Supporting Water Utilities Renewable Energy Transition with PV and Batteries Storage System

In the current era of rapid development in renewable energy, nations are strongly dedicated to mitigating carbon emissions and facilitating the widespread adoption of renewable energy. This commitment has emerged as a shared aspiration for their overall development. The role of high-energy users is at the heart of the renewable energy transition. These users have a higher potential to reduce carbon emissions and energy costs when transitioning to renewable energy. As high energy users, large water utilities face energy consumption and carbon emission challenges. In Australia, achieving zero carbon emissions by 2050 has been a lofty objective(Department of Climate Change, Energy, the Environment and Water, 2022). Many large water utility corporations in Australia are ambitious to achieve net zero carbon. For example, Victorian water utilities will be sourcing 100% of their energy needs from renewable sources by 2035(Department of Energy, Environment and Climate Action, 2023).

The average electricity demand at a water corporation, such as Coliban Water or Sydney Water, reaches more than 1 MW energy consumption throughout the year (8,760 MWh p.a.). This leads to expensive energy bills (more than $1 million p.a.) and intensive carbon emissions (more than 7,000 tons CO^2 p.a.) (Coliban Water, 2021). In response, the State Governments expect water corporations to set their strategic goals towards carbon emissions reduction. Some water corporations, such as Sydney Water and Coliban Water, proactively demonstrate their contributions and leadership in achieving carbon emission targets. For example, Sydney Water has been adopting and investing in the renewable energy system, which covers 20% of the energy usage per year(Sydney Water, 2022), and Coliban Water has committed to reducing 13% of its carbon emissions by 2025 with 4,300 tonnes of CO^2 reduction per year.

Although water corporations are interested in adopting renewable energy in response to the pressure, incorporating renewable energy into water utilities would add complexity to the industry regarding technology and regulation. In addition, uncertainty in investment returns and difficulties in matching energy production with energy demand challenge current investment in renewable energy projects (Tarallo, 2015). These uncertainties may affect the ability of water utilities to increase their future renewable energy generation capacity, thus impacting their ability to achieve established goals. This research will specifically investigate a case study of a water corporation that aims to achieve net zero carbon emissions by 2035. The case study will investigate the potential benefits of the photovoltaic (PV) power generation and battery energy storage systems (BESS) deployment for water corporations from both carbon emission reduction and economic side.

Simulation and Analysis

The simulation and analysis framework also encompasses the potential deployment of future PV systems battery energy storage devices. As shown in Figure 1, this study adopts the data analysis based on one of the wastewater treatment plants of Coliban Water energy demand from 2020-2021; the average energy demand is higher than 1.2 MWh. The estimation, as shown in Table 1, considers three scenarios: 1MW PV system(low), 4MW PV system(medium) and 6MW PV system(high). To further improve the rooftop PV's utilisation and efficiency in the future, there is a need for an energy storage capacity (70% of the PV installed).

The monthly net demand of both scenarios is shown in Figure 2-4; the estimated annual electricity demand offset with scenario A only reaches 18%, scenario B will reach 51%, and scenario C is around 57%. On the carbon emission analysis, as shown in Figure 5- 7, the carbon emission reduction performance of PV with BESS is superior in both scenarios. The carbon emission reduction with scenario A only reaches 13.03%, scenario B will reach 40.98 %, and scenario C is around 49.9%.

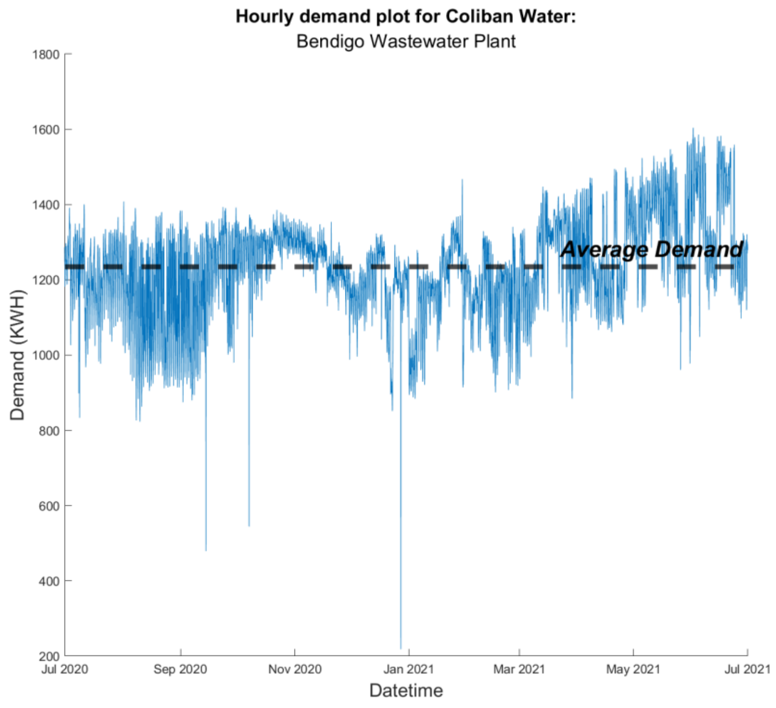

Figure 1 Hourly demand of wastewater plant (2020-2021)

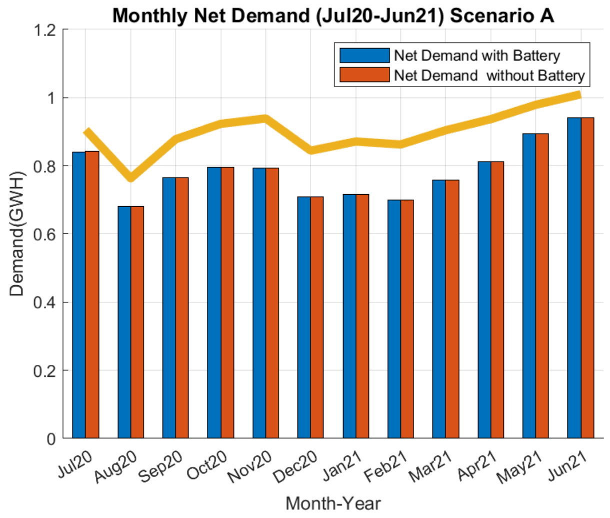

Figure 2 Net electricity demand in Scenario A

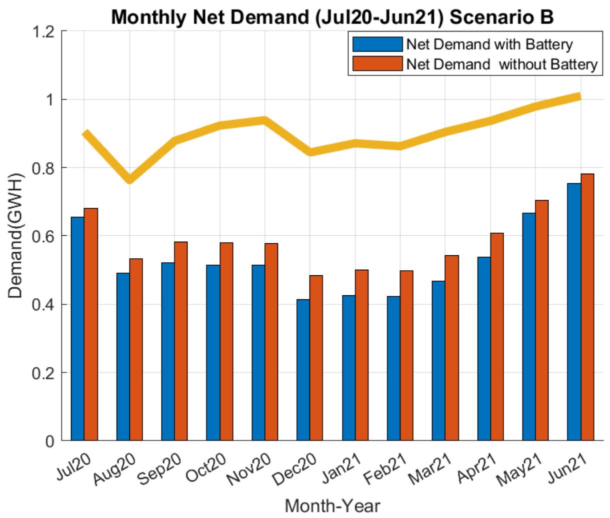

Figure 3 Net electricity demand in scenario B

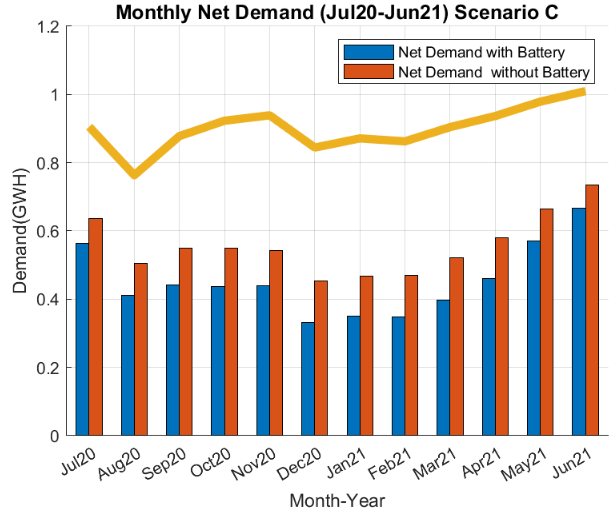

Figure 4 Net electricity demand in Scenario C

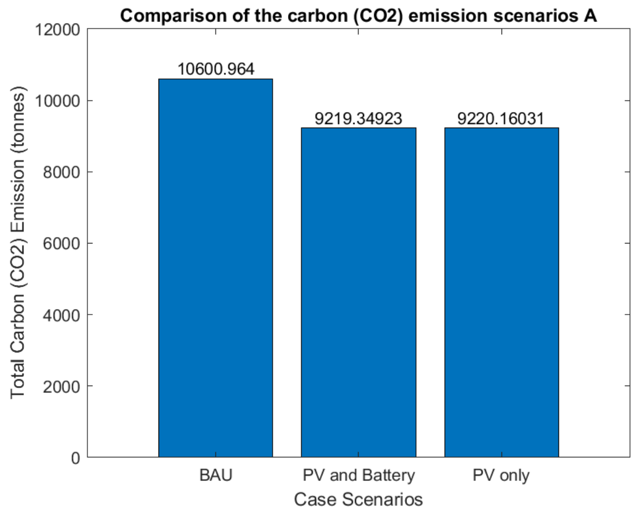

Figure 5 Carbon emissions compare in scenario A

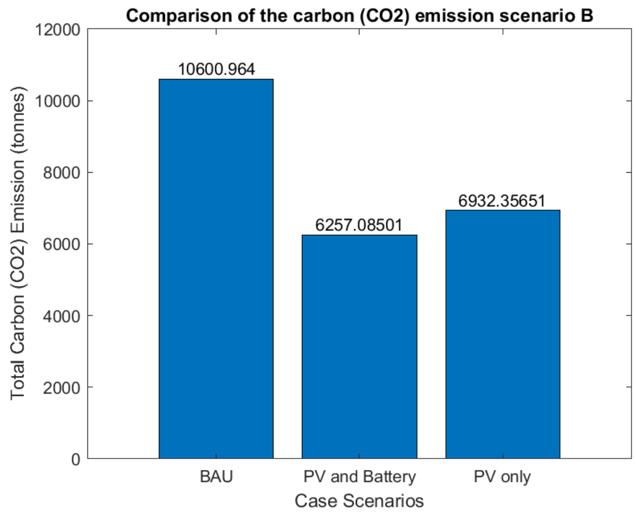

Figure 6 Carbon emissions compare in scenario B

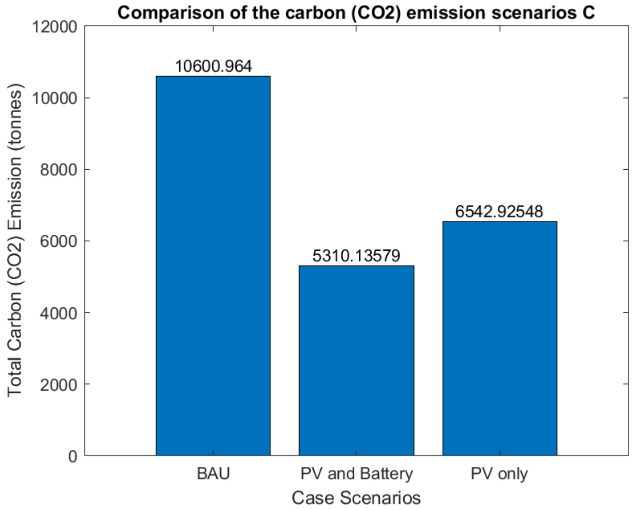

Figure 7 Carbon emissions compared in scenario C

Table 1 The potential scenario cases

Scenario Groups	Scenario cases
A: Potential 1MW PV System	A1. Basic scenario (No battery capacity)
	A2. Battery capacity at 70% of PV capacity
B: Potential 4MW PV System	B1. Basic scenario (No battery capacity)
	B2. Battery capacity at 70% of PV capacity
C: Potential 6MW PV System	C1. Basic scenario (No battery capacity)
	C2. Battery capacity at 70% of PV capacity

Table 2 NPV and estimated payback period for different scenarios

Scenario cases	Estimated initial capital cost (AUD)	25 years NPV with BESS (AUD)	Payback period (year)
1 MW PV + 0.7 MWh battery	2,018,000	3,600,000	12
1 MW PV	1,668,000	478,300	19
4 MW PV + 2.8 MWh battery	8,072,000	2,649,900	20
4 MW PV	6,672,000	342,930	24
6 MW PV + 4.2 MWh battery	12,108,000	924,620	24
6 MW PV	10,008,000	-1,020,100	>25

As shown in Table 2, based on the associated financial metrics and considering positive NPV, reasonable payback period and economic and environmental benefits. The most feasible option for a wastewater plant could be determined as scenario A2. On the contrary, associated with the previous monthly demand offset and carbon mission analysis, scenario B2 appears to be more reasonable.

In conclusion, Scenario B2, featuring a 4 MW PV system with a 2.8 MWh BESS, emerges as the most feasible option. Its positive financial performance, balanced system size, and alignment with sustainability objectives make it a compelling choice for high-energy users seeking to reduce energy costs and carbon emissions effectively while achieving favourable financial returns.

Conclusion

In short, observations and findings regarding the PV and BESS for future development show great potential to significantly offset the study case's electricity demand and help achieve the carbon zero goal. The water utility needs to invest heavily in rooftop PV and BESS systems. In this case study, it is expected to achieve a demand offset of 51% under the best expectations. PV and BESS alone cannot meet 100% locally generated renewable energy. It is also recommended to consider the further development of a medium to large-scale solar farm and the potential utilisation of new technologies, such as building integrated PV and Peer to Peer energy trading from surrounding communities, which will have a greater impact in offsetting electricity demand and achieving net zero with renewable energy.

Reference

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