Passenger Rail Solar Electrification: A Primer

Oregon Department of Transportation Rail Division

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Executive Summary

As Oregon looks to provide more reliable, frequent, and sustainable passenger rail service in the Willamette Valley, the Oregon Department of Transportation (ODOT) is examining existing rail routes for optimal operating and energy options for future intercity passenger service. Intercity passenger service between Portland and Eugene currently runs on the Union Pacific (UP) line. Of the four routes in the Willamette Valley, it is by far the busiest with approximately 20-25 freight trains per day. However an adjacent line, the Portland & Western (PNWR) operated Oregon Electric (OE) line runs two to six freight trains per day. For this reason, the state of Oregon is investigating the opportunities and challenges of moving the intercity passenger service from the UP line to the OE line. Besides freight density, one of the issues to consider is energy use; specifically, can either line be electrified for passenger trains? Because these rail lines are privately owned and operated, it is the sole decision of the host railroad to decide if electrification is an option. Based on conversations with UP and the OE's host railroads, it is ODOT's understanding that electrification is a possibility on the OE, however the UP is not interested in electrification on their mainline.

ODOT's Rail Division, consultants from Parsons Brinkerhoff, and Oregon's Department of Energy conducted a feasibility assessment of electrifying the OE line between Eugene and Southeast Portland at Willsburg Junction with traditional electric sources and solar power generated on publically owned right-of-way.

The Assessment aimed to answer the following questions:

- What are the elements of electrification?
- Are the environmental conditions favorable for solar power?
- Can solar power provide sufficient energy to run electrified passenger trains?
- What are the emissions reductions?
- How much will it cost?

The assessment determined that electrifying the OE line is technically feasible and that it is feasible to supply energy for rail operations through the installation of solar panels (known as photovoltaic or PV panels or arrays) on publically owned right-of-way.

What Are the Elements of Electrification?

Railroad Ownership

There are three separate right-of-way owners along the OE line from Portland to Eugene: Union Pacific (UP) owns two segments including their mainline between Union Station and Willsburg Junction (6 miles) and a segment they lease to PNWR from Willsburg Junction to Tualatin (10 miles); ODOT owns the right-of-way between Tualatin to just North of Keizer (28 miles); and BNSF Railway (BNSF) owns the stretch from North of Keizer to Eugene (76 miles).

The operating rights of the ODOT-owned right-of-way are owned by the PNWR. The sections owned by the BNSF and UP are leased to PNWR. While ODOT may be a willing and active agent in developing electrified rail, the UP, BNSF and PNWR must also agree in order to install infrastructure necessary to electrify. It is critical that any discussion of route electrification include representatives of these entities. It is also assumed that electrification on the 6 mile UP mainline segment between Willsburg Junction to Union Station is improbable.

Catenary versus Third-Rail

Catenary electrification involves the construction of an overhead cable system that supplies energy to electric trains. “Third rail” refers to the construction of a small, ground-level rail that is placed either at the side of the existing right-of-way or in between the tracks. In general, if a train passes through a series of at-grade crossings, use of an exposed third rail is not a viable option due to safety and security reasons. There are over 250 public and private at-grade crossings on this line therefore the assessment assumed that catenary technology is the most applicable technology under current road-rail crossing conditions.

Hybrid Locomotives

If the OE line is electrified, trains will still need to travel on non-electric segments of the UP. Hybrid or “dual-mode” locomotives that can be powered by both diesel and electricity exist and are already in use in other parts of the United States.

In the US, at least three dual-mode locomotive types have been built. The Long Island Rail Road and Metro-North Railroad operate dual-mode diesel-electric/third-rail locomotives between non-electrified territory and New York City, because of a local law banning diesel-powered locomotives in Manhattan tunnels. For the same reason, Amtrak operates a fleet of dual-mode locomotives in the New York area. All three (EMD FL9, P32AC-DM, and EMD DM30AC) operate using a third-rail. In the Pacific Northwest, there are no comparable rail examples, but in the Seattle area, King County/Metro transit buses that enter the downtown Seattle core are dual-mode diesel and electric buses that use overhead catenary.

Dual-mode trains that rely on catenaries for power tend to be more common in Europe. For example, there are dual- mode catenary systems in France (B 81500), Spain (FEVE 1.900 Series), and Switzerland (RhB Gem 4/4). Unfortunately, since dual-mode catenary locomotives have yet to be approved for use in the United States, design and procurement costs will likely be high, as well as general project risk.

Are the Environmental Conditions Favorable for Solar Power Generation?

Yes. Solar power is considered a favorable option when the average annual photo-voltaic solar radiation capacity of an area is about 5.0 kWh per square meter per day. According to estimates by both the US Energy Information Agency and the National Renewable Energy Laboratory, capacity is about 4.0 to 4.5 kWh per square meter per day (approximately 4.0 kWh in Portland, 4.17 kWh in Salem, and 4.13 kWh in Eugene[1]; also the University of Oregon Solar Radiation Monitoring Laboratory monitoring reports cite an annual average of

[1] PVWATTS, a solar energy calculator from the National Renewable Energy Laboratory (http://rredc.nrel.gov/solar/codes_algs/PVWATTS/version1/US/Oregon)

3.8 kWh[2]) – just under the threshold. That said, because the study area so closely meets the threshold, and because the ability of solar arrays to more efficiently capture solar radiation continues to increase, it is worthwhile to continue exploring this option.

Can Solar Power Provide Sufficient Energy to Run Electric Passenger Trains?

Yes. To serve six round trip trains per day would require a one-two Mega Watt (MW) system every 10 miles. Each site would require between six to twelve acres of public land, located very close to the point of connection to the local utility, but not directly in the rail right-of-way. Twelve acre sites will allow for sufficient capacity for load growth for the future electric needs as train service grows.

Under current "net metering" law, each site could not generate more than two MW. Net metering is the term used to define how the energy generated from the solar arrays would be used by the local utility company for sale and distribution then credited against the state's power bill for the energy used by the trains.

What Are the Emissions Reductions?

Green house gas (CO_2) emissions from six diesel roundtrips per day would equal 8,851 tons per year.[3] If 109 miles of the 120-mile corridor was electrified with solar power, greenhouse gas emissions would be reduced to 767 tons per year, a 91 percent reduction.

How Much Will it Cost?

Capital Costs

One of the most significant barriers to the development and use of solar energy is the relatively high capital costs to electrify the line. General costs to electrify a rail line are estimated at $3 million per mile, or $327 million for the 109-mile line segment.[4] The additional costs to electrify with solar power is $300,000 per mile, or an additional 10 percent, bring the entire project cost to $360 million. Two different approaches could be used to finance the solar portion of the capital costs, state ownership or third party ownership.

State Ownership

This approach involves the state purchase and ownership of the solar arrays. Under agreements with the local utilities, power generated would be uploaded to the power grid and

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[2] http://solardat.uoregon.edu/PacNWSolarRadiationDataBook.html

[3] Average diesel locomotive CO_2 emissions is 22.38 pounds per gallon, PB.

[4] Email from Rick Schmedes, PB's lead engineer on the Caltrain Electrification project, March 2009.

then be discounted from the state's electric bill. This option would cost $33 million for solar installation (in addition to the $327 million for electrification which would apply under either scenario). This scenario allows the state to own the arrays and the power they generate.

Third Party Ownership

Third party ownership allows for private companies to leverage federal tax credits and depreciation by paying for the solar power installation costs, however the state would not own the solar assets or the power they generate. This model is being used in ODOT's Solar Highway project.[5] This model would cost the state little to nothing above the initial $327 million used for electrification installation, however the state would need to purchase all electricity necessary to power the trains.

Pay Back Period

If service grows to six roundtrips per day, 1 million gallons of diesel and $3 million in fuel costs will be saved each year. If the state owns the solar resource, the investment for electrification and solar installation ($360 million) will be paid back by year 2050. The pay back period under the third party ownership model would be much longer even though the project costs will be less, since the purchase of electricity would be required.

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[5] More information on the Solar Highway at http://www.oregon.gov/ODOT/HWY/OIPP/inn_solarhighway.shtml

Train Frequency on Rail Line