



International Journal of Powertrains

ISSN online: 1742-4275 - ISSN print: 1742-4267

<https://www.inderscience.com/ijpt>

Performance evaluation of ant colony optimisation suggested energy management in using HOMER

Pothula Jagadeesh, Asapu Siva, Patil Mounica, Putchakayala Yanna Reddy, Guthikonda Tejaswi, M. Mohamed Thameem Ansari, Md. Azahar Ahmed

DOI: [10.1504/IJPT.2025.10069718](https://doi.org/10.1504/IJPT.2025.10069718)

Article History:

Received:	03 February 2022
Last revised:	22 December 2024
Accepted:	02 February 2025
Published online:	10 July 2025

Performance evaluation of ant colony optimisation suggested energy management in using HOMER

Pothula Jagadeesh*

Department of EEE,
SRKR Engineering College,
Bhimavaram, India
Email: jagadeesh.pothula@gmail.com

*Corresponding author

Asapu Siva

Department of EEE,
Shri Vishnu Engineering College for Women,
Bhimavaram, Andhra Pradesh, India
Email: asivaece@svecw.edu.in

Patil Mounica

Department of EEE,
Vardhaman College of Engineering,
Hyderabad, Telangana, India
Email: mounica.p@vardhaman.org

Putchakayala Yanna Reddy

Department of EEE,
Bharat Institute of Engineering and Technology,
Hyderabad, Telangana, India
Email: yannareddy.p@gmail.com

Guthikonda Tejaswi

Department of EEE,
Sri Vasavi Institute of Engineering and Technology,
Pedana, Andhra Pradesh, India
Email: tejathesinger@gmail.com

M. Mohamed Thameem Ansari

Department of Electrical Engineering,
Annamalai University,
Annamalai Nagar, India
Email: ansariauece@gmail.com

Md. Azahar Ahmed

Department of EEE,
SRKR Engineering College,
Bhimavaram, India
Email: azahar.ahmed786@gmail.com

Abstract: This paper addresses power management in Bhimavaram, India, an educational institution. The institution is known to be commercial load supplied from an 11 KV grid, the load deviations are primarily taken into account during the daytime simply due to the working hours of the institution. This optimisation is accompanied by a bidirectional power transfer from the grid to the institution and the institution to the grid. The optimal energy consumption is suggested for renewable power production for a solar plant with 125 kW generation for increasing the efficient utilisation of renewable energy along with reducing the electricity usage based on fossil fuel. Using an ant colony optimisation (ACO) algorithm, the above-mentioned optimal solution is suggested and that is further validated using HOMER Software. In HOMER Software the validation of the solution given by ant colony optimisation algorithm is completed by simulation.

Keywords: ant colony optimisation; ACO; solar power plant; HOMER Software; renewable energy; optimal power management.

Reference to this paper should be made as follows: Jagadeesh, P., Siva, A., Mounica, P., Reddy, P.Y., Tejaswi, G., Ansari, M.M.T. and Ahmed, M.A. (2025) 'Performance evaluation of ant colony optimisation suggested energy management in using HOMER', *Int. J. Powertrains*, Vol. 14, No. 1, pp.29–43.

Biographical notes: Pothula Jagadeesh received his Bachelor of Technology (Electrical and Electronics Engineering) in 2013 from JNTU Kakinada, Master's in Technology (Power Systems and Automation) in 2015 from Andhra University and PhD in Electrical and Electronics Engineering in 2023 from Annamalai University Faculty of Engineering and Technology, Annamalai Nagar, India. His area of specialisation is in power systems and research interest includes microgrids, optimal energy management, automatic generation control, power system dynamics and stability.

Asapu Siva received his BTech in Electrical and Electronics Engineering and subsequently obtained her MTech in Advanced Power Systems from Jawaharlal Nehru Technological University, Kakinada. He received his PhD in Faculty of Electrical Engineering from Sathyabama Institute of Science and Technology, Chennai. He is presently working as a Faculty in the Department of Electrical and Electronics Engineering, Shri Vishnu Engineering College for Women. He has nearly ten years of teaching experience and he published 18 Scopus indexed research articles and two WoS journals. His area of interest includes applications of power electronics in power systems, multilevel inverters, DC-DC converters, and control in renewable systems.

Patil Mounica received her BTech in Electrical and Electronic Engineering from JNTU Hyderabad and an MTech in Power Systems from NIT Calicut and PhD in Power Electronics from NIT Warangal, India, in 2012, 2015, and 2022, respectively. She is currently working as an Associate Professor with the Department of EEE, Vardhaman College of Engineering, Hyderabad, India.

She has published scientific articles in reputed journals and conferences; also has five patents to her name. Her current research interests include solar photovoltaics, IoT, AI, solar stills, smartgrid, and renewable energy systems.

Putchakayala Yanna Reddy is an Assistant Professor at Bharat Institute of Engineering and Technology. He holds a BTech and MTech in Electrical and Electronics Engineering from JNTU Hyderabad. He is pursuing a PhD at NIT Silchar. With 16+ years of teaching experience, he has published 14 papers and is interested in microgrid control, renewable energy, and soft computing. He is a member of ISTE, IAENG, and the Asia Society of Researchers.

Guthikonda Tejaswi completed his PhD from Annamalai University (2024) and Master of Technology from Jawaharlal Nehru Technological University in 2013. His research interests are in renewable energy sources, power electronics, and power systems.

M. Mohamed Thameem Ansari received his Bachelor of Engineering from Madurai Kamaraj University, Master of Engineering and PhD from Annamalai University. He is in the Department of Electrical Engineering, Annamalai University as a Faculty since 1992. His areas of interest are hybrid power systems, restructured power system, automatic generation control, power quality, micro grids and distributed generation, application of intelligent techniques to power system problems.

Md. Azahar Ahmed completed his PhD from Anna University (2022) and Master of Engineering from Andhra University in 2013. His research interest includes micro grid, DC-DC converters, renewable integration, and load frequency control.

1 Introduction

In recent years technological development along with population growth have led to increased consumption of energy, especially in the electricity sector. Furthermore, many remote as well as rural areas, especially in the developing nations, have no electricity access. For overcoming these issues, the production of electricity must be improved. Presently, fossil fuels are a major source of energy worldwide. However, because potential energy needs cannot exceed these services because of their environmental as well as economic issues. Renewable energy has provided important alternatives to fossil-fuel options. Since these utilities are used primarily to provide local prices, there are many challenges, for example high investment costs along with poor supply protection, because of their erratic and unpredictable existence. There have been some issues with the concept of hybrid renewable energy systems (HRESs). HRES is a fusion of solar energies, power and energy storage services such that the load is cross-linked locally and is autonomous. In standalone mode HRESs are utilised in rural as well as remote regions. In this way, because of the unspecified availability of renewable energies, conventional energy resources and energy storage could be utilised on them. Although such renewable resources' production is not sufficient to reach the load at times of low renewable resources output, the remainder of the load could be provided by the support systems. The additional generation can increase the energy storage size and thereby increase the amount of renewable energy that can be stored. Recognitions to the

HRESs: When operated in isolated mode, solar power systems are more stable than other types of renewable power systems. Although many of these institutions can still serve grid-associated functions, it is most common for them to be used in urban locations like cities, hospitals, universities, and factories. As grid electricity costs are low, in this mode the HRES (which stands for hybridising retail energy system) covers the load, as well as charges storages for renewable energy. HRES then flows through the load of money and trades additional energy to the market while the power grid costs are more.

Therefore, energy storages are dispatched to carry load to the grid for trading energy. Only renewable energy generating systems are better in HRES mode. Therefore, HRES introduces such characteristics including the penetration of renewable energies, reduced energy costs (CoEs), and reduced emissions of greenhouse gases and access to electricity for remote as well as rural residents. Such benefits include three comprehensive sustainable development (SD) standards which include economic, social as well as environmental issues. One of the key issues for HRES is the optimum preparation of its compound such as the number of wind turbines (WTs), converter capacity, generator, batteries, photovoltaic (PV) arrays so that key functions are maximised/minimised and any constraint is fulfilled. In this context, numerous software as well as optimisation methods are included in the literature. Among the documentation studied is an extremely valuable study on the benefits of and drawbacks of various operational and planning procedures for HRES. Different optimisation and modelling processes describe the HRESS component (Lambert et al., 2005). It has been established the literature aims to analyses and discuss design and control strategies for standalone HRES (Bernal-Aguistin and Dufo-López, 2009). To help with the optimisation of HRES designs, research on tools and technologies takes place (Erdinc and Uzunoglu, 2012). In Türkay and Telli (2011), different elements of the configuration of the HRESs include converter, battery, PV, and WT. In joint grid-linked modes along with in standalone modes (Hafez and Bhattacharya, 2012), numerous HRES researches are examined, containing planning requirements, optimisation processes, energy efficiency and various configurations.

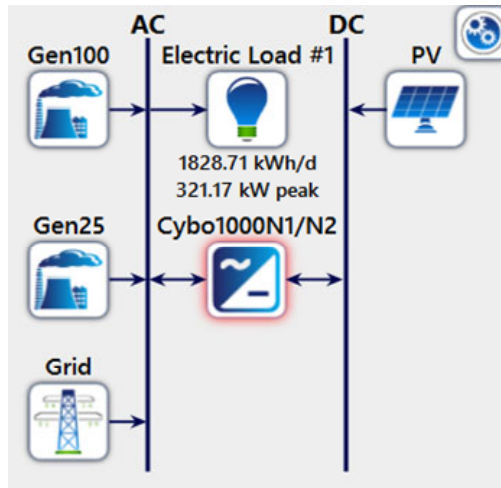
On this basis, the established mathematical model has settled through the ACO: ‘ant colony optimisation’ algorithm (Zhu et al., 2019). Lastly, the effectiveness of the suggested optimisation operation model is checked via simulation outcomes (Crespi et al., 2020; İnan and Baba, 2018). And the optimised solution suggested by the ACO algorithm is further validated utilising ‘Hybrid Optimization Model for Electric Renewables’ (HOMER) software (<http://www.nrel.gov/HOMER>). This HRES size optimisation software has been established by the National Renewable Energy Laboratory (NREL) in the USA, and it is the right HRES size optimisation the above mentioned optimal solution is suggested n software to use for equipment. The program from HOMER is included in many experiments, and that is briefly discussed in a few research articles (Rehman et al., 2012; Fathima and Palanisamy, 2015; Kaundinya et al., 2009; Mahesh and Sandhu, 2015; Khan and Iqbal, 2005; Nfah et al., 2008; Camblong et al., 2009; Alzola et al., 2009; Li et al., 2013; Ashourian et al., 2013; Dalton et al., 2009; Sharma et al., 2019; Costa and Villalva, 2020). Since so many papers have used HOMER to help improve the optimisation of HRESs, a paper which thoroughly analyses all those papers is essential. This study would help researchers in the use of HOMER in their fields for HRESs forecasting. It gives the details necessary to schedule HRES simulation through HOMER, like what frameworks are there for HRESs? How do they function independently or in grid modes? And the papers take care of these indeterminate parameters.

This paper is organised as follows: Section 2 provides a detailed description of system modelling. Optimisation model is covered in Section 3. Section 4 addresses HOMER software. Sensitivity analysis is addressed in Section 5. Simulation results are analysed in Section 6, and the paper concludes in Section 7.

2 System modelling

The following is a research scheme for an educational institution called SRKR Engineering College in South India. Figure 1 gives a block diagram for the system.

Figure 1 Schematic diagram of system (see online version for colours)



Grid supply, a two-way converter along with 125 kW diesel power supply units are involved. As seen in Figure 2, a 125kW power plant with a roof mounted solar power is installed.

Figure 2 Solar power plant installed (see online version for colours)



Table 1 represents the technical data utilised for sub-system in simulation.

Table 1 Technical data used in simulation for the sub-system

Component	Parameters
PV array	125 units of generic flat plate panel PV with 1 kW each, 15.44% efficiency
Bi-directional inverter	130 kW, 96% efficiency
Diesel generator set 1	100 kW, 28.01 L/hr
Diesel generator set 2	25 kW, 7.19 L/hr
Unit price at power grid	₹ 5.90/kWh
Institutional average load	1,828.7 kWh/day

2.1 Solar power plant

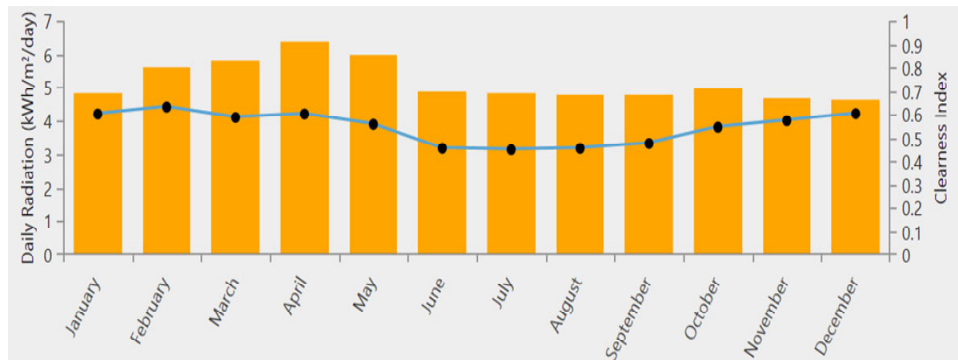
The solar power produced in equation (1) along with Solar Global Horizontal Irradiance (SGHI) data is seen monthly as Figure 3, so that data are derived from the NREL, USA.

$$P_{PV} = P_{PV,STC} f_{PV} \left(\frac{G}{G_{STC}} \right) [1 + \alpha_P (T_C - T_{C,STC})] \quad (1)$$

Here, energy output at STC (standard test situations) is represented by $P_{PV,STC}$,

- PV derating factor $r = f_{PV}$
- irradiance at $STC = G$
- coefficient of energy temperature $= \alpha_P$
- at STC PV module temperature $= T_C$
- G_{STC} : 1,000 W/m
- $T_{C,STC}$: 250.

Figure 3 Average monthly solar GHI data (see online version for colours)



PV array configuration units are designed by utilising further equation.

$$P_{PV,STC} = (N_S \times N_P) P_{m,STC} \quad (2)$$

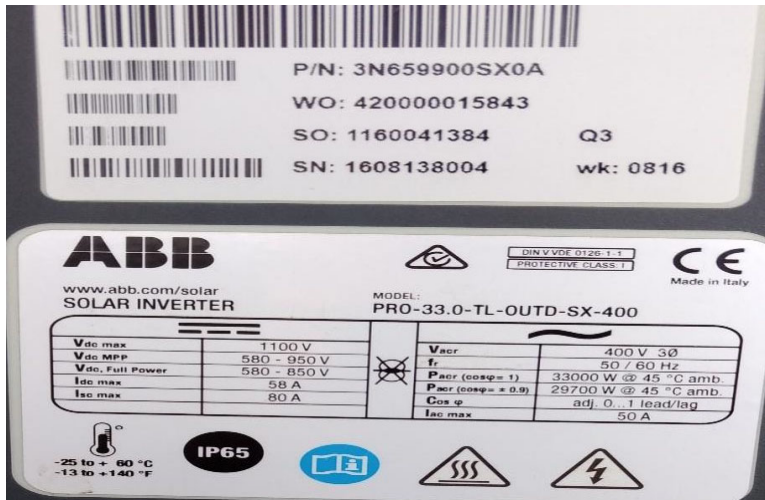
Here,

- PV module energy output = $P_{m,STC}$
- Number of series panels = N_S
- Number of parallel module strings = N_P .

2.2 Converter

The converter is coupled between AC bus as well as DC bus as given in Figure 1. Converter acts as an operating inverter which transmits energy through AC load and PV array. ABB Ltd.'s 3 inverter panels with a power of 33 kW are supplied with a 400 V operating voltage in the test configuration, as shown in Figure 4 is used.

Figure 4 Ratings of practical inverter installed (see online version for colours)



2.3 Load profile

In this paper, the electrical load profile of SRKR Engineering College is chosen for study and given in Figure 5. Figure 5 shows that, for the duration 9 to 18 hours of the day, the load requirement is high which is based on the overall aggregated load for 365 days of the year.

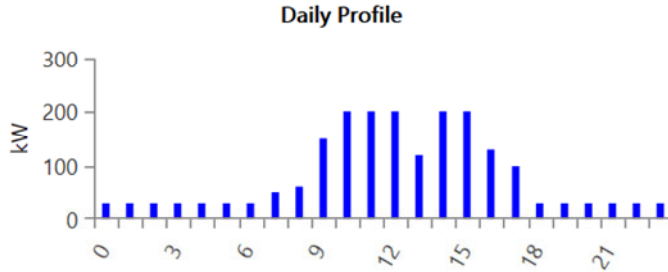
- Load description:

Scaled average energy consumption = 1,828.7 kWh/day

Average load = 76.2 kW

Peak load = 338.94 kW

Load factor = 0.22.

Figure 5 Average daily load profile for 365 days (see online version for colours)

3 Optimisation model

In the suggested optimisation model of educational system, the cost and benefit of trading between institution and power grid, and the power production cost of solar plant are taken as the objective functions. The optimisation model includes an equality constraint, a minimum objective function, and many inequality limitations. In the optimisation model, ACO is used to resolve the issue iteratively, and the present optimal search solution is continuously followed to obtain the global optimal value. The flow chart is demonstrated in Figure 6. In ACO, the updating of pheromones are as follows (Jagadeesh and Veeraj, 2016).

The objective of the modification of the pheromone is to raise the pheromone values for positive solutions and reduce those related to poor solutions. Generally, it is attained:

- 1 by reducing every pheromone value by evaporating the pheromone,
- 2 as well as growing the amounts of pheromones correlated with S_{upd} (selected good solutions set):

$$\tau_{ij} \leftarrow (1 - \rho) \cdot \tau_{ij} + \rho \cdot \sum_{s \in S_{upd} | c_{ij} \in s} F(s) \quad (3)$$

Here S_{upd} indicates the solutions set which is utilised for updating, $\rho \in (0, 1]$ indicates a parameter named evaporation rate, c_{ij} indicates finite set of available solution components along with $F: S \rightarrow R + 0$ represents a function:

$$f(s) < f(s') \Rightarrow F(s) \geq F(s'), \forall s \neq s' \in S \quad (4)$$

$F(\cdot)$ denotes generally known as the fitness function.

The pseudocode for single iteration of ant colony optimisation algorithm is:

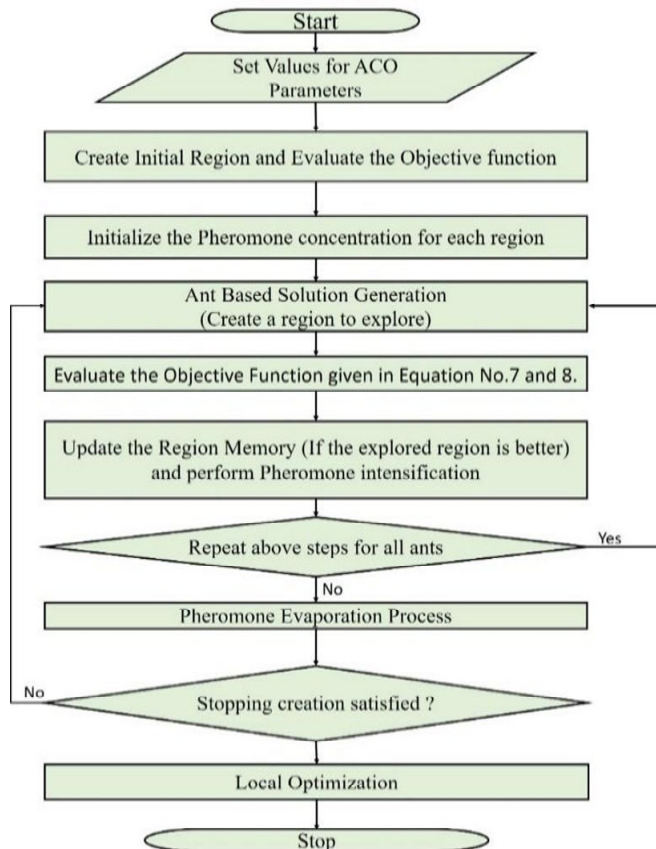
```

Procedure ants (input # of ants per colony, input # of colonies)
Derive parameters
Initialise pheromone and heuristic matrices
for (number of colonies)
Find best route of colony
Determine fitness of best solution
Update pheromone matrix

```

Update heuristic matrix
 End
 Calculate dispatch quantities
 End

Figure 6 Flowchart for ACO (see online version for colours)



4 HOMER Software

HOMER, a modern tool for optimised micro-electricity, makes it easier for a varying range of applications to test the configuration of off-grid networks for grid power system. The HOMER (<http://www.nrel.gov/HOMER>) designs micro energy systems which test various Non-Conventional generation technologies effectively and efficiently. The specification of the system by various constraints as well as sensitivities compares a variety of equipment. HOMER may have an important role in decision making and planning owing to the fact of the versatility of the scheme of rural electrification projects. The research concentrates on the technical characteristics of the system as well as cost of the life cycle. Initial expenses for capital, construction and operation costs of the

initiative shall be covered by LCC. It can perform as well as evaluate thousands of possible system configurations per hour with its high-speed computing. HOMER model simulations are also more accurate than the normal statistical models. HOMER also exhibits simulation results over economic advantages in several tables as well as maps for the evaluation and comparison of configurations.

5 Sensitivity analysis

The HOMER Software executes iterations for every selection including a hybrid energy system sensitivity variable. The sensitivity parameters taken from this research include cost of electrical power acquired from grid and fuel cost, diesel generator maintenance, as well as selling of power to the grid. A test device sensitivity study seen in Figure 1 is agreed with the following criteria of sensitivity as set out in Table 2 that are within e.g., $\pm 5\%$ change of a precise current value as the cost of power purchased from grid is ₹ 5.91/kWh, the fuel cost of the generator is ₹ 90/litre and the power selling through net metering is ₹ 4.5/kWh.

Table 2 Variable parameters for parameter sensitivity analysis

<i>S. no</i>	<i>Cost of power purchased from grid (₹ /kWh)</i>	<i>Cost of fuel price and maintenance of diesel generator (₹ /litre)</i>	<i>Cost of selling excess power (₹ /kWh)</i>	<i>Parameter variation</i>
1	5.51	86	4.1	-4%
2	5.61	87	4.2	-3%
3	5.71	88	4.3	-2%
4	5.81	89	4.4	-1%
5	5.91	90	4.5	Base value
6	6.01	91	4.6	+1%
7	6.11	92	4.7	+2%
8	6.21	93	4.8	+3%
9	6.31	94	4.9	+4%
10	6.41	95	5.0	+5%

6 Simulation results

By applying ACO algorithm for the above case study in MATLAB environment, after running number of iterations for different parameters considered from the grid requirements of the institution, we have obtained the optimal solution as shown in following Figure 7.

From Figure 7, we can observe the percentage of operational cost of the micro grid with different configurations and we can conclude the operational cost of PV plant lone is very less when compare to other configurations but in the night times the PV plant output is zero, so that we can take the combination of power grid and the PV plant because that is the second configuration with very less operational cost.

Figure 7 ACO suggested percentage of operational cost for one day (see online version for colours)

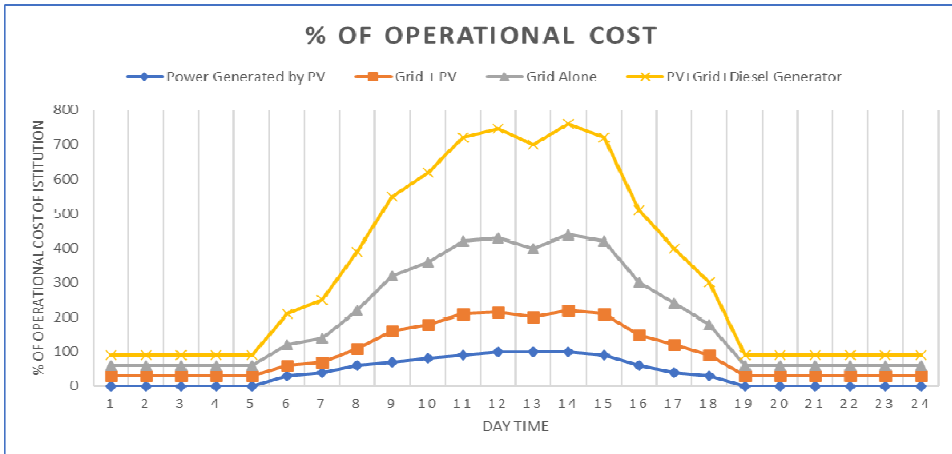
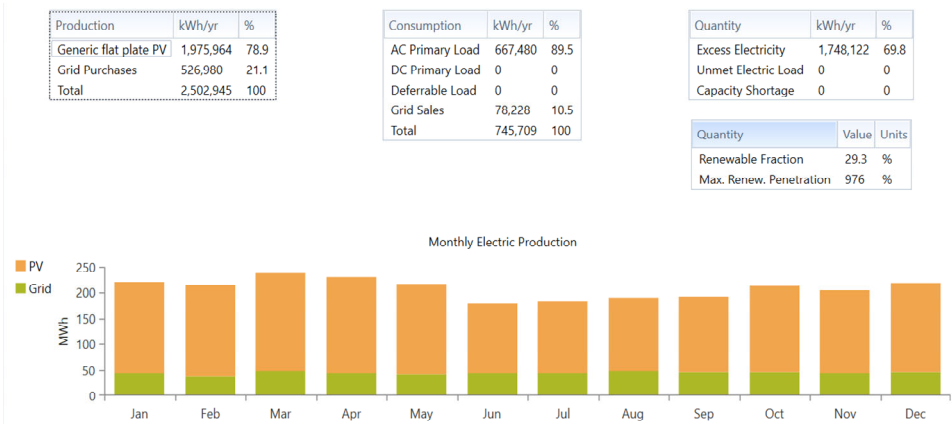


Figure 8 Monthly average energy production (see online version for colours)



In HOMER Software by simulating the above case study, the following results are obtained in real time by the institutions and finally the optimum energy management is proposed for the institution. Figure 8 shows that an entity with the power supply from the electric grid as well as the power produced by the installed solar plant is generated by an average monthly electricity consumption (Jagadeesh et al., 2021).

Figure 9 and Figure 10 demonstrates the power generated by installed 100 kW solar electricity power plant inside the institution with a goal of 365 days a year.

A bi-directional power converter in this model converts power from the distribution grid to institution as well as transmit excess power from institution to the power grid. The findings given in Figure 11 and Figure 12 are generated by the use of Homer tools. Figure 11 shows power purchased amount from the grid while Figure 12 demonstrates the total grid over put exchanged for one year. Results show that additional power can be sold only on the grids during the day, so that the whole institution depends on the electricity acquired by the grid in the night.

Figure 9 Solar plant generated power (see online version for colours)

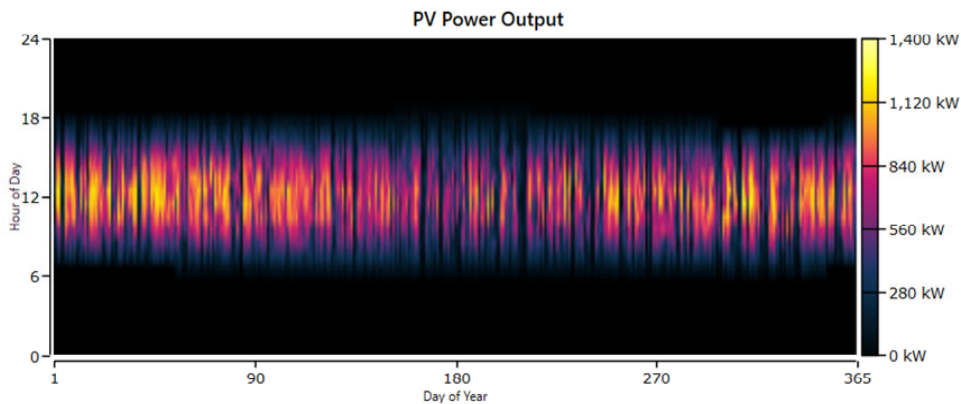


Figure 10 Renewable power share in load (see online version for colours)

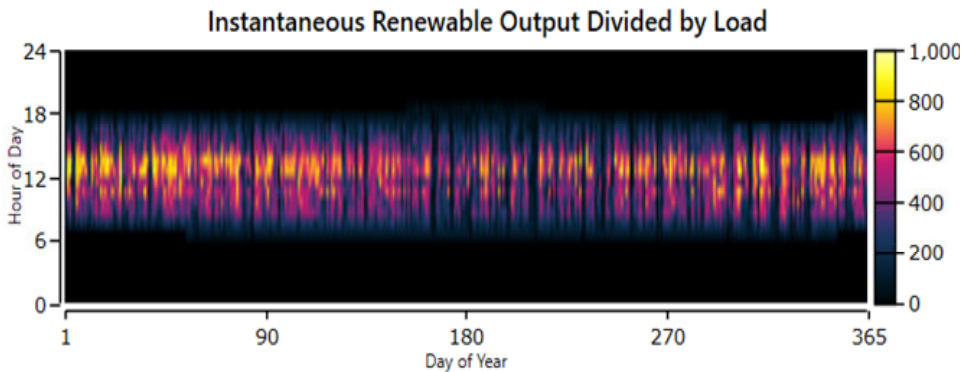


Figure 11 Purchased energy from the grid (see online version for colours)

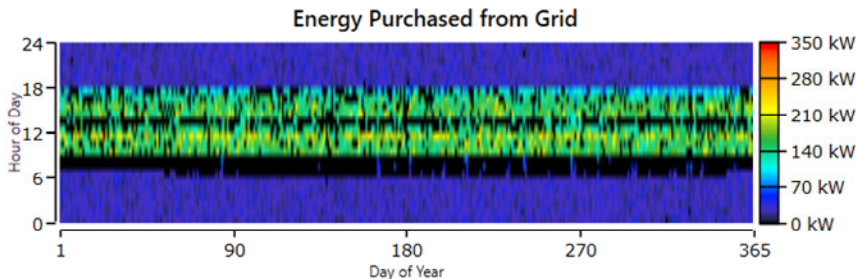
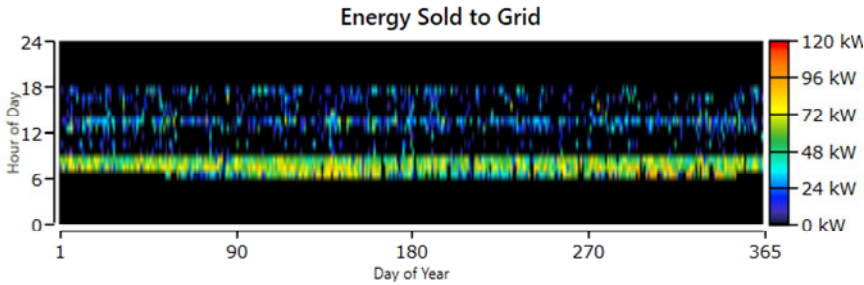


Figure 12 Traded excess energy to the grid using bi-directional converter (see online version for colours)



HOMER suggested optimal solution

The optimal solution, as seen in Figure 13, would be obtained when entire possible number of HREC has been simulated. The findings will be summarised in Table 3 for convenience.

Figure 13 Various HOMER scheduling cases (see online version for colours)

Architecture							Cost			
PV (kW)	Gen100 (kW)	Gen25 (kW)	Grid (kW)	Cybo1000N1/N2 (kW)	Dispatch		NPC (₹)	COE (₹)	Operating cost (₹/yr)	Initial capital (₹)
1,238			999,999	130	CC		₹16.8M	₹1.72	₹919,245	₹4.96M
1,238		25.0	999,999	130	CC		₹17.1M	₹1.74	₹919,019	₹5.21M
1,238	100		999,999	130	CC		₹17.5M	₹1.79	₹918,522	₹5.66M
1,238	100	25.0	999,999	130	CC		₹17.8M	₹1.81	₹918,296	₹5.91M

Table 3 Summary of ACO predicted and homer suggested results

Configuration	ACO predicted results		HOMER suggested results		
	Utilisation of power generation	Percentage of operational cost	COE (cost of energy) in ₹ /kWh	Running cost	Initial cost
PV + converter + grid	97%	112%	₹ 1.72	₹ 0.91M	₹ 4.96M
PV + converter + diesel generator+ grid	88%	700%	₹ 1.74	₹ 0.91M	₹ 5.21M
Grid alone	99%	400%	₹ 1.79	₹ 0.92M	₹ 0.00
Gird + diesel generator	91%	500%	₹ 1.81	₹ 0.91M	₹ 5.01M

From Table 3 based on the ACO algorithm predicted results we can clearly observe that whenever the solar plant and grid operated together the utilisation of total power generation is 97% with a percentage of operational cost of 112%, it is very economical with high utilisation of power generation when compare to remaining three configurations in Table 3. Along with the ACO predicted results we got HOMER suggested results based on the simulation this has been concluded that without operating diesel generator, grid as well as operating solar power plant which could be best energy

management for above taken institution. Moreover, it is found that the cost of the energy (₹/kWh) is marginally very low when compared to remaining three configurations, which allows extra revenues and the elimination of greenhouse gas in the atmosphere by trading the extra excess electricity.

7 Conclusions

This study aimed to optimise energy management for an educational institution in South India using ACO and HOMER Software. The results show that ACO-suggested energy scheduling provides optimal energy management, ensuring economic and efficient load satisfaction. The proposed hybrid system, comprising a 125 kW renewable energy source and diesel generator, offers an optimal energy distribution scheme. This study contributes to the development of efficient energy management systems for hybrid renewable energy applications.

Acknowledgements

The authors are grateful for the facilities provided by authorities of SRKR Engineering College for completing this research.

The authors are thankful to authorities of DST for providing HOMER Software to Centre for Renewable Energy under PURSE II Program to Annamalai University Faculty of Engineering and Technology.

References

- Alzola, J.A., Vechiu, I., Camblong, H., Santos, M., Sall, M. and Sow, G. (2009) 'Microgrids project, part 2: design of an electrification kit with high content of renewable energy sources in Senegal', *Renew. Energy*, October, Vol. 34, pp.2151–219.
- Ashourian, M.H., Cherati, S.M., MohdZin, A.A., Niknam, N., Mokhtar, A.S. and Anwari, M. (2013) 'Optimal green energy management for island resorts in Malaysia', *Renew. Energy*, March, Vol. 51, pp.36–45.
- Bernal-Agustín, J.L. and Dufo-López, R. (2009) 'Simulation and optimization of stand-alone hybrid renewable energy systems', *Renew. Sustain. Energy Rev.*, October, Vol. 13, pp.2111–2118.
- Camblong, H., Sarr, J., Niang, A.T., Curea, O., Alzola, J.A., Sylla, E.H. et al. (2009) 'Micro-grids project, part1: analysis of rural electrification with high content of renewable energy sources in Senegal', *Renew. Energy*, October, Vol. 34, pp.2141–2150.
- Costa, T.S. and Villalva, M.G. (2020) 'Technical evaluation of a PV-diesel hybrid system with energy storage: case study in the Tapajós-Arapiuns extractive reserve, Amazon, Brazil', *Energies*, Vol. 13, No. 11, p.2969.
- Crespi, C., Scollo, R.A. and Pavone, M. (2020) 'Effects of different dynamics in an ant colony optimization algorithm', *7th International Conference on Soft Computing & Machine Intelligence (ISCMI)*, pp.8–11, DOI: 10.1109/ISCMI51676.2020.9311553.
- Dalton, G.J., Lockington, D.A. and Baldock, T.E. (2009) 'Feasibility analysis of renewable energy supply options for a grid-connected large hotel', *Renew. Energy*, April, Vol. 34, pp.955–964.

- Erdinc, O. and Uzunoglu, M. (2012) 'Optimum design of hybrid renewable energy systems: overview of different approaches', *Renew. Sustain. Energy Rev.*, April, Vol. 16, pp.1412–1425.
- Fathima, A.H. and Palanisamy, K. (2015) 'Optimization in microgrids with hybrid energy systems – a review', *Renew. Sustain. Energy Rev.*, May, Vol. 45, pp.431–46.
- Hafez, O. and Bhattacharya, K. (2012) 'Optimal planning and design of a renewable energy-based supply system for microgrids', *Renew. Energy*, September, Vol. 45, pp.7–15.
- İnan, T. and Baba, A.F. (2018) 'Examining the performance of ant colony optimization on shortest path problem: (Aegean sea example)', *2018 Electric Electronics, Computer Science, Biomedical Engineerings' Meeting (EBBT)*, pp.1–5, DOI: 10.1109/EBBT.2018.8391445.
- Jagadeesh, P. and Veeraj, M.S. (2016) 'Particle swarm optimization based power system stabilizer for SMIB system', *International Conference on Emerging Trends in Engineering, Technology and Science (ICETETS)*, pp.1–6, DOI: 10.1109/ICETETS.2016.7603084.
- Jagadeesh, P., Ansari, M.M.T. and Saiveeraj, M. (2021) 'Optimal power management of an educational institution using HOMER', *Journal of Electrical Engineering and Technology*, <https://doi.org/10.1007/s42835-021-00713-9>.
- Kaundinya, D.P., Balachandra, P. and Ravindranath, N.H. (2009) 'Grid-connected versus stand-alone energy systems for decentralized power – a review of literature', *Renew. Sustain. Energy Rev.*, October, Vol. 13, pp.2041–2050.
- Khan, M.J. and Iqbal, M.T. (2005) 'Pre-feasibility study of stand-alone hybrid energy systems for applications in new found land', *Renew. Energy*, May, Vol. 30, pp.835–854.
- Lambert, T., Gilman, P. and Lilienthal, P. (2005) *Micro Power System Modeling with HOMER. Integration of Alternative Sources of Energy*, December, pp.379–418, John Wiley & Sons, Inc.
- Li, C., Ge, X., Zheng, Y., Xu, C., Ren, Y., Song, C. et al. (2013) 'Techno-economic feasibility study of autonomous hybrid wind/PV/battery power system for a household in Urumqi, China', *Energy*, June, Vol. 55, pp.263–272.
- Mahesh, A. and Sandhu, K.S. (2015) 'Hybrid wind/ photovoltaic energy system developments: critical review and findings', *Renew. Sustain. Energy Rev.*, December, Vol. 52, pp.1135–1147.
- Nfah, E.M., Ngundam, J.M., Vandenbergh, M. and Schmid, J. (2008) 'Simulation of off-grid generation options for remote villages in Cameroon', *Renew. Energy*, May, Vol. 33, pp.1064–1072.
- Rehman, S., Mahbub Alam, M., Meyer, J.P. and Al-Hadhrani, L.M. (2012) 'Feasibility study of a wind-PV-diesel hybrid power system for a village', *Renew. Energy*, February, Vol. 38, pp.258–68.
- Sharma, Y., Saxena, B.K. and Mishra, S. (2019) 'Techno-economic analysis of rooftop solar PV system by variation in PV module capacity', *2nd International Conference on Power and Embedded Drive Control (ICPEDC)*, IEEE.
- Türkay, B.E. and Telli, A.Y. (2011) 'Economic analysis of standalone and grid connected hybrid energy systems', *Renew. Energy*, July, Vol. 36, pp.1931–1943.
- Zhu, H., You, X. and Liu, S. (2019) 'Multiple ant colony optimization based on Pearson correlation coefficient', *IEEE Access*, Vol. 7, pp.61628–61638, doi: 10.1109/ACCESS.2019.2915673.

Websites

<http://www.nrel.gov/HOMER>.