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# Sustainable Energy Solutions for Urban Residences in Australia through Hybrid Systems

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**Abstract**
This paper explores the optimization process for sizing a hybrid renewable energy system designed for urban residential buildings in Australia. The renewable energy system in question combines solar photovoltaic panels and small-scale wind turbines. This hybrid system represents a sustainable and green alternative to the conventional electricity generation methods currently in use, which predominantly rely on fossil fuels, particularly coal burning. Such traditional methods are neither environmentally friendly nor sustainable. The proposed hybrid renewable energy system also includes battery racks for energy storage, ensuring that excess energy produced can be stored and used when needed, thereby enhancing the reliability and efficiency of the system. To simulate and evaluate the performance of the hybrid system, the study employs HOMER software, developed by the National Renewable Energy Laboratory in the USA. This software is specifically designed for modeling and optimizing renewable energy systems. The optimization process relies heavily on an economic analysis method known as Net Present Cost analysis. NPC is a critical metric that helps in determining the cost-effectiveness of the energy system over its lifespan. The analysis aims to identify the system configuration that offers the highest energy production, optimal efficiency, and the lowest NPC. This involves considering various combinations of solar PV and wind energy to achieve the best economic and environmental outcomes. The study provides detailed conclusions and recommendations based on the optimization results. These recommendations take into account factors such as the number of occupants in the residential buildings and their corresponding electrical consumption patterns. By analyzing different scenarios of energy consumption and production, the study identifies the most effective combinations of solar and wind energy systems that can meet the energy demands of urban residential buildings in Armidale. One of the key findings is that a balanced combination of solar PV and wind turbines, supported by adequate battery storage, can significantly reduce reliance on fossil fuels and lower overall energy costs for residential buildings. The hybrid system not only offers a sustainable solution but also enhances energy security and reduces greenhouse gas emissions. Policymakers and urban planners are encouraged to consider these findings to promote the adoption of green energy solutions, ultimately contributing to a more sustainable and resilient energy future.
**Keywords:** Hybrid Renewable Energy System, Solar Photovoltaic, Wind Turbines, Energy Storage
**JEL Codes:** Q42, Q55, L94

## 1. INTRODUCTION

The successful implementation of any energy system hinges upon its feasibility, a critical factor that dictates its viability and effectiveness. When it comes to renewable energy systems, assessing feasibility is a multifaceted process encompassing several key considerations. Firstly, the availability of resources plays a pivotal role. Renewable energy sources such as solar, wind, and hydroelectric power must be readily accessible to make harnessing them feasible. This involves evaluating the geographic location and environmental conditions to determine the suitability of the site for energy generation. Secondly, reliability is paramount to ensure that the renewable energy system can reliably meet the energy demands, whether for residential, commercial, or industrial purposes. Factors such as intermittency and variability inherent in some renewable sources like wind and solar energy need to be addressed through technological solutions such as energy storage or grid integration to guarantee a consistent power supply. Furthermore, constructability considerations are vital, especially in urban environments where space is limited. It's essential to assess whether renewable energy systems can be seamlessly integrated into existing infrastructure or incorporated into new construction projects without compromising functionality or aesthetics.

Economic feasibility is another crucial aspect that must be thoroughly evaluated. Beyond initial installation costs, a comprehensive analysis should encompass the entire project lifecycle, including operation, maintenance, and potential revenue streams. This ensures that investments in renewable energy systems are financially sound and offer long-term benefits, such as cost savings or revenue generation. By diligently studying the feasibility of renewable energy systems, stakeholders can make informed decisions and mitigate risks associated with implementation. Moreover, embracing renewable energy alternatives not only contributes to reducing carbon emissions but also fosters sustainability and supports the transition towards a greener and more resilient energy landscape. The expenses linked with generating electricity from fossil fuels are notably high when juxtaposed with small or micro-scale renewable energy alternatives. Fossil fuel-based electricity generation entails substantial costs, including generation expenses,

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transmission costs for extensive networks of either underground or overhead cables spanning hundreds of kilometers, maintenance expenditures, and the inevitable loss of power during transmission due to distance and the aging of conductors/carriers.The financial burden of generating electricity through fossil fuels stands in stark contrast to the potential savings offered by small or micro-scale renewable energy solutions. Traditional fossil fuel-based electricity production involves a myriad of costly processes. Firstly, there are substantial generation expenses, including the procurement of raw materials, operation of complex machinery, and management of by products such as emissions and waste. Additionally, the transmission of electricity over vast distances necessitates significant investment in infrastructure. This includes the installation of extensive networks of cables, either buried underground or suspended on towers, spanning hundreds of kilometers. These transmission lines incur considerable construction and maintenance costs, not to mention the energy loss experienced during transport due to resistance in the conductors and the natural degradation of equipment over time. Conversely, the adoption of small-scale or micro-scale renewable energy solutions presents a compelling economic alternative. By harnessing locally available renewable resources such as solar, wind, or hydroelectric power, communities can drastically reduce their reliance on costly fossil fuels. The decentralized nature of these renewable energy systems minimizes the need for extensive transmission networks, thereby reducing associated expenses. Furthermore, advancements in technology and economies of scale have led to significant cost reductions in renewable energy infrastructure and equipment. Borowy and Salameh (1994) underscored the potential of small-scale renewable energy solutions to alleviate the financial burden of electricity production, particularly in communities with smaller populations. These communities are often found in regional or rural areas, where the benefits of renewable energy adoption are most pronounced. As a case study, the town of Armidale serves as a representative example of such a regional or rural Australian community. By embracing renewable energy solutions tailored to their local context, towns like Armidale can not only achieve energy independence but also stimulate economic growth, foster environmental sustainability, and enhance overall resilience in the face of energy challenges.

Renewable energy has experienced a surge in interest worldwide, primarily driven by the volatile prices of oil, gas, and coal, as well as growing global concerns about carbon emissions and their impact on climate change. While this has led to increased investment and development in renewable energy technologies, it remains unlikely that fossil fuel production will be entirely replaced. Instead, a pragmatic approach involves integrating both fossil fuels and renewable energy sources to create hybrid energy systems, as noted by Elhadidy and Shaahid (2004). Hybrid energy systems combine renewable energy sources with complementary technologies to enhance reliability and efficiency. One such approach involves pairing renewable energies with storage devices, such as battery racks, which are particularly beneficial for standalone systems in urban areas where grid connectivity may be impractical or undesirable. In remote regional or rural areas, an alternative hybrid configuration includes integrating a backup device, typically a diesel generator, to ensure continuous power supply (Bagul et al., 1996). In urban residential settings, both grid-connected and standalone hybrid systems offer viable options, catering to diverse user needs and preferences. However, standalone systems play a crucial role in remote regional and rural areas lacking access to the electricity grid, as highlighted by Elhadidy and Shaahid (2004). By embracing hybrid energy solutions tailored to specific contexts, communities can harness the benefits of renewable energy while ensuring reliability and resilience in their energy supply.

In today's energy landscape, the exploration of stand-alone renewable generation stands as a vibrant domain of research. At its forefront are hybrid systems amalgamating solar photovoltaic and wind turbines. Tailored for micro-scale electricity production, typically ranging from 0.5 kW to 10 kW, these hybrid setups are gaining traction as practical solutions to fulfill the energy requirements of residential dwellings. Their viability hinges on the availability of ample wind and solar resources, a condition increasingly met in various geographical contexts (Castle et al., 1981). Pioneering studies by researchers like Borowy and Salameh (1994) have delved into the intricate dynamics of optimizing photovoltaic (PV) arrays within these stand-alone systems. Their work elucidates the delicate balance required to achieve maximum efficiency and output, laying the groundwork for informed decision-making in system design and implementation. As the demand for decentralized energy solutions burgeons, the significance of such research cannot be overstated. By refining our understanding of hybrid system configurations and their performance metrics, scholars and practitioners alike are driving innovation in stand-alone renewable generation. This trajectory promises to not only bolster energy resilience at the household level but also contribute to broader sustainability objectives, ushering in a more robust and diversified energy landscape for the future.

Additionally, Bagul et al. (1996) contributed to this field by delineating the optimal sizing not only of the PV array but also of the accompanying battery storage systems. Their methodological approach involved utilizing a three-event probability density approximation, offering a nuanced perspective on system design. Subsequently, Markvart (1996) provided further validation through the application of a graphical construction method. This enabled the determination of optimal sizes for PV arrays and wind turbines within hybrid wind/PV systems. Their combined efforts exemplify the interdisciplinary nature of renewable energy research, integrating mathematical modeling and empirical validation to advance our understanding of hybrid system optimization. The HOMER energy modeling software represents a pinnacle in the realm of designing and assessing hybrid power systems. With its versatility and comprehensiveness, HOMER accommodates an extensive array of components, including conventional generators, combined heat and power units, wind turbines, solar photovoltaic arrays, batteries, fuel cells, hydropower setups, biomass inputs, and more. Its utilization spans across continents, with tens of thousands of users worldwide relying on its capabilities. Whether catering to grid-tied or off-grid environments, HOMER plays a pivotal role in orchestrating the seamless integration of variable resources like wind and solar into hybrid systems. By employing sophisticated algorithms and predictive analytics, it empowers engineers and non-professionals alike to conduct intricate simulations of diverse energy configurations. These simulations enable stakeholders to compare outcomes, fine-tune system parameters, and derive realistic projections of both capital investments and ongoing operational costs. What distinguishes HOMER is its accessibility and user-friendly interface, democratizing the process of energy system optimization. Whether in academia, industry, or policymaking, individuals with varying levels of technical expertise can leverage HOMER to explore sustainable energy solutions tailored to their specific needs and constraints. In doing so, they contribute to a global effort to transition towards cleaner, more resilient energy systems that meet the demands of the present while safeguarding the future.

Indeed, HOMER serves as a crucial tool in evaluating the economic viability of hybrid energy systems, facilitating informed decision-making and optimized system design. By simulating various configurations and scenarios, HOMER enables users to gain a deep understanding of how hybrid renewable systems operate and interact with different inputs and conditions. In an era where distributed generation and renewable power projects are witnessing unprecedented growth, HOMER's capabilities are invaluable to a wide range of stakeholders. Utilities, telecom companies, systems integrators, and various project developers rely on HOMER to assess and mitigate the financial risks associated with their hybrid power projects. Whether it's determining the optimal mix of renewable and conventional energy sources, sizing components such as solar panels and batteries, or forecasting long-term costs and savings, HOMER provides the analytical backbone needed to navigate complex energy landscapes. Beyond its software offerings, HOMER Energy fosters a vibrant online community, providing support, resources, and knowledge sharing opportunities for users worldwide. This collaborative ecosystem empowers individuals and organizations to leverage HOMER effectively, driving innovation and sustainability in the global energy transition. As distributed generation and renewable energy adoption continue to accelerate, HOMER remains an indispensable ally in shaping a more resilient and sustainable energy future. The capabilities of HOMER will be tailored to meet the specific research needs of evaluating micro-scale hybrid (solar and wind) stand-alone electricity generation systems with battery racks. This type of simulation has garnered attention from researchers due to its ability to optimize system performance under predefined constraints. Such optimization studies have been conducted in various countries, highlighting the global relevance of this research. For instance, Kamel and Dahl (2005) delved into the economics of a renewable power system tailored for sustainable desert agriculture in Egypt. Their study underscores the potential of hybrid renewable energy systems to address the energy needs of remote and resource-constrained environments while promoting sustainable development.

Similarly, Dalton et al. (2008) explored the feasibility of stand-alone renewable energy systems for commercial applications in Australia. Their research sheds light on the practicality and economic viability of deploying hybrid renewable solutions to meet the energy demands of commercial enterprises, particularly in regions where grid connectivity may be limited or unreliable. By drawing insights from such diverse contexts and applications, researchers can leverage HOMER to inform the design, optimization, and economic analysis of micro-scale hybrid stand-alone electricity generation systems worldwide. This interdisciplinary approach holds promise for advancing renewable energy adoption and fostering sustainable development across various sectors and geographic locations.

The current study focuses on evaluating and optimizing the size of a hybrid solar photovoltaic (PV) and wind system to ensure a dependable and economically viable supply of sustainable energy to the urban residential sector in Armidale, New South Wales, Australia. This research specifically investigates a stand-alone system equipped with battery storage to enhance reliability and energy autonomy. To achieve these objectives, the research leverages the capabilities of HOMER software to conduct comprehensive optimization of the system sizing. By inputting various parameters such as solar irradiance, wind speeds, energy demand profiles, battery characteristics, and economic constraints, HOMER enables the exploration of different system configurations and scenarios.

Through rigorous analysis and simulation, the study aims to identify the optimal combination of solar PV panels, wind turbines, and battery storage capacity that maximizes energy reliability while minimizing costs. By tailoring the system design to the specific characteristics and requirements of the urban residential sector in Armidale, the research endeavors to provide practical insights for implementing sustainable energy solutions in similar contexts. Ultimately, by utilizing HOMER software as a powerful tool for optimization, the study seeks to contribute to the advancement of renewable energy integration and sustainability efforts in urban residential areas, driving towards a cleaner and more resilient energy future.

## 2. METHODOLOGY

Undoubtedly, the economic viability of renewable energy systems is a pivotal consideration that significantly influences decision-making processes. Therefore, conducting a comprehensive cost-benefit analysis holds paramount importance when sizing and optimizing any renewable energy system. In the context of this article, simulation techniques are employed to evaluate each potential system configuration or combination of systems, particularly focusing on hybrid configurations. The primary objective is to maximize the production and efficiency of the system(s) while concurrently minimizing the net present cost (NPC). Essentially, the research aims to identify the optimal system configuration(s) that offer the highest level of energy output and efficiency while achieving the lowest NPC. This continuous optimization process, as outlined by Deshmukh and Deshmukh (2008), entails iteratively refining the system parameters and configurations through simulation-based analyses. By systematically exploring various scenarios and iterations, researchers can pinpoint the most economically advantageous solution(s) that strike a balance between performance and cost-effectiveness. By integrating economic considerations into the optimization framework, the study endeavors to provide valuable insights into the financial feasibility and sustainability of renewable energy deployment in urban residential settings. Ultimately, this holistic approach seeks to facilitate informed decision-making and foster the adoption of renewable energy systems as viable and economically competitive alternatives to conventional energy sources.

Indeed, HOMER's primary financial output, the total Net Present Cost (NPC) of the analyzed system configurations, serves as a comprehensive metric for economic comparison across different energy systems classifications and configurations. The NPC analysis proves particularly valuable due to its ability to reconcile the diverse cost characteristics inherent in renewable and non-renewable energy sources. By encapsulating all relevant costs and revenues over the lifetime of an energy project, the NPC analysis offers a holistic view of the economic viability of various system configurations. It accounts for factors such as initial capital investment, component replacement, maintenance expenses, fuel costs, savings, payback periods, funding sources, interest rates, gains, and losses. This methodological approach is regarded as a globalized method, as it considers the entirety of the project's lifecycle and factors in both short-term and long-term financial implications. The overarching objective of NPC analysis is unequivocal: to identify and nominate the renewable energy system(s) with the lowest NPC while maximizing energy production and efficiency. By leveraging HOMER's capabilities for NPC analysis, researchers can systematically evaluate and compare different system configurations, enabling informed decision-making and the identification of economically optimal solutions. Ultimately, this approach facilitates the transition towards more sustainable and cost-effective energy systems, contributing to broader objectives of energy resilience and environmental stewardship (Dalton et al., 2008).

## 3. OUTCOMES

The replacement cost of turbines being lower than their initial capital outlay is a significant advantage, attributed mainly to the absence of the need for tower replacement at the end of the turbine's projected 25-year lifespan. This factor substantially mitigates long-term operational expenses associated with wind turbine installations, enhancing their economic feasibility. Battery racks serve a pivotal role in renewable energy systems by facilitating energy storage and ensuring a consistent power supply, especially during periods of fluctuating renewable energy generation and peak demand. For hybrid systems, market analysis indicates a capital cost of 600 USD for a 7 kWh battery rack, with replacement costs estimated at 500 USD, making them a cost-effective solution for energy storage. The concept of battery bank autonomy is crucial in determining the appropriate battery size, as it dictates the system's ability to function independently without external power sources. This parameter, which measures the ratio of battery bank size to electric load, influences system reliability and performance. In the study area, consisting of virtual single-story houses with varying bedroom counts (ranging from one to four bedrooms) accommodating different numbers of occupants, typical electrical loads include lighting, kitchen appliances, entertainment devices, computers, electric water heating, and air conditioning. Seasonal categorization of electrical consumption patterns, as outlined in Table 2, offers valuable insights into understanding and analyzing electricity usage trends in urban Armidale households. By considering these factors and consumption patterns, stakeholders can make informed decisions regarding energy system design, equipment selection, and optimization strategies to meet the diverse energy needs of residential areas effectively.

**Table 1: Horizontal wind turbines average costing in USD per unit**

| Item No. | Turbine Rated Power | Capital Cost | O&M Annually | Replacement Cost |
|---|---|---|---|---|
| 1 | 10 kW | 13000 | 100 | 11000 |
| 2 | 5 kW | 8000 | 50 | 7000 |
| 3 | 3 kW | 3200 | 40 | 2700 |
| 4 | 1 kW | 1200 | 30 | 1000 |

**Table 2: Extracted from AGL electricity provider in Australia data for Armidale NSW, Australia**

| | | 1 Occupant | | 2 Occupants | | 4 Occupants | | 6 Occupants | |
|---|---|---|---|---|---|---|---|---|---|
| Season | Months | Total KwH | Avg. Daily KwH | Total KwH | Avg. Daily KwH | Total KwH | Avg. Daily KwH | Total KwH | Avg. Daily KwH |
| Winter | Jun–Jul-Aug | 1700 | 18 | 2255 | 23 | 3160 | 32 | 4070 | 42 |
| Spring | Sept-Oct-Nov | 1150 | 13 | 1440 | 16 | 2020 | 22 | 2600 | 29 |
| Summer | Dec-Jan-Feb | 1300 | 15 | 1630 | 18 | 2280 | 25 | 2940 | 33 |
| Autumn | Mar-Apr-May | 1100 | 12 | 1380 | 15 | 1930 | 21 | 2490 | 27 |

**Table 3: Targeted electrical load to be covered by hybrid renewable solar and wind system**

| Season | Months | 1 Occupant Avg. Daily KwH | 2 Occupants Avg. Daily KwH | 4 Occupants Avg. Daily KwH | 6 Occupants Avg. Daily KwH |
|---|---|---|---|---|---|
| Winter | Jun–Jul-Aug | 9 | 11.5 | 16 | 21 |
| Spring | Sept-Oct-Nov | 6.5 | 8 | 11 | 14.5 |
| Summer | Dec-Jan-Feb | 7.5 | 9 | 12.5 | 16.5 |
| Autumn | Mar-Apr-May | 6 | 7.5 | 10.5 | 13.5 |

Armidale, endowed with abundant renewable energy sources like biomass, geothermal, hydro power, solar, and wind, will be the focus of this paper's investigation into solar photovoltaic (PV) and wind energy. These two sources stand out as the most prominent renewable energy options in the research area, offering significant potential for sustainable power generation. To assess the potential of wind energy, yearly wind profiles for the study area were derived from data obtained from the nearest meteorological station, specifically the Armidale Airport Automatic Weather Station. This data, publicly available on the Australian Bureau of Meteorology website, represents an average of 17 years of observations. Similarly, solar irradiance data were collected from the same source, providing insights into the solar energy potential in Armidale. Analysis conducted using HOMER software demonstrated the adequacy of both wind and solar energy availability throughout the year. This suggests that a hybrid system combining wind and solar energy sources could be effectively deployed in the region. By leveraging the complementary nature of these renewable resources, such a hybrid system could optimize energy generation and enhance overall system reliability and resilience.

The optimization process conducted using HOMER aimed to determine the optimal sizing of components, maximize energy production and efficiency, and assess the Net Present Cost (NPC) for a wind and solar hybrid system tailored to different occupancy rates. Table 4 presents the selected hybrid system components, their quantities, sizing, individual costs, and the total accumulated costs projected over the project's 25-year lifetime. Furthermore, a comprehensive cost comparison was undertaken between the accumulated costs of the hybrid system over 25 years and the existing fossil fuel-based electricity generation and supply system in Armidale. This comparison factored in the current kWh fee rate of 0.35 USD, with an annual adjustment of a five percent increase to cover both inflation and the escalating electricity prices. Table 5 provides a detailed breakdown of the costs associated with each scenario, highlighting the financial implications over the 25-year period across different occupancy rates, ranging from 1 to 6. The analysis overwhelmingly favors the proposed hybrid wind and solar system, demonstrating substantial cost savings compared to the conventional fossil fuel-based electricity generation and supply system. These findings underscore the economic viability and attractiveness of transitioning towards renewable energy solutions, particularly in regions like Armidale, where abundant renewable resources such as wind and solar are available.

**Table 4: Hybrid system optimal size and relevant costing for Armidale NSW**

| Occupants | Daily Load | Hybrid System Components | | | | Total Cost over the project life time (25 Years) | | |
|---|---|---|---|---|---|---|---|---|
| | | Wind Turbines kW | Solar PV Kw | Battery | Converter | Capital | O&M | Total |
| 1 | 9 | 2 x 3kW | 7.5 Kw | 10kWh | 15 kW | 21,150 | 6,250 | 27,400 |
| 2 | 11.5 | 3 x 3kW | 10 Kw | 15Kwh | 20Kw | 30,100 | 8,000 | 38,100 |
| 4 | 16 | 2x5kW | 15 kW | 20Kwh | 25kW | 45,750 | 10,000 | 55,750 |
| 6 | 21 | 1x10Kw+1x5kW | 20kW | 25kWh | 35kW | 60,750 | 13,750 | 74,500 |

Table 4 illustrates the optimal sizing and relevant costing for a hybrid wind and solar system customized for Armidale, NSW, considering varying occupancy rates. Each row corresponds to a different occupancy scenario, ranging from single occupants to families of six, reflecting the diverse energy needs of residential buildings. For each occupancy scenario, the table delineates the daily load requirements and specifies the hybrid system components, including the number and capacity of wind turbines and solar PV panels, as well as the battery size and converter capacity. Additionally, it provides a breakdown of the total cost over the project's 25-year lifespan, comprising capital investment and operation and maintenance (O&M) expenses. The findings underscore the cost-effectiveness of renewable energy adoption in Armidale, with significant total cost savings achievable over the project's lifetime compared to conventional fossil fuel-based electricity generation systems. Despite the initial capital expenditure, the long-term financial benefits of investing in sustainable energy infrastructure are evident across all occupancy scenarios. Furthermore, the inclusion of O&M costs ensures a comprehensive assessment of the total cost of ownership, facilitating informed decision-making by stakeholders and homeowners. This comprehensive analysis highlights the potential of hybrid wind and solar systems to meet energy needs efficiently while contributing to environmental sustainability and economic resilience in the region.

**Table 5: Hybrid system costing versus in use fossil fuel electricity costing for Armidale NSW**

| Occupants | Annual Load Consumption kWh | Target Load kWh | Target Load accumulative costs over (25 years) | Renewable Hybrid System Total Cost | Balance over the project life time (25 Years) |
|---|---|---|---|---|---|
| 1 | 5,250 | 2,625 | 43,850 | 27,400 | 16,450 |
| 2 | 6,705 | 3,352.5 | 56,000 | 38,100 | 17,900 |
| 4 | 9,390 | 4,695 | 78,430 | 55,750 | 22,780 |
| 6 | 12,100 | 6,050 | 101,060 | 74,500 | 26,560 |

Table 5 presents a comparison between the accumulated costs of operating a renewable hybrid energy system and the expenses associated with conventional fossil fuel-based electricity supply over a 25-year period in Armidale, NSW. The analysis considers different occupancy rates, ranging from single occupants to families of six, to capture varying energy consumption patterns. For each occupancy scenario, the table outlines the annual load consumption in kilowatt-hours (kWh) and the corresponding target load, representing the energy demand that needs to be met. It then provides the target load's accumulated costs over 25 years, reflecting the expenses associated with fossil fuel electricity generation and supply.

In contrast, the table also presents the total cost of implementing and operating a renewable hybrid system over the same period. This includes the initial capital investment and ongoing operation and maintenance expenses associated with the hybrid wind and solar infrastructure. The final column in the table indicates the balance between the accumulated costs of the two scenarios over the project's lifetime. A positive balance signifies potential cost savings achieved by adopting renewable energy solutions, whereas a negative balance indicates higher costs associated with the conventional fossil fuel-based electricity supply system. The results underscore the financial benefits of transitioning to renewable energy sources, with substantial cost savings achievable across all occupancy scenarios. By investing in hybrid wind and solar systems, homeowners and stakeholders can not only reduce their long-term energy expenses but also contribute to environmental sustainability and resilience in the Armidale region.

## 4. CONCLUSIONS

In this study, we investigate the viability of a proposed hybrid energy system tailored for residential buildings in urban Armidale, New South Wales, Australia. This hybrid system integrates localized solar and wind generators along with battery racks and converters, aiming to provide a sustainable and reliable source of electricity for urban households. The inclusion of solar and wind generators capitalizes on the abundant renewable energy resources available in the Armidale region. By harnessing sunlight and wind, the hybrid system seeks to maximize energy production while minimizing reliance on traditional grid-supplied electricity. The incorporation of battery racks and converters enhances the system's capacity to store excess energy generated during peak production periods. This stored energy can then be utilized during periods of low renewable energy generation or high electricity demand, ensuring a consistent and uninterrupted power supply to residential buildings. By examining the performance and economic feasibility of this proposed hybrid system configuration, our study aims to contribute valuable insights into sustainable energy solutions tailored to the specific needs and constraints of urban environments in Armidale, NSW, Australia. Through rigorous analysis and optimization, we seek to provide practical recommendations for implementing renewable energy systems that promote energy independence, environmental sustainability, and resilience in residential communities. In this study, we conducted a thorough size optimization and costing analysis for virtual houses, utilizing current market rates as a basis. Our research relied on meteorological data specific to Armidale city, collected over a reliable period of seventeen years. This meteorological data was sourced from a weather station located in the airport area, ensuring accuracy and reliability in our analysis. The choice of the weather station in the airport area was deliberate, as it minimizes potential obstructions and ensures that the recorded meteorological data accurately represents the local climate conditions experienced in Armidale city. By utilizing this comprehensive dataset, we were able to capture the variability and nuances of weather patterns over an extended period, providing a robust foundation for our analysis. With this meteorological data as input, we conducted size optimization and costing analyses for virtual houses, incorporating factors such as solar irradiance, wind speeds, energy demand profiles, and market rates for renewable energy technologies. By aligning our simulations with real-world conditions and market dynamics, we aimed to generate actionable insights and recommendations for implementing renewable energy systems in residential settings in Armidale city. Overall, our study leverages reliable meteorological data and current market rates to inform decision-making and optimize the design and costing of renewable energy systems for virtual houses, contributing to the advancement of sustainable energy solutions in urban environments. The study concluded that deploying the proposed hybrid energy system is a feasible option for meeting a significant portion of the average daily load consumption throughout the year in Armidale. This conclusion is supported by the findings that Armidale possesses considerable potential for both wind and solar energy generation. However, while the technical feasibility of the hybrid system has been established, further research is warranted to explore the financial aspects of implementing such a system. Specifically, additional studies are recommended to investigate various funding options and financing scenarios to facilitate the affordability of this significant investment for households. By delving into the funding options and financing mechanisms available, researchers can provide valuable insights into how households in Armidale and similar urban environments can overcome financial barriers to adopting renewable energy systems. This research can explore strategies such as government incentives, subsidies, grants, low-interest loans, community financing models, and innovative financing mechanisms to make the transition to renewable energy more accessible and affordable for households. Ultimately, by addressing the financial considerations alongside the technical aspects, future studies can contribute to the development of comprehensive and sustainable solutions for transitioning towards renewable energy in urban residential settings like Armidale. This holistic approach will be instrumental in realizing the full potential of renewable energy systems to enhance energy resilience, reduce greenhouse gas emissions, and promote sustainable development.

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