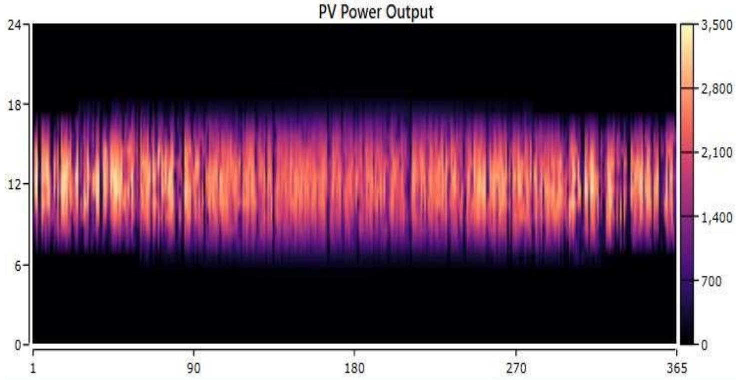
Inflation rate: 15%				S9: G/PV/WT
	S6:G/WT	S7: G/PV	S7: G/PV	(without sale to grid)
Photovoltaic panel (kW)	0	4116	3575	2732
Wind Turbine (unit)	125	0	34	6
Net present value of expenses (M$)	19.3	18.7	18.7	18.9
Electricity cost ($/kWh)	0.082	0.077	0.078	0.084
Initial cost ($M)	6.25	5.54	6.51	3.94
share of Renewables (%)	34.9	39.9	44	29.4
Carbon dioxide emission (kg/yr)	6141370	5520536	5115367	6808622
Purchase of Electricity from the grid (kWh/yr)	9864742	9416278	8713945	10305945

Table 7. Kind of emission for three best scenarios

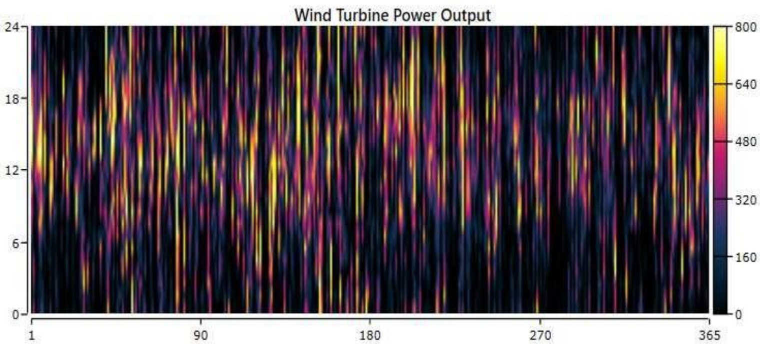
Kind of Emission	Current system (Kg/Yr)	Off Grid (Kg/Year)	Grid Connected (Kg/Year)
Carbon Dioxide	9,642,332	6,292,868	5,115,367
Carbon Monoxide	9,049	32,556	4,801
Unburned Hydrocarbons	2,629,767	1,728	1,395,121
Particulate Matter	1,751	278	929
Sulfur Dioxide	24,228	15,383	12,853
Nitrogen Oxides	34,737	6,240	18,428

Table 8. Summary of characteristics of configurations

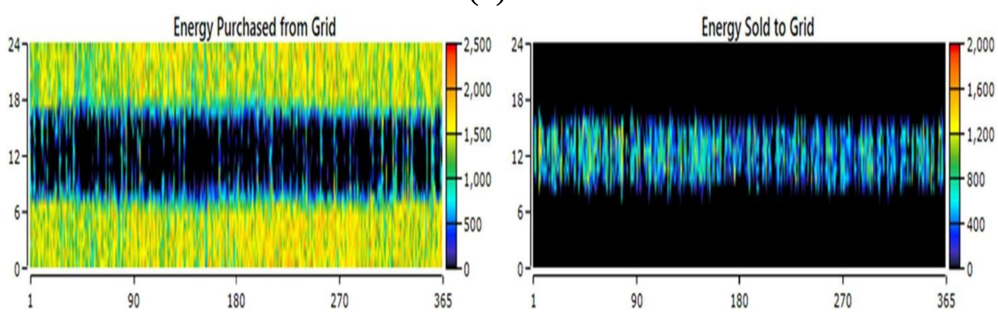
Characteristics of configurations		Net present value of expenses (M$)	Electricity cost ($/kWh)	Carbon dioxide emission (kg/year)
Current system (Power grid) S1: G		19.8	0.088	9642332
Off-grid S5: PV/WT/DG/Batt		27	0.12	6292868
Grid connected	S8: G/PV/WT	18.7	0.078	5115367
	S9: G/PV/WT (without sale to Grid)	18.9	0.084	680862



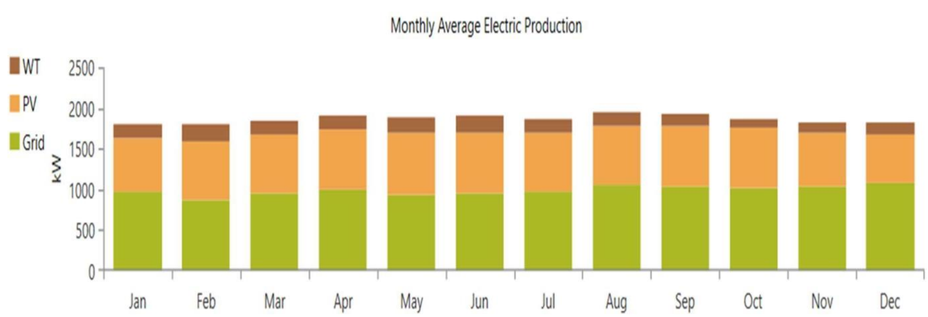
(a)



(b)

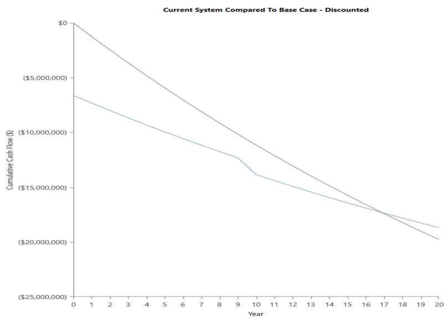


(c1) , (c2)

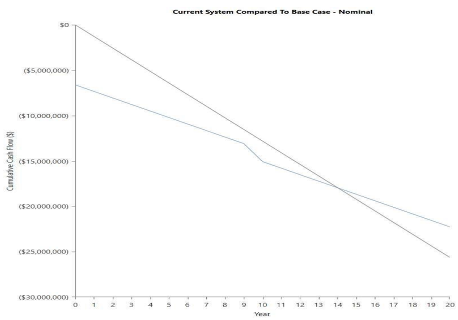


(d)

Fig. 9. The contribution of the portion of the optimal system connected to the grid in providing electricity demand with an inflation rate of 15%: PV (a); WT (b); Electricity exchange with the grid (c1, c2); The monthly share of each supplier component (d)



(a)



(b)

Fig. 10. Comparison of the cash flow of the current system with the proposed system: with interest rate (a); No interest rate (b)

44% of the required electrical energy through renewable energy, which reduces the quantity of carbon dioxide transpiration by 4527 tons per year. By selling excess electricity to the grid, the cost of energy is decreased to 0.078 $/kWh, which means that the cost of electricity needed to supply each cubic meter of freshwater fall down about 11.4%. Also, 47% reduction in carbon dioxide emissions. If selling to the grid is not possible, the cost of energy will be 0.084. The remarkable advantage of Grid-connected (S8: G/PV/WT) is the lowest amount of CO_2 emissions among the scenarios (5115367 kg/year: 25 tons/day). According to the required load and available renewable resources, the hybrid S8: G/PV/WT is chosen as the most feasible scenario. The NPC, COE, and CO2 emissions are gained to be 18.7 M, 0.078/kWh, and 5115367 kg/year, respectively. This study indicated that the grid connected is the most cost-effective option. For future research suggestions, these two options can be considered for studies:

-Research other models of other desalination systems with several capacities and prices.

-Evaluation of thermal load and introduce the optimal scenarios with renewable energies.

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