Wabtec: Freight Segment

Statement of Work

The Future of the Rail Industry

EDSGN 100: Cornerstone Engineering Design

Fall 2021 Client-Driven Design Project

PennState College of Engineering | ENGINEERING DESIGN, TECHNOLOGY, AND PROFESSIONAL PROGRAMS

The Future of the Rail Industry

Project Objective

Research the viability of batteries and hydrogen fuel cells as an alternative to diesel fuel in the rail industry. Design components, including the infrastructure needed, to support the replacement of diesel-powered locomotives in North America. Provide the commercial team with the supporting analysis and a recommendation for a system design using the alternative power sources mentioned above. Information for three different routes in North America will be given to you to determine the amount of energy and power needed to replace the fleet of diesel locomotives.

Project Background

The rail industry makes up about 28% of freight transportation. Reducing emissions in the rail industry could have a large impact on the global carbon footprint. There is a strong push from government officials and regulators, rail customers, and good citizens to identify ways to transport this large amount of freight without the emissions that diesel locomotives expend.

One recent achievement in the rail industry is the first Battery Electric Locomotive (BEL) for heavy haul freight. This unit was deployed by Wabtec for demonstration with BNSF in California. The locomotive operates on all electric batteries and has an energy capacity of 2.4 megawatt hours (MWh). This locomotive is charged by regenerative braking and wayside chargers. This is an amazing achievement, but the work towards zero emissions and green energy cannot stop there. The current design for the BEL locomotive does not provide enough energy to completely eliminate emissions for a given trip. The energy capacity of 2.4 MWh gives you full power for 30 to 40 minutes. In addition, the BEL locomotive is being used as a trailing unit in a combination with diesel-powered locomotives. There has been a fuel and emissions reduction with the introduction of BEL, but not a complete elimination of emissions yet. With high customer demand for a locomotive with higher energy capacity, engineering teams are continuing to research new, more efficient ways to haul heavy freight down the rails. Another concept that is being highly discussed to reduce the emissions associated with freight transportation is hydrogen fuel cell technology. Hydrogen is one of the most abundant elements, but it is rare to find hydrogen in its natural gaseous state. In order to create energy, hydrogen needs to be combined with other elements under certain conditions.

Both battery electric and hydrogen fuel cell technologies have recently made monumental leaps in terms of advancements. More advancements will continue to be made as more research is conducted and designs are adjusted according to those findings and customer needs as mentioned above.

Sponsor Background

Wabtec: Freight Segment (NYSE: WAB, www.wabtec.com) solves the world's toughest transportation challenges. Wabtec builds equipment that moves the rail, mining, and marine industries. Their fuel efficient and lower-emissions freight and passenger locomotives; diesel engines for rail, marine, and stationary power applications; signaling and software solutions; drive systems for mining trucks; and value-added services help their customers grow. Wabtec's newest accomplishment is the FLXdrive Battery Electric Locomotive, running completely off batteries and no diesel. Wabtec is headquartered in Pittsburgh, PA, and employs approximately 27,000 employees worldwide. Wabtec has an install base of over 23,000 locomotives operating globally.

Project Scope

In recent years, electrification has become a broadly researched subject, specifically in the rail industry. In a dynamic society, with zero emissions a large goal for many, the opportunity for developing a locomotive fleet that emits little to no emissions is possible now more than ever. With that being said, Wabtec's executive management is challenging the engineering team to design and propose a system for an alternative powered solution that enables zero emissions on the railroad network, which may include railroads assets such as the locomotive itself as well as supporting infrastructure. Your team should research ways to reduce emissions, specifically using the two energy sources mentioned above that are available to power a locomotive, and recommend a solution that replaces diesel-powered locomotives based on the information provided for specific routes throughout North America. You should take into consideration the future growth of these technologies and what these solutions will offer in the next 10 years."

Product Requirements

For reference, the BEL weighs in at around 430,000 pounds, has a nameplate energy capacity of 2.4 MWh (1.7 MWh usable), and holds approximately 20,000 battery cells. Referring to Figure 1, the BEL is similar in configuration to a diesel locomotive, but the alternator, engine and its cooling system are replaced with batteries. The orange highlighted section is typically where the fuel tank is located, which may not be required in your design. The fuel tank, alternator cab, engine cab, and radiator cab spaces may be utilized for other purposes or adjusted to account for battery or fuel cell mounting.

The recommended system solution should meet all relevant requirements in the selected region, such as regulatory (e.g., in the United States this would be the Federal Railroad Association and Environmental Protection Agency), weight and clearance limits, and Critical to Quality (CTQ) customer requirements. CTQs can be determined through research of existing locomotives operating in the selected region.

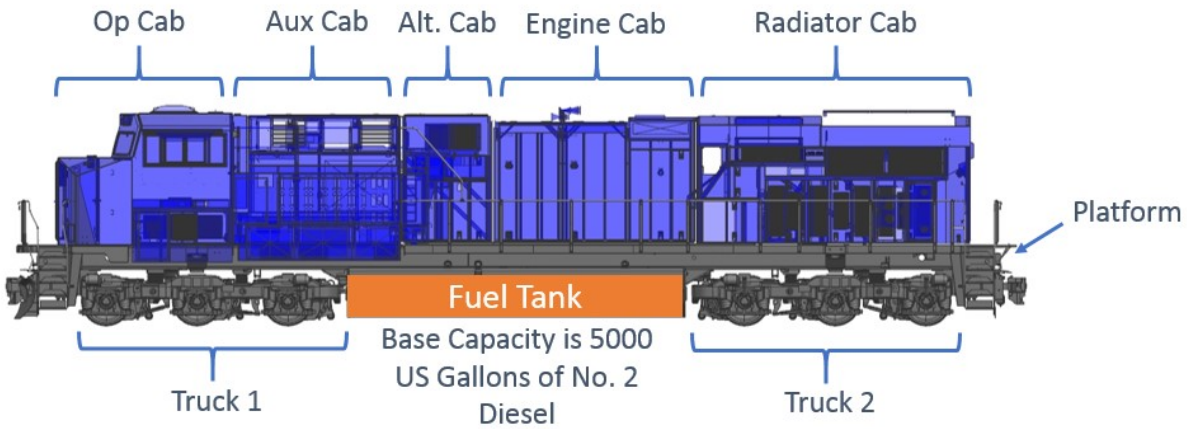

Figure 1: Locomotive Configuration & Design Space Allocations

The scope of this undertaking is to include the following:

- Research alternative power sources such as batteries and hydrogen fuel cells for locomotive application
- Determine the energy and power demands for the three given train routes and create a graphical representation of the energy and power profiles. An example of this is shown in Figure 2 below.
- Evaluate the amount of energy storage (in batteries) and/or hydrogen fuel cells that could feasibly be placed in one locomotive based on railroad standards for weight and size
- Determine the number of locomotives and hydrogen tender cars needed to replace the diesel locomotives on each of the three trains based on your energy and power analysis (note: the solution must be capable of providing the same total power and energy)
- Explore infrastructure needs and changes to support the shift to alternative power sources
- Your team should:
    - Conceptualize and prototype your proposed design
        - E.g., a design for the hydrogen tender and prototype of the hydrogen tank(s) to hold the hydrogen with proper wall thickness and size; design an prototype of supporting infrastructure, etc.
    - Rationale for all recommendations

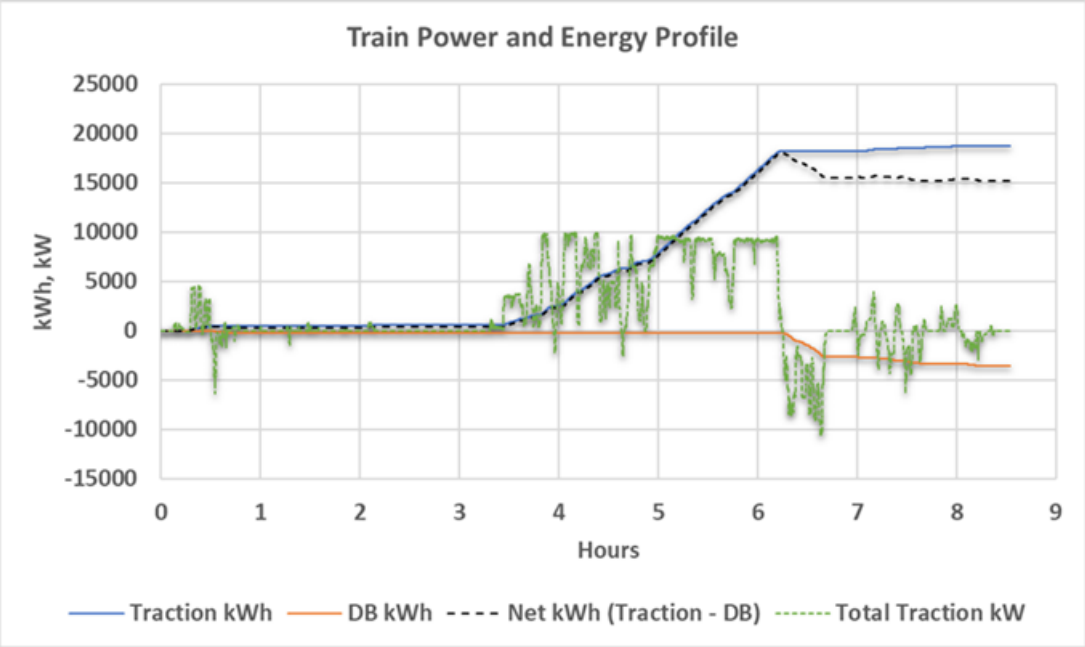

Figure 2: Power and Energy Profile

Additional Resources

- CAD models of base platform for tender car following the locomotive and base locomotive with operator cab.
- Route data to calculate energy profile of diesel locomotive fleet with explanations
- EDSGN 100 Project Website: https://sites.psu.edu/engineeringdesign100/clientcentered-design/current-project/