Solar Powered Transportation – We can do it!

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Abstract: A recent study sponsored by the Mineta Transportation Institute showed that a new approach to urban transportation powered by co-located solar PV with grid tie and local energy storage is feasible and highly desirable for reducing greenhouse gas emissions and soot particulates, while vastly improving traffic safety.

Keywords: Automated transportation networks, solar PV

1. Introduction

Urban transportation around the world suffers from many significant problems that the dominant approaches, in their current form, are unable to solve. Among the most serious are the production of greenhouse gases and pollutants, safety, and congestion. Automated Transit Networks (ATNs) have long been proposed to meet the safety and congestion issues (Furman, et.al., 2014), but it is only recently that solar powered ATNs have been investigated (Furman, et.al, 2021). Figure 1 shows what a section of a solar ATN could look like. The vehicle guideway is shown, above which a canopy of solar PV panels is attached. The passenger vehicles are suspended from, and move along, the elevated guideway infrastructure with support posts spaced approximately every 20 m.

Figure 1: Solar powered automated transit network (ATN) with PV canopy

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A unique feature of the system is its use of offline stations as shown in Figure 2 (where the solar canopy has been removed for clarity). Passenger vehicles travel non-stop from an origin station to a destination station and bypass intermediate stations. The arrows in Figure 2 show that when the vehicle approaches the destination station (such as the one seen in the upper left), the vehicle diverges off the main line to stop while vehicles with other destinations pass by on the main line.

Figure 2: Solar ATN with PV canopy removed to show guideway and offline station

A detailed study sponsored by the Mineta Transportation Institute (MTI) was conducted to investigate the feasibility of providing 24/7 power to a proposed three-mile solar ATN that connects the North and South campuses of San José State University (SJSU), shown in Figure 3. The study optimized a grid-tied solar PV system with local energy storage and developed visualizations of the route (Furman et.al., 2021).

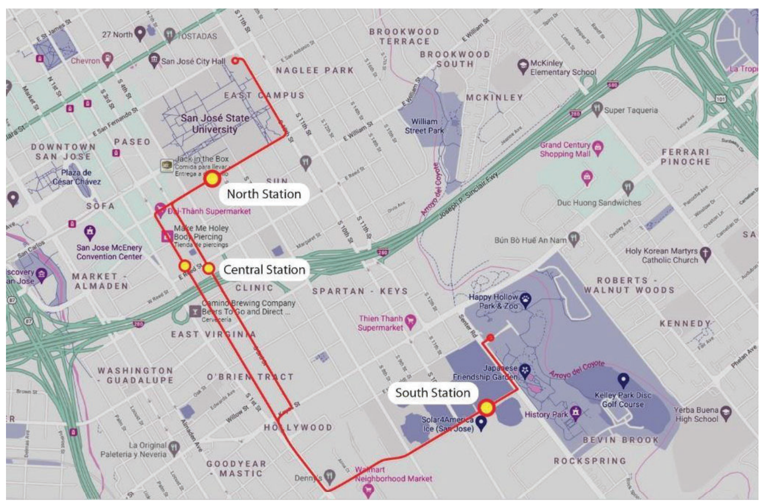

Figure 3: Proposed ATN connecting SJSU campuses

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2. Results of the MTI Study

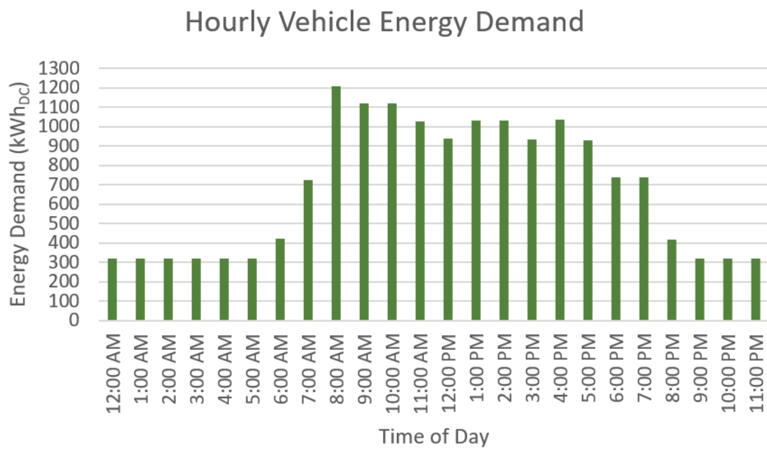

Figure 4: Energy demand based on existing shuttle data

The hourly vehicle energy demand shown in Figure 4 was simulated with SUMO/SUMOPy (Lopez, et.al., 2018 and Schweizer, 2013) using ridership data from the SJSU Park & Ride shuttle bus service. The energy demand of the stations and maintenance depot was also considered, as well as transmission and conversion losses associated with the PV-battery system. Demand peaks in the morning (at the start of the school day), remains steady through the afternoon (as varying class schedules cause students to leave campus at different times), and declines in the evening (until all classes end). By simulating the annual energy sourced

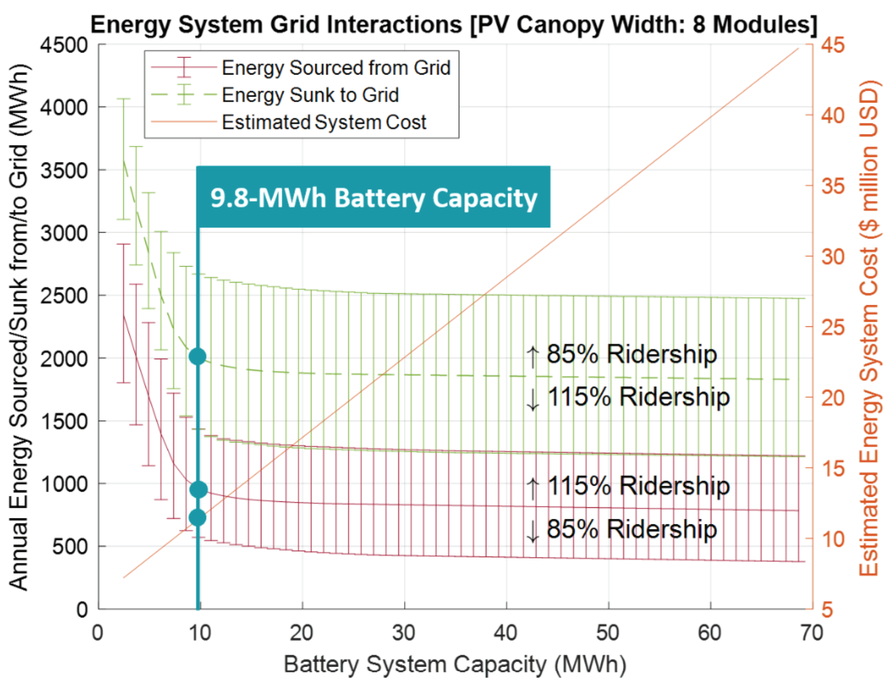

Figure 5: Modeling results for 8-module wide canopy

and sunk from/to the grid for different PV canopy configurations and battery capacities, the most economical system has a 6.2-MW rated PV output and 9.8-MWh storage capacity. The optimized system is denoted by the knee point in Figure 5, beyond which larger (and more expensive) batteries yield diminishing returns in grid independence. The system is summarized in Table 1, with projected energy costs that are comparable

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to those of the existing Park & Ride system, as well as an anticipated 98% reduction in CO2 emissions (Figure 6) and PM2.5 particulates. Finally, the net emissions of the solar ATN are expected to be negative, indicating that more emissions will be reduced (by providing clean energy to the grid) than produced (by using grid energy).

Attribute	Value	Units
Dual-Way Guideway PV Canopy Width	8	Modules
One-Way Guideway PV Canopy Width	6	Modules
Total Number of PV Modules	17,699	Modules
PV System Rated Output	6.2	MW
Total Number of Battery Packs	40	Packs
Battery System Capacity	9.8	MWh
Annual Energy Sourced from Grid	957	MWh
Annual Energy Sunk to Grid	2,000	MWh
Estimated Energy System Cost	$11.4 million	USD
Estimated Energy Cost	$0.153	USD/pass-mi
SJSU Park & Ride Energy Cost	$0.208	USD/pass-mi

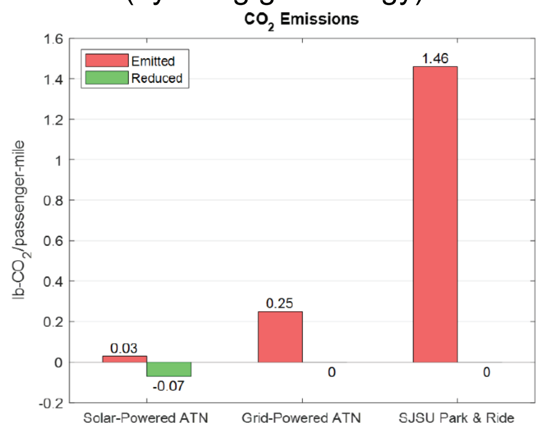

Figure 6: CO2 emissions per passenger-mile

3. Conclusions and Recommendations

This study shows that it IS feasible to power a public transportation system 24/7 with grid-tied, zero net-metered solar PV and local energy storage. Further, it was demonstrated that a solar ATN can provide an equivalent ridership service at a comparable cost to the existing SJSU Park & Ride, yet with net negative emissions. Future work is needed to develop vehicle scheduling and energy management strategies to enhance energy efficiency.

4. Acknowledgments

This work was funded by the California State University Transportation Consortium (CSUTC) led by the Mineta Transportation Institute at San José State University. We also acknowledge: Prof. Joerg Schweizer from the University of Bologna for his help with SUMO/SUMOPy; Eric Cross and his predecessor, James Renelle, from the SJSU Parking organization for data on the SJSU Park & Ride shuttle bus; and the design team assembled by Jorge Rodriguez of RODZMAS including Mario Cruz, Juan Antonio Islas Muñoz, Arturo Millan, César Pérez, Elena Casas, and Juan Méndez, who did stunning work to tell the story about why solar ATN is needed, what it would look like, and how users would experience it.

5. References

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