Battery Electric Switcher Usage Pattern

In this document, the usage pattern of switchers is characterized to analyze infrastructure and equipment requirements for switchers operating in some of California's busiest railyards.

Multiple Switchers, 24/7 Operation (Class I-III Railyards)

Class I, II, and III railyards vary widely, and number of switchers and hours of operations vary depending on the location. Staff research showed that while some railyards have a single switcher, some railyards have more than 30 switchers. For the purpose of this analysis, staff used an example of a railyard with 20 switchers operating 24/7, and each switcher consumes 75,000 gallons of diesel fuel annually.[1] To determine infrastructure needs, staff considered the higher range of switcher operation at a railyard. While some railyards may have higher number of switchers operating, staff research shows that average switcher usage is lower in such cases, and 20 switchers consuming 75,000 gallons of diesel fuel annually represents the energy usage of railyards with the highest switcher activity.

The following assumptions were made to estimate power and energy demand for charging infrastructure:

- Switchers operate 21 hours, before charging 3 hours to full battery capacity.[2]
- 73 percent of energy drawn by the charging infrastructure becomes mechanical work performed by the switcher after various losses.[3]

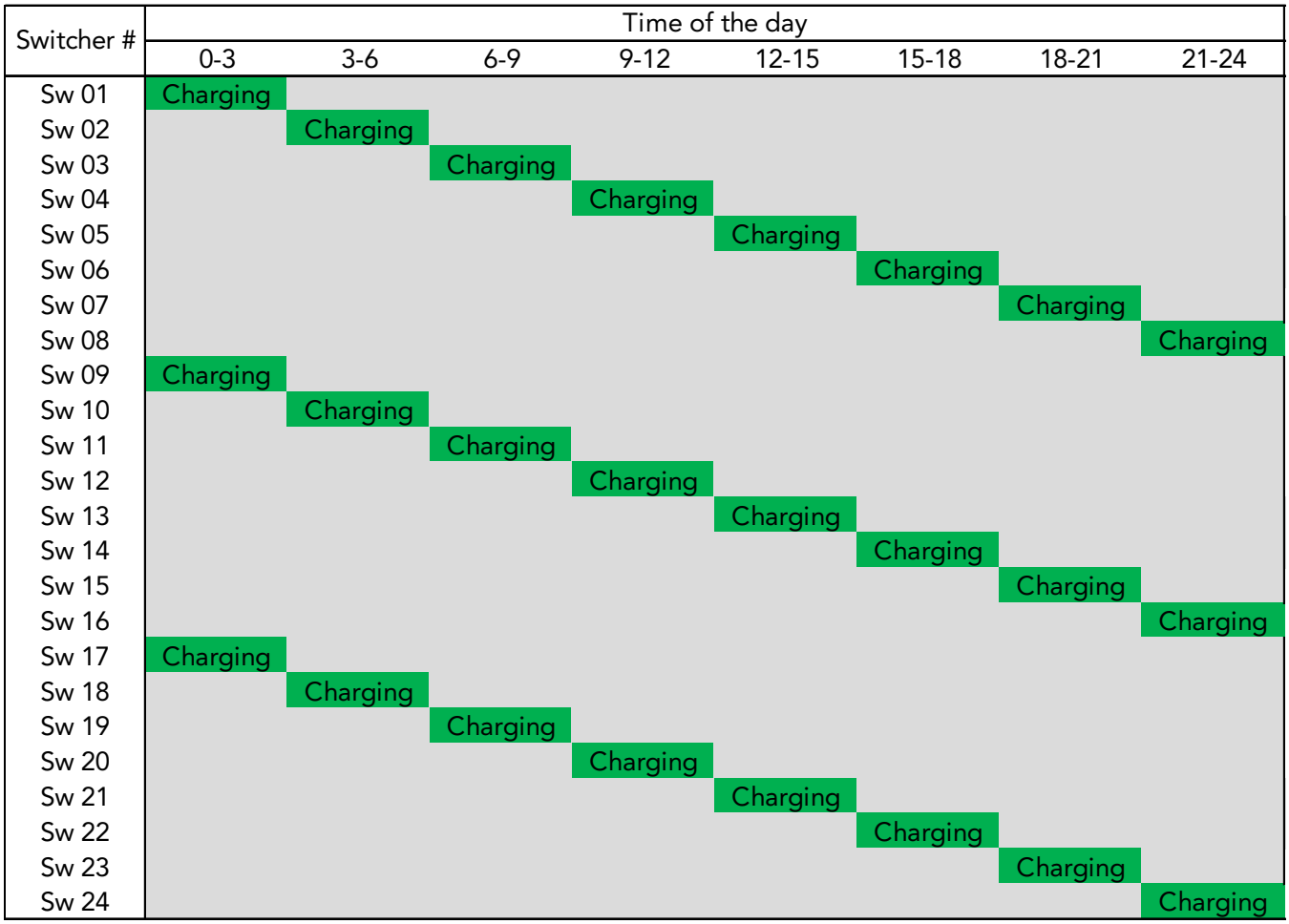
Because each battery electric switcher requires three hours of charging per day, they cannot replace a diesel switcher on one-to-one basis. An example charging schedule is shown in Figure 1. To replace 20 diesel switchers in the example railyard, 23 battery electric switchers and three chargers are required. For simplicity, staff assumed 24 battery electric switchers and three chargers are used, and 21 battery electric switchers are operational at any given time. In other words, each charger supports eight battery electric switchers, and seven of them are on-duty at any given time.

[1] In 2017, 2,986 Class I switchers consumed 223,605,320 gallons of fuel. This averages to each switcher consuming 74,885 gallons per year. 2020 data shows lower usage, but staff used 2017 values to represent the more challenging case. (US EPA, 2020 National Emissions Inventory Locomotive Methodology)

[2] This is a staff assumption. Longer charging time will require a less powerful charger, but more BE locomotives to replace diesel locomotives. Staff selected 3 hours of charging time that resulted in charger power similar to the current product offerings.

[3] This is a high level initial assumption intended as a "ballpark" figure. Staff assumed 10% loss between the grid and battery, 10% loss from parasitic loads, and 90% energy efficiency of battery electric powertrain. Combined, 0.9x0.9x0.9=0.729 of the energy from the grid becomes the mechanical work performed by a BE switcher.

Figure 1: Charging schedule example.



Annual fuel usage of 75,000 gallons per year is equivalent to 205 gallons per day. Assuming fuel efficiency of diesel switcher as 15.2 bhp-hr/gallon,[4] each diesel switcher does 3,123 bhp-hr (or 2.33 MWh) of work per day. To perform this much work, about 2.9 MWh of usable battery capacity is required after accounting for the 20 percent loss from parasitic load and powertrain efficiency. After accounting for the 10 percent charging loss, 3.2 MWh of energy is required at the charger. To charge 3.2 MWh in 3 hours, a charger needs to have 1.1 MW of power. Thus, all three chargers operate continuously 24 hours a day at 1.1 MW power, and the railyard requires about 77 MWh of energy per day, or 28 GWh per year, to charge the battery electric switchers.

For a smaller railyard where each battery electric switcher can spend more than three hours to charge or consumes less than 2.9 MWh of battery capacity each shift, chargers with less power may be used.

[4] US EPA, Emission Factors for Locomotives, April 2009, EPA-420-F-09-025. (weblink: *https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF*).

Single Switcher, Weekly Operation (Industrial Operators)

A typical industrial switcher may consume 10,000 gallons of diesel fuel annually and operate a single 24 hour long shift each week (or 52 shifts per year). Annual fuel usage of 10,000 gallons per year is equivalent to 192 gallons per shift. Assuming fuel efficiency of diesel switcher as 15.2 bhp-hr/gallon,[5] each diesel switcher does 2,923 bhp-hr (or 2.18 MWh) of work per shift.[6] To perform this much work, about 2.7 MWh of usable battery capacity is required after accounting for losses. After accounting for charging losses, 3.0 MWh of energy is required at the charger. With 52 shifts and charging events annually, the energy demand at the charger is 155 MWh of total energy usage annually.

As the switcher has six days to charge between the shifts, the charger can theoretically have as little as 21 kW power. However, assuming more reasonable 12 hours of charging time, charger power is required to be 250 kW. With 1.1 MW charger required for the Class I-III switchers, an industrial switcher can be charged from empty to full in less than three hours.

[5] US EPA, Emission Factors for Locomotives, April 2009, EPA-420-F-09-025. (weblink: *https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF*).

[6] Energy required by industrial operators will be less than this, as industrial switchers have longer idle time and smaller load factor than switchers under the standard US EPA duty cycle, and it results in smaller bhp-hr per gallon.