Iranica Journal of Energy & Environment
Journal Homepage: www.ijee.net
IJEE an official peer review journal of Babol Noshirvani University of Technology, ISSN:2079-2115

A Comprehensive Evaluation of Renewable Energy Systems with a Backup to Provide a Part of Electrical Needs of a Hospital: A Case Study in Grid-connected Mode

I. Pishkar*, S. M. Beigi

Department of Mechanical Engineering, Payame Noor University (PNU), P.O.Box 19395-4697, Tehran, Iran

PAPER INFO

Paper history:
Received 03 April 2023
Accepted in revised form 28 May 2023

Keywords:
Hospital electricity
Sensitivity analysis
Solar energy
Sustainable development
Wind energy

ABSTRACT

With sensitive and important systems in hospitals requiring an uninterrupted power supply, finding solutions for power outages is becoming increasingly crucial. Iran's favorable potential for renewable energy makes wind and solar energy viable options to support hospital electricity needs and contribute to sustainable development goals. The present work investigates, for the first time, the electricity supply of a part of the Parsian Hospital in Shahrekord using HOMER software. The use of real electricity exchange data with the national grid and the new generation of tree-shaped wind turbines are unique advantages. Results show that an optimal renewable energy-based system consisting of two 1-kW solar cells and a 1-kW electric converter costs $0.111 per kWh and solar cells generate 3% or 2999 kWh/year. The optimal scenario produces 55193 kg of CO_2 annually due to national grid electricity use, highlighting the importance of renewable energy adoption in hospitals.

doi: *10.5829/ijee.2024.15.01.01*

NOMENCLATURE

i	Annual interest rate (%)	$E_{load\ served}$	Real electrical load by system (kWh/yr)
N	Useful life-time (year)	ρ	Actual air density (kg/m^3)
O&M	Operations and maintenance ($)	η_{gen}	Electrical efficiency of generator (%)
3E	Energy, Economic, Environmental (-)	P_{gen}	Electricity produced by diesel generators (kW)
$C_{grid,\ energy}$	Total annual energy charge (kWh)	$\dot{m}_{fuel}$	Fuel consumption of generator (units/hr)
$C_{sell\ back}$	The sellback rate ($/kWh)	P_{WTG}	Power output of wind turbine (kW)
C_{power}	The grid power price ($/kWh)	$P_{WTG,\ STP}$	Power output of wind turbine at standard pressure and temperature (kW)
$E_{net\ grid\ purchases}$	The net grid purchases (grid purchases minus grid sales) (kWh)	LHV_{fuel}	Lower heating value of fuel (MJ/kg)
Y_{PV}	Output power of solar cell under standard conditions (kW)	PV	Photovoltaic (-)
f_{PV}	Derating factor (%)	ρ_0	Air density at standard pressure and temperature equal to 1.225 kg/m^3
$\overline{G_T}$	Incident radiation on the cell's surface on a monthly basis (kW/m^2)	LCOE	Levelized cost of energy ($/kWh)
$\overline{G_{T,STC}}$	Incident radiation on the cell's surface under standard conditions (1 kW/m^2)	RES	Renewable energy sources (-)
P_{PV}	Output power of PV cells (kW)	$C_{ann,total}$	Total annual cost ($)

*Corresponding Author Email: *iman7449@gmail.com* (I. Pishkar)

Please cite this article as: I. Pishkar, S. M. Beigi, 2024. A Comprehensive Evaluation of Renewable Energy Systems with a Backup to Provide a Part of Electrical Needs of a Hospital: A Case Study in Grid-connected Mode, Iranica Journal of Energy and Environment, 15(1), pp.1-9. Doi: 10.5829/ijee.2024.15.01.01

INTRODUCTION

Access to constant and stable electricity is crucial for the effective and efficient performance of medical equipment [1, 2]. Due to technical and operational issues in Iran's national electricity grid, it is not always feasible to rely on urban electricity for hospital equipment [3]. Therefore, hospitals should have electrical backup equipment available for each electronic device used, given their significance. Iran has excellent potential for wind and solar energy [4-7], which are also environmentally friendly [8]. Thus, it is logical and necessary to utilize these sources to provide a portion of hospital electricity.

Researchers believe that renewable energies can become the primary choice for energy production due to the limited resources of fossil fuels and environmental pollution [9]. Iran, with its geographical location, has significant potential in renewable energy production, making it necessary to prioritize renewable energy development [10].

Table 1 summarized some recent works in the field of hospital electricity supply using renewable energy.

Based on the information presented in Table 1, it is evident that incorporating renewable energy sources into hospital electricity supply is a highly strategic move. Additionally, none of the previous studies have examined the impact of annual interest rates and diesel prices on the technical, economic, and environmental aspects of the system under investigation. Therefore, this study aims to assess the feasibility of utilizing renewable energy sources to provide a portion of Shahrekord Parsian Hospital's electricity needs. The primary objective is to identify the most cost-effective wind and solar-based system that can be connected to the national electricity grid using HOMER software. This study investigates various factors such as renewable energy usage, cost per kWh of electricity produced, annual electricity grid purchases, sensitivity analysis on interest rates and fossil fuel prices, among others.

The scientific novelty of the present work lies in its comprehensive analysis and assessment of the feasibility and effectiveness of integrating renewable energy systems with backup to meet a portion of a hospital's electricity demand. This study presents a unique approach to address the challenges associated with ensuring a reliable and sustainable power supply for critical healthcare facilities, which has significant implications for energy policy, healthcare management, and environmental sustainability. The research findings provide valuable insights into the technical, economic, and environmental aspects of renewable energy integration in grid-connected hospital settings, contributing to the advancement of knowledge in this field.

Investigated area and its potential

Shahrekord, located 85 km southwest of Isfahan, is a central city in Iran and serves as the capital of Chaharmahal and Bakhtiari province. The city has a population of 190,441 people and sits at an altitude of 2060 m above the sea level, making it the highest provincial capital in Iran. Shahrekord boasts good wind and solar potential, placing it among the top 50% of high-potential areas in the country according to Iran's

Table 1. Recent studies in the field of supplying electricity to hospitals using renewable energy.

Location	Renewable energy type	Wind turbine type	Sensitivity analysis	Connection	Electricity consumption (kWh/day)	Levelized cost of electricity ($/kWh)	Ref.
Iran	Solar, Wind	Horizontal axis	No	Off-grid	19	0.721	[11]
Saudi Arabia	Solar, Fuel cell	-	Yes	Off-grid	33.76	0.105	[12]
Iran	Solar, Wind	Vertical axis	Yes	Off-grid	54	0.636	[13]
Saudi Arabia	Solar, Biogas	-	Yes	On-grid	250	0.21	[14]
Turkey	Solar	-	Yes	On-grid	25108	0.05	[15]
Ethiopia	Solar	-	No	Off-grid	77	0.359	[16]
India	Solar	-	Yes	Off-grid	220	0.11	[17]
Malaysia	Solar	-	Yes	On-grid	22128	0.022	[18]
Nigeria	Solar, Wind	Horizontal axis	Yes	On-grid	19	0.096	[19]
Iran	Solar, Wind	Vertical axis	Yes	On-grid	246	0.111	Present work

wind and solar atlases [20, 21].

Chaharmahal and Bakhtiari province offers a clean climate, cold mineral water springs, pristine nature, medicinal plant species, and relaxing natural attractions that make it a promising destination for health tourism. The authors of this work aim to develop the necessary infrastructure to promote health tourism in the region. Parsian Hospital in Shahrekord is the only private sector hospital in Chaharmahal and Bakhtiari province with 7 floors and 18 thousand m^2 of infrastructure and is under investigation by the authors.

METHODOLOGY

The HOMER software is responsible for assessing and designing micropower systems that are optimal for small power generation in two states: connected and disconnected from the power grid, in order to achieve desired application goals [22]. Once the possible configurations have been simulated, the HOMER system presents a list of configurations sorted by total net present cost, allowing for comparison of different system design options [23]. To gain a better understanding of the software's functionality, as well as its inputs and outputs, Figure 1 displays a flowchart of how the software operates [24].

Input data and governing equations

The most crucial data required by the software is the hourly electricity consumption over a year, which is obtained by reading the hospital's electricity meter. Based on the hospital's electricity consumption data, January has the highest demand for electricity, with a maximum amount of 60 kW. Other important data include solar radiation intensity and wind speed, which are based on a 20-year average for the region in question. The price of diesel used is \$0.06 per liter[1], while the project has a useful life of 25 years and an annual interest rate of 18% [25]. Table 2 provides information on device prices and specifications used in the simulated system.

In relation to the pricing of renewable electricity sold to and purchased from the national electricity grid, the prices are based on literature [26] and were provided in response to a query from technical experts at the electricity organization. The pricing structure includes a three-time tariff and an incentive price for purchasing renewable electricity. It should be noted that these prices apply to systems with a capacity of less than 20 kW. The cost of purchasing electricity from the grid during low-load, mid-load, and peak times is \$0.005, \$0.007, and \$0.012 per kWh, respectively. The corresponding prices for selling electricity to the grid are \$0.0318, \$0.0445, and \$0.0763 per kWh, respectively.

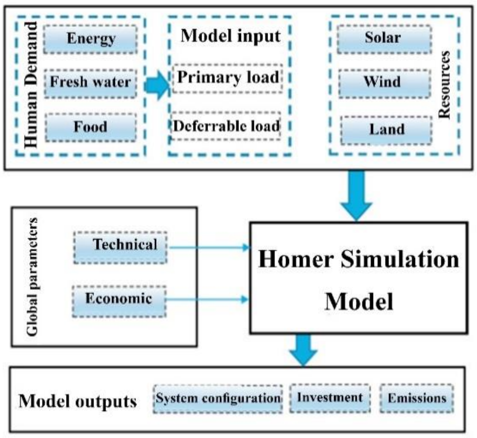


Figure 1. General framework of operations performed by HOMER software [24]

HOMER software uses equations 1 and 2 to calculate the output power of solar panels and wind turbines, respectively [27, 28].

$$P_{pv} = y_{pv} \cdot f_{pv} \left(\frac{\bar{G}_T}{\bar{G}_{T,STC}}\right) \quad (1)$$

$$P_{WTG} = \frac{\rho}{\rho_0} \times P_{WTG,STP} \quad (2)$$

The efficiency of the diesel generator in HOMER software is obtained by the following equation [29].

$$\eta_{gen} = \frac{3.6\ P_{gen}}{\dot{m}_{fuel} \times LHV_{fuel}} \quad (3)$$

In the HOMER software, electricity exchange with the national grid is obtained by the following equation [30].

$$C_{grid,energy} = \sum_{i}^{rates} \sum_{j}^{12} \begin{cases} E_{net\ grid\ purchases,i,j} \cdot c_{power.i} & if\ E_{nt\ grid\ purchases,i,j} \geq 0 \\ E_{net\ grid\ purchases,i,j} \cdot c_{sellback.i} & if\ E_{net\ grid\ purchases,i,j} < 0 \end{cases} \quad (4)$$

Economic calculations in the software, which include determining the parameters of the total net present cost and the adjusted cost of electricity, are performed by the following equations [31-34].

$$\text{Total NPC} = \frac{C_{ann,total}}{\frac{i(1+i)^N}{(1+i)^N+1}} \quad (5)$$

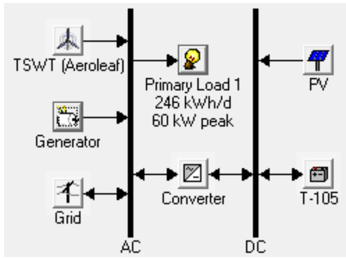
$$LCOE = \frac{C_{ann,total}}{E_{Load\ served}} \quad (6)$$

Results

The wind speed data of the Lutak station was used to validate the present work. A comparison was made between the Weibull function drawn by Teimourian

[1] http://www.globalpetrolprices.com/diesel_prices

Table 2. Information of the investigated system

Equipment	Cost ($)			Size (kW)	Other information	Schematic
	Capital	Replacement	O&M			
Converter [23]	200	200	10	0-5	Lifetime: 10 years Inverter Efficiency: 90% Rectifier Efficiency: 85%	
PV [23]	3200	3000	0	0-20	Lifetime: 20 years Derating factor: 75 % Tracking system: No	
Battery Trojan T-105 [23]	174	174	5	0-20	Lifetime: 845 kWh Nominal specs: 6V, 225 Ah	
Generator [23]	200	200	0.5	0-5	Lifetime: 15000 h Max. efficiency: 50%	
Tree shape wind turbine (TSWT) [35]	35000	35000	200	0-3	Lifetime: 19 years Hub height: 6.8 m Rated power: 11.7 kW AC	

et al. [39] and the present work, as shown in Figure 2. The data used by Teimourian et al. [36] were obtained through fitting wind energy data for parameters c and k equal to 7.22 and 1.6, respectively, using an analytical method. In contrast, the present work was done using HOMER software, resulting in c and k values of 7.36 and 1.97, respectively. The Weibull function was chosen for validation as it measures wind occurrence potential and actual probability fit. Figure 2 demonstrates good agreement between the results of the Weibull function of the present work and Teimourian et al.'s [36] findings.

In the present study, sensitivity analysis was utilized to evaluate the annual interest rate and fuel price in order to determine the most optimal outcome. After simulating all modes using software, it was determined that an interest rate of 18% and a fuel price of $0.06 were the most suitable parameters for the investigated system. All

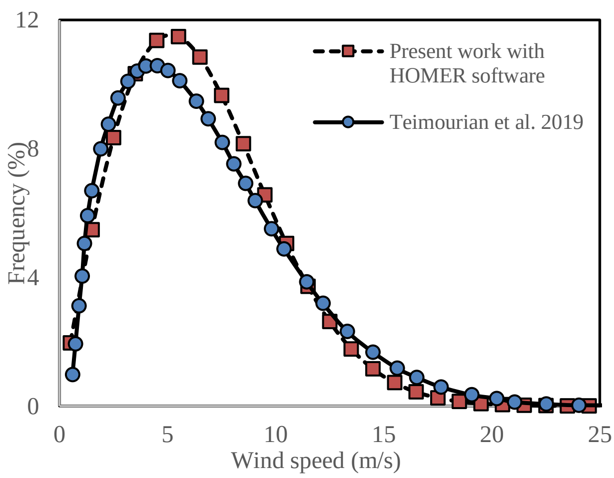


Figure 2. Validation of the results of the HOMER software compared to the work of others [36] using the Weibull function

results presented in this work are based on these two data points, with the system being connected to the power grid and capable of exchanging up to 1000 kW of electricity.

Table 3 displays the results of 12 examined scenarios, with scenario 1 being determined as the most economic option with a total net present cost of $54,303 and a cost of $0.111 per kWh of electricity produced. This scenario utilizes two 1 kW solar panels and a 1 kW electrical converter, with solar panels producing approximately 3% (2999 kWh/year) of the total electricity produced throughout the year.

The software output for the first three days of January is shown in Figure 3, indicating that due to limitations in electrical conversion capacity, there is approximately 267 kWh/year of excess electricity produced by solar cells that cannot be converted to AC power and sold to the power grid. Adding an electrical converter would not be economical and would increase costs; instead, it is recommended to use a battery for storage which would result in further cost increases.

Figure 4 illustrates the power output generated by solar panels, with electricity production occurring for 4384 hours due to solar exposure. The capacity factor of the solar panels is 17.1%, resulting in an average output power of 0.34 kW. The uniform cost of electricity is $0.399/kWh.

Table 4 displays the amount of electricity exchanged with the national electricity grid, indicating that most of the produced solar electricity is consumed and only a small amount is sold to the national electricity grid. The annual amount of electricity purchased from the grid is 87337 kWh, while only 5 kWh of electricity is sold to the national grid. In scenario one, where the electric converter functions solely as an inverter due to non-operational diesel generators and wind turbines, the performance factor of the inverter is calculated as 1.28%. The inverter experiences an annual loss of 273 kWh with a main annual performance of 4384 hours. The pollutants produced by the power grid include 55193 kg of CO_2, 239 kg of SO_2, and 117 kg of NOx annually.

In scenario six, where only one wind turbine with a capacity of 1 kW is used to supply required electricity, each kWh produced costs $0.171 - approximately a 54% increase from scenario one. This scenario has a total NPC of $83,838 with only 4% supplied by wind turbine-generated electricity and 96% supplied by grid-generated electricity. Pollutants caused by grid-generated electricity include 54554 kg CO_2, 237 kg SO_2, and 116 kg NO_x annually according to Table 3 results.

Table 3 presents the results for scenario 12, which utilizes two 1 kW solar panels, a wind turbine, a generator, 4 batteries, and a 1 kW electric converter. The cost per kWh of electricity is $0.184, with a total NPC of $91,059. The generator requires 128 liters of fuel and operates for 624 hours annually. The wind turbine produces 4% of the electricity, while the solar panel produces 3%, the diesel generator produces 1%, and the grid produces 92%. The diesel generator is started 152 times per year and has a useful life of 24 years. The batteries have their highest charge in March and never reach zero charge throughout the year. They have a loss of 257 kWh/year and a useful life of 10 years.

Table 5 shows that scenario 12 purchases 83,821 kWh from the grid while selling only 573 kWh to the national grid. In July, it sells the highest amount of renewable electricity to the grid at 106 kWh while the lowest amount of renewable electricity to the grid only 19 kWh in February. During hot months when national electricity consumption is high, renewable energy production also increases. Scenario 12 emits pollutants including 52949 kg of CO_2, 0.831 kg of CO, 0.0921 kg of unburned carbon, 0.0627 kg of fine matter, 229 kg of SO_2,and119 kg of NO_x per year due to power grid and diesel generator fuel use.

The results of the sensitivity analysis are shown in Figure 5. Based on the results, since the optimal system includes the national electricity grid, the price of diesel has no effect on the results, but with an increase in the

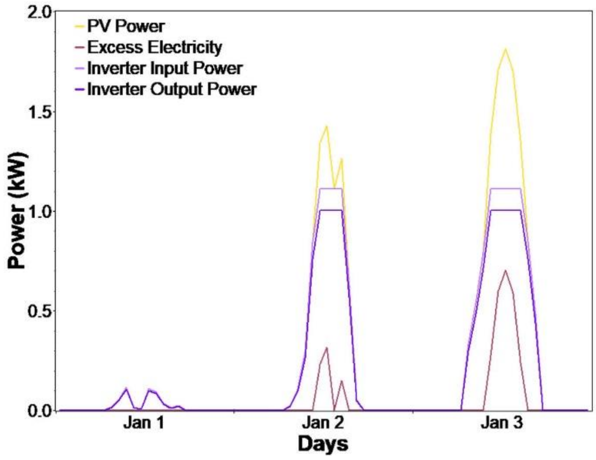


Figure 3. The relationship between the output power of solar panels with the performance of the electrical converter and excess electricity in the first three days of January (first scenario)

Table 3. The results of the analysis performed on different scenarios

Scenario	Components	Total NPC ($)	LCOE ($/kWh)	Renewable energy (%)	Diesel consumption (L)	Diesel generator (hrs)
1	2 PV, 1 Converter	54303	0.111	3	0	0
2	2 PV, 1 Converter, 5 Diesel generator	54444	0.109	3	341	333
3	2 PV, 1 Converter, 1 Battery	54534	0.111	3	0	0
4	2 PV, 1 Converter, 1 Diesel generator, 1 Battery	55050	0.112	3	39	190
5	1 Wind turbine, 5 Diesel generator	83805	0.168	4	345	337
6	1 Wind turbine	83838	0.171	4	0	0
7	1 Wind turbine, 1 Battery, 1 Converter	84285	0.171	4	0	0
8	1 Wind turbine, 1 Battery, 1 Converter, 1 Diesel generator	85741	0.174	4	134	655
9	2 PV, 1 Converter, 5 Diesel generator, 1 Wind turbine	88928	0.178	6	371	362
10	2 PV, 1 Converter, 1 Wind turbine	89360	0.181	7	0	0
11	2 PV, 1 Converter, 1 Wind turbine, 1 Battery	89453	0.182	7	0	0
12	2 PV, 1 Converter, 1 Wind turbine, 4 Battery, 1 Diesel generator	91059	0.184	7	128	624

annual real interest rate, the total NPC drastically decreases. In other words, an increase in inflation will make the use of the national electricity grid more justified.

The results of the superior scenario were compared with the traditional scenario (only the national power grid) in Figure 6. Based on the results, it can be seen that during the useful life of the project, there is a very slight difference between the results of the superior scenario and the traditional scenario from the economic point of view. But it should be mentioned that based on environmental analysis, the best scenario leads to a reduction of more than 1.6 tons of produced pollutants during the year, which is due to the production of solar electricity.

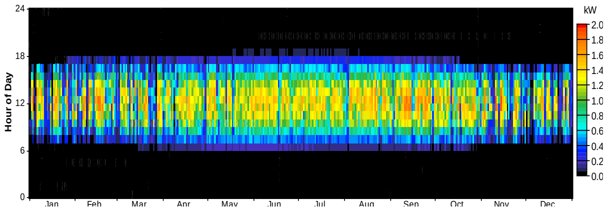


Figure 4. Output power of solar panels in different days of the year (first scenario)

Table 4. Amount of electricity purchased from the network and sold to the network (first scenario)

Month	Electricity sold (kWh)	Electricity purchased (kWh)
January	1	7423
February	0	6522
March	0	7619
April	0	7238
May	2	7193
June	0	7253
July	1	7346
August	0	7721
September	0	7228
October	1	7237
November	0	7116
December	0	7441
Yearly	5	87337

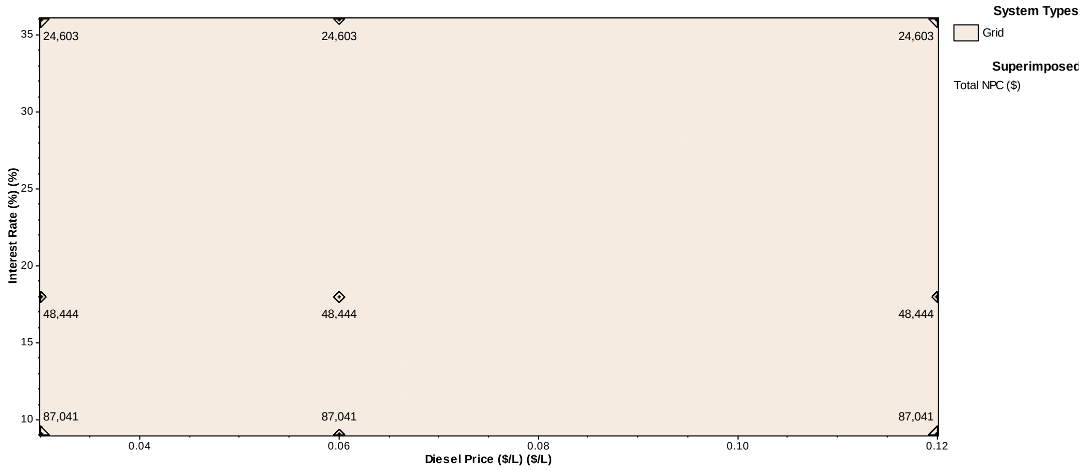


Figure 5. Results of sensitivity analysis on fuel price parameters and annual real interest rate

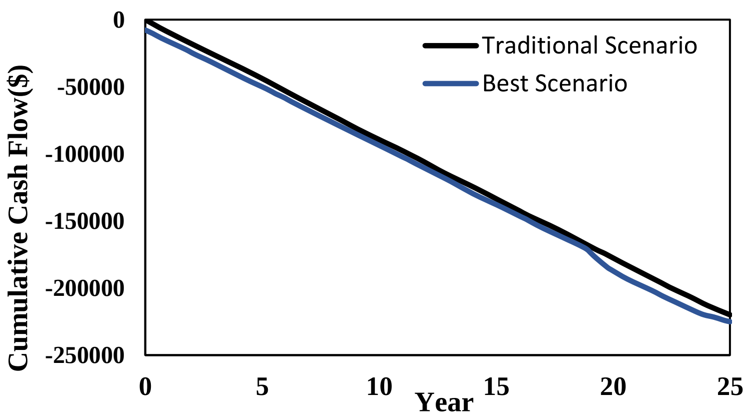


Figure 6. Comparison of the results of the best scenario with the traditional scenario (only national power grid)

Table 5. The amount of electricity purchased/sold from/to the national electricity grid (scenario 12)

Month	Electricity sold (kWh)	Electricity purchased (kWh)
January	28	7189
February	19	6290
March	33	7321
April	47	6933
May	60	6746
June	78	6866
July	106	6934
August	70	7382
September	49	6950
October	49	6982
November	26	6915
December	31	7212
Yearly	573	83821

CONCLUSION

Continuous availability of electricity is very important and critical for healthcare organizations because every second without electricity can become a matter of life or death. Therefore, the aim of the present work is the feasibility of supplying a part of the electricity of Parsian Hospital located in Shahrekord using wind and solar energy, which uses national grid electricity and diesel generator as backup systems. In order to find the optimal hybrid system, HOMER software was used, which performs technical-economical-energy-environmental analyses on all 299376 available configurations. The use of a three-time electricity tariff, taking into account the incentive purchase price of renewable electricity, the use of updated equipment price data and the inflation rate, as well as the use of the new generation of wind turbines, are among the advantages of the present work compared to previous similar works. These advantages make the results of the present work more consistent with the existing reality. The important results of the present work are:

- The solar panel-based scenario is the most economical with a price of $0.111 per kWh and a total NPC of $54,303.
- In the best scenario, 3% of the total energy required is provided by solar energy and the amount of pollution caused by the use of the national electricity grid is about 55 tons/year.
- The lowest cost per kWh of electricity produced is $0.109, which corresponds to the solar panel-diesel generator scenario.
- The highest percentage of electricity production by renewable energies is 7%, which is seen in the solar panel-wind turbine scenarios.
- The use of solar panels in Shahrekord is superior to the use of wind turbines.

REFERENCES

1. Jahangiri, M., Khalili Geshnigani, M., Beigi Kheradmand, A. and Riahi, R., 2023. Meeting the Hospital Oxygen Demand with a Decentralized Autonomous PV System: Effect of PV Tracking Systems, *Iranian Journal of Science and Technology, Transactions of Electrical Engineering,* 47(2), pp. 601-615. Doi:10.1007/s40998-022-00564-8
2. Shahgholian, S., Taheri, M. and Jahangiri, M., 2023. Investigating the Cost-Effectiveness of Solar Electricity Compared to Grid Electricity in the Capitals of Middle Eastern Countries: A Residential Scale Case Study, *International Journal of Photoenergy,* 2023, pp. 8028307. Doi:10.1155/2023/8028307
3. Razmjoo, A., Ghazanfari, A., Jahangiri, M., Franklin, E., Denai, M., Marzband, M., Astiaso Garcia, D. and Maheri, A., 2022. A Comprehensive Study on the Expansion of Electric Vehicles in Europe, *Applied Sciences,* 12(22), pp. 11656. Doi:10.3390/app122211656
4. Chowdhury, T., Chowdhury, H., Hasan, S., Rahman, M. S., Bhuiya, M. and Chowdhury, P., 2021. Design of a stand-alone energy hybrid system for a makeshift health care center: A case study, *Journal of Building Engineering,* 40, pp. 102346. Doi:10.1016/j.jobe.2021.102346
5. Mostafaeipour, A., Qolipour, M., Rezaei, M., Jahangiri, M., Goli, A. and Sedaghat, A., 2021. A novel integrated approach for ranking solar energy location planning: a case study, *Journal of Engineering, Design and Technology,* 19(3), pp. 698-720. Doi:10.1108/JEDT-04-2020-0123
6. Riahi Zaniani, J., Taghipour Ghahfarokhi, S., Jahangiri, M. and Alidadi Shamsabadi, A., 2019. Design and optimization of heating, cooling and lightening systems for a residential villa at Saman city, Iran, *Journal of Engineering, Design and Technology,* 17(1), pp. 41-52. Doi:10.1108/JEDT-01-2018-0003
7. Sedaghat, A., Mostafaeipour, A., Rezaei, M., Jahangiri, M. and Mehrabi, A., 2020. A new semi-empirical wind turbine capacity factor for maximizing annual electricity and hydrogen production, *International Journal of Hydrogen Energy,* 45(32), pp. 15888-15903. Doi:10.1016/j.ijhydene.2020.04.028
8. Kalbasi, R., Jahangiri, M., Nariman, A. and Yari, M., 2019. Optimal design and parametric assessment of grid-connected solar power plants in Iran, a review, *Journal of Solar Energy Research,* 4(2), pp. 142-162. Doi:10.22059/jser.2019.282276.1114
9. Jahangiri, M., Mostafaeipour, A., Rahman Habib, H. U., Saghaei, H. and Waqar, A., 2021. Effect of emission penalty and annual interest rate on cogeneration of electricity, heat, and hydrogen in Karachi: 3E assessment and sensitivity analysis, *Journal of Engineering,* 2021, pp. 1-16. Doi:10.1155/2021/6679358
10. Mostafaeipour, A., Fakhrzad, M. B., Gharaat, S., Jahangiri, M., Dhanraj, J. A., Band, S. S., Issakhov, A. and Mosavi, A., 2020. Machine learning for prediction of energy in wheat production, *Agriculture,* 10(11), pp. 517. Doi:10.3390/agriculture10110517
11. Alizadeh, K., Jahangiri, M. and Bakhtdehkordi, M., 2021. Comprehensive 3E analysis and optimization of off-grid renewable-based microgrids to meet the clinic energy demand, a case study for medical tourism, *Energy Equipment and Systems,* 9(3), pp. 291-305. Doi:10.22059/ees.2021.246081
12. Alsagri, A. S., Alrobaian, A. A. and Nejlaoui, M., 2021. Techno-economic evaluation of an off-grid health clinic considering the

current and future energy challenges: a rural case study, *Renewable Energy,* 169, pp. 34-52. Doi:10.1016/j.renene.2021.01.017

13. Ghaderian, A., Jahangiri, M. and Saghaei, H., 2020. Emergency power supply for NICU of a hospital by solar-wind-based system, a step towards sustainable development, *Journal of Solar Energy Research,* 5(3), pp. 506-515. Doi:10.22059/jser.2020.306423.1166
14. Alotaibi, D. M., Akrami, M., Dibaj, M. and Javadi, A. A., 2019. Smart energy solution for an optimised sustainable hospital in the green city of NEOM, *Sustainable Energy Technologies and Assessments,* 35, pp. 32-40. Doi:10.1016/j.seta.2019.05.017
15. Çetinbaş, İ., Tamyurek, B. and Demirtaş, M., 2019. Design, analysis and optimization of a hybrid microgrid system using HOMER software: Eskisehir osmangazi university example, *International Journal of Renewable Energy Development (IJRED),* 8(1), pp. 65-79. Doi:10.14710/ijred.8.1.65-79
16. Tarekegn, Y. and Tesfaw, D., 2018. Design and Simulation of Uninterrupted power supply system of a Clinic With the help of stand by photo voltaic generator, *International Journal of Scientific Research Engineering & Technology* 7(4), pp. 293-301.
17. Chowdary, M. N., Nagar, M. K., Kumar, M., Kant, N., Paswan, M. and Kumar, S., 2018. Hybrid System Analysis with Renewable Energy and Thermal Energy for Health Clinic–A Case Study, *International Research Journal of Advanced Engineering and Science,* 3(2), pp. 303-308. Available at: https://irjaes.com/wpcontent/uploads/2020/10/IRJAESV3N2P954Y18.pdf
18. Isa, N. M., Tan, C. W. and Yatim, A., 2017.A techno-economic assessment of grid connected photovoltaic system for hospital building in Malaysia, IOP conference series: materials science and engineering: IOP Publishing, pp. 012016, Doi:10.1088/1757-899X/217/1/012016
19. Usman, R. and Gidado, A., 2017. Feasibility analysis of a grid connected PV/wind options for rural healthcare centre using homer, *European Journal of Engineering and Technology,* 5(3), pp. 12-20. Available at:: https://www.idpublications.org/ejet-vol-4-no-3-2016/
20. Iran wind map, 2021. Vortex. Available at: https://vortexfdc.com/knowledge/iran-wind-map (Accessed: 22 April 2021).
21. The World Bank, 2020. Solar resource maps of Iran, Photovoltaic electricity potential. Global Solar Atlas 2.0, Solar resource data: Solargis. Available at: https://solargis.com/maps-and-gis-data/download/iran (Accessed: 22 April 2021).
22. Ganjei, N., Zishan, F., Alayi, R., Samadi, H., Jahangiri, M., Kumar, R. and Mohammadian, A., 2022. Designing and sensitivity analysis of an off-grid hybrid wind-solar power plant with diesel generator and battery backup for the rural area in Iran, *Journal of Engineering,* 2022, pp. 4966761. Doi:10.1155/2022/4966761
23. Alayi, R., Seydnouri, S. R., Jahangeri, M. and Maarif, A., 2022. Optimization, sensitivity analysis, and techno-economic evaluation of a multi-source system for an urban community: a case study, *Renewable Energy Research and Applications,* 3(1), pp. 21-30. Doi:10.22044/rera.2021.10752.1054
24. Ye, B., Jiang, J. and Cang, Y., 2019. Technical and economic feasibility analysis of an energy and fresh water coupling model for an isolated island, *Energy Procedia,* 158, pp. 6373-6377. Doi:10.1016/j.egypro.2019.01.256
25. Abed, A. M., Lafta, H. A., Alayi, R., Tamim, H., Sharifpur, M., Khalilpoor, N. and Bagheri, B., 2022. Utilization of animal solid waste for electricity generation in the Northwest of Iran 3E analysis for one-year simulation, *International Journal of Chemical Engineering,* 2022, pp. 4228483. Doi:10.1155/2022/4228483
26. Renewable Energy and Energy Efficiency Organization (SATBA), Ministry of Energy, 2021. [In Persian] Available at: https://www.satba.gov.ir/fa/guidance/guidance/guidance1 (Accessed: 27 September 2021).
27. Jahangiri, M., Karimi Shahmarvandi, F. and Alayi, R., 2021. Renewable energy-based systems on a residential scale in southern coastal areas of Iran: trigeneration of heat, power, and hydrogen, *Journal of Renewable Energy and Environment,* 8(4), pp. 67-76. Doi:10.30501/jree.2021.261980.1170
28. Mostafaeipour, A., Sedaghat, A., Hedayatpour, M. and Jahangiri, M., 2020. Location planning for production of bioethanol fuel from agricultural residues in the south of Caspian Sea, *Environmental Development,* 33, pp. 100500. Doi:10.1016/j.envdev.2020.100500
29. Abdali, T., Pahlavan, S., Jahangiri, M., Alidadi Shamsabadi, A. and Sayadi, F., 2019. Techno-Econo-Environmental study on the use of domestic-scale wind turbines in Iran, *Energy Equipment and Systems,* 7(4), pp. 317-338. Doi:10.22059/ees.2019.37669
30. Teshnizi, E. A., Jahangiri, M., Shamsabadi, A. A., Pomares, L. M., Mostafaeipour, A. and Assad, M. E. H., 2021. Comprehensive Energy-Econo-Enviro (3E) Analysis of Grid-Connected Household Scale Wind Turbines in Qatar, *Jordan Journal of Mechanical & Industrial Engineering,* 15(2). Doi:10.22059/ees.2019.97897.1198
31. Jahangiri, M., Shamsabadi, A. A., Nematollahi, O. and Mostafaeipour, A., 2020. Enviro-economic investigation of a new generation of wind turbines, *International Journal of Strategic Energy & Environmental Planning,* 2(3), pp. 43-59.
32. Moein, M., Pahlavan, S., Jahangiri, M. and Alidadi Shamsabadi, A., 2018. Finding the minimum distance from the national electricity grid for the cost-effective use of diesel generator-based hybrid renewable systems in Iran, *Journal of Renewable Energy and Environment,* 5(1), pp. 8-22. Doi:10.30501/jree.2018.88377
33. Saghaei, H., Elyasi, P. and Shastri, B. J., 2022. Sinusoidal and rectangular Bragg grating filters: Design, fabrication, and comparative analysis, *Journal of Applied Physics,* 132(6).
34. Tang, A., Alsultany, F. H., Borisov, V., Mohebihafshejani, A., Goli, A., Mostafaeipour, A. and Riahi, R., 2022. Technical, environmental and ranking analysis of using solar heating: A case study in South Africa, *Sustainable Energy Technologies and Assessments,* 52, pp. 102299. Doi:10.1016/j.seta.2022.102299
35. Mostafaeipour, A., Rezaei, M., Jahangiri, M. and Qolipour, M., 2020. Feasibility analysis of a new tree-shaped wind turbine for urban application: A case study, *Energy & Environment,* 31(7), pp. 1230-1256. Doi:10.1177/0958305X19888878
36. Teimourian, A., Bahrami, A., Teimourian, H., Vala, M. and Oraj Huseyniklioglu, A., 2020. Assessment of wind energy potential in the southeastern province of Iran, *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects,* 42(3), pp. 329-343. Doi:10.1080/15567036.2019.1587079

Persian Abstract

چکیده

سیستم‌های حساس و مهم در بیمارستان‌ها، باید هنگام قطع برق شهر به کار خود ادامه دهند. در غیر این صورت مشکلات مالی و جانی به وجود می‌آید. با توجه به این موارد، ضرورت چاره‌اندیشی برای مواقع قطعی برق بیشتر از قبل مشخص می‌شود. به دلیل برخورداری از پتانسیل مطلوب انرژی‌های تجدیدپذیر در ایران، استفاده از انرژی‌های باد و خورشید به عنوان پشتیبان برق بیمارستان‌ها قابل توجیه است و از این طریق می‌توان در جهت اهداف توسعه پایدار نیز گام برداشت. در کار حاضر برای نخستین بار تامین بخشی از برق بیمارستان پارسیان شهرکرد با استفاده از نرم¬افزار هومر مورد بررسی قرار گرفته است. استفاده از داده¬های واقعی تبادل برق با شبکه برق سراسری و استفاده از نسل جدید توربین‌های بادی درختی شکل از مزیت¬های کار حاضر می‌باشند. نتیجه شبیه‌سازی‌ها نشان داد که اقتصادی‌ترین سیستم مبتنی بر انرژی تجدیدپذیر شامل دو پنل خورشیدی یک کیلوواتی و یک مبدل الکتریکی یک کیلوواتی می‌باشد که دارای هزینه ۰/۱۱۱ دلار بر کیلو وات ساعت می‌باشد. در بهینه‌ترین حالت ممکن، ۳٪ برق تولیدی یعنی ۲۹۹۹ کیلووات ساعت در سال توسط پنل‌های خورشیدی تولید می‌شود که دارای هزینه خالص کل ۵۴۳۰۳ دلار می‌باشد. در سناریو بهینه بدلیل استفاده از برق شبکه سراسری، سالانه ۵۵۱۹۳ کیلوگرم آلاینده دی‌اکسیدکربن تولید می‌شود.