Solar-Powered Automated Transit – Its Time is NOW!

ATRA Pulse article

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On September 10, 2018, California governor Jerry Brown signed Senate Bill 100, a landmark piece of legislation that requires all of the state's electricity to come from carbon-free sources by 2045[1]. While this ambitious goal will significantly reduce the state's contribution of greenhouse gas (GHG) emissions, because 56% of the state's power currently comes from non-renewable sources, it still leaves the largest source of GHG emissions in the state, that due to transportation, essentially unaffected[2]. Indeed, our transportation systems appear to be locked-in to fossil fuels for the foreseeable future. Drastic changes in consumer behavior and governmental policy will be needed to achieve global climate change mitigation goals for 2040 and 2050[3], and even these may not be enough to avoid widespread irreversible damage to life on the planet[4]. The retreat from Obama-era environmental policy by the present US federal administration makes it hard to see how the US is going to step up to the challenges and entailments that will be involved to even make modest *incremental* improvements such as a widespread expansion of plug-in hybrid and battery electric vehicles that will be needed for a de-carbonized transportation future. In fact, the inaction on the part of 'grownup' leaders is being challenged by a group of children who are suing the United States government for failing to adequately protect the Earth from the effects of climate change[5]. The kids have it right in their lawsuit: the time is *now* for revolutionary change in our approach to transportation. Futurist Buckminster Fuller presciently addressed the predicament we are in regarding transportation[6]:

> *"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."*

We are taking Bucky's advice in what we are doing in the Spartan Superway project at San José State University. We propose a new model for urban transportation using automated transit networks (ATN or 'podcars')[7] that are 100% powered by solar energy. In our approach we use podcars that are *suspended* from the guideway, rather than the more typical approach where the podcars ride on top of the guideway. Figure 1 below depicts such a guideway in front of City Hall in San José, California.

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[1] Chediak, M. (2018, September 10). California Governor Jerry Brown Signs Bill for Carbon-Free Power by 2045. Retrieved October 19, 2018, from https://www.bloomberg.com/news/articles/2018-09-10/california-s-brown-signs-bill-for-carbon-free-power-by-2045.

[2] California Greenhouse Gas Emissions for 2000 to 2016. (2018, July 11). Retrieved October 19, 2018, from https://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2016/ghg_inventory_trends_00-16.pdf, https://www.arb.ca.gov/cc/inventory/data/data.htm.

[3] Miotti, M., Supran, G. J., Kim, E. J., & Trancik, J. E. (2016). Personal vehicles evaluated against climate change mitigation targets. Environmental science & technology, 50(20), 10795-10804. (https://pubs.acs.org/doi/abs/10.1021/acs.est.6b00177)

[4] CarbonBrief In-depth: Scientists discuss key findings of the IPCC's special report on 1.5C. (2018, October 10). Retrieved November 16, 2018, from https://www.carbonbrief.org/in-depth-scientists-discuss-key-findings-of-the-ipccs-special-report-on-1-5c

[5] Parker, L. (2018). 'Biggest case on the planet' pits kids vs. climate change. National Geographic News. Retrieved from https://news.nationalgeographic.com/2017/03/kids-sue-us-government-climate-change/

[6] Sieden, L. S. (2011). A Fuller View: Buckminster Fuller's Vision of Hope & Abundance for All. Divine Arts. p. 358.

[7] Podcar concept as described by ATRA: http://www.advancedtransit.org/advanced-transit/concept-description/

One of the major reasons why we have opted for suspending vehicles from the guideway is that doing so frees the top of the guideway for placement of solar photovoltaic (PV) panels to collect the energy needed to power the system. Superway was not the first to suggest solar powered suspended podcars, JPods (www.jpods.com) has been working on this approach since 1998. More recently, the Futran Group (https://futrangroup.com/) has demonstrated suspended vehicle operations since 2014 and plans to use PV to power their system, and Supraways (http://www.supraways.com/) also proposes renewably powered suspended podcars.

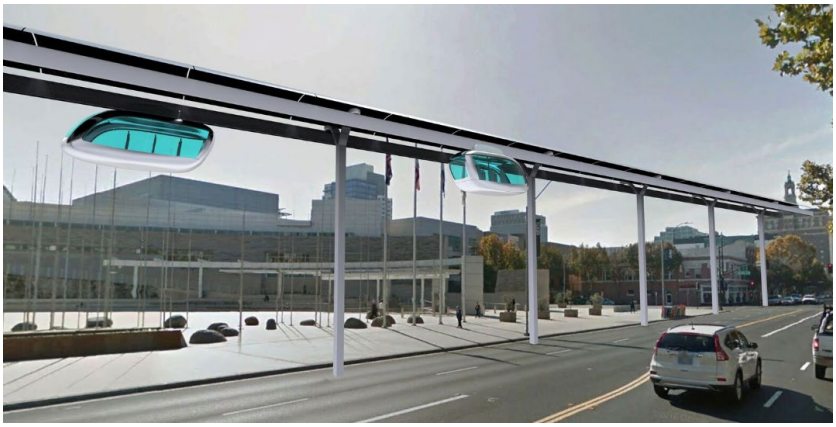

Figure 1. Solar-powered ATN guideway in downtown San José. (courtesy of Paul Albulet, Albulet Design)

Several studies by affiliated researchers[8,9,10] have demonstrated that an ATN system with a PV canopy of modest dimensions is capable of capturing enough energy to power itself 24/7 on an annualized basis (net-zero energy).

A comment that we sometimes receive from people who see our solar-powered approach for the first time is, "*You don't HAVE TO put solar panels on top of the guideway. You could just purchase electric power from renewable sources on the grid, or just put the panels in a solar farm somewhere…*" Such comments are true, *but*… there are good reasons why it makes sense to add PV panels on the guideway:

1. **The energy source is collocated where it is used.**

With a PV canopy above the guideway, no additional land is needed, and transmission costs are minimized. Local energy collection coupled with local energy storage has the potential to create a highly-resilient, grid-independent system to enable a highly reliable transportation system[11]. The PV canopy could even be sized to provide power to nearby businesses or other uses.

2. **The PV canopy provides shade for podcars below the guideway**

It turns out that the energy requirements for heating, ventilation, and air conditioning (HVAC) for podcars are significant, especially for cooling. Shading can significantly reduce the energy required for

[8] Branco, L., Rosenfeld, E., Neto, D., and Furman, B. (2016). Case Study of a Solar Power Installation on an Automated Transit Network in San José. ASES National Solar Conference 2016, San Francisco, CA, USA July 10-13, 2016 (available at: http://proceedings.ises.org/paper/solar2016/solar2016-0020-Branco.pdf).

[9] Swenson, R. (2014). Solar Skyways. Energy Procedia, 57, 109-116. (available at: https://tinyurl.com/yc953erl).

[10] Bjork J., Isaksson B., Jansson C., Jansson H., Lindholm E., Naslund, C. (2013). Solar Skyways: Conditions for a Personal Rapid Transit (PRT) System in Uppsala, Uppsala University. (available at: https://www.inist.org/library/).

[11] Pojani, D., & Stead, D. (2015). Sustainable urban transport in the developing world: beyond megacities. Sustainability, 7(6), 7784-7805. (available at: https://www.mdpi.com/2071-1050/7/6/7784/htm)

cooling podcars in the summer[12,13]. This is especially important for implementations of ATN in low-latitude cities where solar insolation is intense.

3. The PV canopy provides opportunity to improve the visual aesthetic of an elevated guideway

Solar PV is most often located in remote 'farms' or on rooftops, where in both cases, visual impact is a relatively insignificant concern. Solar powered ATN with overhead guideways faces a significant challenge to mitigate its visual impact. However, we think that as more architects, artists, and engineers catch the vision for how solar powered transportation can revolutionize urban life, we will see guideways that are visually appealing and will integrate pleasingly in the built environment. Figure 2 shows how some curvature added to a parking lot PV canopy adds visual appeal to what otherwise might have been an uninteresting flat covering.

Figure 2. PV canopy at Plantronics, Inc. in Santa Cruz, CA. (https://tinyurl.com/y9yhtm76)

The recent United Nations Intergovernmental Panel on Climate Change (UN IPCC) report underscores the global existential threat that climate change poses and sounds the alarm for urgent action[14]. The fact that transportation accounts for about 72% of the petroleum use in the US[15] and a corresponding amount of GHG emissions, the need for fossil fuel-free transportation approaches are needed NOW. Solar powered ATN is poised to make a significant impact on global GHG emissions and significantly improve the quality of life in urban areas[16].

[12] Dominguez, A., Kleissl, J., Luvall, J. (2011). Effects of Solar Photovoltaic Panels on Roof Heat Transfer, UC San Diego, Department of Mechanical and Aerospace Engineering. (available at: http://maeresearch.ucsd.edu/kleissl/pubs/DominguezetalSE2011.pdf)

[13] Macia, N., Ishioye, J. P., Dotson, B., & Macia, M. (2008). Impact of shading on cooling and heating load. In ASEE Annual Conference and Exposition, Conference Proceedings. (available at: https://peer.asee.org/impact-of-shading-on-cooling-and-heating-load)

[14] UN IPCC *Special Report on Global Warming of 1.5 °C* (IPCC, 2018). http://www.ipcc.ch/report/sr15/

[15] Estimated U.S. Energy Consumption in 2017. (n.d.). Retrieved November 16, 2018, from https://flowcharts.llnl.gov/content/assets/images/energy/us/Energy_US_2017.png

[16] Furman, B., Swenson, R., Hagstrom, E. (2017). Spartan Superway Development: A White Paper. (available at: https://www.inist.org/library/2017-03-14.FurmanSwensonHagstrom.SpartanSuperwayWhitePaper.SpartanSuperway.pdf)

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