Data-Driven Energy Sustainability

A Focus on Green Energy Consumption Transition and ESG Impacts on People and Business Investments

Executive Summary

This analysis reveals critical insights into energy consumption patterns, highlighting significant opportunities for businesses to enhance their ESG performance and drive operational efficiencies. Peak energy demand, correlating with temperature and occupancy, underscores the need for strategic interventions. By prioritizing renewable energy adoption, particularly in large-scale commercial and residential spaces, businesses can mitigate environmental impact and reduce operational costs influencing the other demographics. Leveraging targeted incentives, advanced analytics for optimized energy management, and community engagement, organizations can accelerate the transition to sustainable energy solutions. Furthermore, partnerships with green-branded SMEs, coupled with financial institutions offering favorable credit terms, will foster innovation and expand market reach. Ultimately, proactive investment in renewable energy and smart technologies not only strengthens a company's environmental stewardship but also enhances its competitive advantage in a rapidly evolving market.

Energy Consumption Behavior

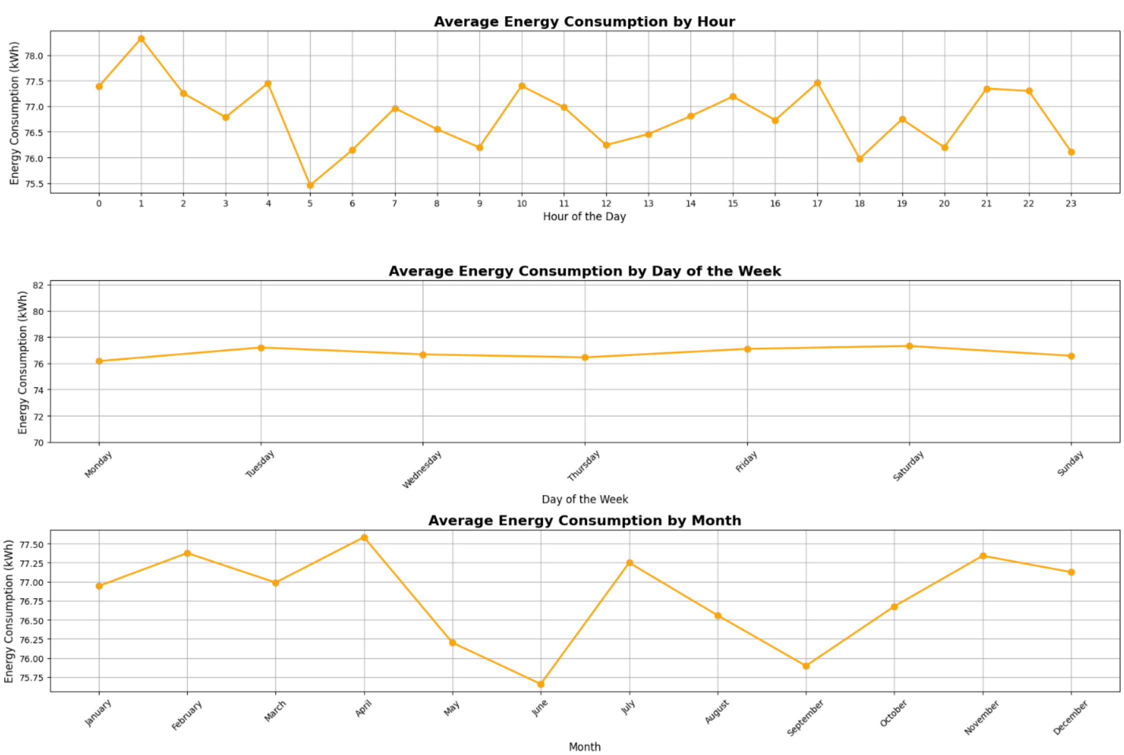

Figure 1: Energy Consumption Behavior

Temperature Correlation

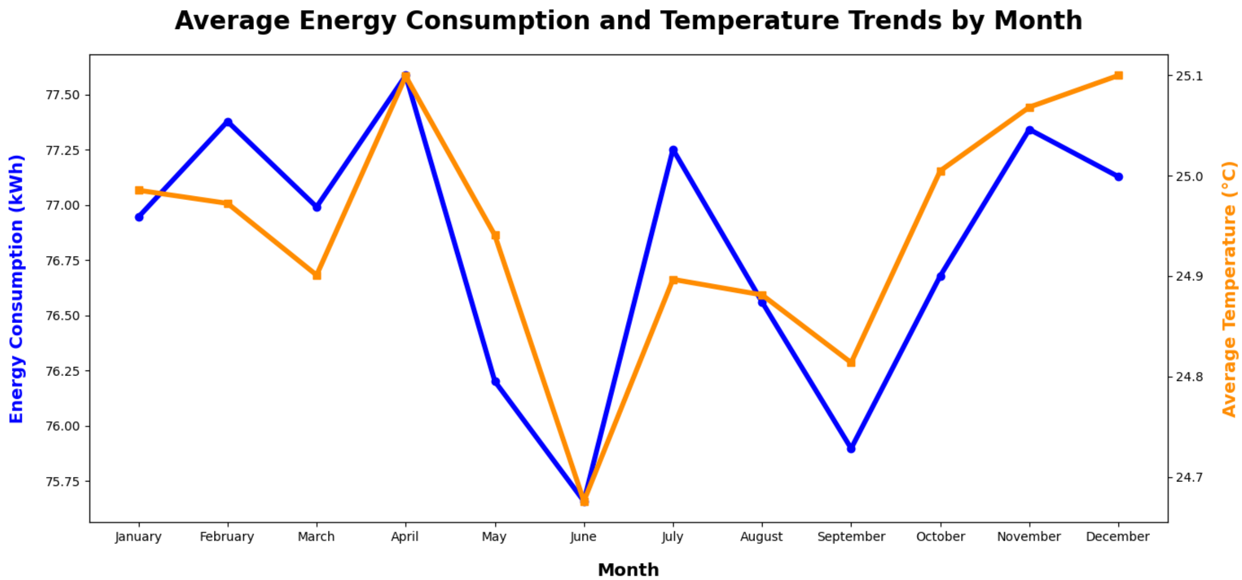

Figure 2: Energy and Temperature

We all know that energy creates heat, and in this case, the data explains the same with the energy consumption behavior monthly. There is a correlation between the energy and temperature produced to the atmosphere, and they vary depending on the seasons and needs. For example, the first and last quarter of the year, it is perhaps winter and Christmas which makes a greater consumption for warmth, decorations, and businesses.

However, Figure 3 examines the deviations by month of the trends between renewable energy and temperature; it shows a contrasting correlation. This implies equipping residential and commercial properties with more renewable energy devices can reduce the level of heat generated man activities. Especially, the spikes of temperature drops during March and June when the green energy usage compels before and within the months. Green energy appears to slow down the rise of temperature, such as in the last two months, though winter, the increase of renewable maintains the temperature from reaching over 25 degree Celsius when people need heat and lights for winter events, giving an alternative for energy efficiency, and it can be seen that the total energy consumption at those times is also eased.

One consideration is that the temperature in each property is accumulated by the occupancy rate of the regions or properties. The more residence or workers in the building, the more activities occur, the more heat is emitted. Figure 4 demonstrates the connections of the attributes associating with renewable energy. It is proven that temperature accounts contradictive commotion with the renewable energy factor but entails a strong relationship with the energy consumption over than 50%. In turn, the occupancy rate is the second strong correlating feature of the total energy used with 14%. Hence, it is statistically approachable to say that occupancy rate effects energy consumption then compels the temperature then.

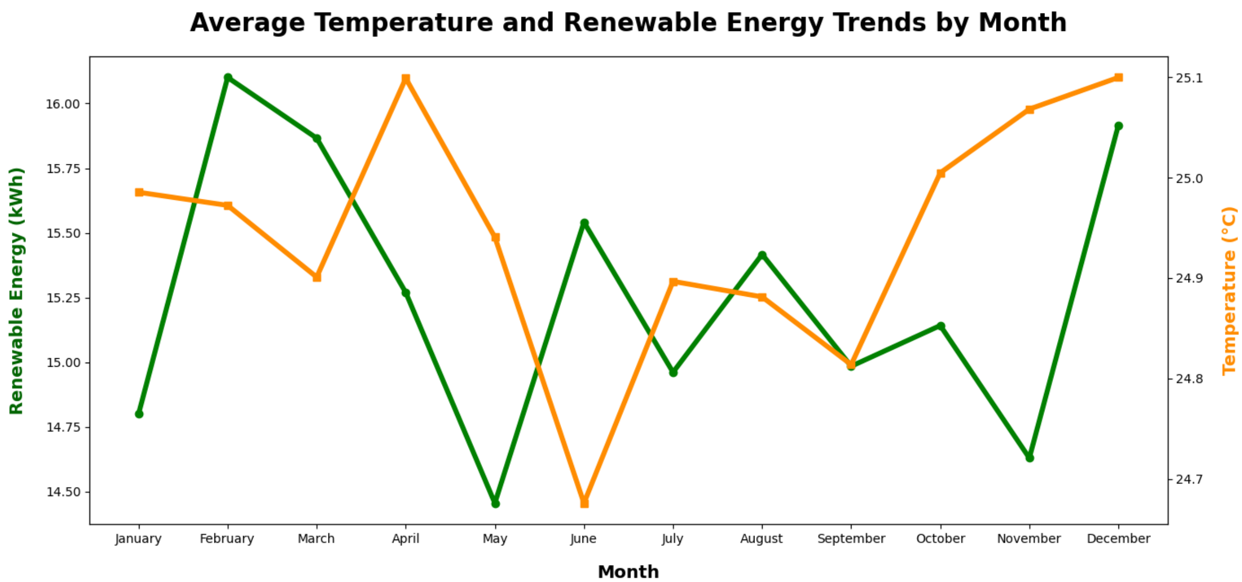

Figure 3: Renewable and Temperature

Nonetheless, the direct effect of occupancy over temperature is not strong, suggesting people have various options on how they operate energy for their activities. This is where the renewable aspect comes to play. On the other hand, the number of people seemingly using renewable energy is not also extensive, which can be a matter of activity-operational requirements for certain tasks of using energy types, a motivation criterion to encourage switching to more renewable technologies, or financial barriers to equip in certain properties.

Let focus on the demographics residing by square footage to analyze more about the temperature nature in Figure 5. In all areas, almost the same number of average people between 4 and 5 assert diverse increments of temperature degrees, just by different space of environments the increments of temperature on average alter significantly, though, with the similar amount of people.

Interestingly, the middle area distribution of 14 to 16 hundred square footage exhibits the lowest heat while larger ones obtain more temperature, probably due to commercial spaces like offices, garages, warehouses, or mid-sized or larger homes with more appliances to maintain and satisfy. Interestingly, the smaller areas generate relative heat with people in larger areas, it can be the attribute of space where the little spaces make less room for the heat to circulate, giving the data the figure.

To ensure the assumptions from Figure 5 is reasonable, Figure 6 enhances on the utility's applications of Heat, Ventilation, and Air Conditioning (HVAC) and lighting over the areas of the occupants. It is true that the larger the area of where the people are the more operational activities of energy usage is required, and this can be for large residential, commercial, and industrial spaces. The lower group areas do not use much of the HVAC and lighting; hence, it is because heat is trapped in smaller spaces.

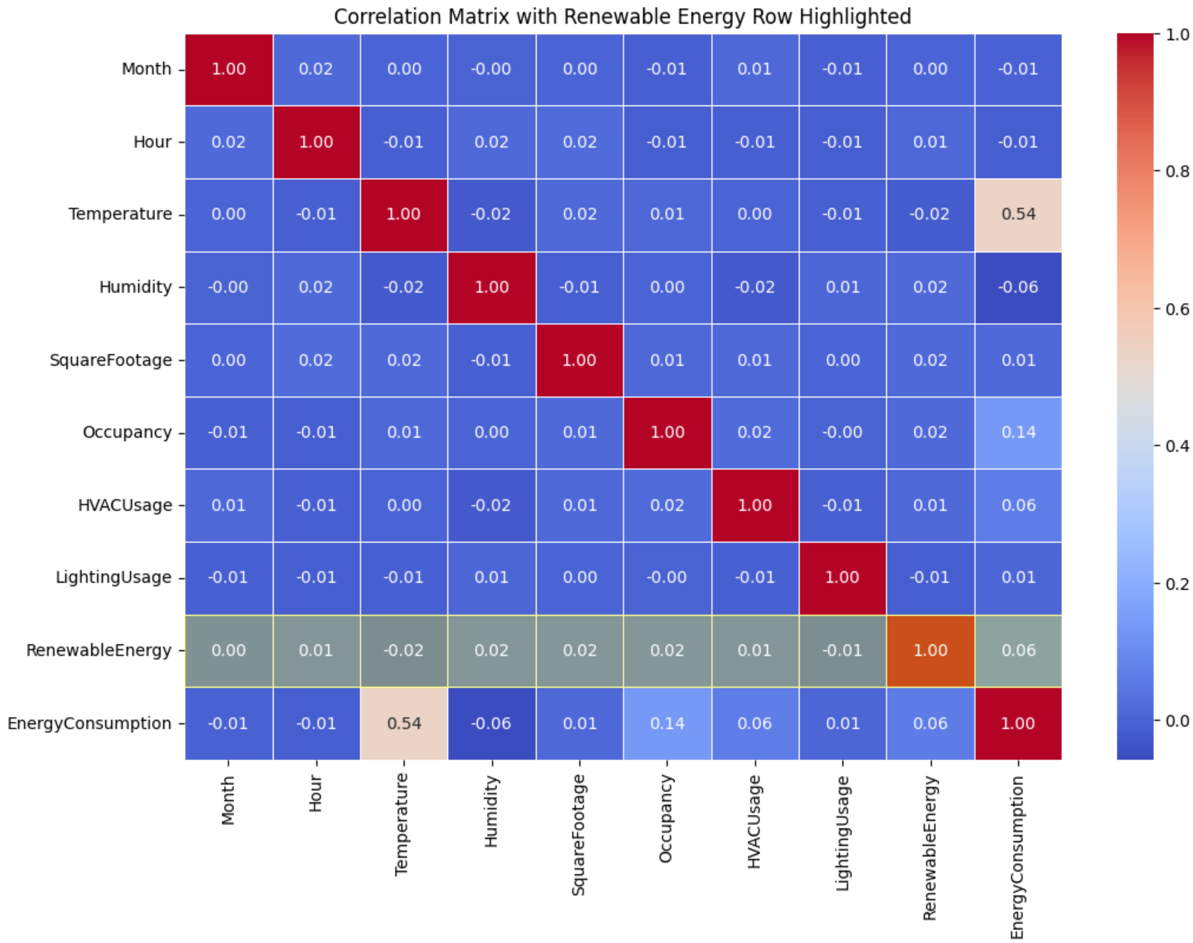

Figure 4: Correlation Matrix

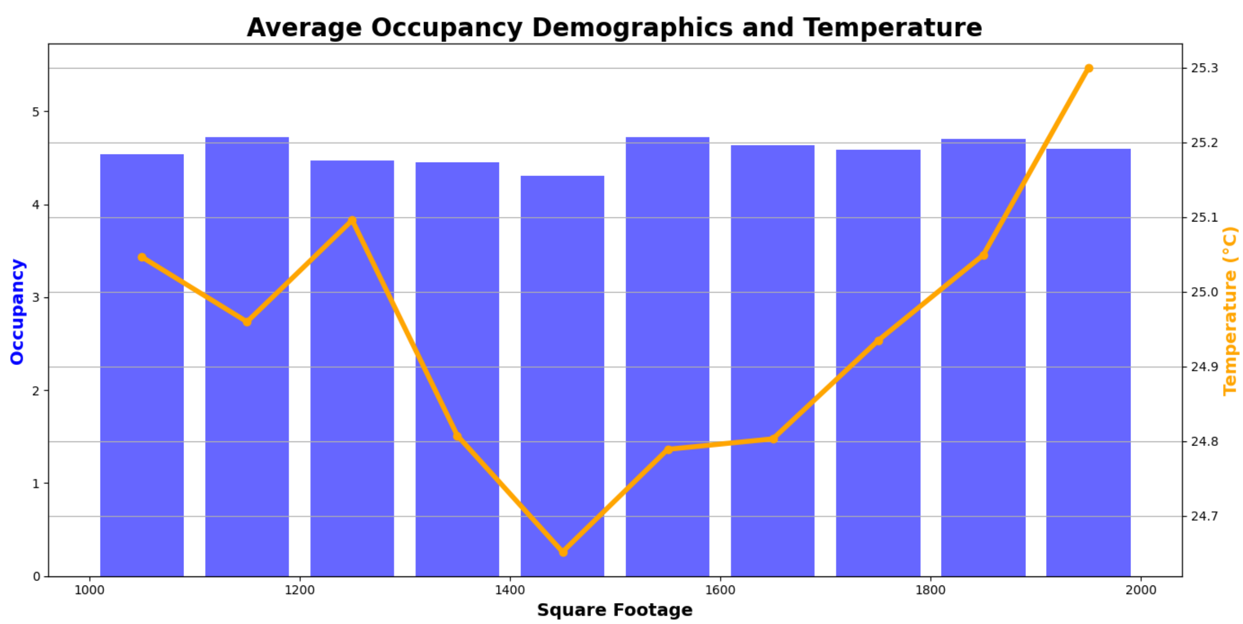

Figure 5: Occupancy vs Temperature

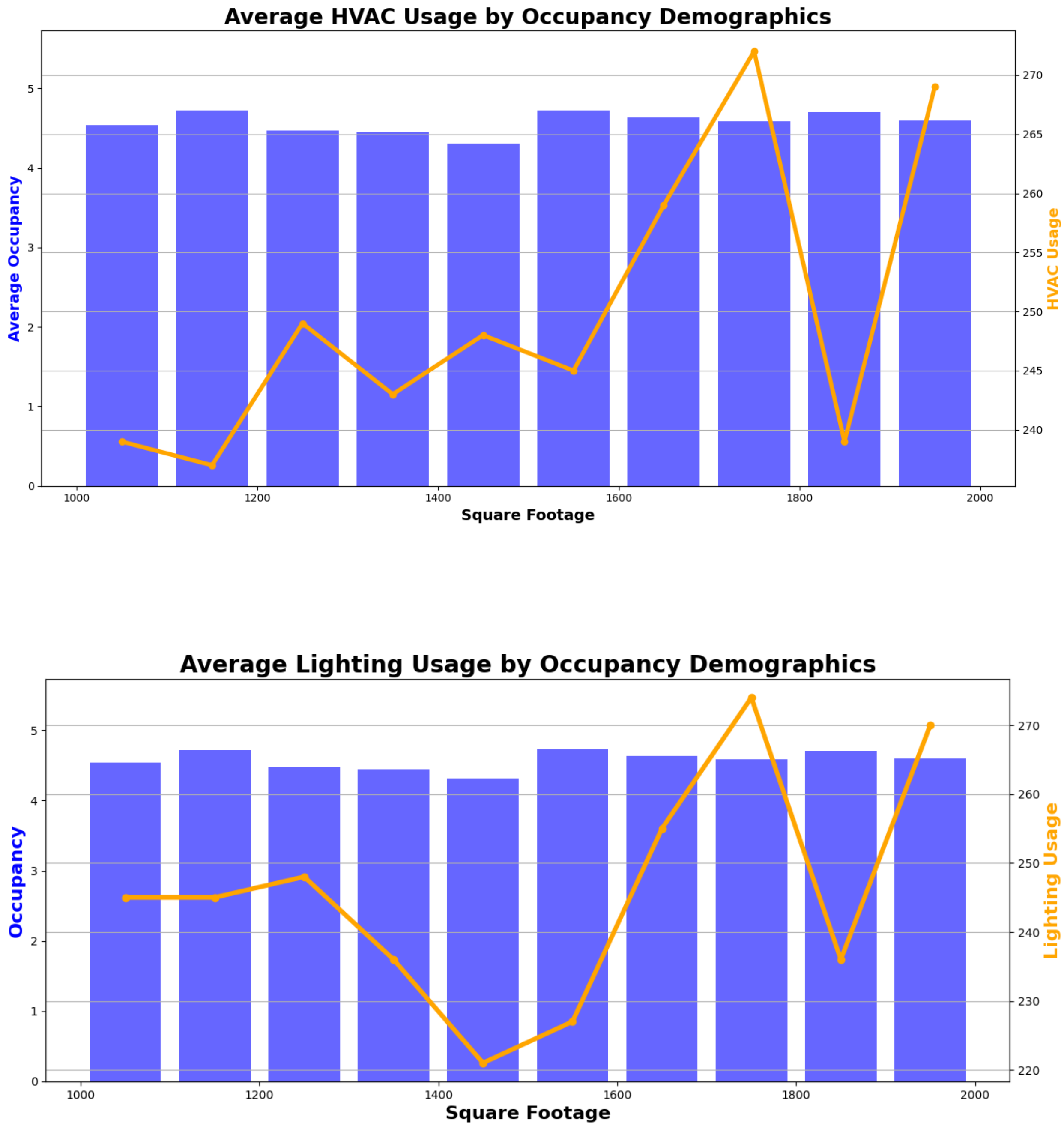

Figure 6: Utility Usage vs Occupancy

Renewable Energy Indicator

Green power sources assist in slowing down the rise of temperature in developed demographics with buildings and infrastructure, as displayed in earlier graphs. What the audience would like to know if it can replace it to improve the efficiency of the city. Based on Figure 6, it shows that the difference of energy consumption both renewable and non-renewable in a timely based, which adds up to the total energy usage. It appears that there is a 15 KWh of green energy in every 77 KWh of total energy consumed on average; that is about 20% of green energy on average in all sizes of properties every month. The distribution chart gives a clear view of how much we need to improve to allocate the clean energy to operate communities or cities instead of 80% depending on non-renewable sources.

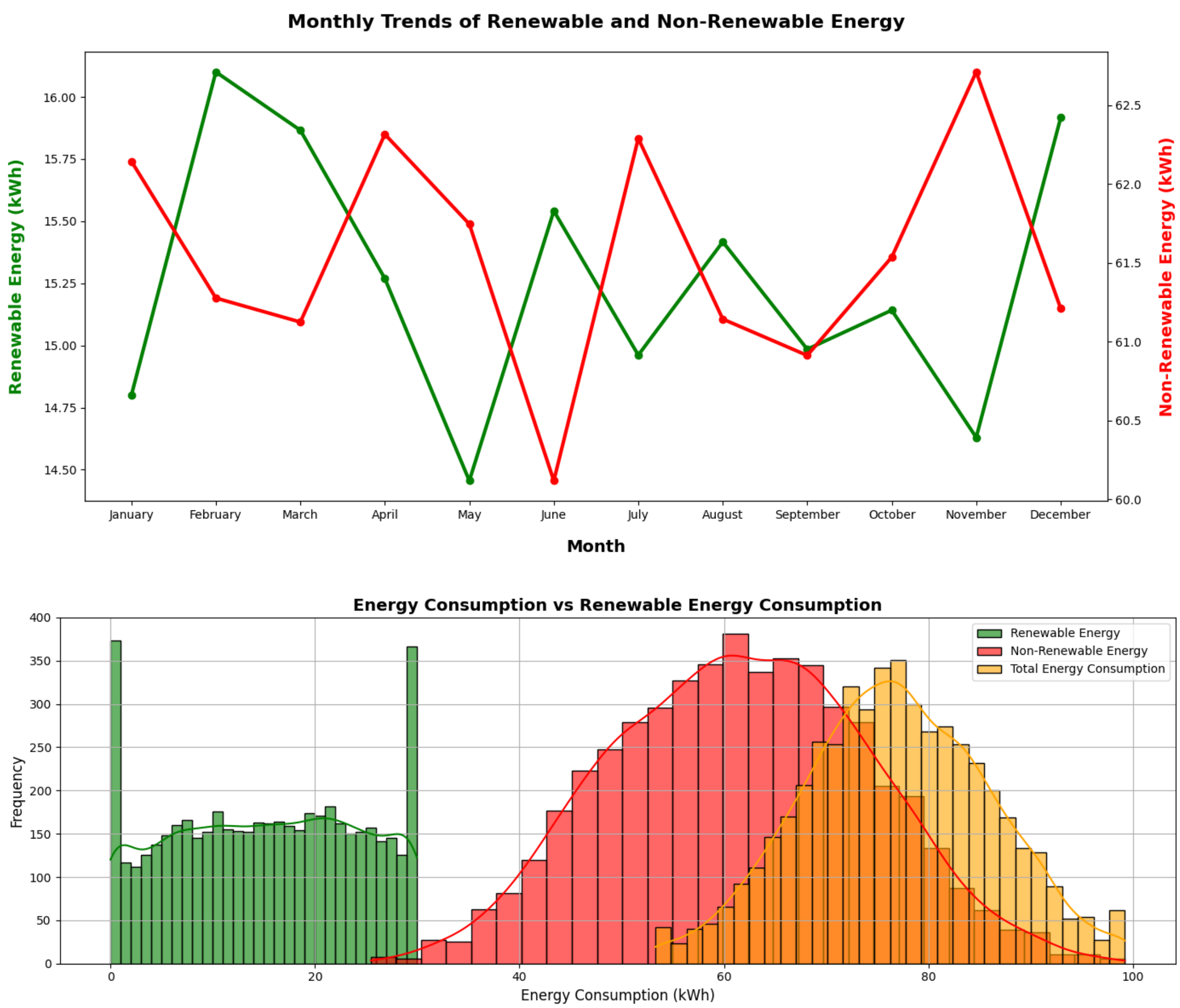

Figure 7: Renewable vs Non-renewable

The question is what can we do to increase clean energy applications? The answer lies on our customer who are the occupants in those areas to apply the idea of renewable energy. Since the average on each area group is between 4 to 5 inhabitants, what happens when the population grow in the next year, and people are occupying in more spaces together? According to Figure 8 on Sensitivity Analysis, it shows that if population does grow in every area size from 4.5 on average to 6.5 on average, time by time, it is possible for the residents or workers to have renewable energy conducted in their places from 15.2 to 16.7 KWh on average. Also, as the renewable and non-renewable energy has an inverse relationship, the dependence on non-renewables are seen to be declining. Therefore, clean energy will have more share in the market in the near future when population accumulates.

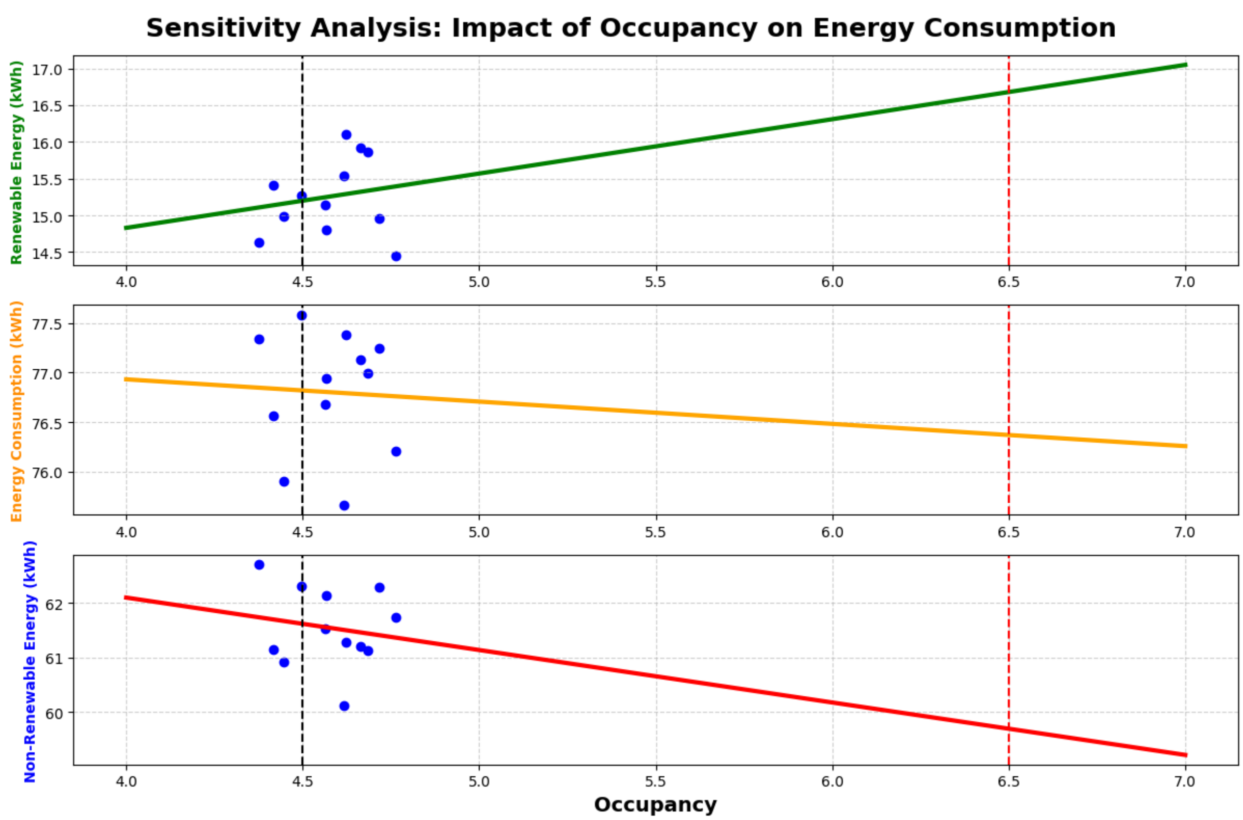

Figure 8: Energy Sensitivity Analysis on Occupants

Recommendation and Implication for Clean Energy Improvement

Evidently, the sensitivity analysis compelled a promotion of the average consumption of renewable energy in each area group when the average occupants rise from 6 to 7 on average, which is a good news for the concern of ESG on the environment dimension for making the supply chain, commercial property networks, and communities to mainly adopt clean energy sources. Figure 9 implies areas of residents where they need to be encouraged or supported to execute green energy policies. There is a good amount of green energy between 13 and 14 hundred squared footage. This can be a learning experience of adoption to enhance the feasibility of other areas. It also show opportunities of future clients and partnerships with the segment of those large area groups to make their operations more sustainable in the long term since we know that they consist the most usage of Lighting and HVAC.

Firstly, there is already a gaining momentum from areas more than 16 hundred squared feet. As a result, doing an extra analysis of cost reduction and renewable energy adoption can promote more participation from those large areas who are seemingly wealthier and brand-committed to adopt or afford. Second, since more influential places are using green energy devices for homes and operations it will directly set as an example for the lower areas to see it as a standard of living of reducing cost and contributing to the healthy environment. As the people in large areas consume these technologies, more will be available for demand making those green technologies becoming more and more affordable and accessible for services to gain the market in specific regions of areas with similar amount of people on average. Thus, this will be an ideal strategy for organizations to uphold green ideas when occupants are increasing in the future.

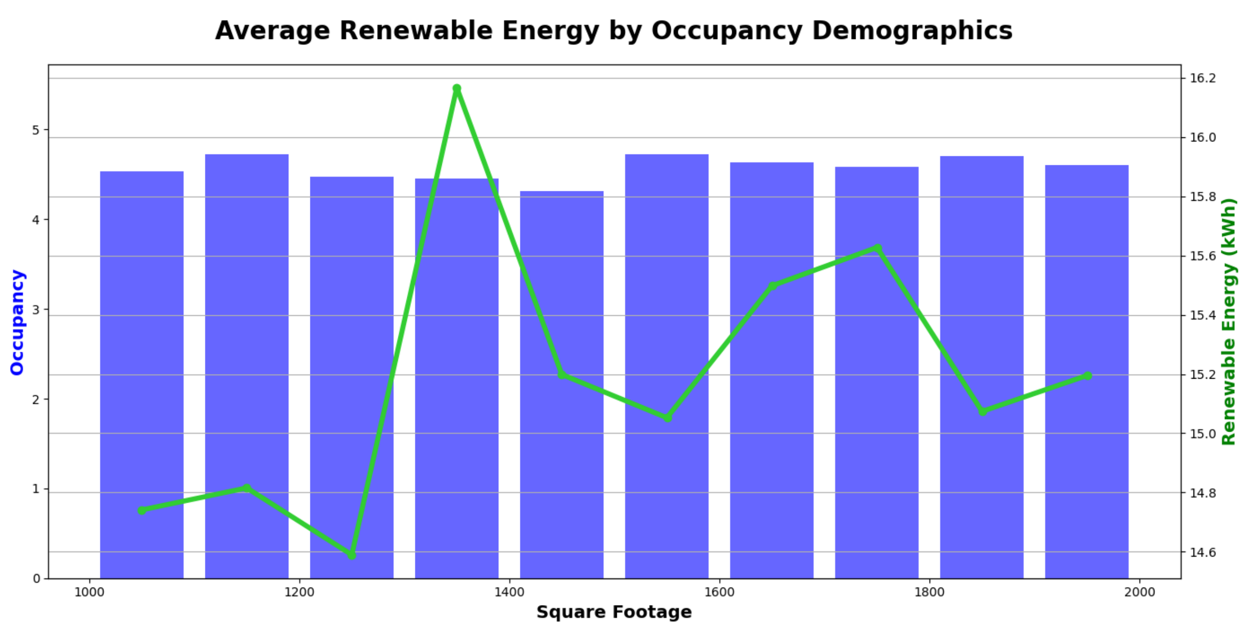

Figure 9: Renewable energy consumption by area

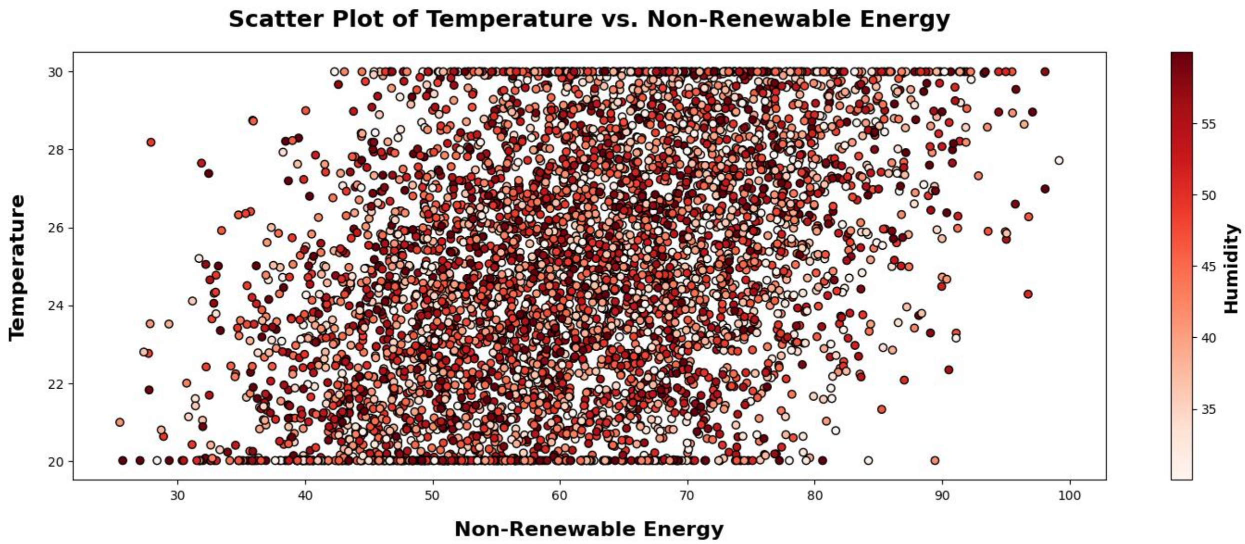

Figure 10: Humidity vs Temperature & Non-renewable energy

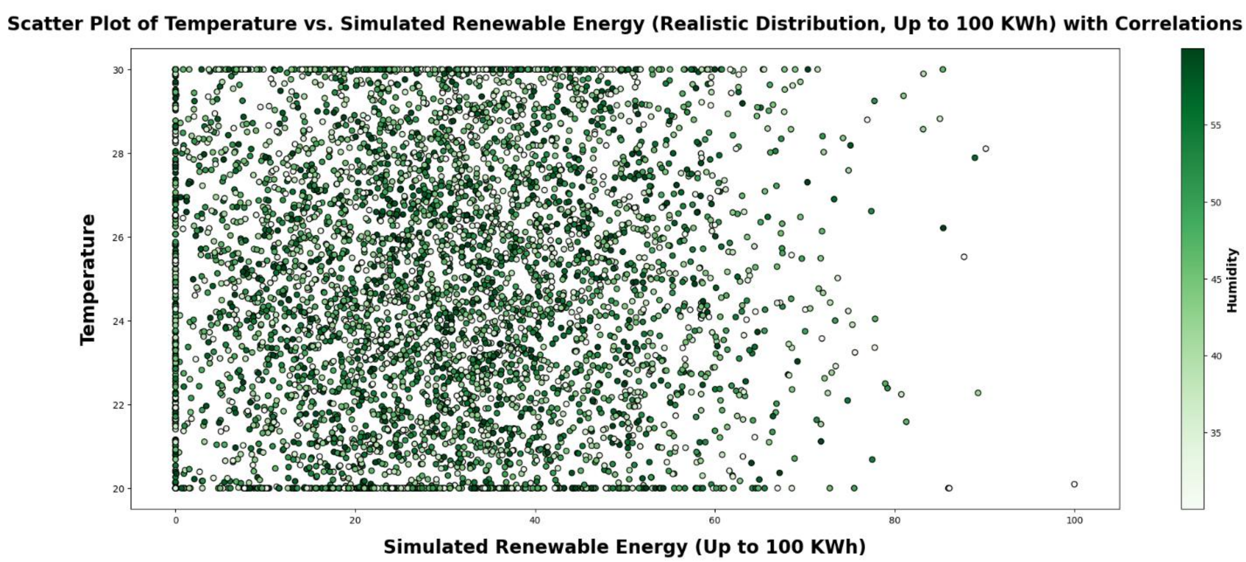

Figure 11: Humidity vs Temperature & Renewable energy

In addition, non-renewable energy demonstrates more humidity alongside the soaring of temperature. For indoors, it makes way for mold and mildew to grow negatively impacting the internal air quality for occupants if the pattern continues to increase when population grows in the next future (Bracamonte, 2024). Further, high humidity obstruct the human bodies to sustain its cool temperature through sweating, giving the affect of heat strokes (Guarnieri, Olivieri, Senna, & Vianello, 2023). What is more menacing is that high moisture tend to keep viruses or infectious bacteria from evaporating as they are uniformed in droplets of water; therefore, it is common for people to transfer infections from one to another (Liu, Cao, Xia, Pan, Rao, Chen, & Zare, 2024). Not to mention on the structural governance side that the more moisture there is, the prone it is for building structures to be impaired, such as leading wood to rot, metal to corrode, and concrete to weaken; inducing more costs in the future for residents and organizations, make the communities and cities unsustainable (Worrall, 2023).

As a consequence, adopting green power sources at early stages also have advantages for future health considerations and sustainability in terms of building structure and finance. Figure 11 engages a simulation of renewable energy implementation with capacity extension the same as the non-renewable one; the current one is at its maximum of 30 KWh, referred to the appendix. It considers the correlation of the current available data of renewable energy with humidity and temperature. As the simulation tries to approach to the limit capacity like the real data of the non-renewable energy up to 100 KWh, it gives a scenario where there is less intense affects for the green energy source to influence the moisture. The humidity appears to be balanced even if we increase the current 30 KWh maximum capacity of renewable energy to 100 KWh when the demand grows. This will inverse the impact of high humidity and elevate the environmental harmony, social health, financial sustainability, structural governance.

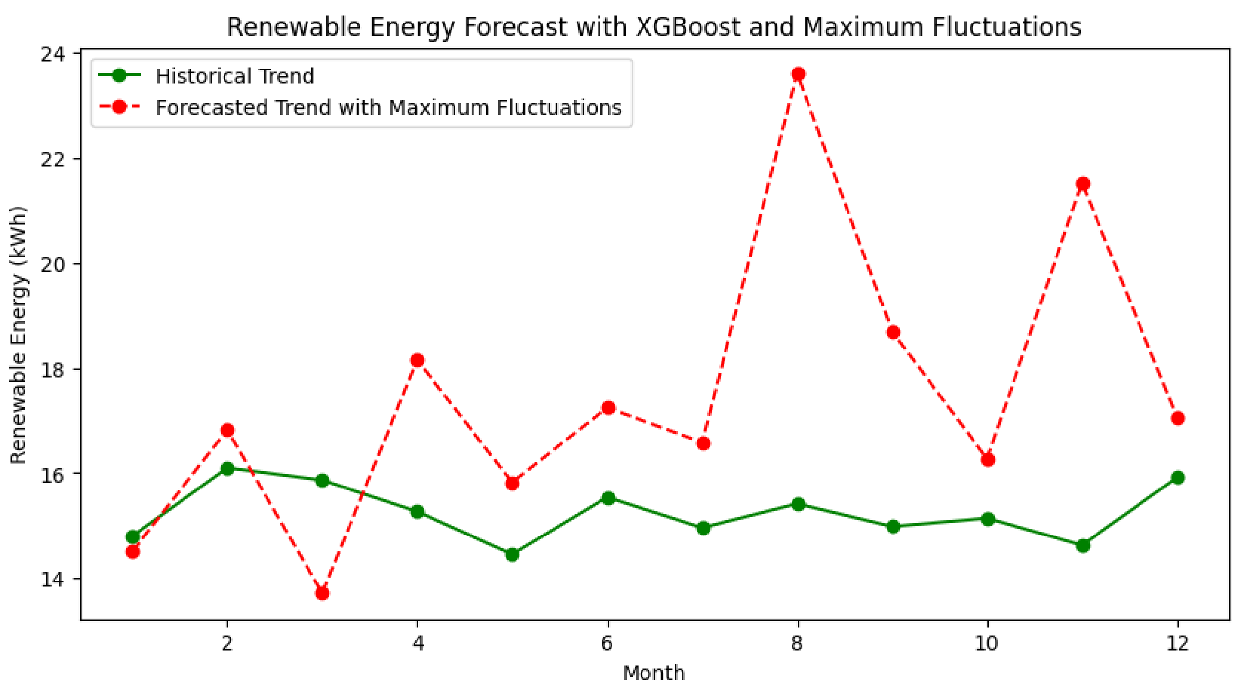

Figure 12: Green energy adoption prediction

To support these findings and implications, Figure 12 offers a forecast in the next 12 months of the behavior of green energy consumption compared with the present one. The model is partitioned into 80% for training and 20% for testing with the MSE of 0.28 using XGBoost model. It is one of the advanced machine learning algorithm in dealing with time series and preventing overfitting the model for great accuracy (Jurasz, & Abdulla, 2024). If people and organizations are aware of the disadvantages and the costs they have to balance their reluctance over the application of green energy, one can witness a great climb and improvement from 16 KWh to 24 KWh as the new maximum green energy consumption by month, based on the model.

Therefore, to improve underrepresented communities, renewable energy companies can gain tax incentives and subsidizing for placing and testing their technologies for the residents to be aware of the ESG concern and advance themselves to smart home technology for energy efficiency, like battery storage to address intermittency issues with solar and wind power, proposed by IEA (2024). Additionally, to motivate SMEs, partnering with those existing green brand or energy technology companies can help with their operational efficiency as those larger companies intend to expand their ESG portfolio in sectors of businesses and CSR. Financial institutions can offer more credit to those green energy-branded SME's to foster their eligibility and credibility for investors (Yoon & Lee, 2023). For large corporations, they should apply advanced analytics with their existing green energy to optimize efficiency in detecting worker occupancy with energy consumption and automatic ventilation systems in buildings, warehouses, and manufactures to affirm the humidity level for employees and sustainability. Finally, the advocation of policies for high income people to use high-quality and sustainable green products of energy sources to incentivize their bank credits.

In conclusion, people and organizations should begin initiatives to adopt, partner, and collaborate to not just maintain but advance their environmental, social, financial, and governance dimensions whether it is in community or city scale. The more people are reached with these messages, the sooner the result can be in a much more favorable and productive timeframe.

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Appendix

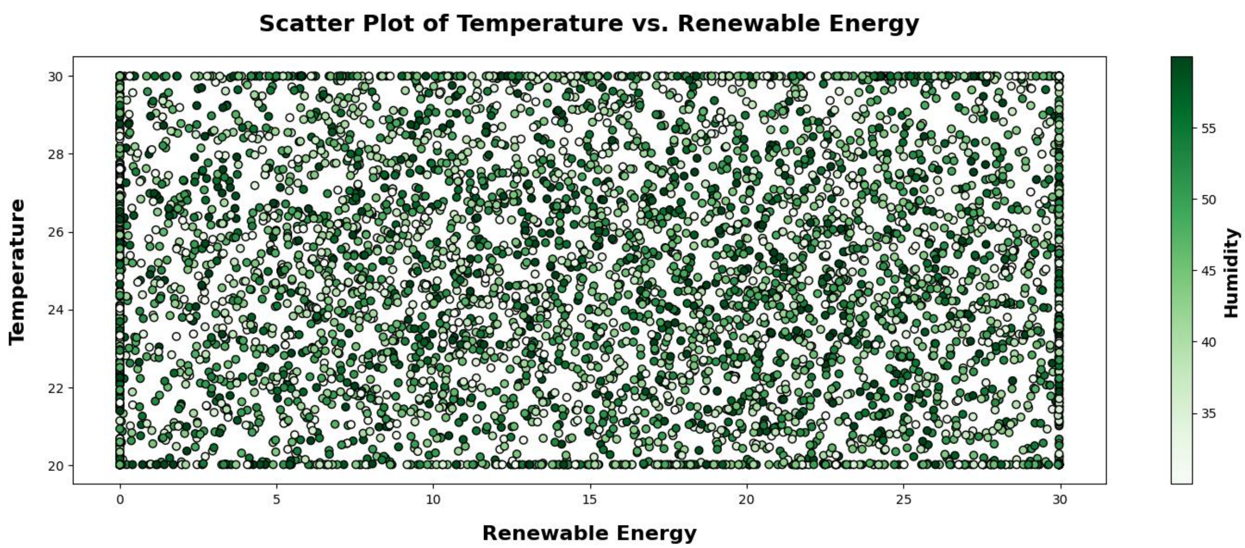

Figure A-1: Green energy effect over humidity alongside temperature