

A Comparative Analysis of Virtual Community Energy Storages in The India Compared to Individual Batteries Based on Behavior Based Synthetic Load Profiles Using COPRAS Method

*Nathiya Murali, Sathiyaraj Chinnasamy, M. Ramachandran, Libiya Saravanan

REST Labs, Kaveripattinam, Krishnagiri, Tamil Nadu, India

*Corresponding Author Email: nathiyamurali6775@gmail.com

Abstract.: Community-driven energy initiatives have gained prominence as a strategy to tackle energy-related issues and promote sustainable development while engaging local communities. This study employs the COPRAS (COmplex Proportional ASsessment) technique to assess the feasibility of community-based energy options in seven Indian states: Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh. The assessment focuses on six key factors: Economic advantages, Education and acceptance, Climate protection and sustainability, Community cohesion and self-empowerment, Renewable Energy (RE) generation targets, and Innovation. The results emphasize the diverse benefits of community-led energy projects across these states. In conclusion, the COPRAS-based evaluation highlights the manifold advantages of community energy projects in Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh. This research offers valuable insights for policymakers, stakeholders, and local communities, showcasing how community-based energy approaches can effectively address energy challenges while fostering economic growth, environmental sustainability, and community empowerment. Notably, Arunachal Pradesh ranks highest in community energy benefits, while Karnataka ranks lowest. These findings encourage further exploration and investment in community energy endeavors, offering a promising path towards a resilient and sustainable energy future.

keywords: Virtual social storage, personal batteries, India, artificial load profiles, behavior, energy management, COPRAS, comparative analysis, optimization, literature review

1. INTRODUCTION

Community Energy is frequently associated with the idea of decentralized, sustainable energy production. Whether it involves harnessing solar energy, wind power, or combined heat and power (CHP) systems, these methods of generating energy share a common trait: scalability. Local communities can establish these energy sources, rather than relying solely on large energy corporations. Governments often back these renewable energy projects to achieve environmental goals and ensure energy stability. Support programs in many countries play a pivotal role in determining the economic viability of community energy projects and contribute to the divergent approaches to Community Energy on a national level. While Community Energy has gained considerable traction recently, there exist obstacles that impede its further expansion. Eliminating these barriers could lead to additional societal advantages. While certain articles concentrate on specific contextual factors that influence Community Energy progress, this review presents a systematic summary that compares different regions. Bromley's differentiation highlights various avenues through which community advantages could emerge, as well as the intricate concept of 'social approval.' When benefits are acknowledged in return for development permissions within a framework of genuine freedom to reject a proposal or request alterations, it becomes conceivable for specific community members to negotiate benefits that wouldn't leave them feeling worse off overall. Within these arrangements, the community benefits themselves can contribute to fostering societal acceptability. This diverges from retrospectively providing community benefits based on a liability rule, which functions as compensation for developmental costs. In this scenario, the acceptability of the situation isn't based on a priori acceptability to the affected community, and it doesn't necessarily imply that the benefits will invariably prevent affected social groups from feeling worse off. A summary of ongoing studies related to community energy storage is provided. The analysis reveals a surge in activities within this domain over the past ten years. Furthermore, the review

demonstrates that strategically positioned energy storage units can lead to a reduction in the peak loads experienced by secondary substations under certain circumstances. This alleviation of stress on the power grid has the potential to curtail the need for extensive grid reinforcement, thereby leading to cost savings. Additionally, end consumers can achieve cost savings on their electricity bills through strategies such as demand shifting and leveraging tariff optimization. However, the extent of these advantages hinges on factors such as the specific control algorithms employed, the layout of the grid, and the size of the storage units. A key hurdle involves adapting the existing legal framework to accommodate viable business models in this field. This article aims to examine whether specific circumstances exist in which offering community benefits can increase local approval for wind energy projects, particularly when discussions about bribery are prominent. The study focuses on two factors: the formal inclusion of community benefits as a policy requirement and how developers communicate their intentions regarding these benefits (such as admitting or denying that they are provided for commercial gain). The goal is to determine if these measures can counteract the perception of community benefits as bribes, thereby maintaining local support for an offshore wind farm. By pursuing this objective, the research contributes valuable insights into the optimal design and communication of community benefits and compensatory payments often associated with locally unpopular energy facilities. The wind power sector has been a pioneer in advancing the concept of Community Benefits Agreements in India. A report from 2007 highlighted various reasons for implementing these benefits, including fostering positive relationships with the local community, compensating for disruptions to the environment and daily life caused by construction activities, and distributing the advantages of wind energy as a shared resource that belongs to everyone. The report also pointed out that unlike housing projects, wind energy projects tend to offer fewer direct benefits to the immediate area where they are situated. More current guidelines for optimal practices in English wind farms emphasize that community benefits play a crucial role in distributing the value that wind energy can bring to the local community. Looking specifically at Welsh wind farms and energy policies, Cowell et al. (2011) underscore a significant motivation related to responsibility, suggesting that providing reparations or benefits to affected communities is essential for developments justified on a broader public interest basis. A previous instance of a Community Benefits Agreement in a different energy sector pertained to the construction of the Sizewell B nuclear power station, which was completed in 1995 and remains the most recent addition to the UK's nuclear new build projects.

2. MATERIALS AND METHOD

Materials: In the Indian states of Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh, the adoption of community energy solutions has gained momentum as an alternative to conventional fossil fuel-based energy sources. These states have recognized the importance of transitioning to cleaner and more sustainable energy options to address environmental concerns, energy security, and economic development. Here's how each of these states has utilized community energy alternatives. The success of community energy is measured through several key evaluation parameters, including economic benefits, education and acceptance, climate protection and sustainability, community building and self-realization, renewable energy generation targets, and innovation of evaluation parameters.

Tamil Nadu: Known for its favorable wind energy potential, Tamil Nadu has been a pioneer in community-based wind energy projects. Local communities come together to install and manage wind turbines, allowing them to generate electricity for local consumption and contribute to the state's renewable energy targets.

Kerala: With its abundance of rivers and water bodies, Kerala has explored community hydroelectric projects. Small-scale hydropower initiatives involving local communities contribute to decentralizing energy production and reducing carbon emissions.

Punjab: Punjab's agricultural landscape has led to the adoption of community-based biomass projects. Farmers and rural communities collaborate to produce bioenergy from agricultural waste, promoting sustainable waste management and rural development.

Karnataka: Solar energy initiatives have gained momentum in Karnataka, with communities setting up solar panels on rooftops, public buildings, and unused lands. These projects enhance energy self-sufficiency and support the state's commitment to renewable energy.

Haryana: In Haryana, community energy efforts revolve around biogas production from organic waste, particularly in rural areas. This approach helps manage waste, reduce pollution, and provide renewable energy options for local communities.

Andhra Pradesh: Community energy projects here encompass a mix of solar, wind, and biomass initiatives. Local communities collaborate with government agencies and private partners to establish and manage these projects, leading to improved energy access and socio-economic development.

Arunachal Pradesh: This northeastern state's rich hydropower potential has encouraged community-based micro and mini hydropower projects. These projects empower remote communities by providing reliable electricity for their needs and supporting local livelihoods.

Economic Benefits: One of the primary drivers behind the adoption of community energy is its potential for generating economic gains. By engaging local communities in energy production, states can reduce reliance on expensive fossil fuels, lower energy costs, and create new avenues for employment and income generation. This bolsters local economies and ensures more equitable distribution of energy-related benefits.

Education and Acceptance: Community energy projects provide educational opportunities that promote awareness and understanding of renewable energy technologies. Through participation in planning, implementation, and management, communities gain insights into clean energy solutions, fostering a sense of ownership and pride. This increased knowledge and acceptance contribute to the long-term success of such initiatives.

Climate Protection and Sustainability: Community energy plays a vital role in mitigating climate change by reducing greenhouse gas emissions. By shifting away from carbon-intensive energy sources, states can achieve their climate targets and contribute to global sustainability efforts. Moreover, these projects often prioritize environmentally sensitive practices, such as utilizing local resources and minimizing ecological impact.

Community Building and Self-Realization: Community energy projects empower local residents to actively engage in decision-making processes, enhancing a sense of community ownership and cohesion. As communities collaborate on clean energy initiatives, social ties strengthen, fostering a deeper connection among residents. This process contributes to a heightened sense of self-realization and collective well-being.

Renewable Energy Generation Targets: Community energy projects align with state and national renewable energy generation targets. By tapping into local resources and expertise, states can accelerate the transition to a clean energy future while diversifying their energy mix and enhancing energy security.

Innovation: Community energy encourages innovative solutions tailored to specific regional needs and challenges. Local communities often develop creative approaches to energy generation, distribution, and consumption, fostering a culture of continuous improvement and adaptability.

Method: Zavadskas and Kaklauskas introduced the COPRAS technique in 1996, marking its initial inception. This method commonly serves as a secondary tool within Multi-Criteria Decision Making (MCDM) challenges. This is primarily due to the prerequisite of employing another MCDM approach, such as AHP (Analytic Hierarchy Process), ANP, or SWARA (Step-wise Weight Assessment Ratio Analysis), to establish the criteria weights initially. The distinctive advantage of this approach over alternative MCDM methods lies in its reliance on significance, along with its assumption of the direct and utility-based relationship between the assessed alternatives and the criteria. This dependence is proportionally elucidated through a set of criteria, encompassing both weights and criterion values. Over recent years, researchers have consistently turned to this method for their studies. This approach is highly uncomplicated and easily comprehensible. Numerous studies have concentrated on employing the conventional COPRAS technique. The inherent uncertainty surrounding attribute values and their significance has prompted researchers to enhance the COPRAS methodology within this context. Fouladgar et al. (2012) introduced a novel hybrid model for appraising operational strategies by integrating ANP and fuzzy COPRAS. Peng and Dai (2017) devised MABAC (Multi-Attributive Border Approximation Area Comparison), WASPAS (Weighted Aggregated Sum Product Assessment), and Complex Proportional Assessment (COPRAS) to address hesitant fuzzy soft decision-making issues. The COPRAS technique's extensive utility across diverse decision-making domains in recent times is attributed to these merits. The complex proportional assessment (COPRAS) technique for preference ranking, primarily developed by Zavadskas et al., assumes direct and proportional relationships between the importance and usefulness of available options, even when conflicting criteria are present. It evaluates alternatives based on their performance across multiple criteria and their corresponding weights. COPRAS employs a decision-making approach that considers both ideal and ideal-worst solutions. In the context of evaluating and selecting alternative materials for engineering challenges, COPRAS follows a systematic ranking and assessment process to determine the significance and utility of each option. This methodology has been effectively employed in solving diverse problems within fields like construction, property management, and economics. The COPRAS technique is applicable in multi-criteria decision-making situations, involving both the maximization and minimization of criteria values. This method distinguishes between two types of criteria: those associated with benefits and those linked to costs, treating them individually. Consequently, the rankings of alternatives obtained through the COPRAS approach may exhibit variations in comparison to alternative methods, thus enhancing precision in the assessment and confirmation of computation outcomes [11]. The computation process utilizing the COPRAS methodology involves the following sequential steps.

3. RESULT AND DISCUSSION

TABLE 1. Community Energy

	Economic benefits	Education and acceptance	Climate protection and sustainability	Community building and self-realization	RE generation targets	Innovation
Tamil Nadu	44.91	37.901	47.28	38.1714	42.5435	41.462
Kerala	43.371	32.408	33.97	28.4027	27.5109	43.517
Punjab	37.55	34.941	28.05	31.4699	35.8695	49.433
Karnataka	34.785	27.564	31.66	46.6227	40.3594	43.091
Haryana	51.487	41.633	29.23	42.2249	42.4685	26.829
Andhra Pradesh	31.803	40.052	28.14	49.9753	29.0181	32.731
Arunachal Pradesh	47.352	39.834	35.9	40.9401	28.697	38.4

Table 1 Shows the Community energy benefits of using COPRAS method. The alternatives are Tamilnadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh and Arunachal Pradesh. The Economic benefits, Education and acceptance, Climate protection and sustainability, Community building and self-realization, RE generation targets and Innovation are used this evaluation parameter.

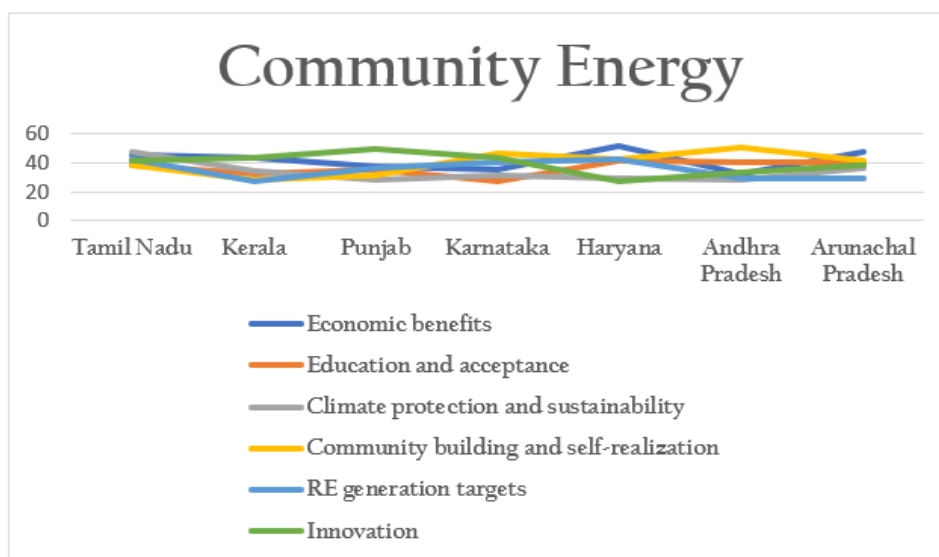


FIGURE 1. Community Energy

Figure 1 Shows the Community energy benefits of using COPRAS method. The alternatives are Tamilnadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh and Arunachal Pradesh. The Economic benefits, Education and acceptance, Climate protection and sustainability, Community building and self-realization, RE generation targets and Innovation are used this evaluation parameter.

TABLE 2. Normalized Data

	Normalized Data					
Tamil Nadu	0.1542	0.1490	0.2019	0.1374	0.1726	0.1505
Kerala	0.1489	0.1274	0.1450	0.1022	0.1116	0.1580
Punjab	0.1289	0.1374	0.1198	0.1133	0.1455	0.1795
Karnataka	0.1194	0.1084	0.1352	0.1678	0.1638	0.1564
Haryana	0.1768	0.1637	0.1248	0.1520	0.1723	0.0974
Andhra Pradesh	0.1092	0.1575	0.1201	0.1799	0.1177	0.1188
Arunachal Pradesh	0.1626	0.1566	0.1533	0.1474	0.1164	0.1394

Table 2 Shows the Normalized data matrix for the alternatives are Tamilnadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh and Arunachal Pradesh. The Economic benefits, Education and acceptance, Climate protection and sustainability, Community building and self-realization, RE generation targets and Innovation.

TABLE 3. Weight

	Weight					
Tamil Nadu	0.25	0.25	0.25	0.25	0.25	0.25
Kerala	0.25	0.25	0.25	0.25	0.25	0.25
Punjab	0.25	0.25	0.25	0.25	0.25	0.25
Karnataka	0.25	0.25	0.25	0.25	0.25	0.25
Haryana	0.25	0.25	0.25	0.25	0.25	0.25
Andhra Pradesh	0.25	0.25	0.25	0.25	0.25	0.25
Arunachal Pradesh	0.25	0.25	0.25	0.25	0.25	0.25

Table 3 Equal weighting: Each weight is 0.25, meaning that all six indicators receive equal importance regardless of the composite index or rating framework used. This implies that no single criterion is given priority over the others. The democratic approach of equal distribution (0.25 × 6 columns would not equal 1.0 per state, so these are likely normalized weights) reflects an unbiased method where each dimension contributes equally to the final assessment. State balance: Seven states representing diverse geographical and economic profiles, from the southern states (Tamil Nadu, Kerala, Karnataka, Andhra Pradesh) to the north (Punjab, Haryana) and the northeastern regions (Arunachal Pradesh), are considered equally, indicating that the weighting framework is standardized rather than context-specific. Implications: This uniform approach ensures objectivity and comparability across states, but may overlook regional variations.

TABLE 4. Weighted normalized decision matrix

	Weighted normalized decision matrix					
Tamil Nadu	0.04	0.04	0.05	0.03	0.04	0.04
Kerala	0.04	0.03	0.04	0.03	0.03	0.04
Punjab	0.03	0.03	0.03	0.03	0.04	0.04
Karnataka	0.03	0.03	0.03	0.04	0.04	0.04
Haryana	0.04	0.04	0.03	0.04	0.04	0.02
Andhra Pradesh	0.03	0.04	0.03	0.04	0.03	0.03
Arunachal Pradesh	0.04	0.04	0.04	0.04	0.03	0.03

table 4 Shows the Weighted normalized decision matrix for the alternatives are Tamilnadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh and Arunachal Pradesh. The Economic benefits, Education and acceptance, Climate protection and sustainability, Community building and self-realization, RE generation targets and Innovation.

TABLE 5. Bi, Ci, Min (Ci)/Ci and Qi

	Bi	Ci	Min (Ci)/Ci	Qi
Tamil Nadu	0.126	0.115	0.8074	0.225
Kerala	0.105	0.093	1.0000	0.228
Punjab	0.097	0.110	0.8484	0.201
Karnataka	0.091	0.122	0.7619	0.184
Haryana	0.116	0.105	0.8818	0.224
Andhra Pradesh	0.097	0.104	0.8929	0.206
Arunachal Pradesh	0.118	0.101	0.9222	0.231

Table 5 presents a comparative analysis of community energy for different states, namely Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh. The table provides insights into the values of four specific metrics: Bi, Ci, Min (Ci)/Ci, and Qi. This represents a certain measure or index associated with each state. For instance, Tamil Nadu has a Bi value of 0.126, Kerala has 0.105, Punjab has 0.097, Karnataka has 0.091, Haryana has 0.116, Andhra Pradesh has 0.097, and Arunachal Pradesh has 0.118. This is another index or value assigned to each state. The Ci values for the respective states are Tamil Nadu (0.115), Kerala (0.093), Punjab (0.110), Karnataka (0.122), Haryana (0.105), Andhra Pradesh (0.104), and Arunachal Pradesh (0.101). This metric represents the minimum value of Min (Ci)/Ci for each state divided by the Ci value itself. It indicates a relative proportion of the minimum Ci value to the Ci value. The values in this column are: 0.8074 for Tamil Nadu, 1.0000 for Kerala, 0.8484 for Punjab, 0.7619 for Karnataka, 0.8818 for Haryana, 0.8929 for Andhra Pradesh, and 0.9222 for Arunachal Pradesh. This parameter signifies a certain characteristic or quality associated with each state. The Qi values are: 0.225 for Tamil Nadu, 0.228 for Kerala, 0.201 for Punjab, 0.184 for Karnataka, 0.224 for Haryana, 0.206 for Andhra Pradesh, and 0.231 for Arunachal Pradesh.

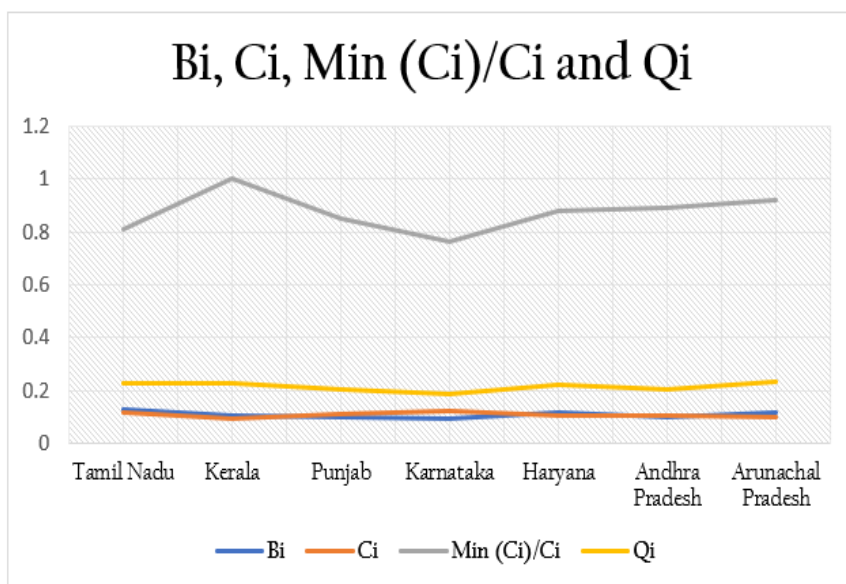


FIGURE 2. Bi, Ci, Min (Ci)/Ci and Qi

Figure 2 presents a comparative analysis of community energy for different states, namely Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh. The table provides insights into the values of four specific metrics: Bi, Ci, Min (Ci)/Ci, and Qi.

TABLE 6. Ui and Rank

	Ui	Rank
Tamil Nadu	97.4364	3
Kerala	98.6035	2
Punjab	86.7459	6
Karnataka	79.6611	7
Haryana	97.0760	4
Andhra Pradesh	89.1832	5
Arunachal Pradesh	100.0000	1

Table 6 show the we present a ranking of different states in India based on their Community Energy performance. Community Energy refers to the collective efforts and initiatives undertaken by a community or region to generate, distribute, and manage energy resources in a sustainable and inclusive manner. This ranking is determined using the Ui (Utility Index) values assigned to each state, along with their corresponding ranks. Arunachal Pradesh stands out as the top-ranking state in terms of Community Energy with a Ui value of 100.0000. This indicates that the state has achieved the highest level of performance and efficiency in its community energy initiatives. Kerala holds the second position in the ranking, boasting a Ui value of 98.6035. The state has demonstrated significant progress in fostering community-led energy projects and practices. Tamil Nadu secures the third rank with a Ui value of 97.4364. The state's commendable efforts in promoting community-based energy solutions have contributed to its high ranking. With a Ui value of 97.0760, Haryana occupies the fourth spot in the ranking. The state has made substantial strides in developing community-centric energy programs. Andhra Pradesh takes the fifth position, achieving a Ui value of 89.1832. The state's commitment to community energy initiatives has led to its notable ranking in this context. Punjab ranks sixth, having a Ui value of 86.7459. The state's initiatives towards community energy solutions have placed it within the top tier of performers. Finally, Karnataka rounds up the ranking in the seventh position with a Ui value of 79.6611. While the state demonstrates efforts in community energy, there is room for further improvement to reach higher ranks.

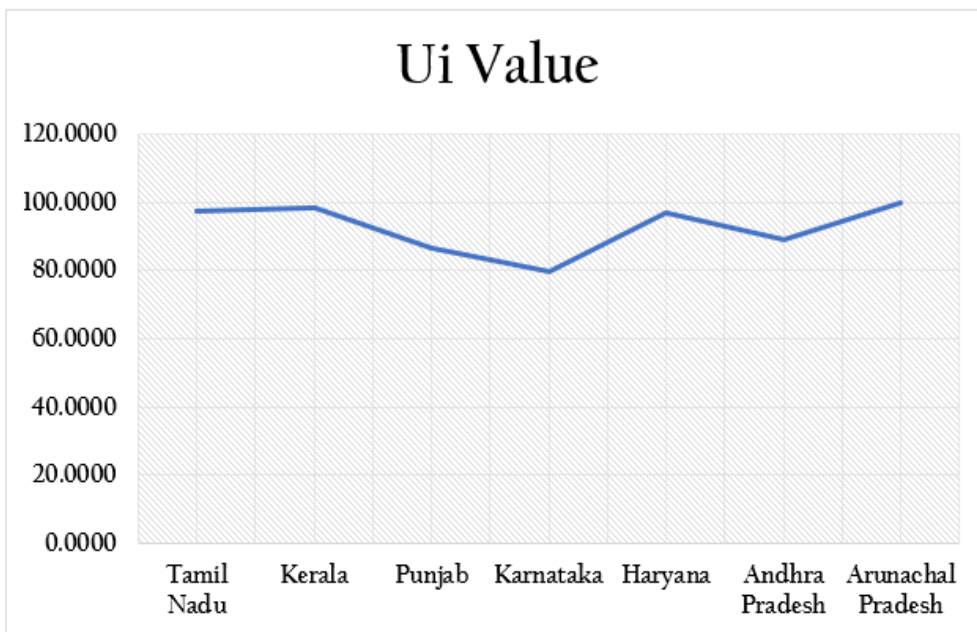


FIGURE 3. Ui value

Figure 3 represents the Community Energy Index (U_i) values for various states in India, including Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh. The Community Energy Index (U_i) is a metric that assesses the level of community engagement, participation, and overall effectiveness in implementing community-based energy initiatives within each state.

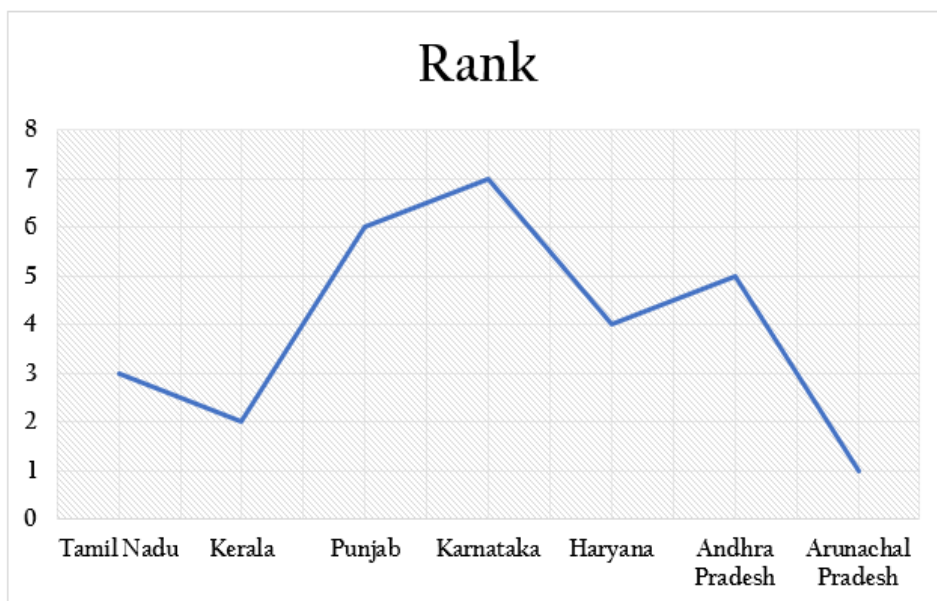


FIGURE 4. Community energy benefits rank

Figure 4 shows the relative level of advancement and effectiveness of community energy initiatives in various states. The numbers assigned to each state indicate their position in the ranking, with lower numbers indicating higher rankings. Arunachal Pradesh holds the top position in the ranking, indicating that it has shown exceptional progress and commitment to community energy projects. This may be due to strong policy support, active community participation, successful implementation of renewable energy projects, or a combination of these factors. Kerala is ranked second, indicating its notable involvement and achievements in community energy endeavors. The state might have successfully implemented community-based renewable energy projects and displayed a high level of community engagement. Tamil Nadu holds the third position in the ranking, demonstrating a substantial commitment to community energy initiatives. The state has likely made significant

strides in adopting renewable energy technologies and engaging local communities in their development. Haryana is ranked fourth, suggesting its active participation in community energy projects. The state may have made commendable efforts to promote and implement renewable energy projects at the community level. Andhra Pradesh occupies the fifth spot in the ranking, indicating its involvement in community energy initiatives. The state has likely taken steps to encourage community participation in renewable energy development. Punjab is ranked sixth, reflecting its engagement in community energy projects. The state might have undertaken initiatives to harness renewable energy resources with the active involvement of local communities. Karnataka holds the seventh position in the ranking, suggesting its presence in the community energy landscape. The state may have initiated renewable energy projects with community participation.

4. CONCLUSION

The adoption of community-based energy initiatives in states such as Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh mark a significant shift toward sustainable development, underscoring the potential of renewable energy sources to reshape the energy sector. Key factors evaluated—including economic gains, education and acceptance, climate protection, community cohesion, renewable energy targets, and innovation—collectively highlight the diverse benefits of these initiatives. From an economic perspective, community energy projects have not only created local employment opportunities but have also enhanced energy affordability and reduced reliance on fossil fuels. These states have also prioritized education and public acceptance, equipping their populations with knowledge about renewable technologies, fostering active engagement, and support for sustainable energy solutions. This educational approach contributes to climate protection by lowering greenhouse gas emissions and promoting a cleaner environment, aligning with global sustainability objectives. Furthermore, the development of community energy projects has spurred unity and collaboration among residents, instilling a sense of ownership and shared responsibility. This collective effort not only strengthens social bonds but also fosters a sense of self-realization as communities witness the tangible outcomes of their contributions to a more environmentally friendly future. The achievement of renewable energy targets showcases the effectiveness of these initiatives in meeting energy needs while lessening ecological impact. Innovation is a central aspect of this movement, with these states adopting inventive approaches and technologies to optimize the potential of alternative energy sources. Such innovation not only drives technological progress but also sets a precedent for other regions to emulate. In conclusion, the embrace of community-based energy solutions in Tamil Nadu, Kerala, Punjab, Karnataka, Haryana, Andhra Pradesh, and Arunachal Pradesh demonstrates a forward-looking approach to energy generation and consumption. The comprehensive advantages of these initiatives, as seen through economic, educational, environmental, social, and innovative lenses, are exemplified by the leading community energy benefits in Arunachal Pradesh and the comparatively lower ranking of Karnataka.

REFERENCE

- [1]. Brummer, Vasco. "Community energy—benefits and barriers: A comparative literature review of Community Energy in the UK, Germany and the USA, the benefits it provides for society and the barriers it faces." *Renewable and Sustainable Energy Reviews* 94 (2018): 187-196.
- [2]. Rakesh Mittapally, "Data-Driven Prediction of Mechanical Properties in 3D-Printed Composites Using Hybrid Machine Learning Models." *Journal of Data Science and Information Technology* 2, no. 2 (2025): 1-16.
- [3]. Cowell, Richard, Gill Bristow, and Max Munday. "Acceptance, acceptability and environmental justice: the role of community benefits in wind energy development." *Journal of Environmental Planning and Management* 54, no. 4 (2011): 539-557.
- [4]. N Palaniraj Dipak Uchampalli, "Role of Circular Economy in Agriculture Leveraging Long Term Growth and Prosperity - AN OVERVIEW", *IOSR JOURNAL OF ECONOMICS AND FINANCE*, 14(4), 2023, 15-17.
- [5]. Panagiotou, Konstantina, Christian Klumpner, and Mark Sumner. "Being a member of an energy community: Assessing the financial benefits for end-users and management authority." In *2017 IEEE 26th International Symposium on Industrial Electronics (ISIE)*, pp. 957-963. IEEE, 2017.
- [6]. Rakesh Mittapally. "Revolutionizing Business Intelligence: Introducing Tableau as A Self-Service Bi Reporting Tool Using Moora Method." *International Journal of Computer Engineering and Technology (IJCET)* 16, no. 3 (2025): 433-463.
- [7]. Chandrasekar Raja, M. Ramachandran, Vimala Saravanan, Manjulaselvam, "Improving Fault-Tolerance in Nano-Computing Circuits Through Design Optimization Using the Electric Method", *REST Journal on Data Analytics and Artificial Intelligence*, 4(2), June 2025, 94-108.

- [8]. Schlund, Jonas, Noah Pflugradt, David Steber, Urs Muntwyler, and Reinhard German. "Benefits of virtual community energy storages compared to individual batteries based on behaviour based synthetic load profiles." In 2018 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe), pp. 1-6. IEEE, 2018.
- [9]. Karthik Perikala, "Architecting MCP-Based Platforms for Enterprise-Scale Agentic Generative AI" 3(2), 2025, 1-8. DOI: <https://doi.org/10.55124/JBID.V2I3.264>
- [10]. Vidhya Prasanth, Chinnasami Sivaji, M. Ramachandran, Ramya sharma, "Water footprint of a tropical beef cattle production system: impact of individual animal and forage management using the WSM method", REST Journal on Emerging trends in Modelling and Manufacturing, 10(1) march 2024, 39-46.
- [11]. Miss Tasmiya Mirza, Miss Shah Amreen, Dr. Sabina Shaikh, "Impact of Artificial Intelligence on Student Learning and Education." International Journal of Research & Technology 13, no. S4 (2025): 247-261.
- [12]. Homsy, George C. "Capacity, sustainability, and the community benefits of municipal utility ownership in the United States." Journal of Economic Policy Reform 23, no. 2 (2020): 120-137.
- [13]. Karthik Perikala, "Structured Language Interpretation Using Small Language Models for Real-Time Systems", 2(2), 2025, DOI: <https://doi.org/10.55124/JDIT.V2I2.272>
- [14]. Walker, Benjamin JA, Duncan Russel, and Tim Kurz. "Community benefits or community bribes? An experimental analysis of strategies for managing community perceptions of bribery surrounding the siting of renewable energy projects." Environment and Behavior 49, no. 1 (2017): 59-83.
- [15]. Divya Soundarapandian, "Investigate the Role of Digital Media in Shaping Cultural Identity using ARAS Method", Journal of Data Science and Information Technology, 2(2), 2025, 1-10.
- [16]. Wijethunge, A. H., J. V. Wijayakulasooriya, Janaka B. Ekanayake, and A. Polpitiya. "Coordinated operation of the constituent components of a community energy system to maximize benefits while considering the network constraints." Journal of Electrical and Computer Engineering 2019 (2019): 1-16.
- [17]. Divya Soundarapandian, "Reliability Analysis of Data Science Workflow Components Using SPSS A Correlation-Based Study", International Journal of Computer Science and Data Engineering, International Journal of Computer Science and Data Engineering, 1(2), 2024, 1-7.
- [18]. Felgenhauer, Markus F., Matthew A. Pellow, Sally M. Benson, and Thomas Hamacher. "Evaluating co-benefits of battery and fuel cell vehicles in a community in California." Energy 114 (2016): 360-368.
- [19]. Tirumala Rao Gundala, "Predictive Analytics for SSO Performance: Improving Authentication Response Times in Oracle Enterprise Environments Using Linear Regression, Random Forest Regression." International Journal of Computer Science and Data Engineering 2, no. 4 (2025): 1-6.
- [20]. Hoffman, Steven M., and Angela High-Pippert. "From private lives to collective action: Recruitment and participation incentives for a community energy program." Energy Policy 38, no. 12 (2010): 7567-7574.
- [21]. Tirumala Rao Gundala "Predictive Performance Modeling of Java-Based Microservices in Dynamic Cloud Environments Using Machine Learning Focus: ML prediction and Java optimization." International Journal of Cloud Computing and Supply Chain Management 1, no. 4 (2025): 1-7.
- [22]. Glasson, John. "Large energy projects and community benefits agreements-some experience from the UK." Environmental Impact Assessment Review 65 (2017): 12-20.
- [23]. Sardi, Junainah, Nadarajah Mithulanathan, Marcus Gallagher, and Duong Quoc Hung. "Multiple community energy storage planning in distribution networks using a cost-benefit analysis." Applied energy 190 (2017): 453-463.
- [24]. Uchampalli, Dipak, E. Girish Kumar, and S. Vikrant. "Ecosystem services-an overview." Indian Journal of Economics and Development 5, no. 7 (2017): 1-5.
- [25]. Kaur, Jaswinder; Khanna, Rajesh; Kartikeyan, Machavaram Venkata; "Optimization and development of O-shaped triple-band microstrip patch antenna for wireless communication applications", IETE Journal of Research, 60(2), 2014, 95-105.
- [26]. Munday, Max, Gill Bristow, and Richard Cowell. "Wind farms in rural areas: How far do community benefits from wind farms represent a local economic development opportunity?" Journal of Rural Studies 27, no. 1 (2011): 1-12.
- [27]. Vahdani, Behnam, S. Meysam Mousavi, R. Tavakkoli-Moghaddam, A. Ghodrathnama, and Mehrdad Mohammadi. "Robot selection by a multiple criteria complex proportional assessment method under an interval-valued fuzzy environment." The International Journal of Advanced Manufacturing Technology 73 (2014): 687-697.
- [28]. Sharma, Rashbha; Khanna, Rajesh; Geetanjali; "Compact sub-6 GHz and mmWave 5G wideband 2x 1 MIMO antenna with high isolation using parasitically placed double negative (DNG) isolator", Wireless Personal Communications, 122(3), 2022, 2839-2857.
- [29]. Balali, Amirhossein, Alireza Valipour, Rodger Edwards, and Robert Moehler. "Ranking effective risks on human resources threats in natural gas supply projects using ANP-COPRAS method: Case study of Shiraz." Reliability Engineering & System Safety 208 (2021): 107442.
- [30]. Mishra, Arunodaya Raj, Pratibha Rani, and Kamal Raj Pardasani. "Multiple-criteria decision-making for service quality selection based on Shapley COPRAS method under hesitant fuzzy sets." Granular Computing 4 (2019): 435-449.
- [31]. Sukumaran, C., M. Ramachandran, Chinnasami Sivaji, and Manjula Selvam. "Ranking of Product in E-store using WASPAS method." REST Journal on Banking, Accounting and Business 1, no. 1 (2022): 1-9.
- [32]. Keshavarz Ghorabae, Mehdi, Maghsoud Amiri, Jamshid Salehi Sadaghiani, and Golnoosh Hassani Goodarzi. "Multiple criteria group decision-making for supplier selection based on COPRAS method with interval type-2 fuzzy sets." The international journal of advanced manufacturing technology 75 (2014): 1115-1130.

- [33].Saha, Abhijit, and Himadri Majumder. "Multi criteria selection of optimal machining parameter in turning operation using comprehensive grey complex proportional assessment method for ASTM A36." *International Journal of Engineering Research in Africa* 23 (2016): 24-32.
- [34].Nitika, J Kaur, R Khanna, Novel monkey-wrench-shaped microstrip patch sensor for food evaluation and analysis, "International Journal of RF and Microwave Computer-Aided Engineering", 102(4), 2022, 1443-1456.
- [35].Chatterjee, Prasenjit, Vijay Manikrao Athawale, and Shankar Chakraborty. "Materials selection using complex proportional assessment and evaluation of mixed data methods." *Materials & Design* 32, no. 2 (2011): 851-860.
- [36].Ünver, Muharrem, and Ibrahim Cil. "Material selection by using fuzzy complex proportional assessment." *Emerging Materials Research* 9, no. 1 (2020): 93-98.
- [37].P Chawla, R Khanna, Design, "analysis and comparison of various MEMS switches for reconfigurable planar antenna", *Acta Polytech Hung*,11(10), 2014, 21-40.
- [38].Roozbahani, Abbas, Hamed Ghased, and Mehdi Hashemy Shahedany. "Inter-basin water transfer planning with grey COPRAS and fuzzy COPRAS techniques: A case study in Iranian Central Plateau." *Science of the Total Environment* 726 (2020): 138499.
- [39].Sukumaran, C., D. Selvam, M. Sankar, V. Parthiban, and C. Sugumar. "Application of artificial intelligence and machine learning to predict basketball match outcomes: a systematic review." *Computer Integrated Manufacturing Systems* 28 (2022): 998-1009.
- [40].Kustiyahningsih, Yeni, and Ismy Qorry Aini. "Integration of FAHP and COPRAS method for new student admission decision making." In *2020 Third International Conference on Vocational Education and Electrical Engineering (ICVEE)*, pp. 1-6. IEEE, 2020.
- [41].Sukumaran, C., and P. J. Sebastian. "Effect of Inclusive Games and Physical Exercises on Selected Physical Variables among the Intellectually Challenged Children." *Annals of the Romanian Society for Cell Biology* 26 (2022): 1442-1450.
- [42].Rani, Pratibha, Arunodaya Raj Mishra, Raghunathan Krishankumar, Abbas Mardani, Fausto Cavallaro, Kattur Soundarapandian Ravichandran, and Karthikeyan Balasubramanian. "Hesitant fuzzy SWARA-complex proportional assessment approach for sustainable supplier selection (HF-SWARA-COPRAS)." *Symmetry* 12, no. 7 (2020): 1152.
- [43].Sabina Ashfaque Shaikh, "Intelligent Tutoring Systems and Personalized Learning: A Thorough Secondary Research Examination." *International Journal of Research & Technology* 13, no. S4 (2025): 533-543.
- [44].Mishra, Arunodaya Raj, Pratibha Rani, Abbas Mardani, Kamal Raj Pardasani, Kannan Govindan, and Melfi Alrasheedi. "Healthcare evaluation in hazardous waste recycling using novel interval-valued intuitionistic fuzzy information based on complex proportional assessment method." *Computers & Industrial Engineering* 139 (2020): 106140.