

Solar-Powered Automated Transportation Networks

A Bold Leap Forward for Truly Sustainable Transportation

Burford Furman
San José State University

Ronald Swenson
INIST

Jackson Fogelquist
University of California, Davis

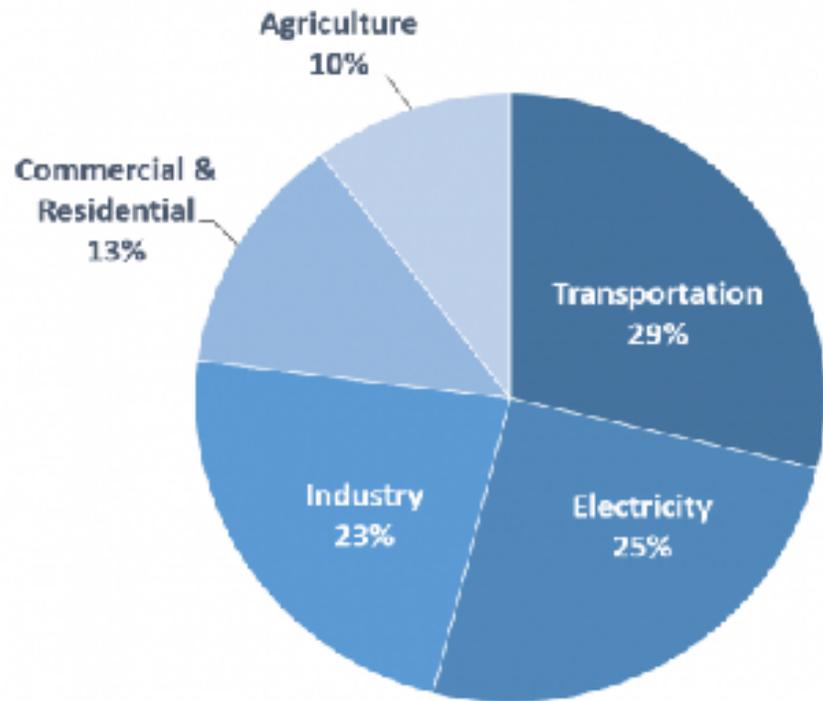


2021 International Transport Forum Pre-summit Research Day: Transport Innovation
for Sustainable Development: Re-shaping Mobility in the Wake of Covid-19

May 11 - 12, 2021

Radical reductions in carbon emissions are needed in the transportation sector

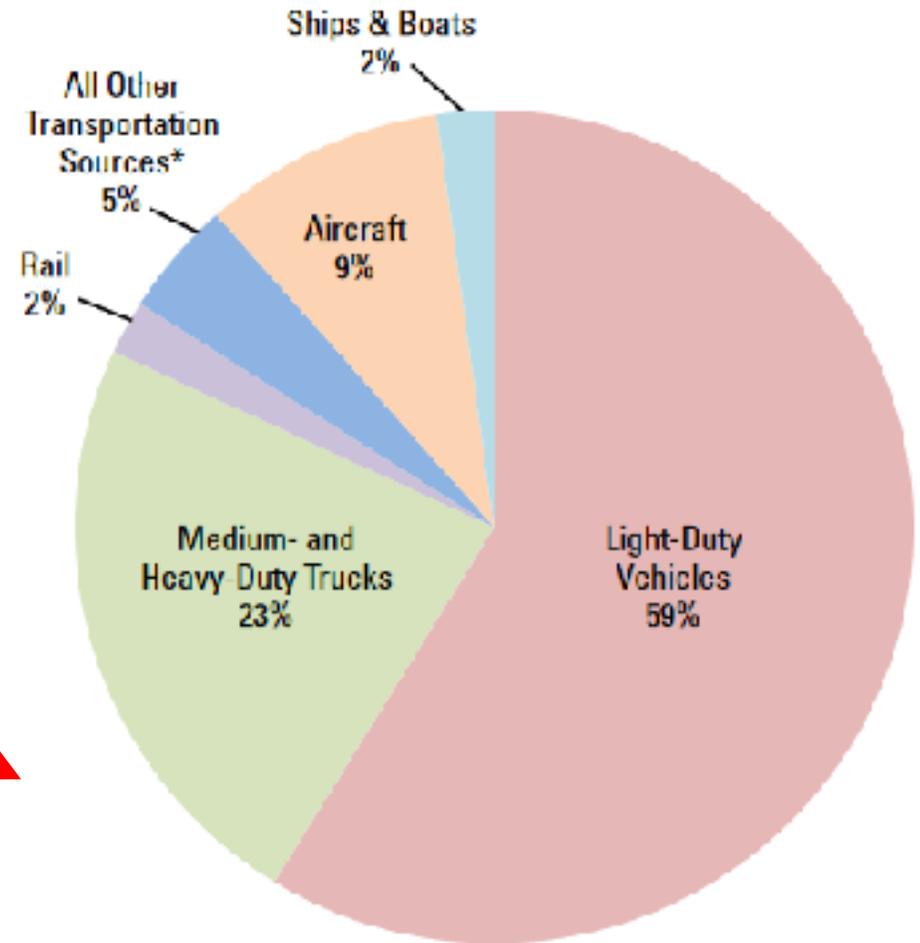
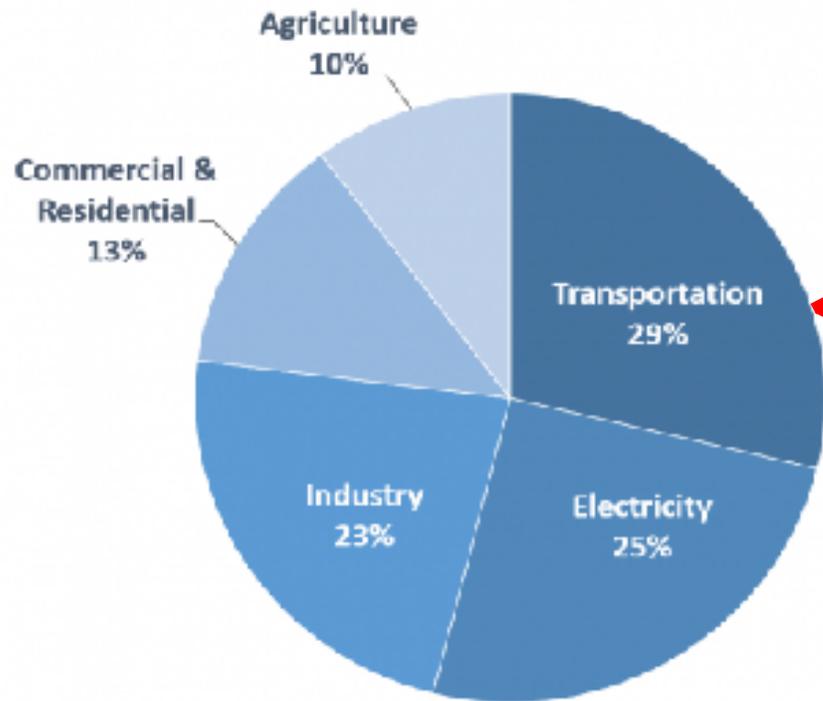
Total U.S. Greenhouse Gas Emissions
by Economic Sector in 2019



Source: <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

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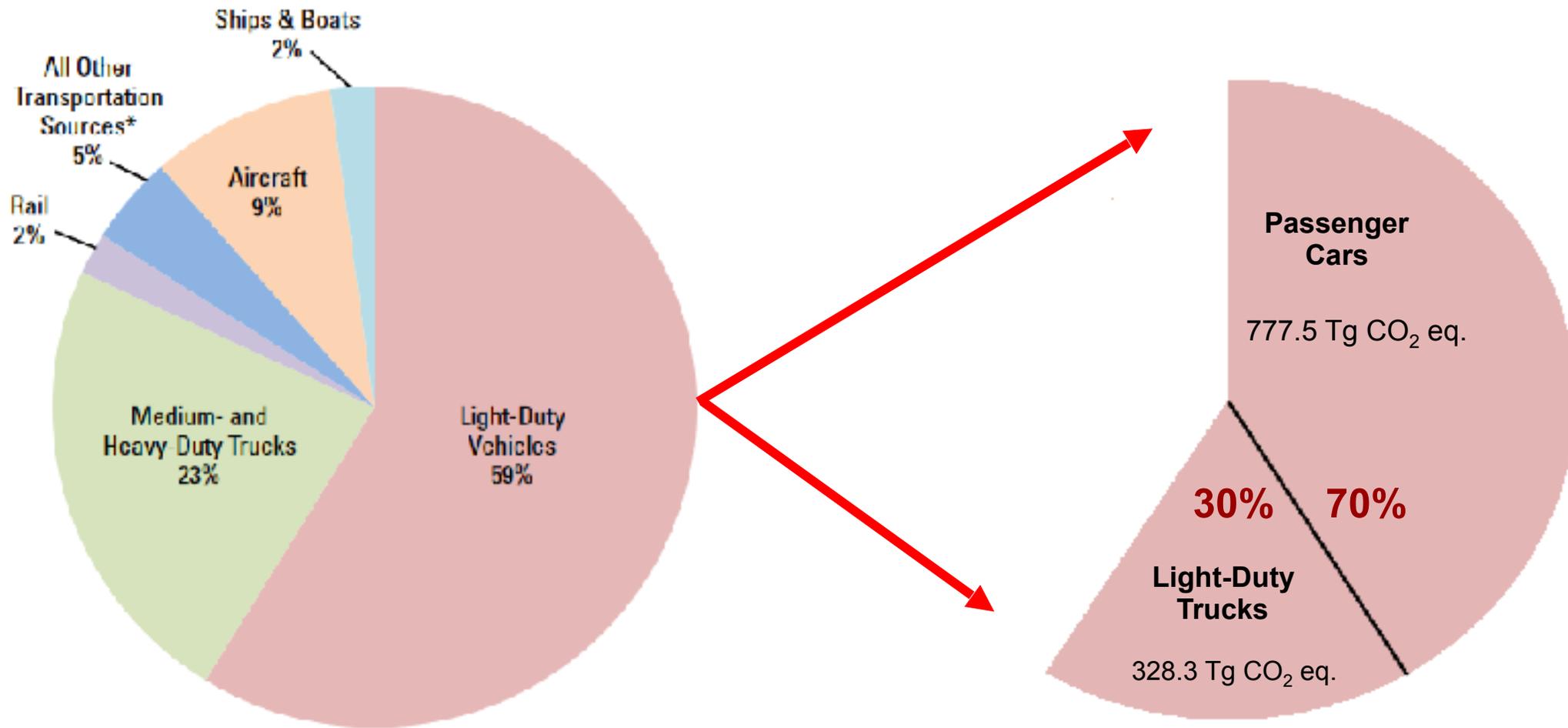


Source: <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

Source: <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ZK4P.pdf>

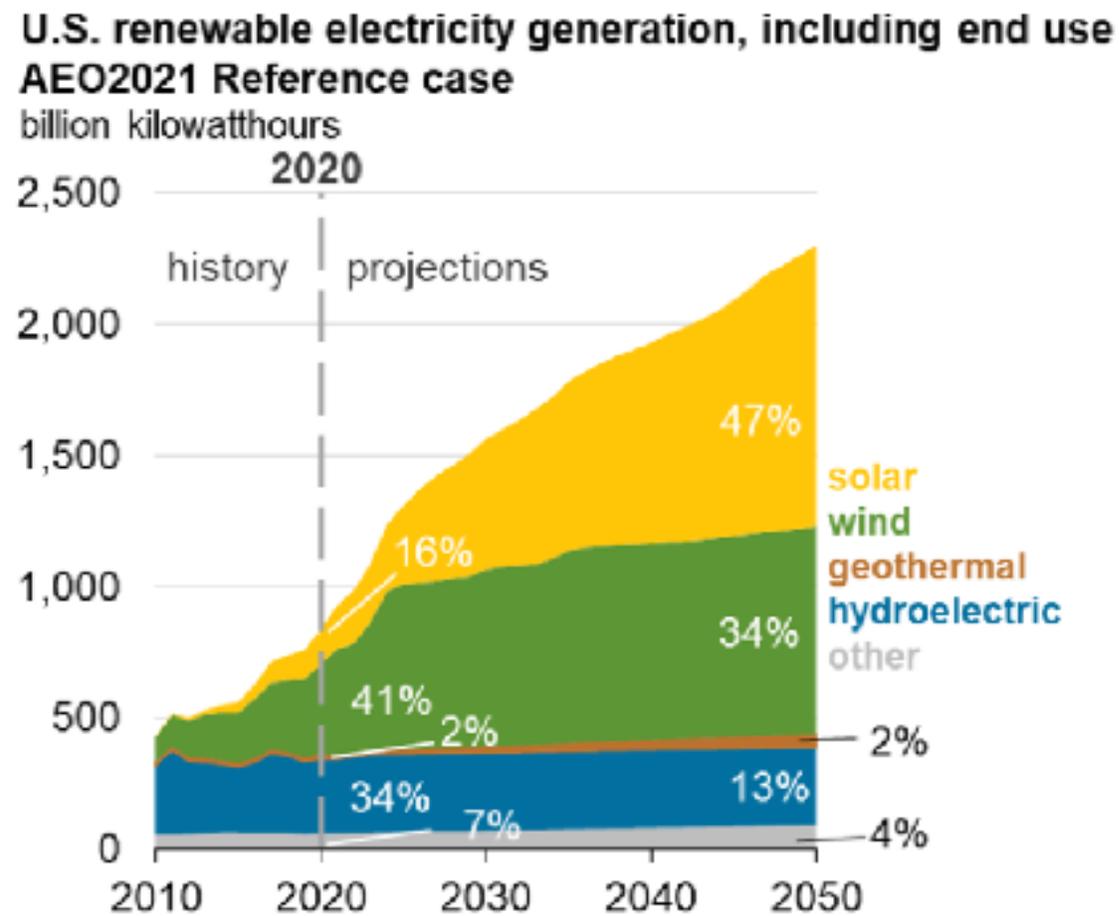
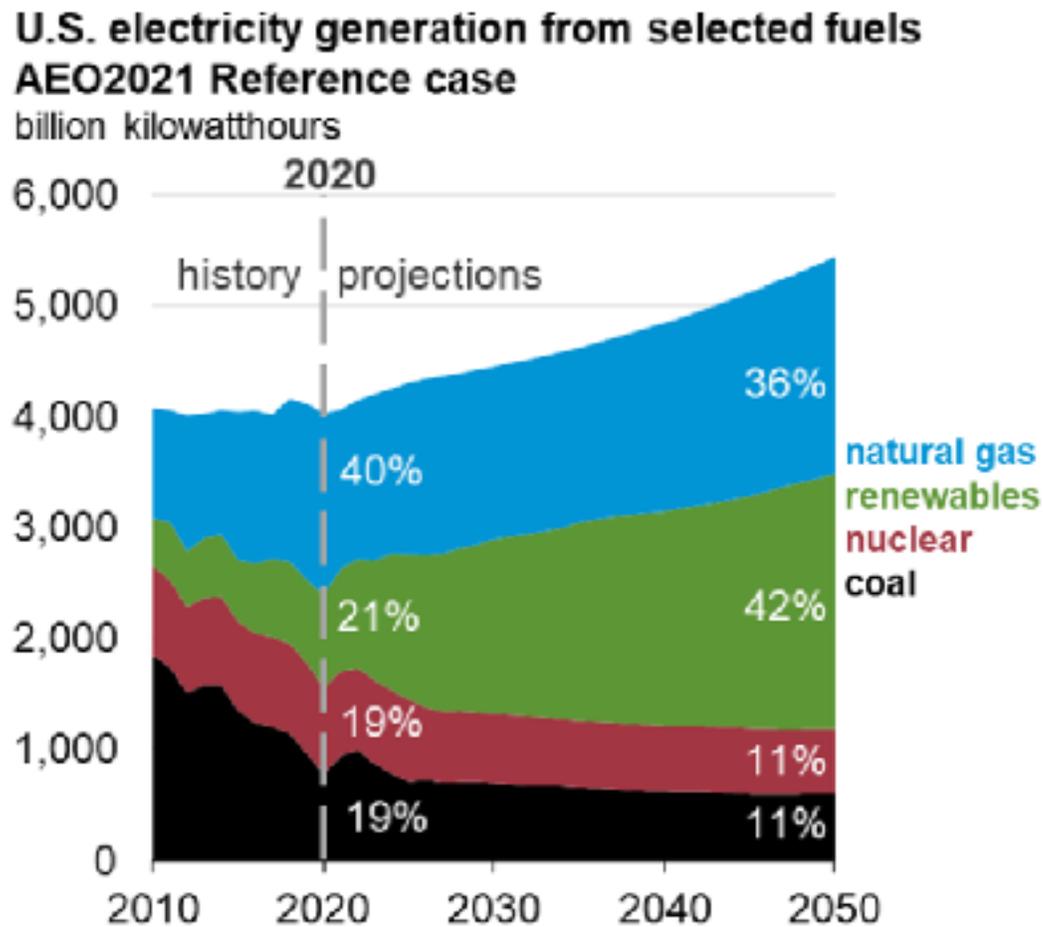
(2018 Data)

Passenger automobiles are the largest contributors of GHGs in the Light-Duty Vehicles category



Source: U.S. Environmental Protection Agency (EPA). June 20, 2020: <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ZK4P.pdf>

Electrification of passenger vehicles is a step in the right direction, BUT...



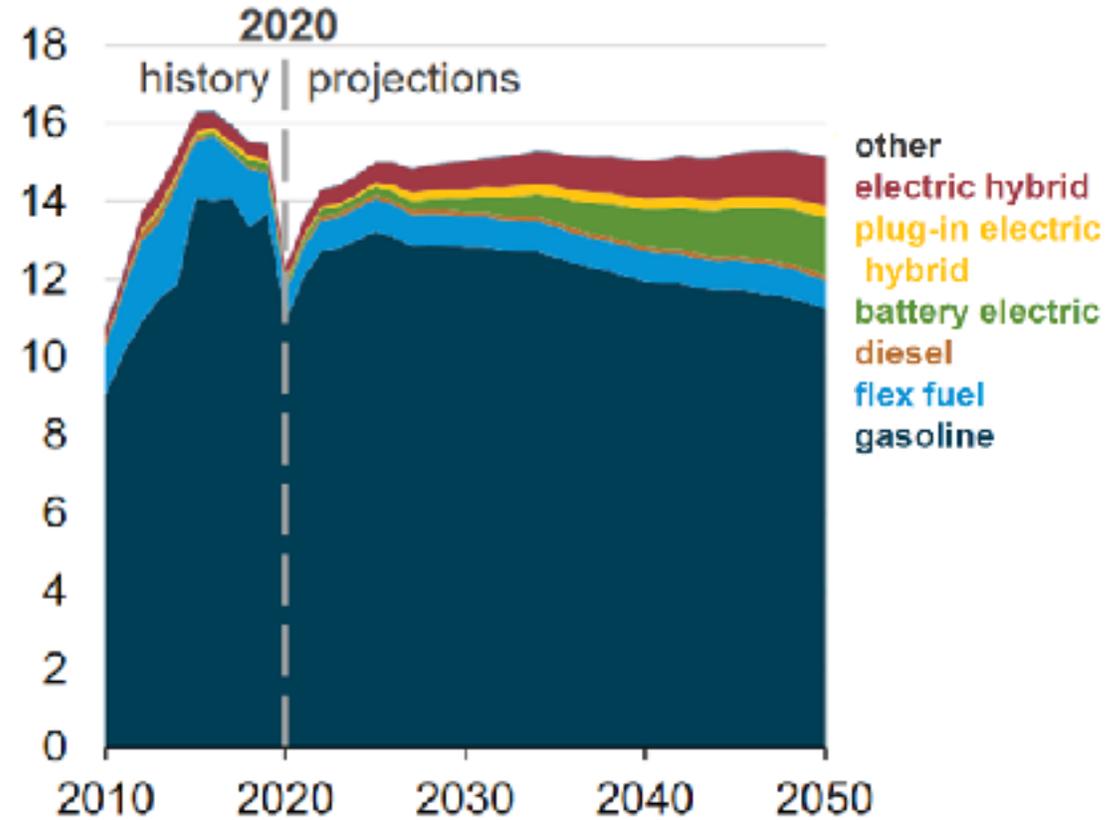
Source: U.S. Energy Information Administration, Annual Energy Outlook 2021 (AEO2021) https://www.eia.gov/outlooks/aeo/pdf/AEO_Narrative_2021.pdf

Electrification of passenger vehicles is a step in the right direction, BUT...

Light-duty vehicle sales by technology/fuel

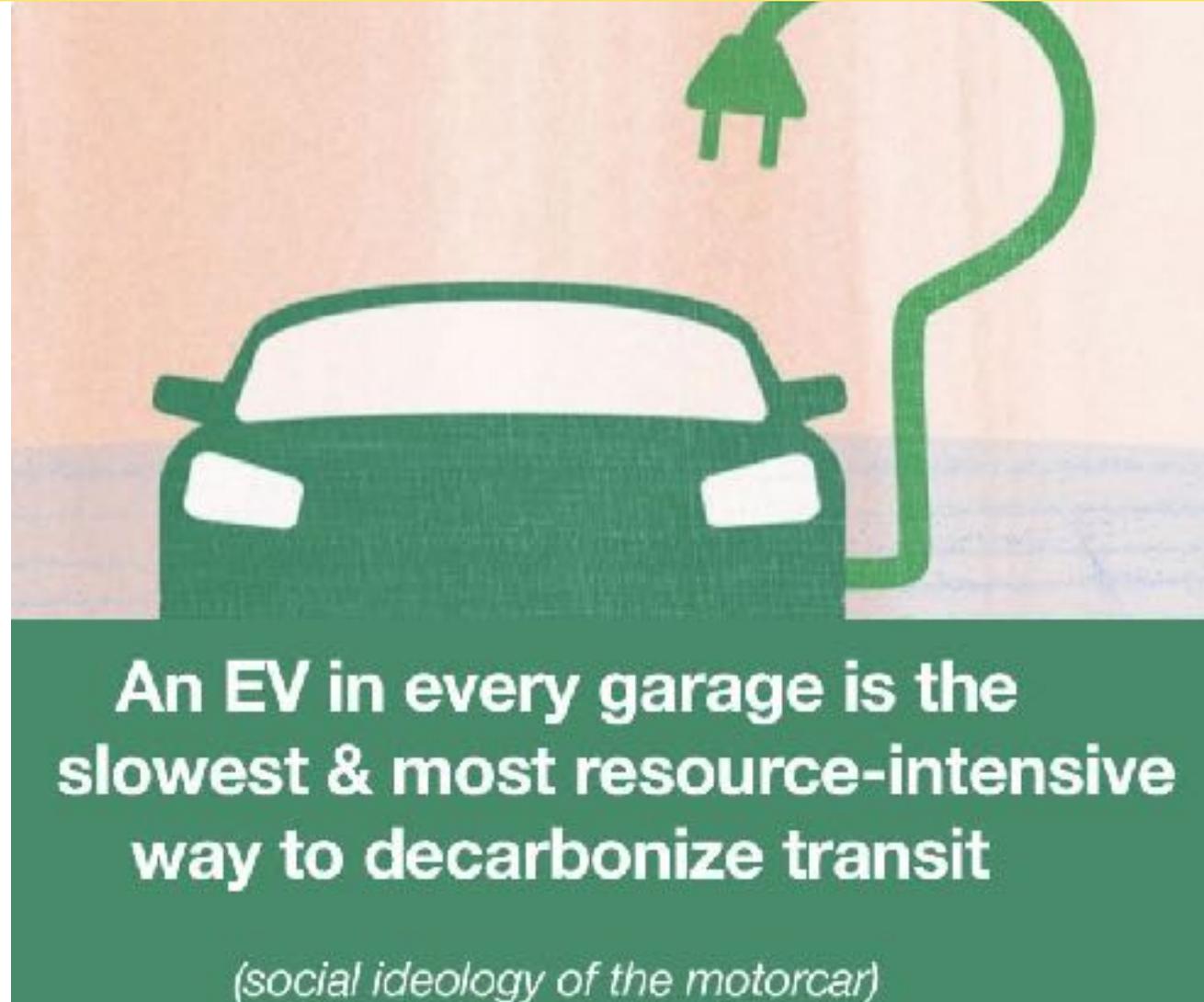
AEO2021 Reference case

millions of vehicles



Source: <https://www.eia.gov/outlooks/aeo/pdf/05%20AEO2021%20Transportation.pdf>

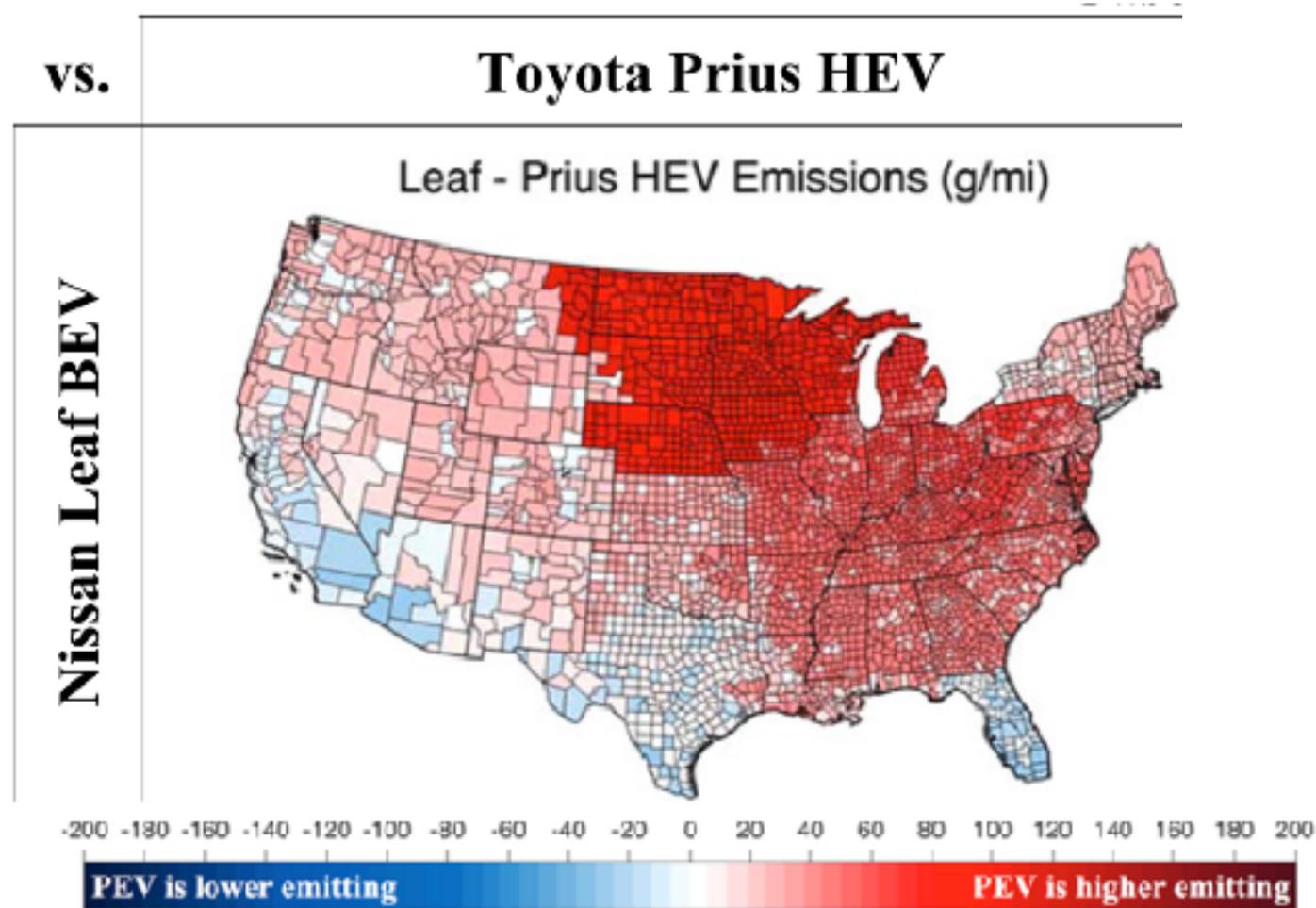
Electrification is not always the best approach for limiting GHGs



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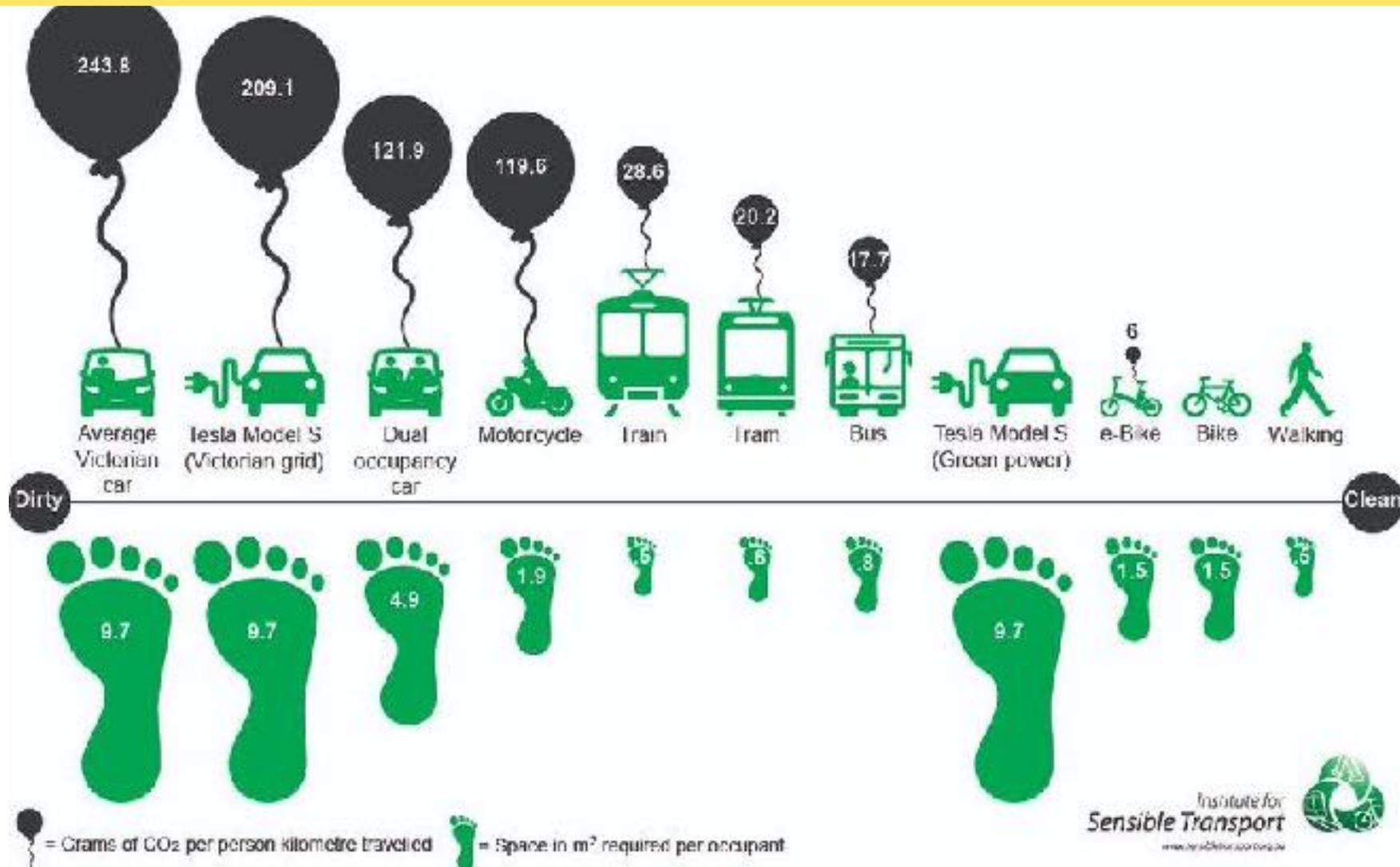


Electrified vehicles are only as 'clean' as the grid that supplies them

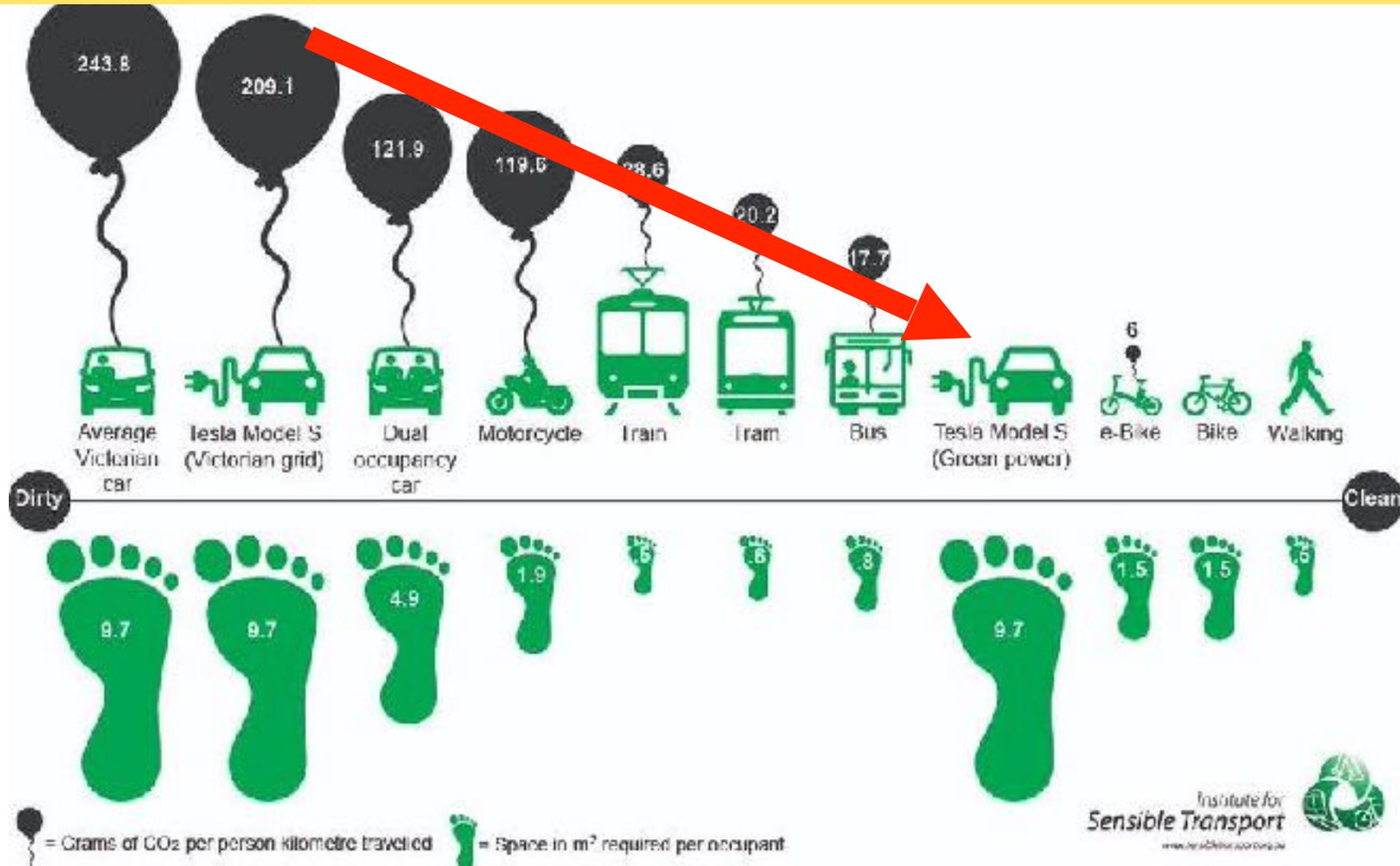


Source: Tugce Yuksel et al 2016 Environ. Res. Lett. 11 044007 <https://iopscience.iop.org/article/10.1088/1748-9326/11/4/044007>

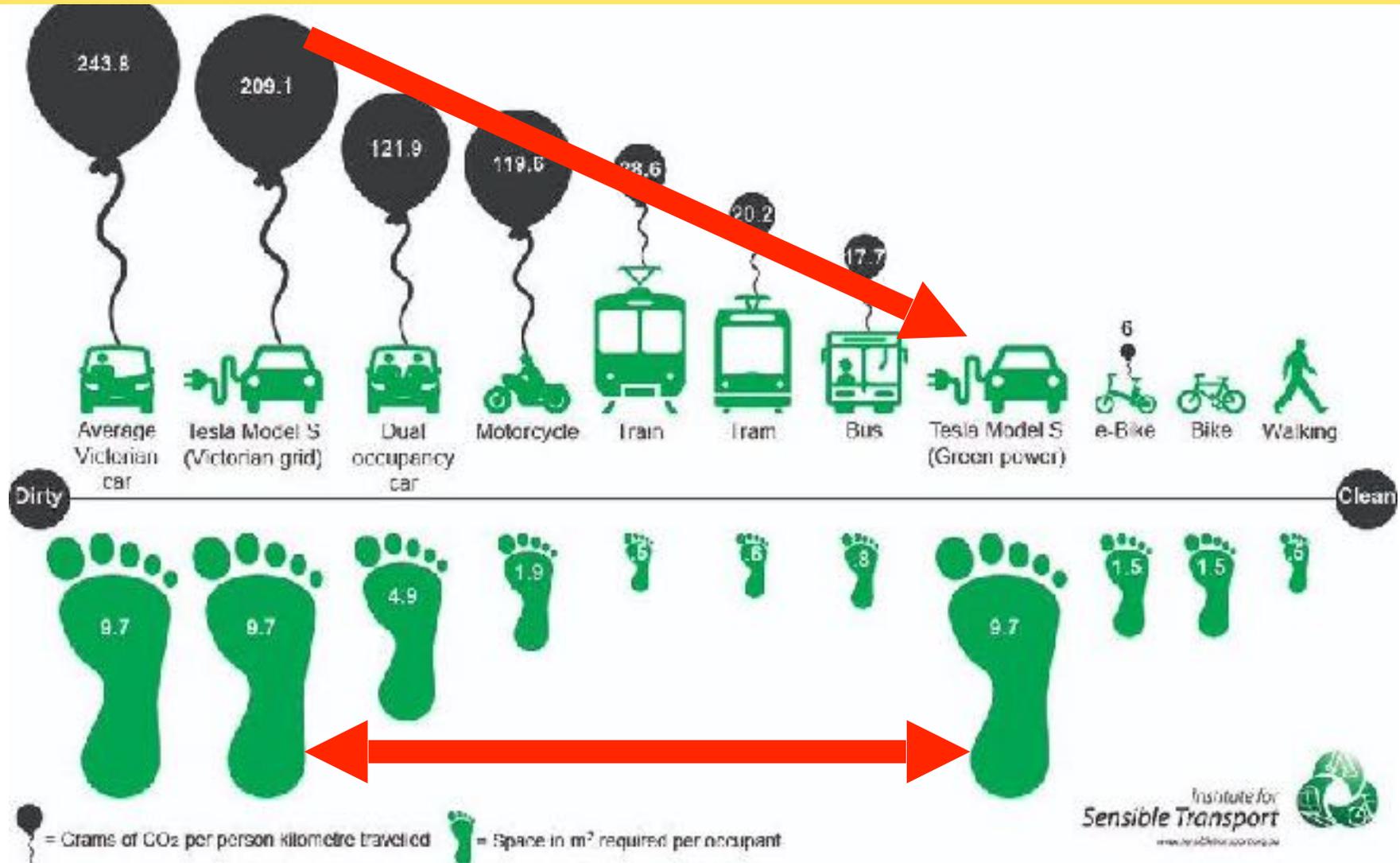
EVs may reduce carbon footprints, but not the *physical* footprint



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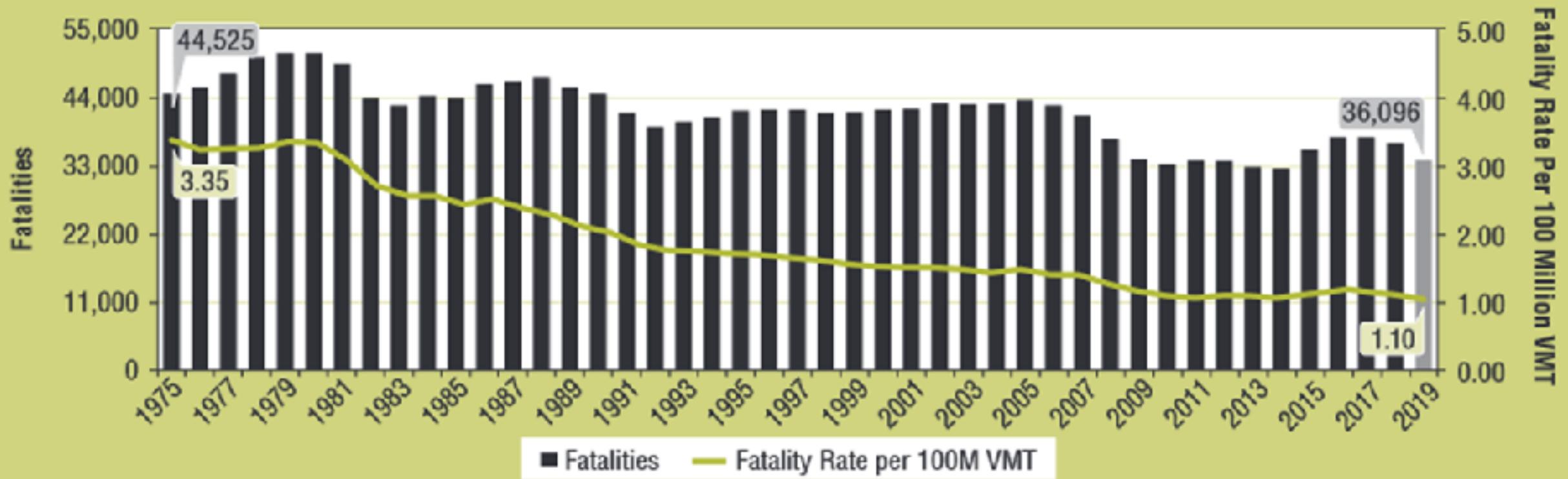


There are other significant problems to be addressed in the transportation sector



<http://bit.ly/3nA2swl>

Automobile-related fatalities continue at 'crisis' levels



<https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813060>

Our transportation system does not lead to human flourishing



We propose a more effective solution

Solar-powered
Automated Transportation Networks
(ATN)

Spartan Superway is 100% solar-powered, zero-emission public transport



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A compelling design case is beginning to emerge - think of the rotary telephone, before the...



Ron Swenson



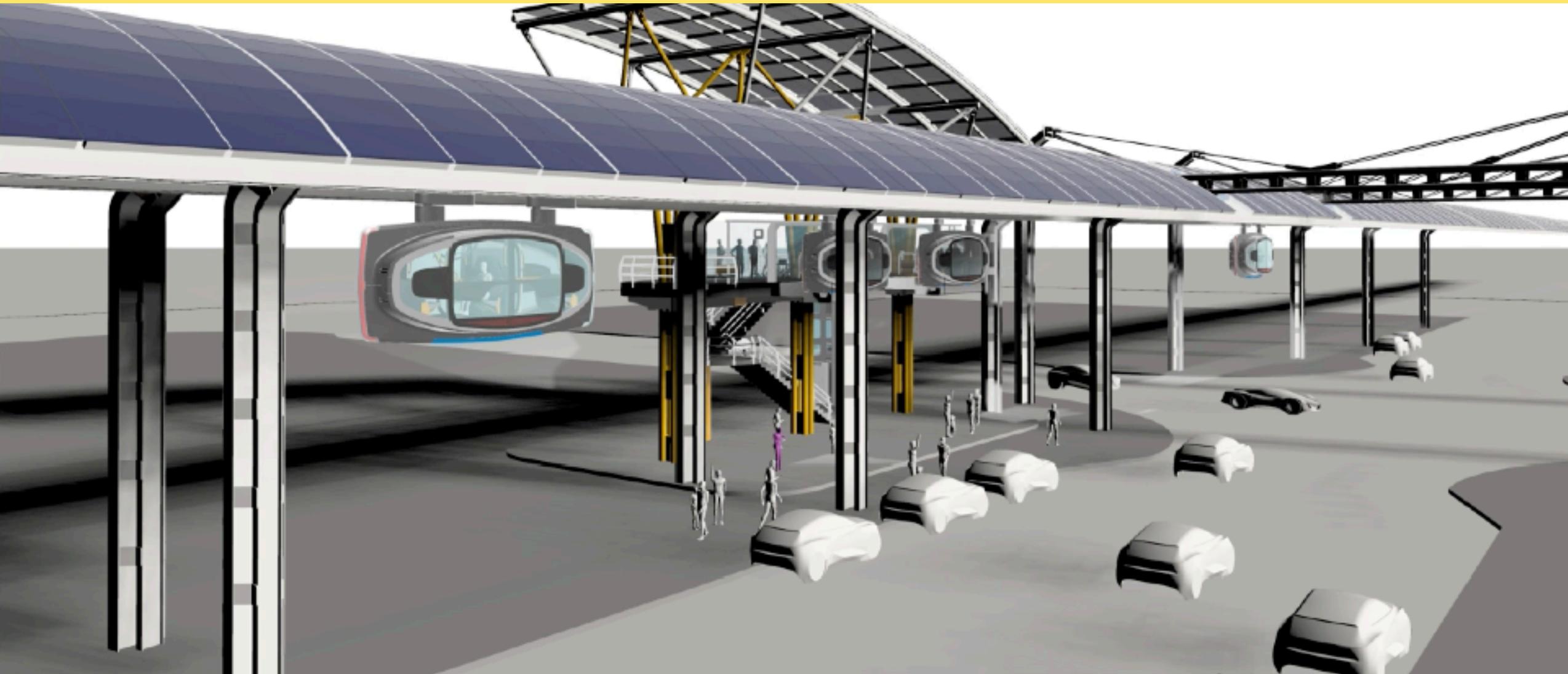
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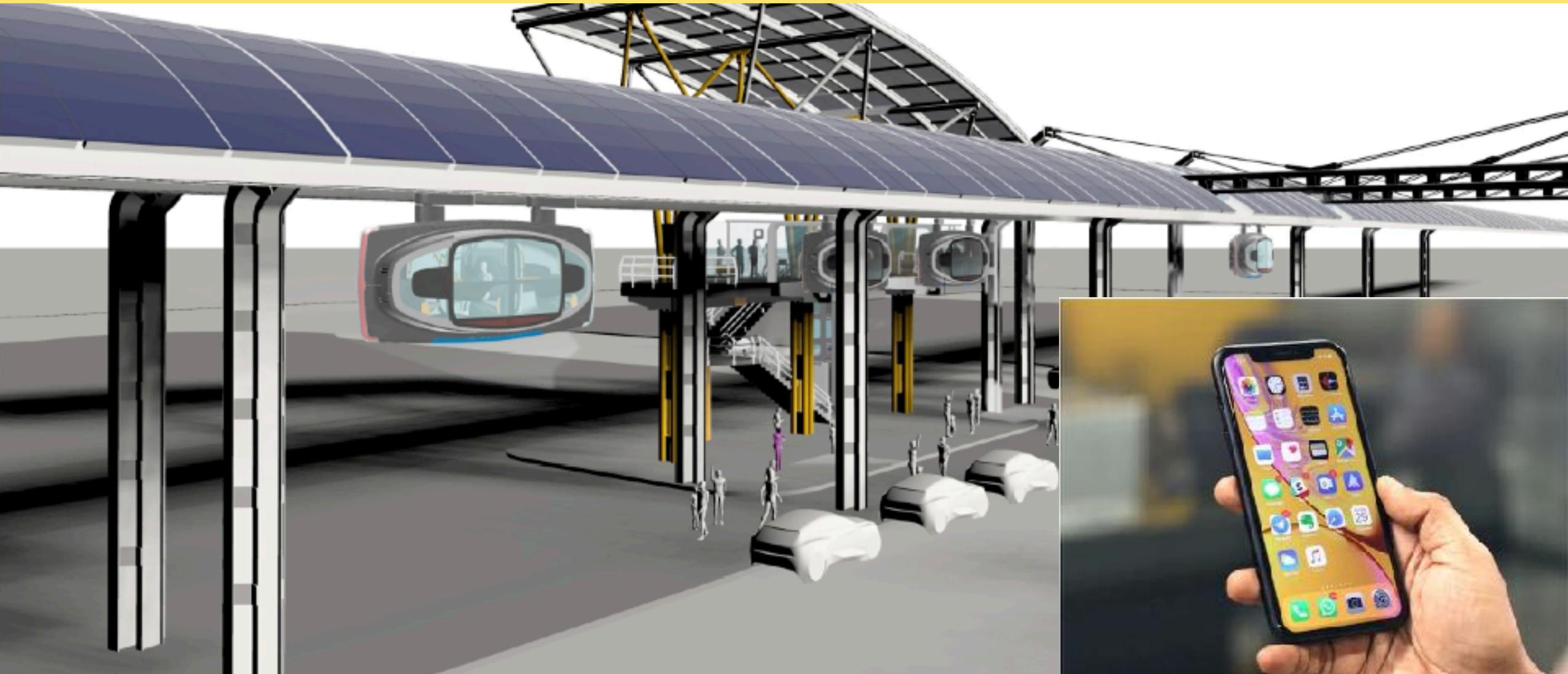
... iPhone



Ron Swenson



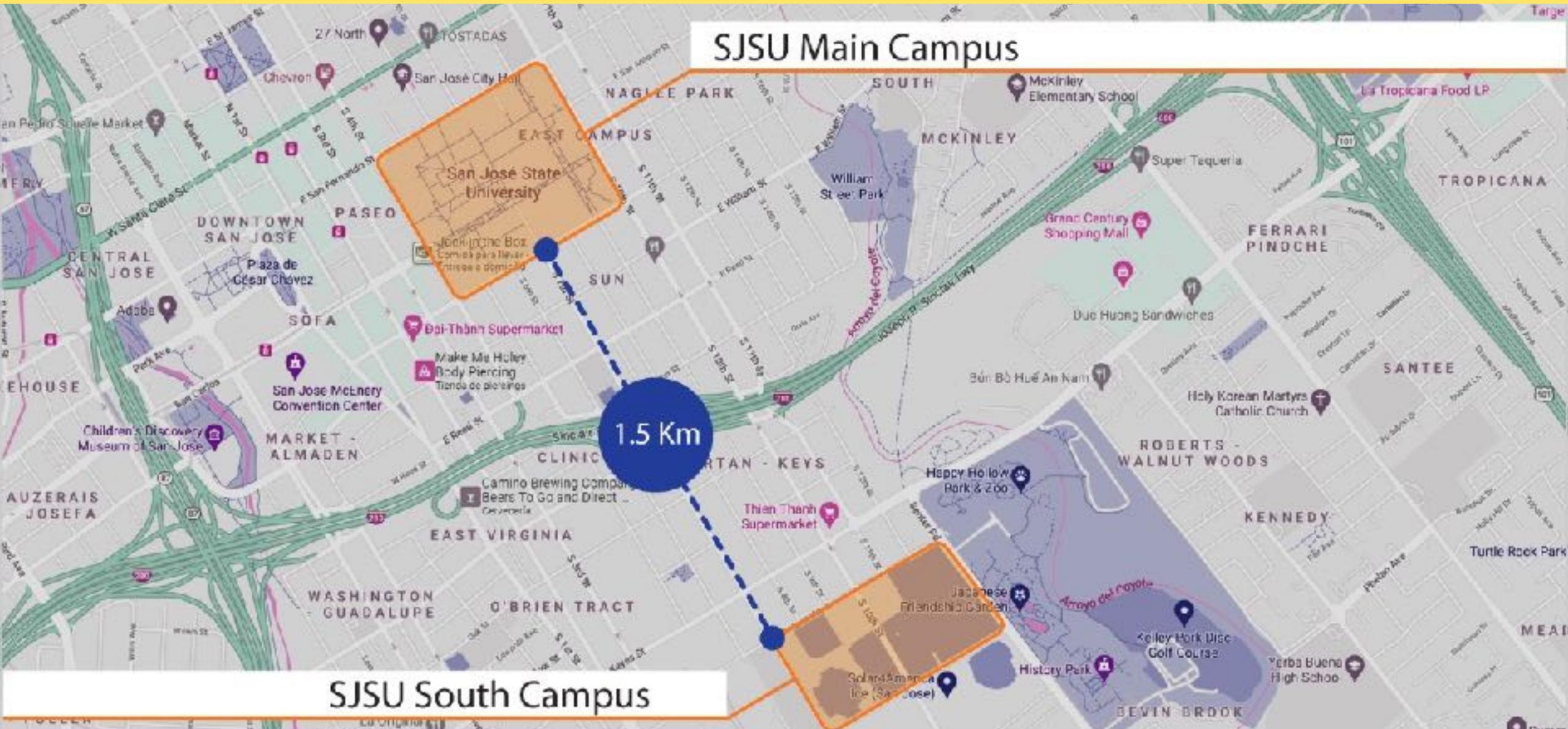
... iPhone



Ron Swenson



We are designing a Spartan Superway network to connect SJSU campuses



Ron Swenson



The first campus station is in a convenient central location



Ron Swenson



The middle station is near a secondary school and is bike accessible



Ron Swenson



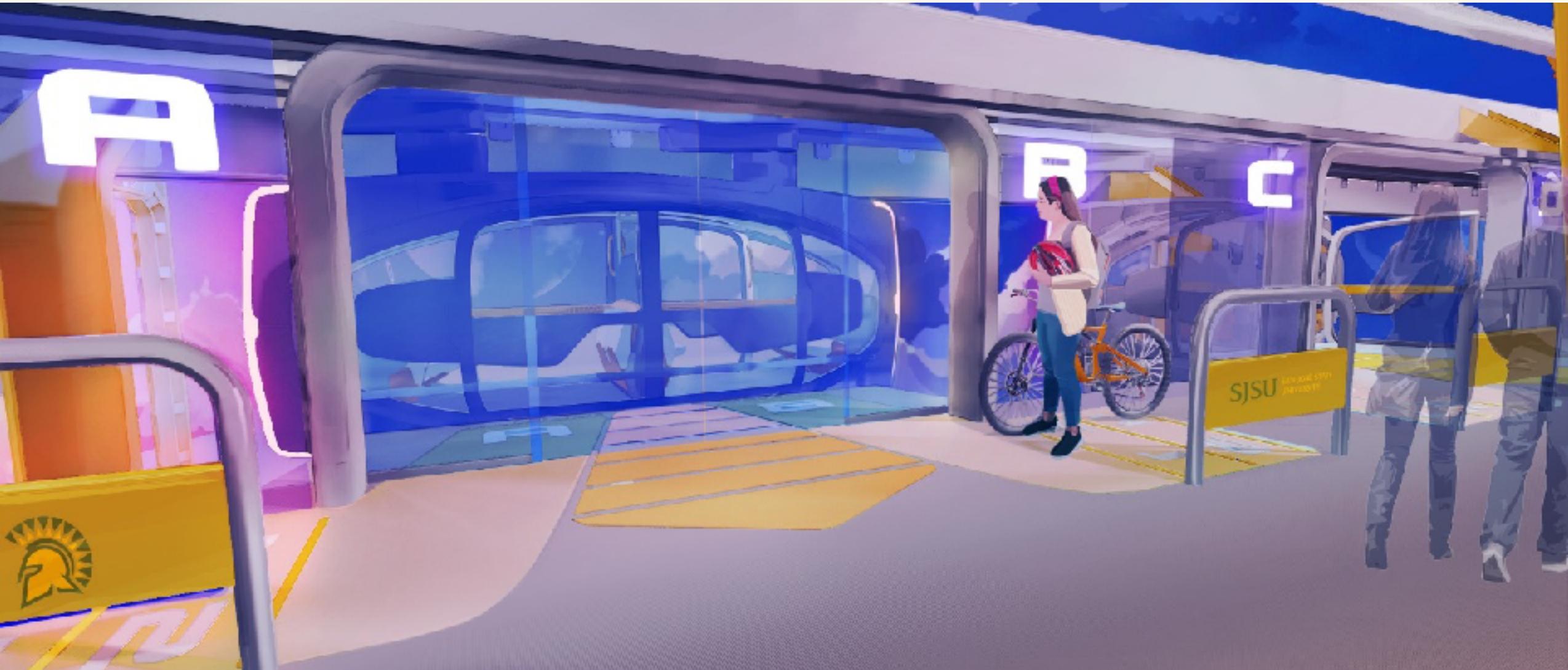
The south station serves football, baseball, ice skating, golf, track, and a new parking garage



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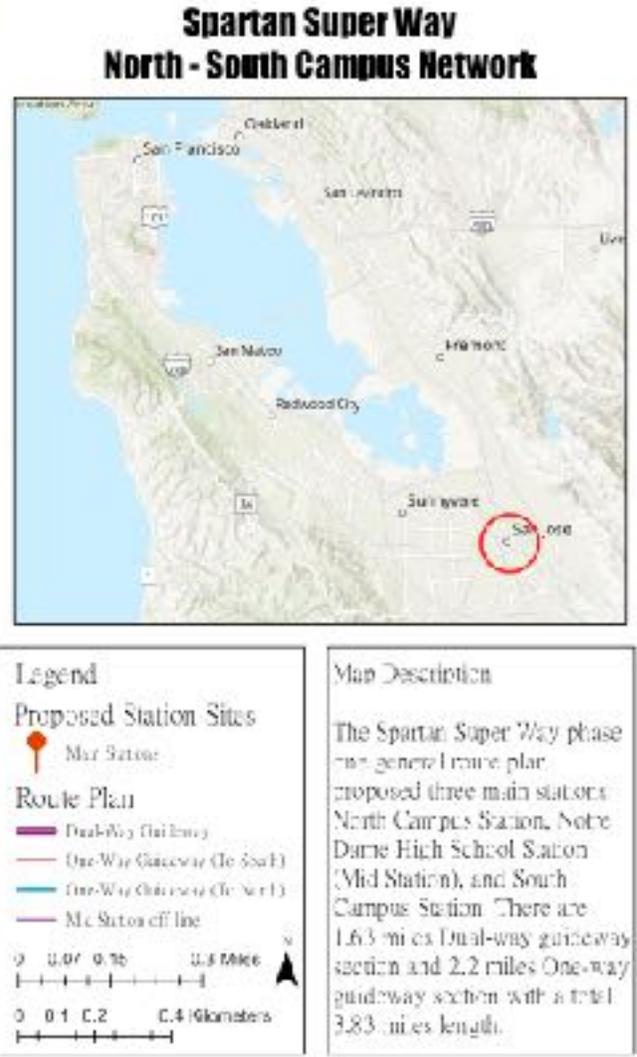
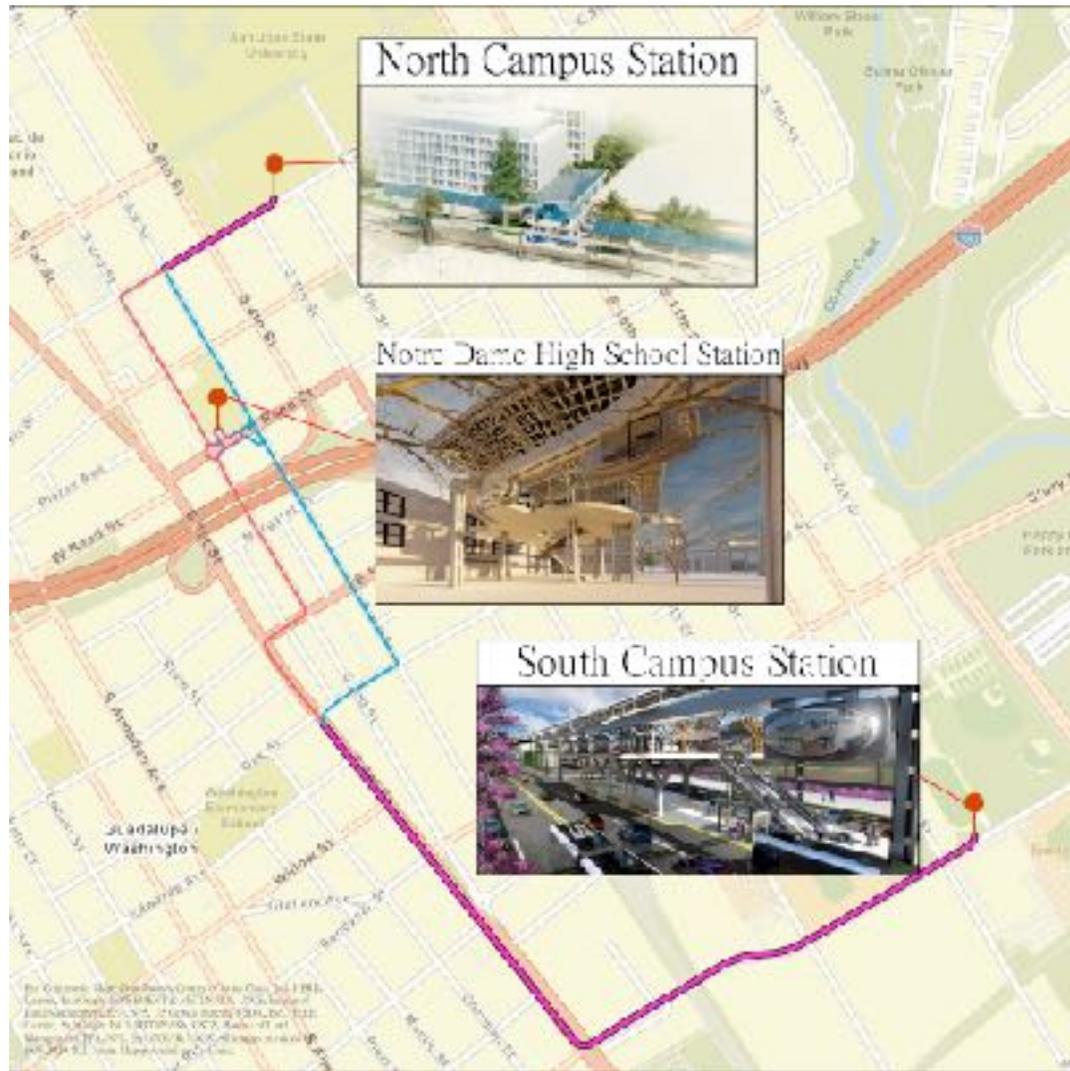
Ron Swenson



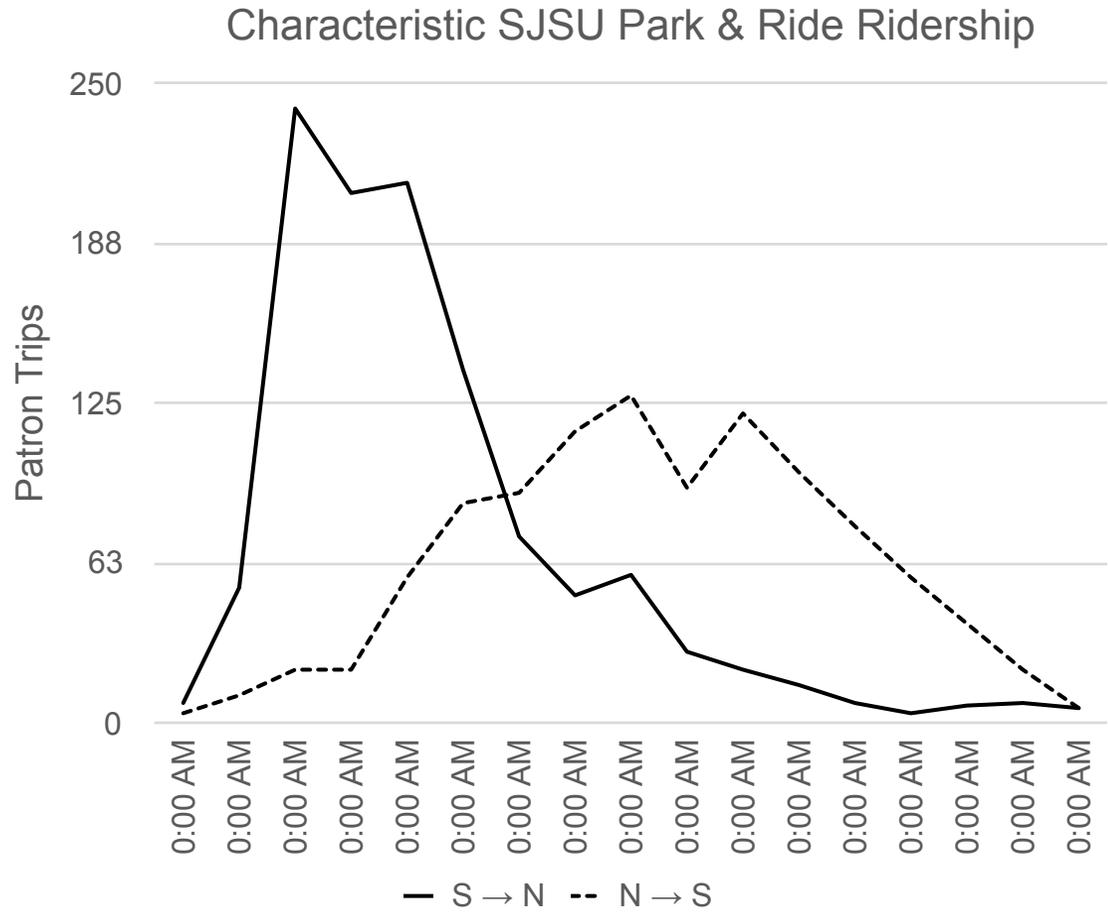
We analyzed a proposed network

North-South San José State University
Campus Shuttle Replacement

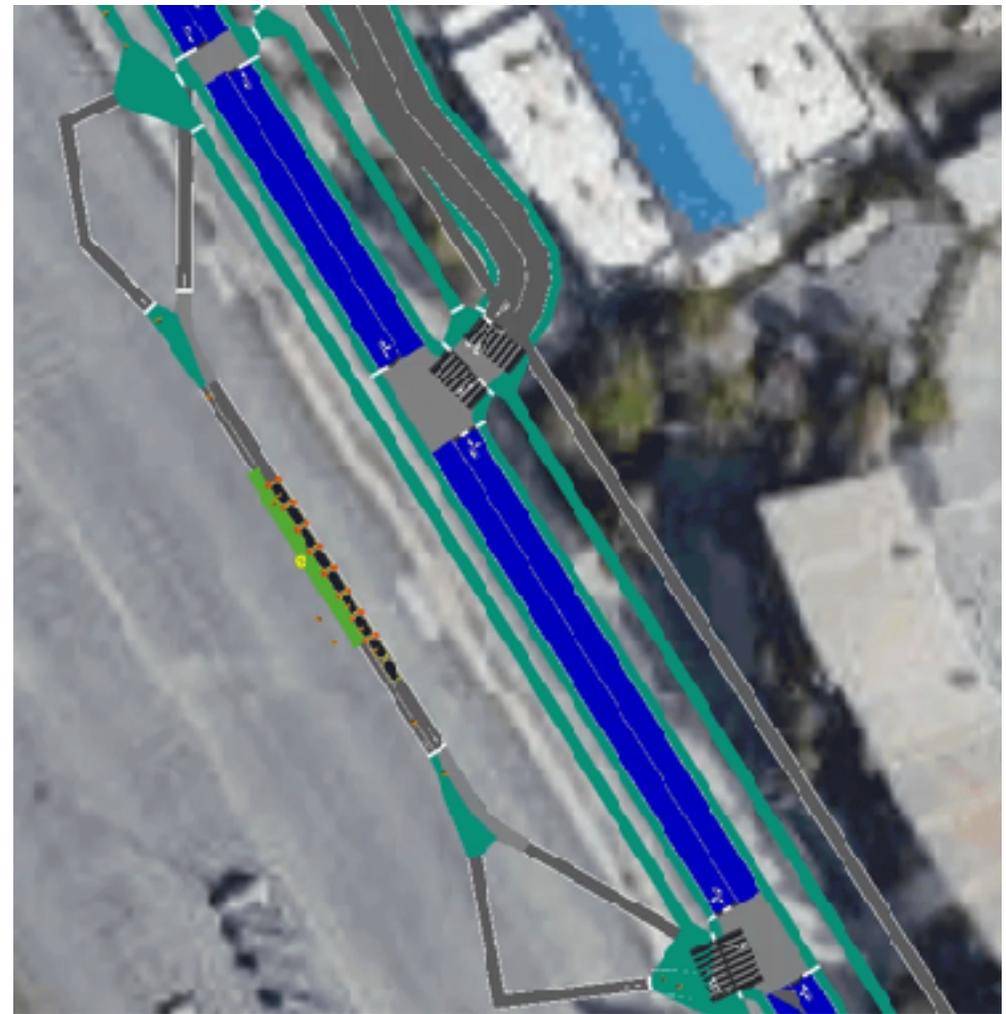
A 5-km ATN route has been proposed to connect the north and south campuses of San José State University



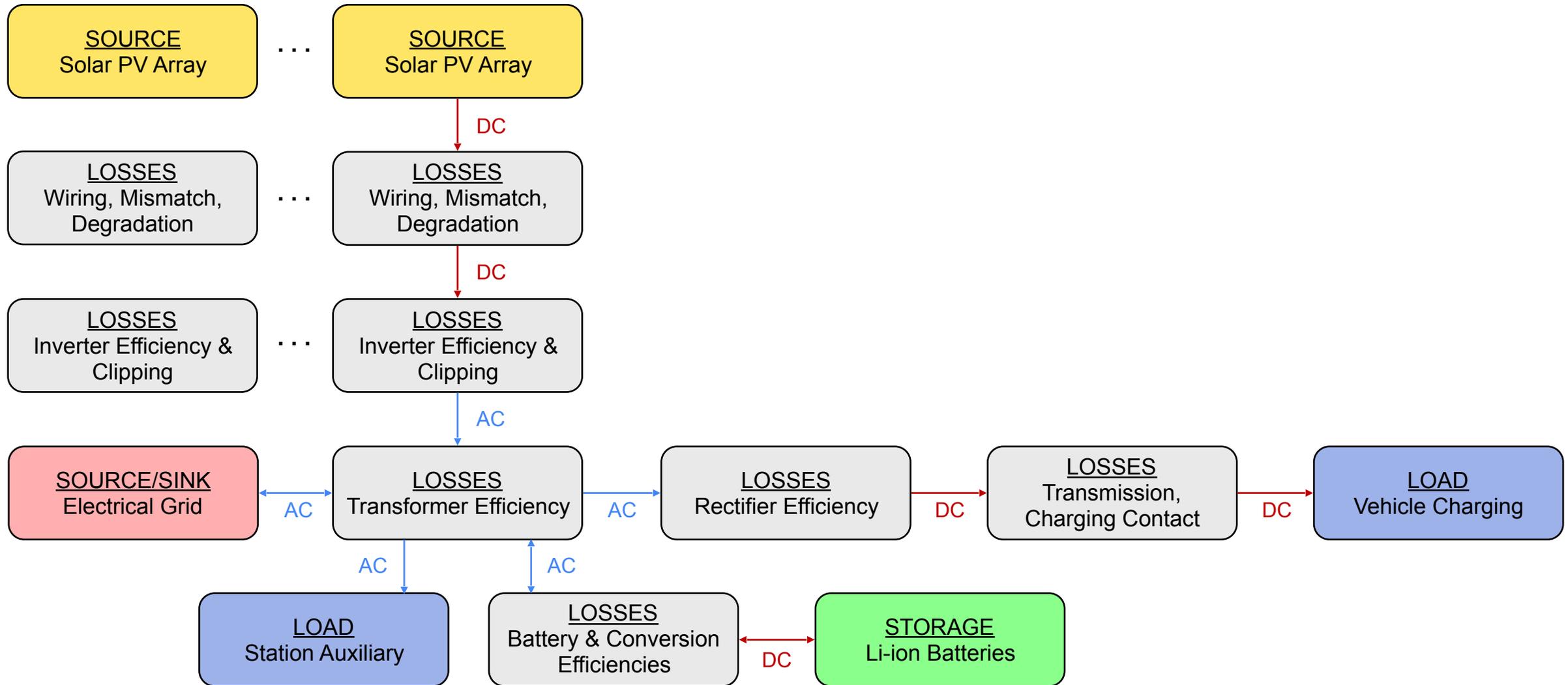
SUMOPy was implemented to simulate the transient energy demand of the proposed ATN system using SJSU Park & Ride ridership data



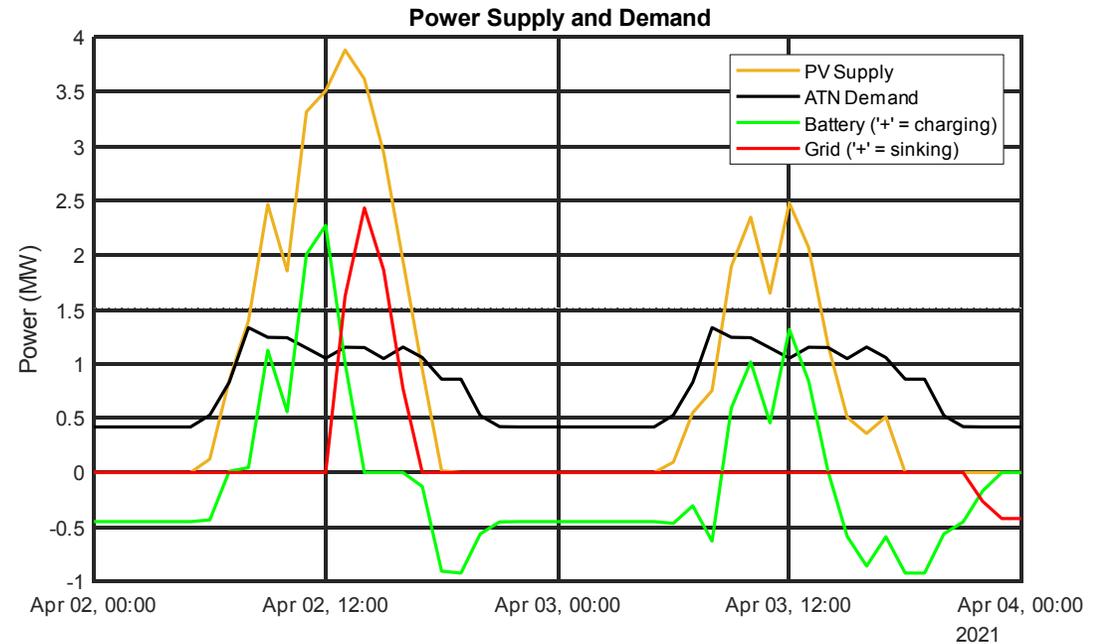
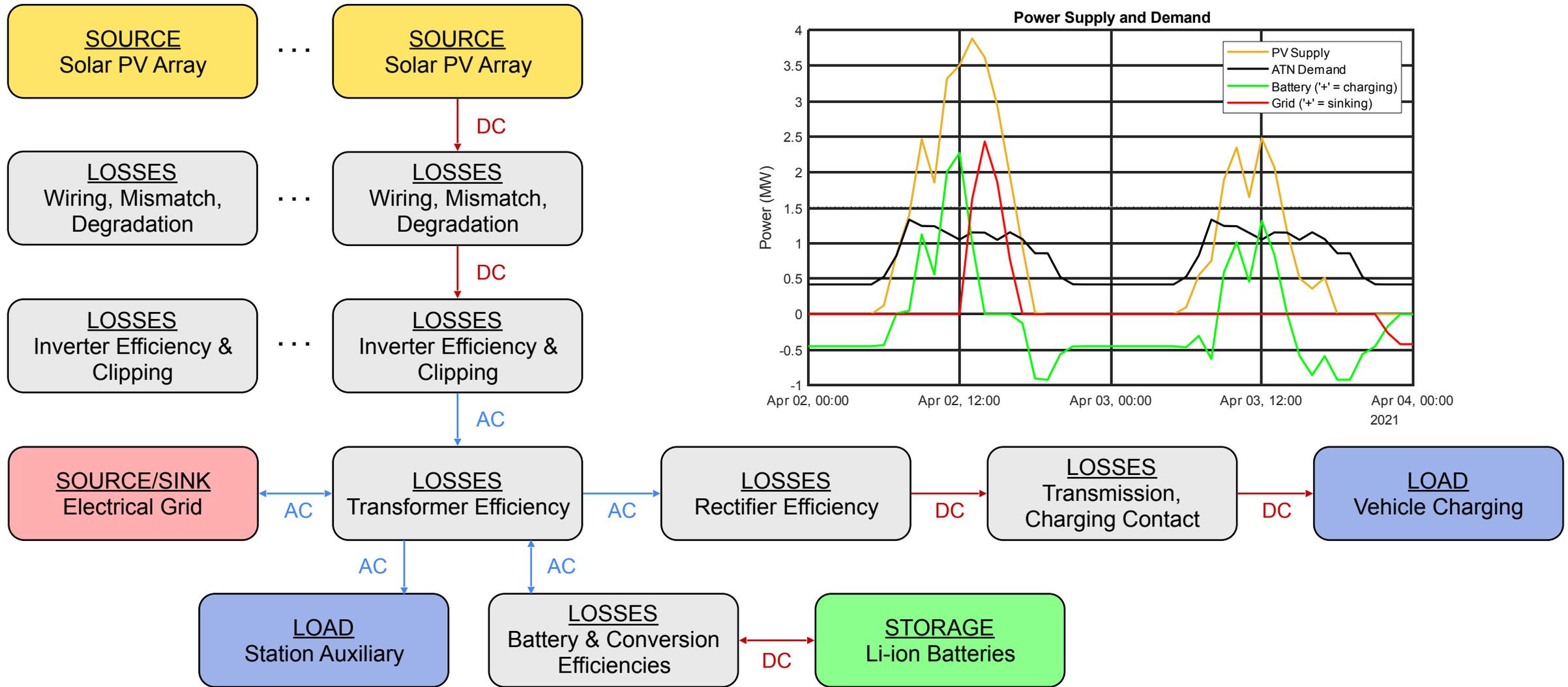
[E. J. Cross, "SJSU Park & Ride: Passengers by Stop and Hour Report 2019-2020," San José State University, San Jose, CA, 2020.]



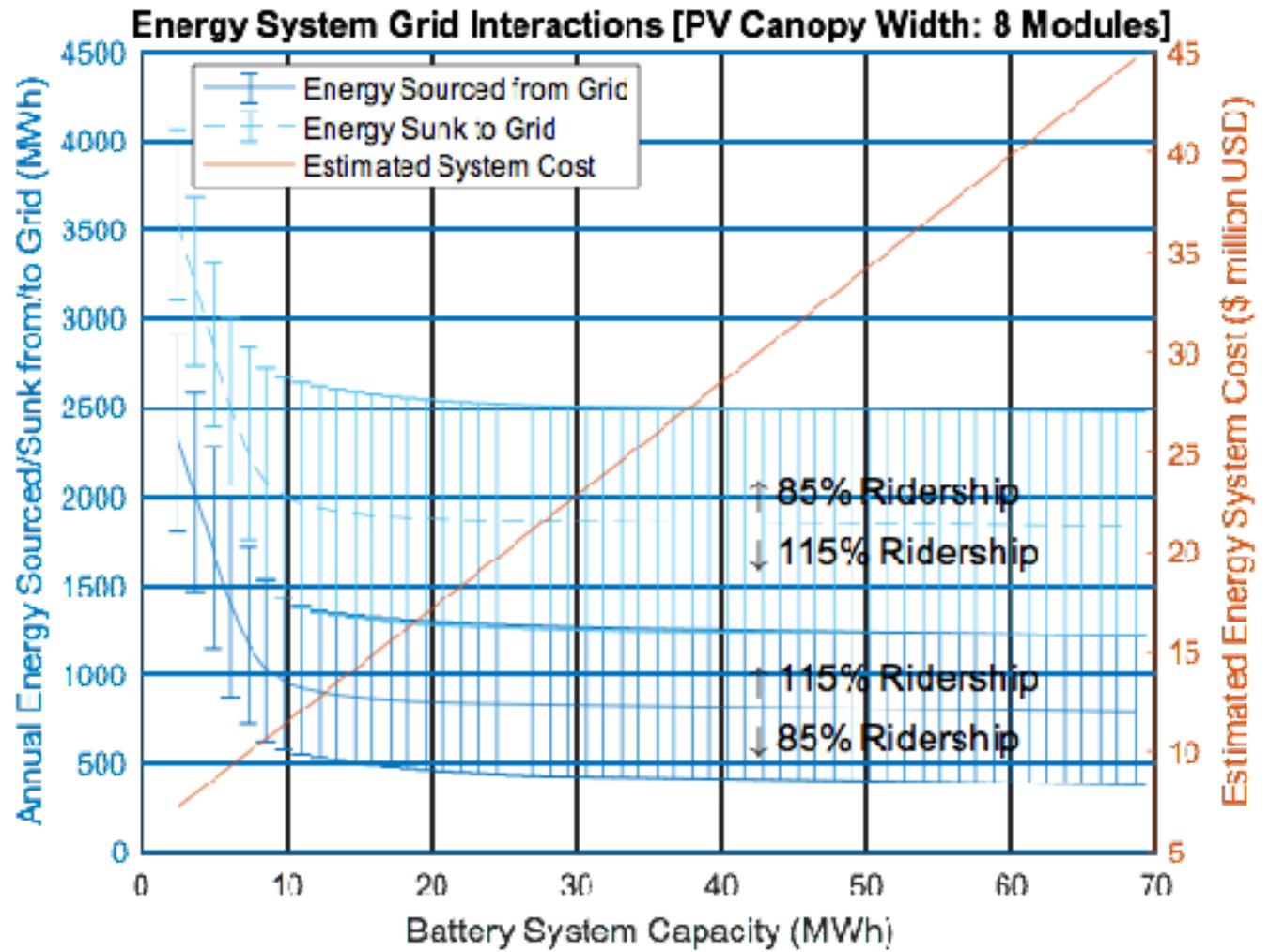
A transient energy model was developed to simulate the interactions between the ATN, PV, grid, and battery systems



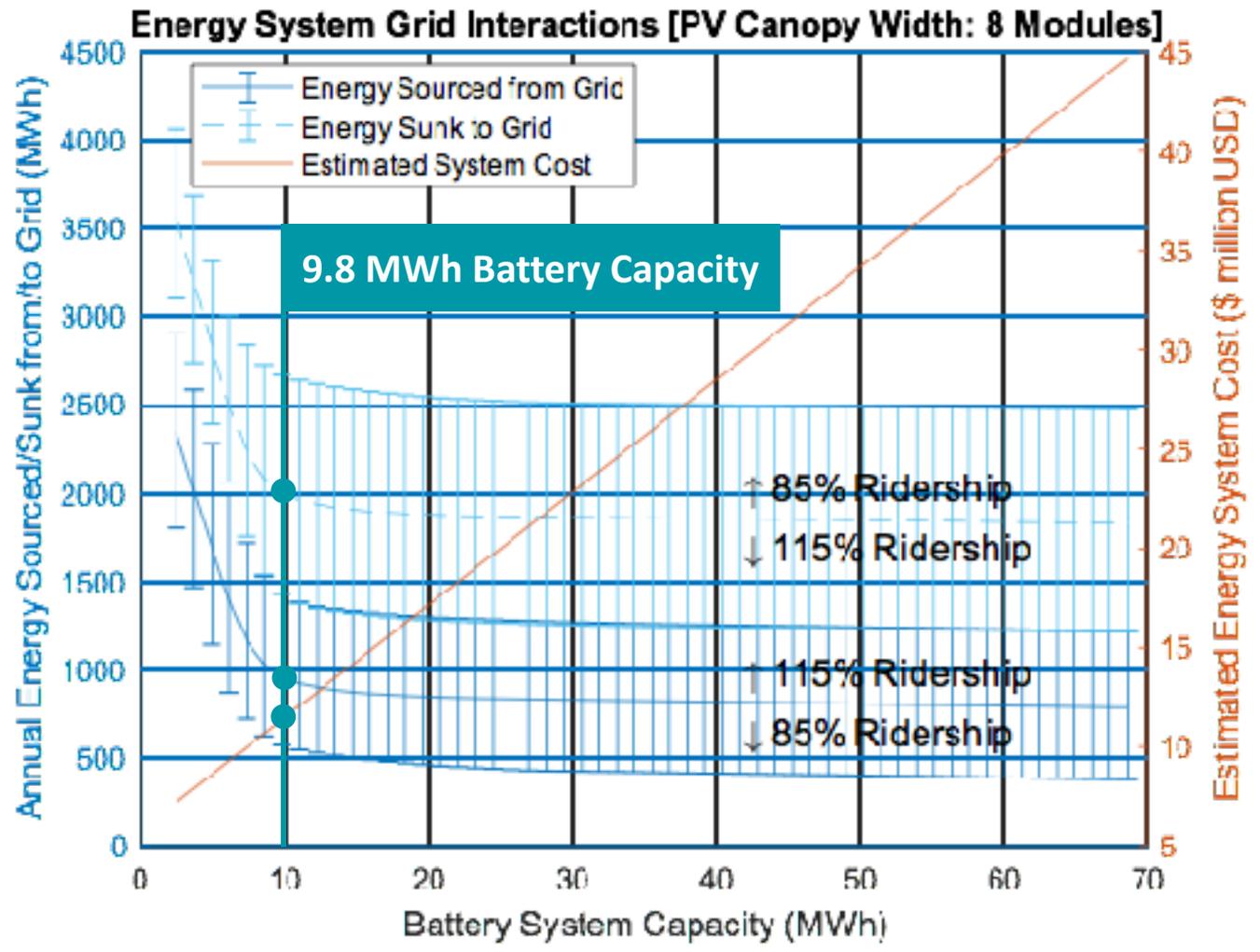
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An eight-module-wide PV canopy can maintain net positive electricity generation for a ridership uncertainty of $\pm 15\%$



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Source: <https://www.tesmanian.com/blogs/tesmanian-blog/tesla-powerpack-in-japan>

It costs 8% less to power the ATN with solar energy than with electricity purchased from the grid, per US DOE LCOE calculation

$$\text{LCOE} = \frac{\sum_{t=1}^n \left[\frac{I_t + M_t + F_t}{(1+r)^t} \right]}{\sum_{t=1}^n \left[\frac{E_t}{(1+r)^t} \right]}$$

I_t : Investment Expenditures

M_t : O&M Expenditures

F_t : Grid Expenditures

E_t : ATN Energy Demand

r : Discount Rate

n : Life of System

[D. Feldman, V. Ramasamy, R. Fu, A. Ramdas, J. Desai and R. Margolis, "U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020," National Renewable Energy Laboratory, Golden, CO, 2021.]

[Electricity Local, "San Jose Electricity Rates," 2021. [Online]. Available: <https://www.electricitylocal.com/states/california/san-jose/#ref>.]

[Lazard, "Lazard's Levelized Cost of Storage Analysis: Version 4.0," Hamilton, BM, 2018.]

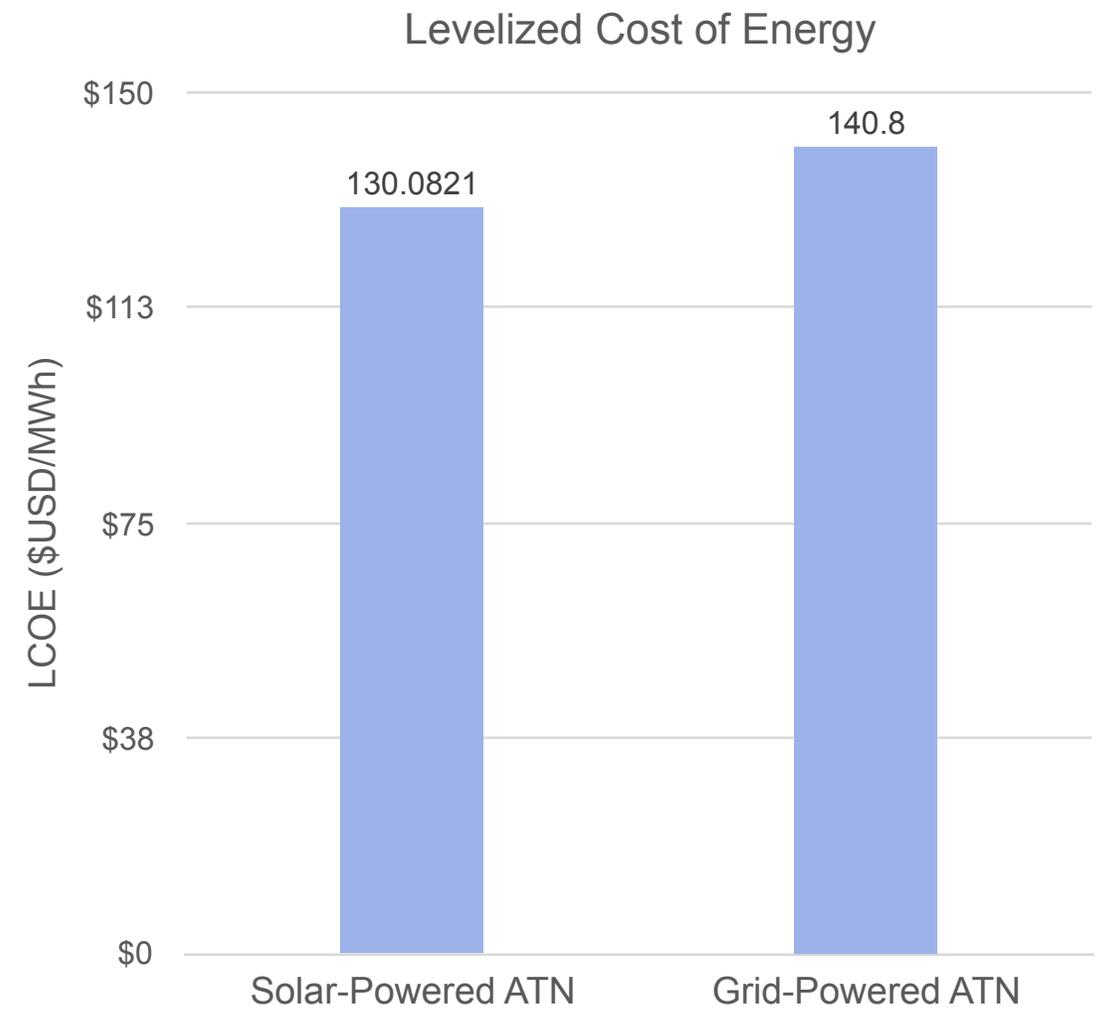
[PG&E, "Surplus Energy Credit," 2021. [Online]. Available: https://www.pge.com/en_US/residential/solar-and-vehicles/green-energy-incentives/getting-credit-for-surplus-energy/getting-credit-for-surplus-energy.page.]

[U.S. Department of Energy, "Levelized Cost of Energy (LCOE)," DOE Office of Indian Energy, Washington, DC, 2015.]

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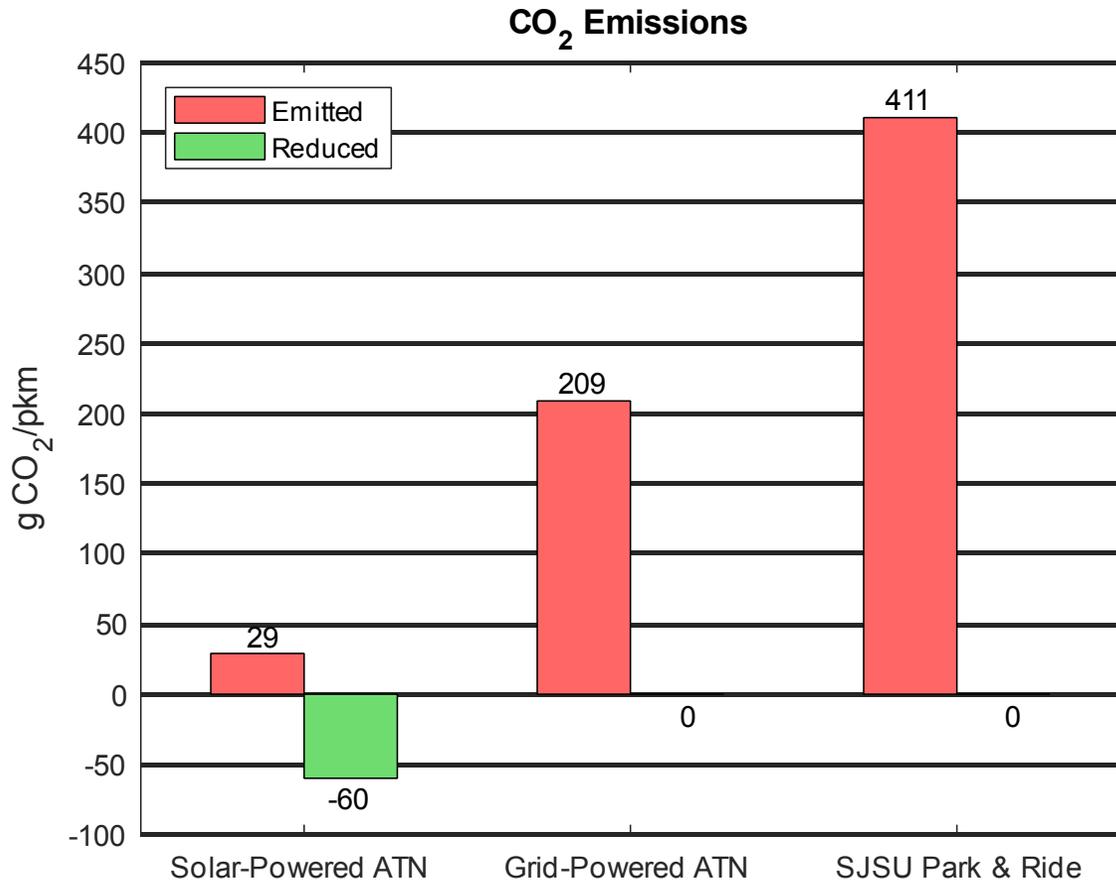
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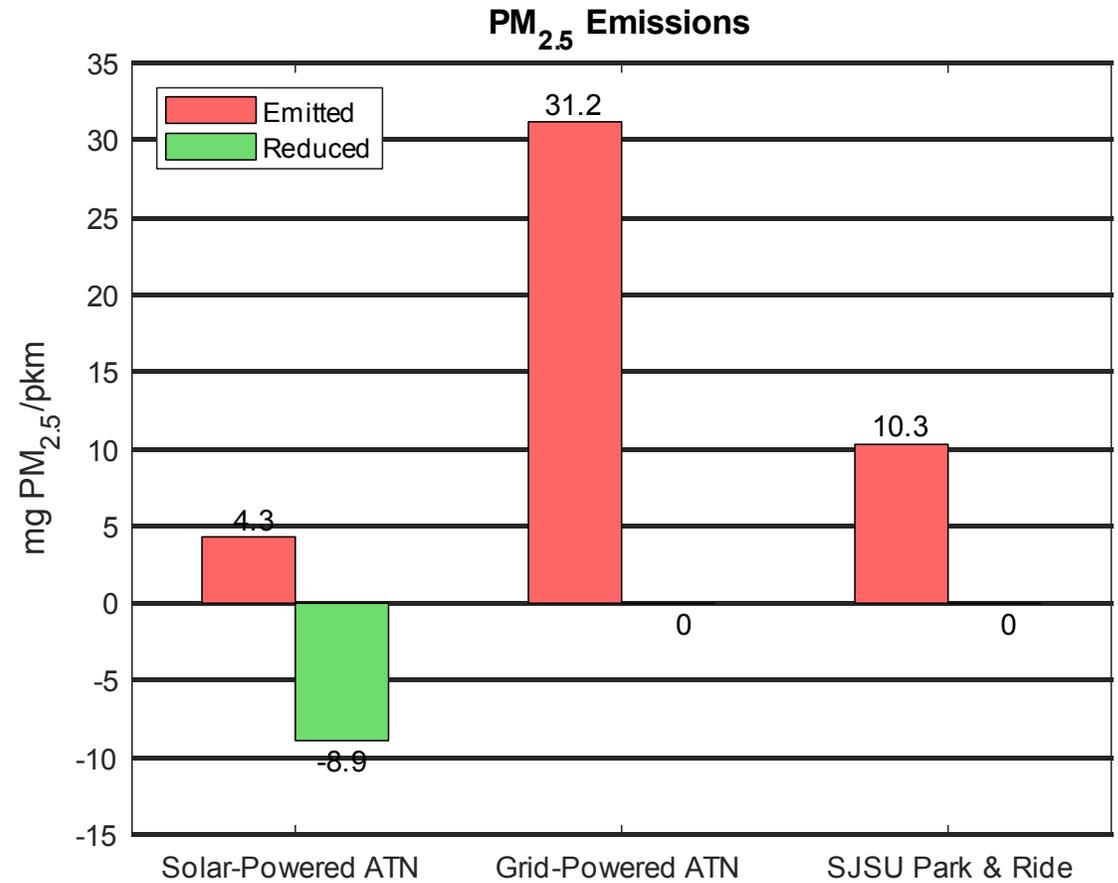
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 [U.S. Department of Energy, "Levelized Cost of Energy (LCOE)," DOE Office of Indian Energy, Washington, DC, 2015.]

Solar-powered ATN was the only system under study to produce net negative CO₂ and PM_{2.5} emissions



[City of San José, "2017 Inventory of Community Greenhouse Gas Emissions," ICLEI - Local Governments for Sustainability USA, San Jose, CA, 2019.]

[U.S. Energy Information Administration, "Carbon Dioxide Emissions Coefficients," February 2016. [Online]. Available: https://www.eia.gov/environment/emissions/co2_vol_mass.php.]



[Bureau of Transportation Statistics, "Estimated U.S. Average Vehicle Emissions Rates per Vehicle by Vehicle Type Using Gasoline and Diesel," U.S. Department of Transportation, April 2018. [Online]. Available: <https://www.bts.gov/content/estimated-national-average-vehicle-emissions-rates-vehicle-type-using-gasoline-and->]

[U.S. Environmental Protection Agency, "Estimating Particulate Matter Emissions for eGRID," Washington, DC, 2020.]

The viable energy system has a PV rated output of 6.2 MW and Li-ion battery capacity of 9.8 MWh



Jack Fogelquist



We have a plan

Let's work together to mitigate climate change



Ron Swenson

Mobilising research and fostering innovation

- 35% of Horizon Europe will fund new solutions for implementing the Green Deal
- 4 Green Deal Missions will help deliver large-scale changes
- Partnerships with industry and Member States will support R&I on strategic sectors such as transport, energy...

Conventional approaches will not be sufficient

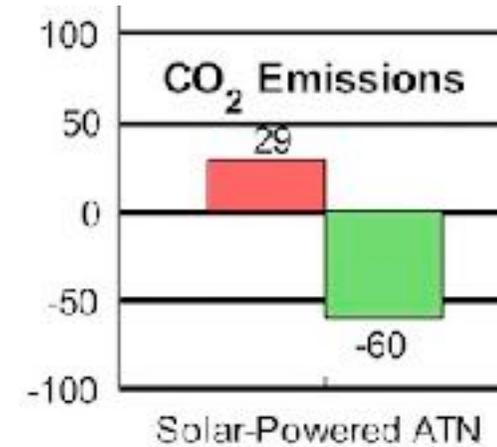
Be bold and inspirational

Conventional approaches will not be sufficient



Philippe Froissard is right. Conventional approaches will not be sufficient... ... we must be bold and inspirational

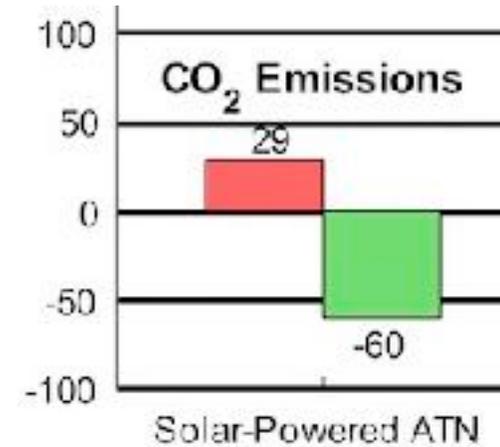
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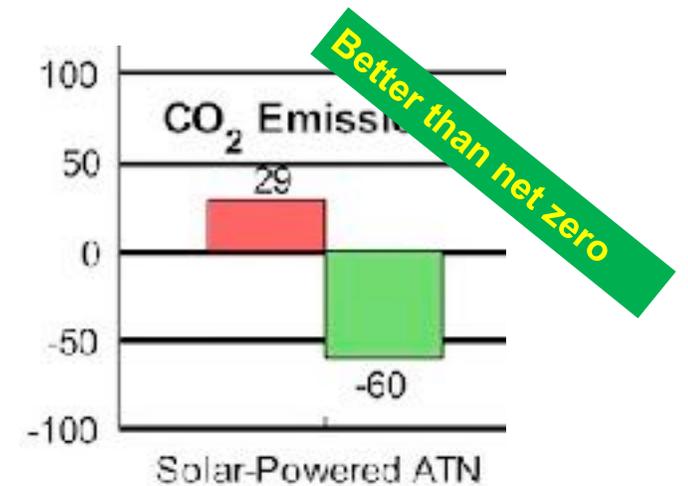
We have shown you how to weave this solution into the urban fabric of your cities



Philippe Froissard is right. Conventional approaches will not be sufficient...
... we must be bold and inspirational

If anyone else can deliver zero emissions and zero collisions, then by all means, go with them — there is no time to waste

If no one else has done it, then we challenge you to challenge us



We propose these clear, bold policies:

1. Encourage privately funded solar-powered transit networks
2. Require $\geq 100\%$ solar power to grant rights-of-way
3. Charge operators 5% of gross revenue for rights-of-way



25 MPG



25 MPG



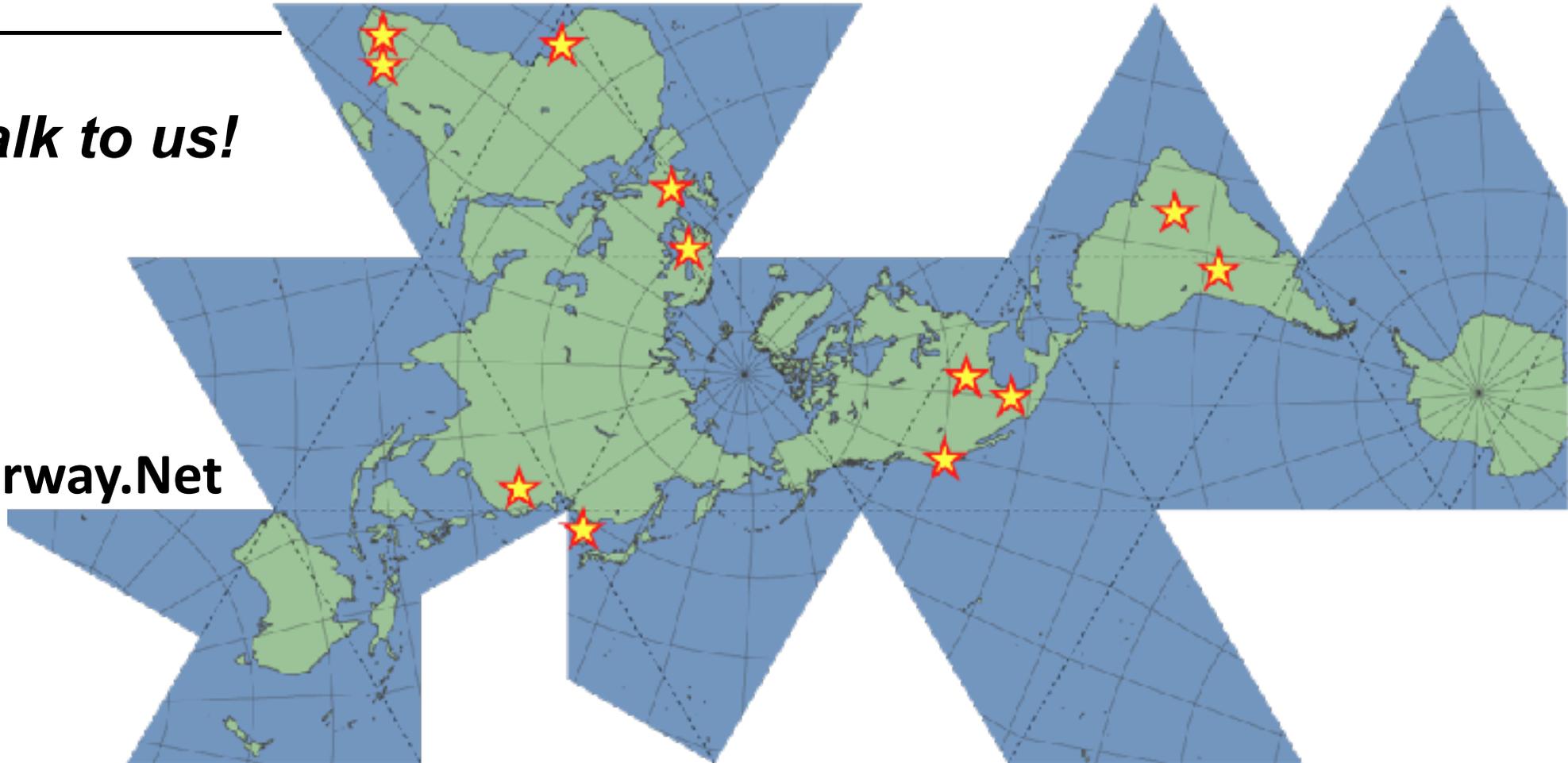
Net Zero or better

These are steps that we can take together to create Spartan Superway networks

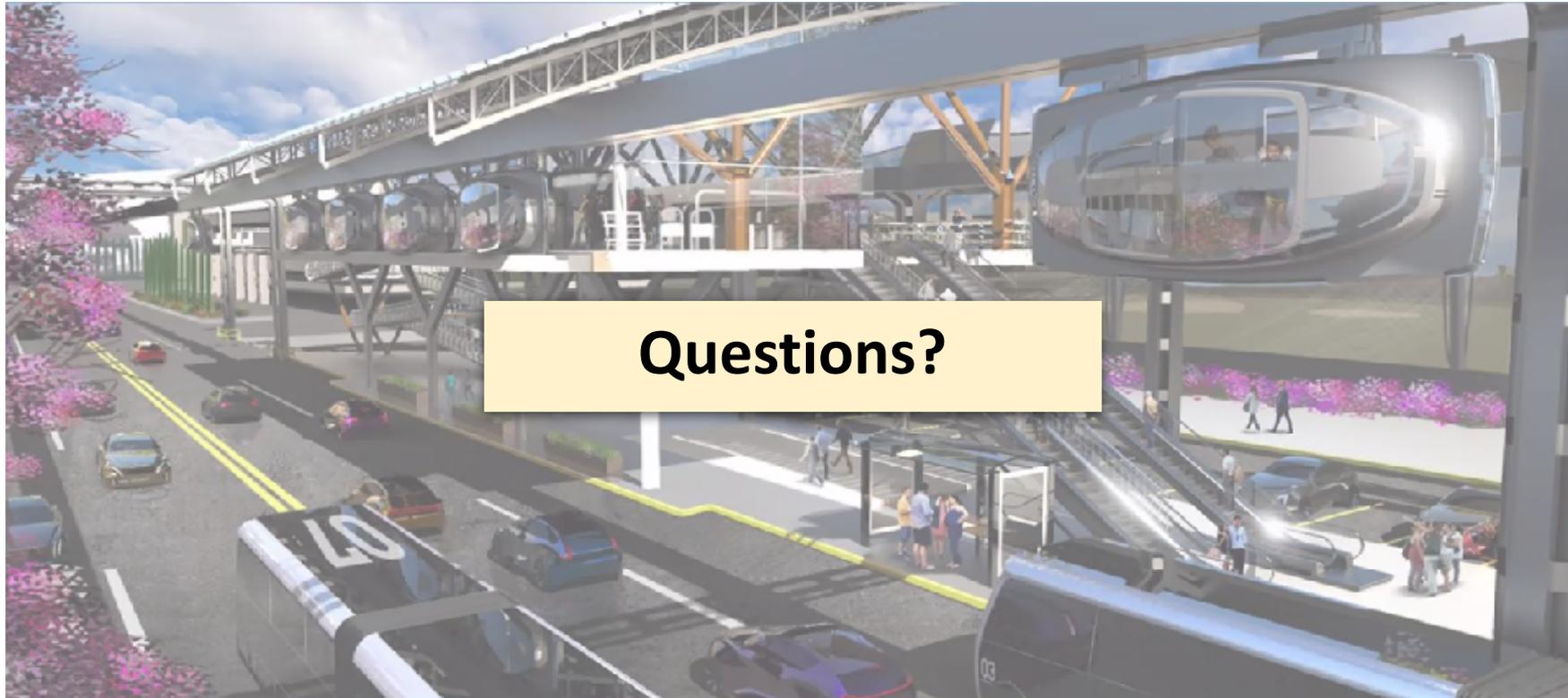
Convene your cities, universities, and industries to join Spartan Superway

... and come talk to us!

www.SpartanSuperway.Net



Thank you for your attention!



Sponsored by the Mineta Transportation Institute,
<https://transweb.sjsu.edu/>



About Us

Presenter Information - Burford Furman

Burford (Buff) Furman, PhD, PE
Professor, Mechanical Engineering
MTI Research Associate
San Jose State University



- **Research interests**
 - Automated transit
 - Automation and control
 - Sensors and measurements
- **Recent publications**
 - **Automated Transit Networks (ATN): A Review of the State of the Industry and Prospects for the Future**, Mineta Transportation Institute, CA-MTI-14-1227, September 2014. [http://](http://transweb.sjsu.edu/project/1227.html)

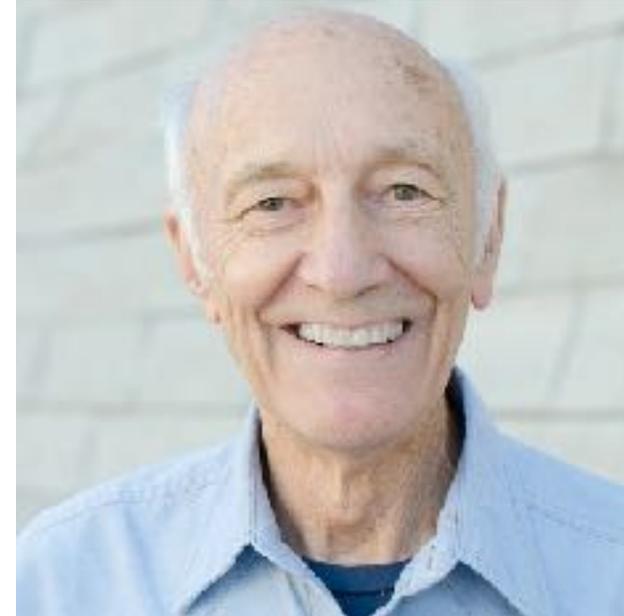
transweb.sjsu.edu/project/1227.html

Presenter Information - Ron Swenson

Ron Swenson

International Institute of Sustainable Transportation

- **Research interests**
 - Solar-Powered Transportation
 - Bioclimatic Design
- **Recent publications**
 - **The Solarevolution: Much More with Way Less, Right Now**—*The Disruptive Shift to Renewables, **Energies***, August 2016
 - **Mitigating Climate Change with Solar-Powered Transit**, *Podcar City 10*, Antwerp, September 2016
 - More at www.swenson.com/ron/library



Presenter Information – Jackson Fogelquist

Jackson (Jack) Fogelquist

PhD Student, Mechanical Engineering
University of California, Davis



- **Research interests**
 - Solar-Powered Transportation
 - Battery Modeling & Estimation
- **Recent work**
 - **Computational Aid for Designing PV Canopy for Solar-Powered Transit**, MS Project Report, Mechanical Engineering, San José State University, May 2019.

Rodz+ Academy in México is our design lead

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ACADEMY

SABER MÁS

