DesertXpress Enterprises, LLC High-Speed Rail Energy Economy Ratio

LCA.8144.211.2023

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DISCLAIMER

ACKNOWLEDGEMENT

Life Cycle Associates, LLC performed this study under contract to DesertXpress Enterprises, LLC. Husein Cumber was the project manager.

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Summary

This report presents an energy efficiency ratio (EER) analysis for the high-speed rail (HSR) line proposed for operation from Rancho Cucamonga, California to Las Vegas, Nevada by DesertXpress Enterprises, LLC, a Nevada limited liability company, which does business as Brightline West (formerly dba XpressWest). HSR is currently not a certified fuel pathway in the California Air Resource Board (CARB) Low Carbon Fuel Standard (LCFS) Regulation. Developing a certified LCFS pathway requires calculating an EER that can be used to generate an EER-adjusted carbon intensity value for the pathway. Options for developing an EER include comparing HSR energy consumption to that of a hypothetical equivalent, such as a diesel train, or to displaced established transportation modes (DTM). The DTM approach was implemented in this evaluation.

An extensive literature search was conducted to identify the most current and representative data to use in the HSR EER model for the proposed DesertXpress Rancho Cucamonga to Las Vegas (RC-LV) Line. Data were evaluated and analyzed in an EER model developed in a format compatible with CARB guidance (CARB, 2014).

Preliminary EER model results indicate a baseline EER value for the proposed DesertXpress RC-LV HSR Line of 11.62 based on actual HSR route distance and 11.68 for a displaced-distance basis.

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Terms and Abbreviations

Authority	California High Speed Rail Authority
Btu	British thermal unit
CA	California
CA-GREET	California Greenhouse gases Regulated Emissions Energy use in Transportation Model
CARB	California Air Resources Board
CHSR	California High Speed Rail
CI	Carbon Intensity
DTM	Displaced Transportation Mode
EER	Energy Economy Ratio
EMFAC	Emissions Factor Inventory
EV	Electric vehicle
GGRF	Greenhouse Gas Reduction Fund
GHG	Greenhouse Gas
GREET	Greenhouse gases, Regulated Emissions, Energy Use in Transportation Model
GVRW	Gross Vehicle Rated Weight
HSR	High-Speed Rail
kWh	kilo-Watt hour
LCFS	Low Carbon Fuel Standard
LDA	Light Duty Automobile
LDT	Light Duty Truck
LDV	Light Duty Vehicle
LHV	Lower Heating Value
LRT	LCFS Reporting Tool
LSE	Load Serving Entity
LTO	Landing and Take Off
MDV	Medium Duty Vehicle
MJ	Megajoule
MOT	Mode of Transportation
MPG	Miles per Gallon
MPDGe	Miles per Diesel Gallon Equivalent
MPGGe	Miles per Gallon Gasoline Equivalent
MW	Mega-Watt
RFG	Reformulated Gasoline
RP	Revealed Preference
SP	Stated Preference
VMT	Vehicle Miles Traveled

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1. INTRODUCTION

This report to presents an energy efficiency ratio (EER) analysis for the high-speed rail (HSR) line proposed by DesertXpress Enterprises, LLC[1] (DesertXpress) from Rancho Cucamonga, CA to Las Vegas, Nevada for use in the California Air Resource Board (CARB) Low Carbon Fuel Standard (LCFS) Regulation. Currently, the LCFS does not include an EER value for electric power used in HSR. A determined EER would be used for calculating the fuels displaced from HSR operation.

1.1 Background

HSR is defined by the U.S. Department of Transportation Federal Railroad Administration (FRA) as intercity passenger rail service that is reasonably expected to reach speeds of at least 110 miles per hour (49 USC §26106(b)(4)). In subsequent rulemaking, the FRA defined a Tier III passenger rail service to facilitate the safe implementation of nation-wide, interoperable high-speed passenger rail service at speeds up to 220 mph (USDOT FRA, 2018). Regulation specifies a fully grade-separated, dedicated right-of-way for operations above 125 mph. The strategic plan for national HSR service defines the HSR-Express categorization as exhibiting the following characteristics (USDOT FRA, 2009).

- Frequent, express service between major population centers 200 to 600 miles apart, with few intermediate stops
- Top speeds of at least 150 mph on completely grade-separated, dedicated rights-of-way (with the possible exception of some shared track in terminal areas)
- Intended to relieve air and highway capacity constraints

In California, the transportation sector is the highest emitter of greenhouse gases (GHG), contributing 40.1% of the state's total emissions (CARB, 2019). Figure 1 represents tailpipe emissions from on-road vehicles and direct emissions from other off-road mobile sources. Electrification of transportation provides a valuable approach to decarbonizing the transportation sector. California is car-centric and roadways are increasingly becoming congested. Considering increased population growth, creation of zero-emission transportation networks, such as HSR, is a potential solution to reduce roadway congestion, greenhouse gas (GHG) emissions, and associated airborne pollutants.

HSR development has a long history in California and a longer history in Asia and Europe (EESI, 2018). The first HSR system in Japan began operating in 1964, and in Europe, France began operating HSR in 1981. California began investigating HSR in 1981. Planning for a statewide HSR system gained traction when the California Legislature created the intercity High-Speed Rail Commission in 1993 and charged it to conduct a feasibility study. After the commission concluded that a statewide HSR project was feasible in 1996, the Legislature passed the High-Speed Rail Act. This Bill created the California high-speed rail Authority (Authority) and charged it to prepare a plan to design, construct, and operate an HSR system to connect the state's major metropolitan

[1] A Nevada limited liability company which does business as Brightline West (formerly dba XpressWest).

areas. In 2008, voters approved Proposition 1A (Prop 1A), a $9.95 billion bond measure with $9 billion dedicated to the development and construction of Phase 1 of the HSR. Prop 1A, now in statute, further defines high-speed rail in California. Specifically, (d) *High-speed train* means a passenger train capable of sustained revenue operating speeds of at least 200 miles per hour where conditions permit those speeds (Legislative Analyst's Office, 2008). Prop 1A also requires the Authority to operate high-speed service without a subsidy, and for Phase 1, to connect the major cities in the Bay Area, Central Valley, and Los Angeles Basin with specific travel times.

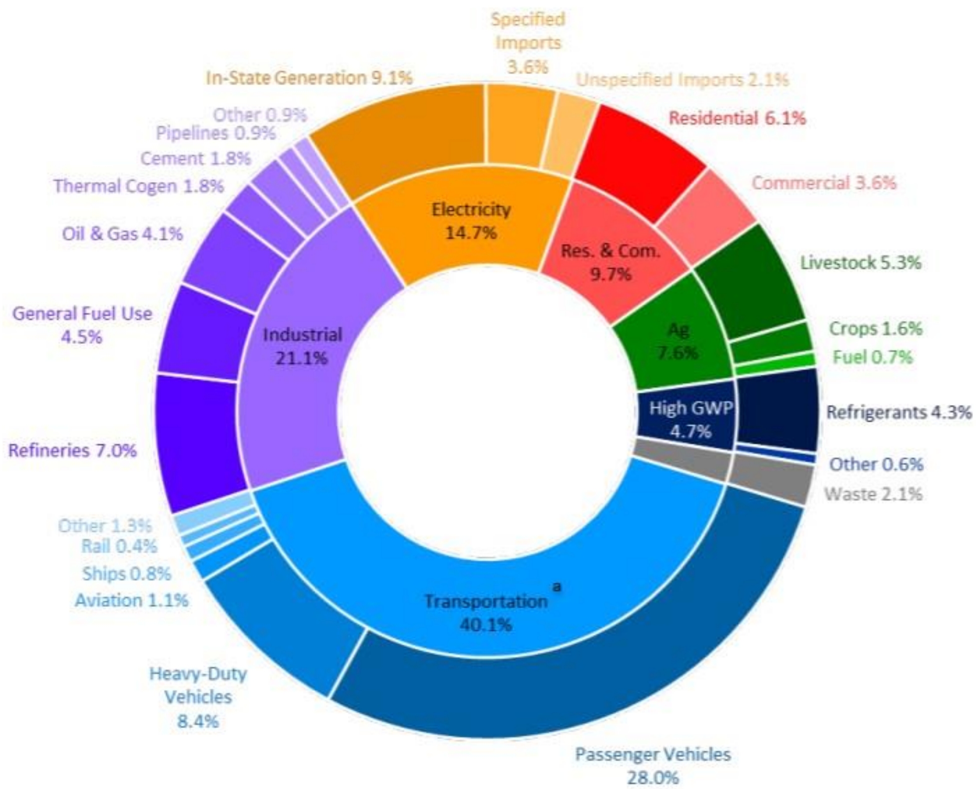

Figure 1. 2017 California greenhouse gas emissions by sector
Source: CARB, 2019

In 2009, California secured $3.3 billion from the Federal American Recovery and Reinvestment Act as well as other funds available through federal appropriations and grants to support the planning and environmental work, final design, and construction of the first segment of the CHSR. In 2012, the California State Legislature appropriated $8 billion in federal and state funding for planning, preliminary design, environmental clearance, and construction of Central Valley HSR and 15 "bookend" and connectivity projects throughout the State. In June 2014, then-Governor Jerry Brown apportioned 25% of the state's annual Greenhouse Gas Reduction Fund (GGRF), which was created by a portion of the Cap-and-Trade auction proceeds, to fund CHSR for one year. CA Senate Bill 862, passed in 2014, continuously allocated the 25% GGRF and provided a $400 million loan from the GGRF to the Authority (California Legislative Information, 2014). Construction of an initial test section of 119 miles between Madera and Poplar Avenue, north of Bakersfield, commenced in 2015.

The California high-speed rail system, as part of a statewide rail modernization plan, is intended to become the backbone of electrified rail transportation in California. The Authority's plan (2020a) is to complete an initial operating segment between Merced and Bakersfield and to complete the entire Phase 1 area, connecting the San Francisco and the Los Angeles "mega-regions", in building blocks. A second phase of the program includes extension of high-speed rail to Sacramento and San Diego, covering 800 miles with up to 24 stations.

DesertXpress has pursued development of an HSR line between Southern California and Las Vegas, Nevada since 2007. Construction of an HSR line from Rancho Cucamonga, California to Las Vegas is planned to commence in 2023. Rancho Cucamonga, located near the base of the I-15 corridor through the San Gabriel Mountains, serves as the primary gateway for road-based travel from California to Las Vegas. All freeway routes from southern California converge on the I-15, making the Rancho Cucamonga station highly accessible to road-based as well air travelers.

DesertXpress is a unit of Florida East Coast Industries, which operates the Brightline passenger rail system from Miami to Orlando. Substantial progress has been made towards funding the project, purchasing land for stations, a maintenance yard, and related residential and commercial development, as well as receiving granted use of federal highway land. Considerable funding for this $4.8 billion project has been secured through a combination of federal and state programs. In October 2019, the California Infrastructure and Economic Development Bank approved $3.25 billion in tax-exempt bonds for this project (Victor Valley News Group, 2019). On March 9, 2020, the U.S. Department of Transportation approved $1 billion in tax-exempt private activity bonds. In April 2020, California government officials signed off on issuing $2.4 billion in tax-exempt bonds (Ohnsman, 2020). Nevada officials approved the issuance of $800 million to fund the Nevada section of the HSR.

Future HSR service is planned for extension across the High Desert Corridor to Palmdale, CA, enabling seamless integration with the California HSR (High Desert Corridor Joint Powers Authority, 2017).

Investment grade ridership studies indicate the need for a transportation alternative connecting Las Vegas with Southern California. An average of 38 million people visited Las Vegas between 2005 and 2014, and over 42.1 million visited in 2018. From 2010 to 2018, visitor volume has increased at a compound annual growth rate of 1.5%, representing a rebound from the declines observed in 2008 and 2009 associated with this recession period. The percent of total visitors to Las Vegas that travel from Southern California has ranged from 29% in 2004 to 19% in 2018, demonstrating a strong travel market from this region (URS, 2005) (GLS Research, 2018). In 2018, 90% of the visitors from Southern California drove to Las Vegas on Interstate-15 (I-15). Uncongested drive time on the I-15 is 4-6 hours and travel at peak times (Thursday and Friday northbound, Sunday southbound) is often significantly longer. HSR may decrease travel time, and improve safety, reliability, and convenience of travel.

1.2 The High-Speed Rail Vision

HSR systems exist in many European and Asian countries. In China, HSR lines have proven their profitability, and throughout Asia and Europe, HSR is providing a lower cost and shorter travel time alternative to air travel for many of the shorter routes. By increasing the number of cities that have HSR hubs, this network-effect has the potential to geometrically multiply the utility of HSR to travelers, and thereby provide long-term economic and lifestyle benefits for all residents and visitors. The U.S. High Speed Rail Association describes how HSR offers significant time savings compared with flying or driving between San Francisco and Los Angeles (EESI, 2018) (Figure 2). The Authority's 2020 Business Plan provides further detail on comparative travel times for car, existing rail, and HSR, between multiple locations in California (Figure 3).

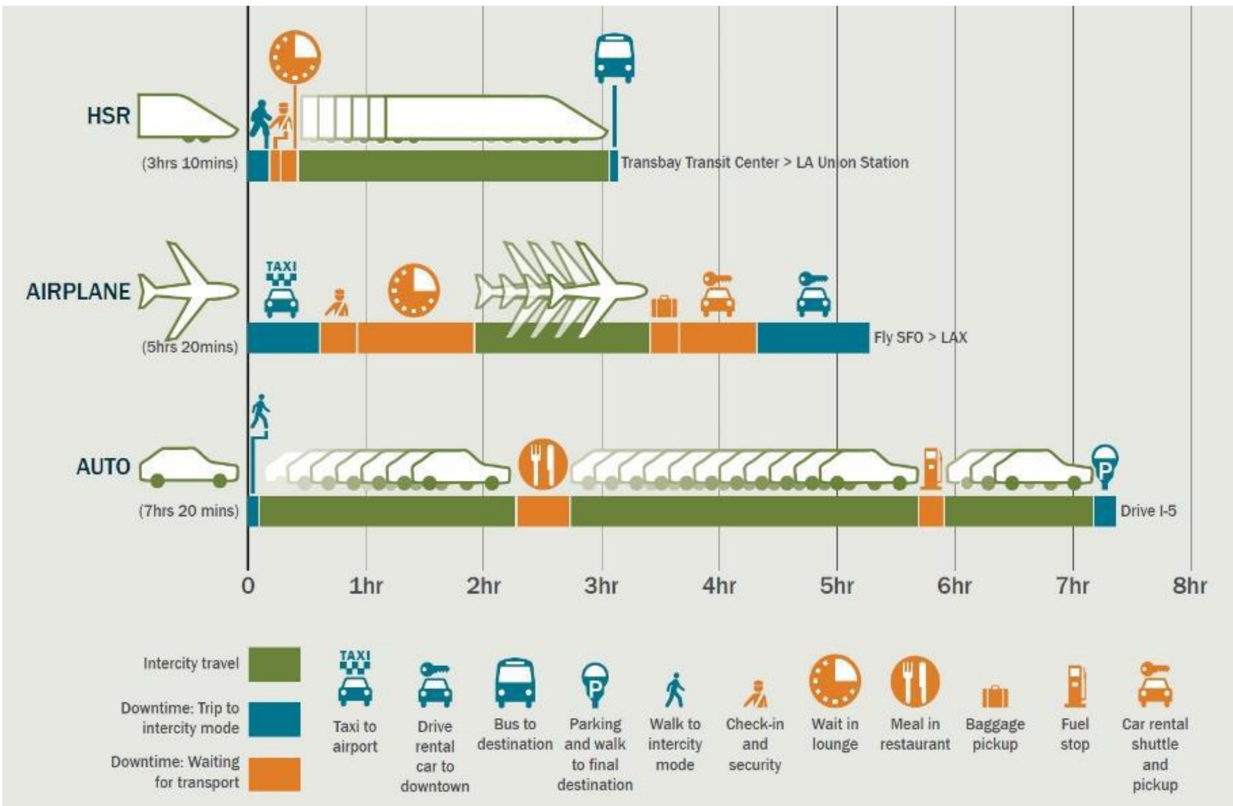

Figure 2. Door-to-door travel times between San Francisco and Los Angeles, California
Source: EESI, 2018

HSR advocates argue that the same criterion used to evaluate highway and airport projects—the ability to move people and goods—should be the primary consideration for HSR. Reducing the number of vehicles traveling on roads can translate into large energy savings and reduced reliance on fossil fuels. The International Union of Railways estimates that HSR is more than four times as energy efficient as driving in cars and nearly nine times more efficient than flying (EESI, 2018). In terms of environmental considerations, HSR offers a path lower in GHG than any other existing modes of transportation (CARB, 2018a).

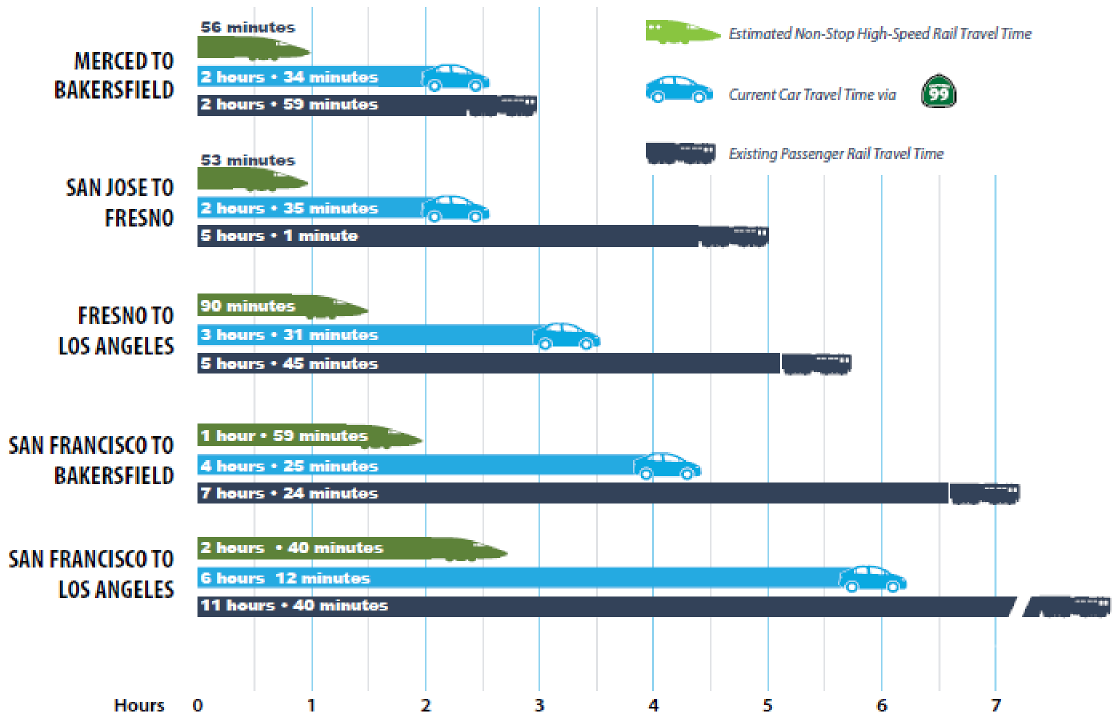

Figure 3. Comparative travel times for passenger car, conventional rail, and high-speed rail
Source: California High-Speed Rail Authority, 2020a

Key findings from Haas, 2014, a scholarly review of literature for model shift and high-speed rail, include the following:

- All studies reviewed clearly identified HSR as being extremely competitive with other travel modes, thereby providing "a reasonably secure basis for inferring that new HSR systems placed in appropriate travel corridors and managed well are likely to result in significant amounts of modal shift. Essentially the literature affirms that HSR has resulted in significant-to-dramatic mode shifts where it has been systematically evaluated" (pp4).
- The most extensive and convincing information pertains to displacement of airline service. Research concerning direct competition with automobiles, express buses, and other modes is less developed, yet still indicates HSR service likely will effectively win market share.
- "With respect to a handful of key characteristics, the geography and demography of the planned system place it (*sic* CHSR) within a 'sweet spot' of factors known to enhance HSR competitiveness. Among these, the California system may potentially encompass the following:
    - Middle-range route distance (approximately 800 km);
    - Density of cities served;
    - Planned travel times under three hours;
    - Planned accessibility of stations in major urban centers;
    - Planned high frequency of service;
    - Planned connectivity to other modes;
    - Projected congestion and delays associated with other modes" (pp29).

The anticipated outcomes for operation of DesertXpress HSR along the Interstate-15 corridor include:

- Reducing vehicle and greenhouse gas emissions;
- Mitigating roadway congestion along the I-15, one of the nation's most congested corridors;
- Decreasing travel time between Los Angeles and Las Vegas;
- Providing reliable, sustainable, efficient and safe rail transportation as an attractive alternative to travel by car, motor coach, or airplane;
- Enabling productive use of time during travel;
- Creating jobs and stimulate economic development around station sites;
- Providing incentives for development of HSR through the High Desert Corridor, directly connecting Las Vegas, via Rancho Cucamonga to the planned California HSR station in Palmdale, CA (Figure 4).

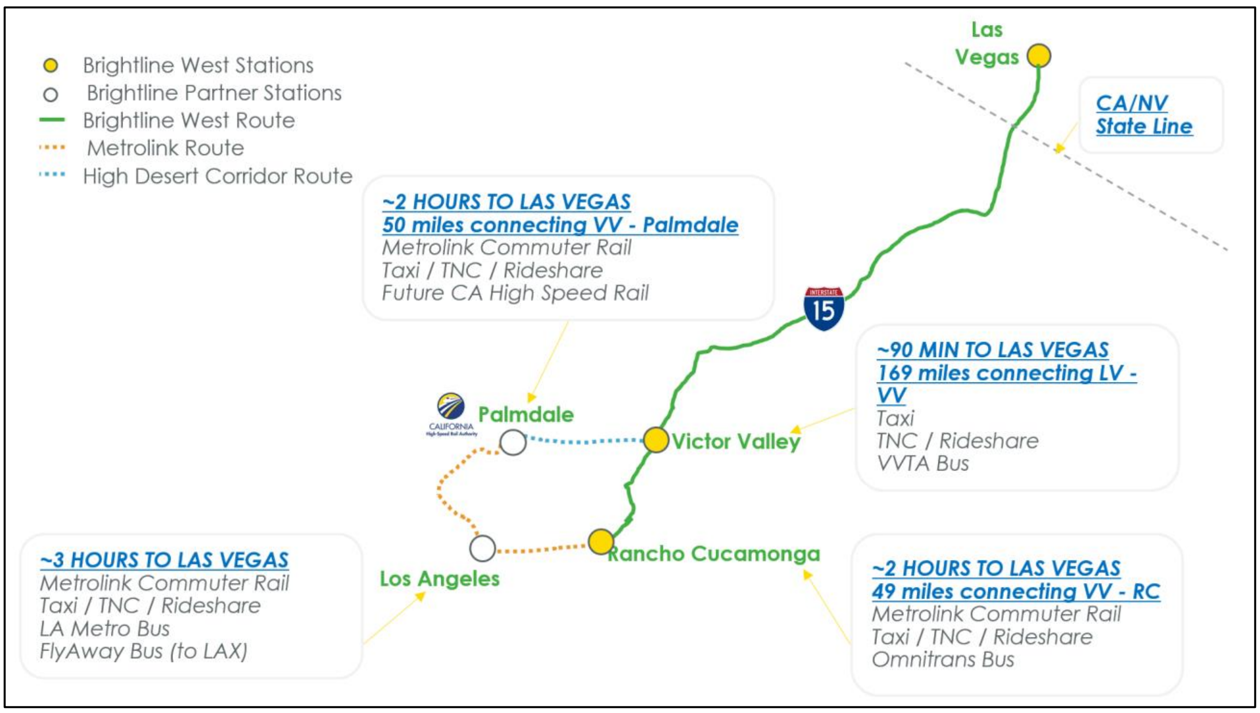

Figure 4. Locations of planned high-speed rail development between Las Vegas and the Los Angeles Basin

1.2.1 Rancho Cucamonga to Las Vegas Roll Out

DesertXpress's 218-mile route planned from Rancho Cucamonga, CA to Las Vegas, Nevada, includes 34 miles in Nevada; thus, approximately 184 miles of this route within California would displace conventional fuels and potentially generate credits under the LCFS (CARB, 2018a). The maximum train speed is expected to be 186 mph with an option to travel up to 200 mph for this planned two-hour trip. The proposed 54-mile High Desert Corridor segment (High Desert Corridor Joint Powers Authority, 2017) is anticipated to achieve travel between Rancho Cucamonga and Palmdale in under 30 minutes and would create a valuable link between the California High Speed Rail (CHSR) network and Las Vegas, via Rancho Cucamonga, using DesertXpress infrastructure.

The CHSR, as part of the statewide rail modernization plan, is intended to become the backbone of electrified rail transportation in California. The Authority's plan is to connect San Francisco and the Los Angeles Basin and eventually extend to Sacramento and San Diego, totaling 800 miles with up to 24 stations. In accordance with California Proposition 1A, the total non-stop trip time between San Francisco and Los Angeles must not exceed 2 hours, 40 minutes, meaning an average speed of 195 mph must be maintained. In blended/shared corridors, trains will be slowed to 110 mph, as required by regulation, however, in other areas, trains may achieve up to 220 mph (California High-Speed Rail Authority, 2020a).

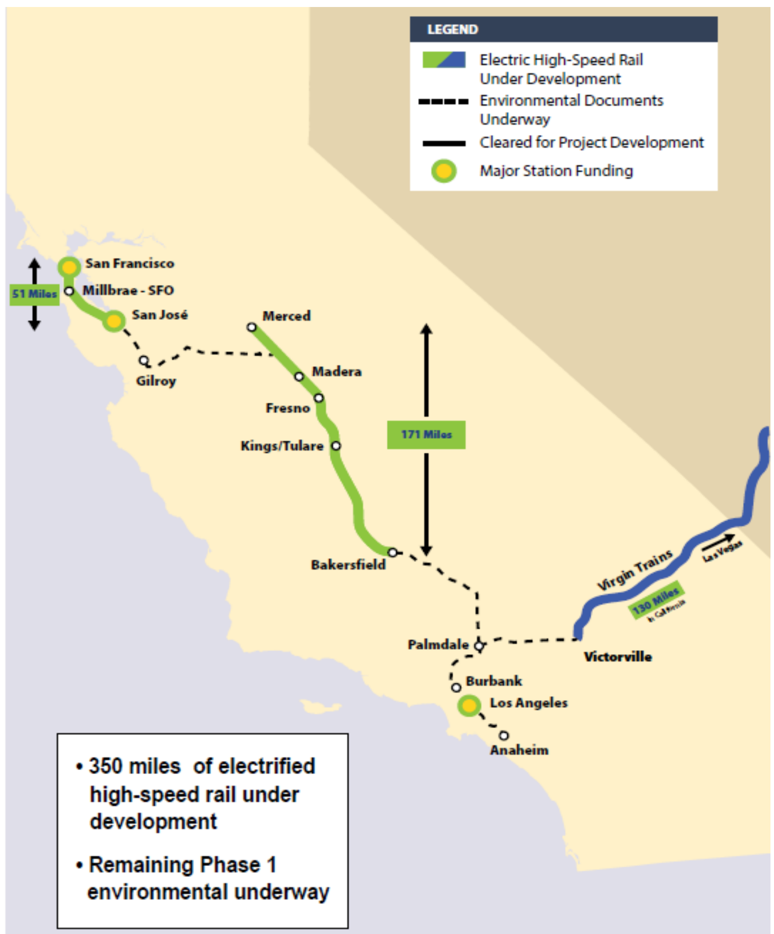

Figure 5. Anticipated roll-out of HSR infrastructure in California and Las Vegas, Nevada
Source: California High-Speed Rail Authority, 2020a

1.3 California Low Carbon Fuel Standard

The Low Carbon Fuel Standard (LCFS) is a fuel-neutral, market-based program designed to reduce the average carbon intensity (CI) of transportation fuels used in California. Administered by CARB, it provides an incentive for electric vehicles operating with low to zero emissions. Low CI fuel producers and users of electricity as transportation fuel can opt in to the LCFS Reporting Tool (LRT) and generate credits that can be sold or traded through this system with obligated parties, including petroleum importers, refiners, and wholesalers. Fuel producers with a CI value above the LCFS compliance curve generate deficits and, therefore, need to purchase credits from the LCFS market each year to balance their deficits.

1.3.1 Credit Generation for Fixed Guide Systems

LCFS credits and deficits are determined for a fuel based on the amount sold, its CI, and the efficiency by which a powertrain converts the fuel into useable energy. To qualify for LCFS credits, HSR falls under the category of Other Electric Transportation Applications per §95483(c)(6).

Per §95483(c) of the LCFS Regulation (CARB, 2018a), the EV credit (C_e) is based on several parameters using the following formula that applies to all fuels in general:

§ 95486.1. Generating and Calculating Credits and Deficits Using Fuel Pathways.

(a) *General Calculation of Credits and Deficits Using Fuel Pathways.* LCFS credits or deficits for each fuel or blendstock for which a fuel reporting entity is the credit or deficit generator will be calculated according to the following equations:

(1) $Credits_i^{XD}/Deficits_i^{XD}(MT) = \left(CI_{standard}^{XD} - CI_{reported}^{XD}\right) \times E_{displaced}^{XD} \times C$

where:

$Credits_i^{XD}/Deficits_i^{XD}(MT)$ is either the number of LCFS credits generated (a zero or positive value), or deficits incurred (a negative value), in metric tons, by a fuel or blendstock under the average carbon intensity requirement for gasoline (XD = "gasoline"), diesel (XD = "diesel"), or jet fuel (XD = "jet");

$CI_{standard}^{XD}$ is the average carbon intensity requirement of either gasoline (XD = "gasoline"), diesel (XD = "diesel"), or jet fuel (XD = "jet") for a given year as provided in sections 95484(b), (c) and (d), respectively;

$CI_{reported}^{XD}$ is the adjusted carbon intensity value of a fuel or blendstock, in gCO_2e/MJ, calculated pursuant to section 95486.1(a)(2);

$E_{displaced}^{XD}$ is the total quantity of gasoline (XD = "gasoline), diesel (XD = "diesel"), or jet (XD = "jet") fuel energy displaced, in MJ, by the use of an alternative fuel, calculated pursuant to section 95486.1(a)(3); and

C is a factor used to convert credits to units of metric tons from gCO_2e and has the value of:

$$C = 1.0x10^{-6} \frac{(MT)}{(gCO_2e)}$$

(2) $CI_{reported}^{XD} = \frac{CI_i}{EER^{XD}}$

where:

CI_i is the carbon intensity of the fuel or blendstock, measured in gCO_2e/MJ, determined by a CA-GREET pathway or a custom pathway and incorporates a land use modifier (if applicable); and

EER^{XD} is the dimensionless Energy Economy Ratio (EER) relative to gasoline (XD = "gasoline"), diesel (XD = "diesel"), or jet fuel (XD = "jet") as listed in Table 5. For a vehicle-fuel combination not listed in Table 5, $EER^{XD} = 1$ must be used unless an applicant is granted certification of an EER-adjusted CI value pursuant to section 95488.7(a)(3).

(3) $E_{displaced}^{XD} = E_i \times EER^{XD}$

where:

E_i is the energy of the fuel or blendstock, in MJ, determined from the energy density conversion factors in Table 4, except as noted in subsection (4) below.

The calculation in equation (1) shows the direct conversion from kilowatt hour (kWh) of power to LCFS credits as a simplified formula.

$$Credits_e = e(kWh) \times 3.6\frac{MJ}{kWh} \times (CI^{XD} \times EER - CI^e)/10^6 \qquad \text{Eq (1)}$$

where:

$Credits_e$ = LCFS credits (tonne CO_2e)
e = kWh of electric power consumed in charging
CI^{XD} = Carbon intensity of displaced fuels for LCFS target. This value is in grams of CO_2 equivalent per megajoule (g CO_2e/MJ) and is set to decline every year until reaching a target of 20% less than the 2010 baseline by the year 2030.
EER = Energy economy ratio, for example, 3.4 MJ of gasoline are displaced for 1 MJ of electric power for battery EVs
CI^e = Carbon intensity of electric power; currently this value is 81.49 g CO_2e/MJ (3.6 MJ/kWh)

1.3.2 Prior EER Evaluations

CARB's staff report on initial statement of reasons (ISOR) for the proposed amendments to the LCFS (CARB, 2018b) describes the following five EER analyses:

- Liquified petroleum gas relative to conventional diesel vehicles
- Liquified petroleum gas relative to gasoline for a spark-ignited-engine powered vehicles
- Electric transport refrigeration units
- On-road electric motorcycles
- Battery electric truck and bus energy efficiency compared to conventional diesel vehicles

These EERs compare expected energy use and associated greenhouse gas emissions for different vehicle technologies and fuel types. Of these five, the 2018 EER comparing battery electric truck and bus energy efficiency compared to conventional diesel vehicles provides the closest example EER to compare to the analysis presented here. CARB (2018c) found a statistically significant correlation between the EER and average driving speed for battery electric trucks and buses when compared to equivalent conventional diesel trucks and buses for a wide range of vehicle types and weight classes. Fuel economy comparisons for electricity are commonly developed on a miles per diesel gallon equivalent (MPDGe) basis. EERs for fixed guideway systems are based on megajoules (MJ) per number of passenger-miles traveled (CARB, 2016a). CARB initially estimated an EER for battery electric trucks based on a limited 2007 data set, and in 2018 updated this EER with a larger, more robust dataset based on three primary data sources that measured diesel fuel and electricity for comparable vehicles and loads on the same test cycles. As this process demonstrates, EERs can be refined as additional robust data become available. The possible approaches to developing an HSR EER are presented in the following section.

EER For Rail

CARB supports electrifying the transportation sector as indicated in the LCFS regulation (CARB, 2018a) which states:

> *In California, these systems can provide lower carbon transportation for millions of passenger trips (American Public Transportation Association Transit Ridership Report 2014). Providing an opportunity for credit generation for use of electricity as a transportation fuel supports the overall purpose of the LCFS to reduce the carbon intensity of the transportation fuel pool in California, reduce California's dependence on petroleum, create a lasting market for clean transportation technology, and stimulate the production and use of alternative, low carbon fuels.* p. III-7.

CARB's description (2018a) for fixed guideway systems is listed below in equation (2):

$$EER = \frac{energy\ (MJ)/(total\ passengers)(total\ miles\ traveled)_{displaced\ mode}}{energy\ (MJ)/(total\ passengers)(total\ miles\ traveled)_{fixed\ guideway\ system}} \qquad \text{Eq (2)}$$

As illustrated in equation (2) and stated in LCFS Guidance (CARB, 2020), a critical aspect of the EER methodology is accurately identifying the displacement baseline. In reference to high-speed rail, this guidance specifies that "the displacement baseline may be a combination of multiple transport applications rather than a one-to-one replacement of a particular application. For example, a new high-speed train project may be shown to displace passenger vehicles, air transport, and bus transport" (CARB, 2020, pp3). Moreover, with respect to source data, this guidance specifies that "the applicant may clearly identify the displacement baseline and provide a justification along with all the data or references relied upon to make that determination. The applicant may rely on academic and market research, study, reports, surveys, etc., to make that determination" (CARB, 2020 pp3).

1.4 HSR EER Options

HSR is not currently a certified fuel pathway in the CARB LCFS Regulation (Figure 6). Table 5 of the LCFS Regulation (Appendix B) lists EER values for several fuel-vehicle combinations that are used for calculating credits or deficits as per §95486.1(a) (CARB, 2020). HSR is not included in this table. If a fuel-vehicle combination is not represented by an EER value in Table 5 and both the fuel and vehicle type are eligible under the LCFS (§95482), the reporting entity may request an EER-adjusted CI for reporting and credit generation purposes. Options to developing an EER include the following:

1) HSR operators submit individual Tier 2 pathway applications that either compare HSR energy consumption to that of a hypothetical equivalent, such as a diesel train, or to displaced established transportation modes (DTM);

2) CARB staff develop an EER as part of the rulemaking process.

This report presents an approach to calculating an EER-adjusted CI value using a DTM method applicable for either a Tier 2 pathway application or future modification to the LCFS Regulation.

Appendix C describes a design-based pathway approach for the DesertXpress HSR route from Rancho Cucamonga, California to Las Vegas, Nevada.

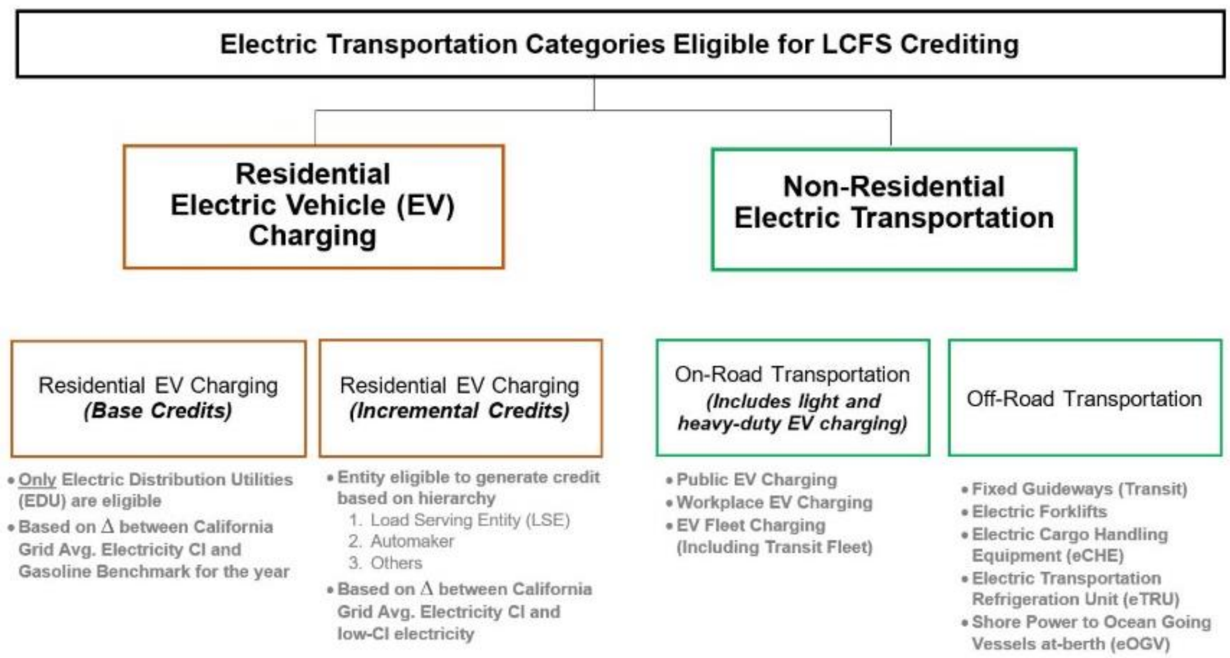

Figure 6. Electric transportation categories eligible for LCFS crediting.
Source: https://ww2.arb.ca.gov/resources/documents/lcfs-electricity-and-hydrogen-provisions

To request an EER-adjusted CI using a Tier 2 pathway application pursuant to §95488.7(a)(3), an applicant must provide the following:

1. CA-GREET Model (unless proposed fuel qualifies for a Lookup Table pathway);
2. A Life Cycle Analysis Report that describes the full fuel life cycle and a detailed description of the calculation of the fuel pathway CI;
3. A letter of intent to request an EER-adjusted CI and why the EER values provided in Table 5 do not apply;
4. Supplemental information including a detailed description of the methodology used, all assumptions made, and all data and references used for calculation of the proposed EER-adjusted CI value. The methodology used must compare the useful output from the alternative fuel technology.

For a Tier 2 pathway to be certifiable by CARB's Executive Officer, the fuel pathway applicant must demonstrate that the life cycle analysis prepared in support of the pathway application is scientifically defensible in the Executive Officer's best engineering and scientific judgment.

1.4.1 California HSR Greenhouse Gas & Air Pollutant Emission Co-Benefits Quantification Methodology

The California Air Resources Board (CARB), in consultation with the Authority, developed a methodology (Quantification Methodology) to estimate greenhouse gas (GHG) emission reductions and air pollutant emission co-benefits associated with operation of an HSR system in California. For the purpose of reporting annually to the California Legislature on expenditures of Greenhouse Gas Reduction Funds (GGRF) used to develop California HSR, the Authority annually reports to CARB the total net GHG emission reductions and air pollutant emission co-benefits resulting from high-speed rail service estimated using a prescribed Quantification Methodology. CARB consults with the Authority to review and update the Quantification Methodology as necessary.

The HSR Quantification Methodology relies on outputs from CARB's Mobile Source Emission Factor Model (EMFAC) and the Authority's Business Plan Model (BPM) Version 3. It summarizes the Authority's ridership model, methods, and emission factors used in their approach and associated with:

- Mode shift from low-occupancy auto vehicle miles traveled (VMT) to the HSR system;
- Mode shift from air travel to the HSR system; and
- 100-percent shift from higher-emitting energy sources and petroleum-based fuels to cleaner renewable energy sources for rail operations.

The Authority updates ridership forecasts for the business plan every two years using the business plan model (BPM). These forecasts are produced by the Authority in consultation with the Ridership Technical Advisory Panel (RTAP) and the Authority's Peer Review Group (PRG). Ridership model forecasts are also reviewed by the United States Government Accountability Office and an independent financial advisory firm specializing in infrastructure projects.

Development of this Quantification Methodology required a significant level of coordination between highly qualified and established entities. Data sources adopted for use in the Quantification Methodology, including EMFAC, and displaced transportation mode data from travel surveys were also used for calculating the DesertXpress HSR EER.

2. HSR EER Model Development

Data sources evaluated and used to develop the HSR EER model are described in the following sections. Data quality and model assumptions are also discussed.

2.1 EER

An EER is a dimensionless value that represents the efficiency of a fuel used in a powertrain compared to a reference fuel. EERs typically represent a comparison of miles per gasoline gallon equivalent (MPGGe) between two fuels. In this case, the EER represents a comparison between electric HSR and displaced modes of transportation, including passenger car, motor coach bus, and airplane. The following calculations show the EER for the composite of DTMs.

2.1.1 EER Calculations

Equations (3) and (4) describe two different approaches to calculating an EER. Each approach requires a different representation of essentially the same data. A primary distinction is the use of aggregate passenger data versus the use of explicit factors for transportation power consumption and mode share. Both approaches are described here.

Equations (3) and (4) below provide equivalents to CARB's EER (equation (2)) described for Fixed Guideway Applications. Equation (3) describes the approach to calculating EER using ridership and revenue forecasting data based on sample surveys, such as described in Steer (2019) and Cambridge Systematics (2016).

EER Calculation Using HSR Ridership and Revenue Forecasts

$$EER_{HSR} = \frac{E_{LDV}/\Sigma P_{LDV} \times D_{LDV} + E_{air}/\Sigma P_{air} \times D_{air} + E_{bus}/\Sigma P_{bus} \times D_{bus}}{E_{HSR}/\Sigma P_{HSR} \times D_{HSR}} \qquad \text{Eq (3)}$$

where

E_{LDV} = energy use for passenger light duty vehicle (LDV) – car or light truck (MJ/mi)
P_{LDV} = total passenger volume travelling by LDV (passengers/yr)
D_{LDV} = distance traveled by LDV (mi)
E_{air} = energy use for airplane (MJ/mi)
P_{air} = total passenger volume travelling by airplane (passengers/yr)
D_{air} = distance traveled by airplane (mi)
E_{bus} = energy use for motor coach bus (MJ/mi)
P_{bus} = total passenger volume travelling by motor coach bus (passengers/yr)
D_{bus} = distance traveled by motor coach bus (mi)
E_{HSR} = energy use for high-speed rail (MJ/mi)
P_{HSR} = total passenger volume travelling by high-speed rail (passengers/yr)
D_{HSR} = distance traveled by high-speed rail (mi)

In equation (3), the total displaced passenger travel ($\Sigma P_{LDV} + \Sigma P_{air} + \Sigma P_{bus}$), is equivalent to the respective percentage of transportation modes displaced by HSR, e.g., light-duty vehicle, airplane, and motor coach bus.

While the sum of passengers travelling from Rancho Cucamonga to Las Vegas traverse similar routes, the distances traveled by each respective form of transportation differ: $D_{HSR} < D_{LDV} < D_{air}$. Ridership and revenue forecasts anticipate that ΣP_{HSR} will likely experience a small inducement factor (about 0.8% in initial year of operation, projected to double by 2035) (Steer, 2019). Such inducement for additional HSR trips to Las Vegas, however, is offset by the shorter travel distance to Las Vegas by the HSR compared to air and LDV modes.

EER Calculation Using Occupancy Factors

Equation (4) describes a simplified approach utilizing passenger occupancy rates rather than total passenger volume. Here the DTMs based on passenger ridership are represented as mode shares. The model is reduced to fuel consumption, passenger load, and mode shares which removes total passenger use-rate from the analysis.

$$EER = \frac{E_{LDV}/p_{LDV} \times M_{LDV} \times D_{LDV} + E_{air}/p_{air} \times M_{air} \times D_{air} + E_{bus}/p_{bus} \times M_{bus} \times D_{bus}}{E_{HSR}/p_{HSR} \times D_{HSR}} \quad \text{Eq (4)}$$

where

E_{LDV} = energy use for passenger light duty vehicle – car or light truck (MJ/mi)
p_{LDV} = passenger occupancy for LDV (passengers/yr)
M_{LDV} = mode share for LDV (%P)
D_{LDV} = distance traveled by LDV (mi)
E_{air} = energy use for airplane (MJ/mi)
p_{air} = passenger occupancy for airplane (passengers/yr)
M_{air} = mode share for airplane (%P)
D_{air} = distance traveled by airplane (mi)
E_{bus} = energy use for motor coach bus (MJ/mi)
p_{bus} = passenger occupancy for motor coach bus (passengers/yr)
M_{bus} = mode share for motor coach bus (%P)
D_{bus} = distance traveled by motor coach bus (mi)
E_{HSR} = energy use for high-speed rail (MJ/mi)
p_{HSR} = passenger occupancy for high-speed rail (passengers/yr)
D_{HSR} = Distance traveled by high-speed rail (mi)

The simplified analysis represented by equation (4) was implemented in this study because it provides greater transparency and inputs that are more readily verified. Many sources of information can substantiate fuel use and average passenger load/occupancy for automobiles and airplanes. The DTM is best-based on surveys, as this represents the counterfactual activity of the HSR passenger.

EER results are presented both as actual HSR route distance passenger miles, based on CARB guidance (2016b)[2], and for the sake of comparison, as displaced transport distance miles.

Equation (4) provides the basis for determining an aggregate EER for all displaced transportation modes, which include gasoline, diesel, and jet fuels. Implementation of the EER for credit generation could be accomplished by calculating the displaced energy for each transportation mode, as illustrated in Appendix C.

2.2 Data Source Evaluation

The EER calculation requires two primary data sources:

1) passenger loads for each mode of transportation; and
2) energy usage by the focus transportation mode (i.e., HSR) compared to transportation modes that the HSR is anticipated to displace (light-duty vehicle, motor coach bus, and airplane).

A literature search provided the most representative and current data for fuel consumption and passenger loads per mode of transport (MOT). Findings are presented in the following sections. The proposed approach to a design-based pathway application for the DesertXpress RC-LV route, based on the data presented below, is described in Appendix C.

2.2.1 Passenger Load Data

Data sources evaluated to represent the percent of HSR-displaced long-distance travel by transportation mode share (M) and vehicle passenger occupancy (p) in the HSR EER model (equation (4)) are described below.

Displaced Transportation Mode

Several data sources reporting results of surveys aimed at identifying travel patterns from California to Las Vegas are described below and summarized in Table 2. For this study, the DesertXpress data were used as input to the HSR EER model (parameter M, equation (4)), as they represented the most up-to-date and geographically-specific data (Steer, 2019).

XpressWest (DesertXpress) Ridership and Revenue Forecasts, 2019:
This study included an extensive program of primary data collection in 2015, 2016, 2019, including travel behavior surveys with 4,072 respondents, to provide an accurate representation of existing "in-scope" market and an understanding of traveler preferences (Steer, 2016 and 2019). Table 1 summarizes the associated data collection program. All data collection modes and years represented in Table 1 pertain to DTM, whereas only the 2016 data based on behavioral research pertains to passenger occupancy.

[2] Footnote 14, page 5 of 13.

High Desert Corridor Joint Powers Authority (HDC JPA) Ridership and Revenue Forecasts, 2017:
HDC JPA, in partnership with the San Bernardino Association of Governments, the Los Angeles Metropolitan Transportation Commission, the Southern California Association of Governments, the CHSR, and DesertXpress, funded an Investment Grade Ridership and Revenue Report by Steer, Davies and Gleave (2016). The 2016 travel behavior survey of over 4,000 respondents represented demand for travel between California and Las Vegas and specified regional travel between Southern California and Las Vegas. This report is the primary source reporting the behavioral research as referenced in Steer (2019). Results from this survey, the Las Vegas Visitor and Convention Authority visitor statistics and surveys (2015), and 2014 California statistics on state visitors and their origins were used to estimate the total size of the "in-scope" travel market from California to Las Vegas.

Table 1. XpressWest (DesertXpress) Ridership and Revenue Forecast Data Collection Program

	Years Collected	Component	Objectives
Market Growth	2016	Applied analysis research	Develop understanding of the evolution of the Las Vegas visitor market. Support analysis of historical trends.
Cell phone data	2015 & 2019	Trip origin and destination	Provide patterns of trips between California and Las Vegas
GPS data	2015 & 2019	Trip origin and destination	Validation of patterns of trips between California and Las Vegas
Google travel times	2016 & 2019	Current journey times	Collation of "real time" journey times to support congestion and journey time variability assumptions included in demand forecasting model
Behavioral research	2016	Focus groups	Qualitative overview traveler priorities and preferences;
		Online & postcard surveys	Quantitative data including travel mode and group size

Source: Steer, 2019

CHSR Business Plan Ridership and Revenue Model version 3 (BPM-V3), 2016:
In total, the BPM-V3 main mode choice model estimation dataset used responses from approximately 42,000 households. Referenced datasets included the following:

1) 2013-2014 survey data for revealed preference/stated preference (RP/SP) for travel greater than 50 miles from a traveler's home measured by straight-line distance length in a geographic information system (Cambridge Systematics, 2015);
2) 2012-2013 California Household Travel Survey data (Cambridge Systematics et al., 2012); and
3) 2005 RP/SP survey (Cambridge Systematics, 2006).

The RP data from the Cambridge Systematics (2006, 2015) surveys reflected actual survey respondent travel mode, whereas the SP indicated predicted behavioral response to a future scenario where HSR would be a travel option. For the purpose of estimating displaced travel by HSR, only RP data were included as reference values in this study. Although this data source pertains to a broader geographic scope than the Rancho Cucamonga-Las Vegas (RC-LV) travel corridor, it is useful for comparison to a California-wide EER perspective and for evaluating similarity between regional and state-wide travel behaviors.

XpressWest (DesertXpress) Ridership and Revenue Study, 2005:
This data set included a survey of users of the Interstate-15 (I-15) highway to determine the share of travel along this corridor that was bound for Las Vegas and improve upon then-available statistics from the Las Vegas Convention and Visitor Authority (LCVCA) (URS, 2005). Between November 10 and 13, 2005, three types of data were collected on a daily basis, directly from passenger vehicle drivers traveling on the I-15: mainline classification counts, ramp license plate counts, and interviews at the parking lots of service stations and restaurants.

Las Vegas Convention & Visitor Center (LVCVA) Visitor Profile Study, 2018.
This study was conducted monthly and includes findings from 3,600 interviews conducted by GLS Research to ascertain multiple statistics, including mode of transport to Las Vegas from all destinations. As such, it provides a broader set of statistics than the studies mentioned previously in this section and does not specifically pertain to travel from Southern California, nor solely along the I-15 corridor. Data for mode of transport to and from Las Vegas was aggregated into two categories: travel by airline, and ground transportation, which included automobiles, recreational vehicles, trucks, motorcycles, and buses.

Table 2. Survey Results to Determine Displaced Transportation Mode for Travel Between Southern California and Las Vegas, Nevada

Data Source	Year Data Collected	Light Duty Vehicle	Motor Coach Bus	Airplane	Conven-tional Rail
XpressWest (DesertXpress) Ridership & Revenue 2005 *Solely on I-15 Corridor to LV*	2005	72.1%	na	NA	NA
High Desert Corridor Joint Powers Authority 2016 *Southern CA to LV*	2014-2015	79%	8%	12%	NA
XpressWest (DesertXpress) Ridership & Revenue 2019[a]	2015-2019	75.9%	9.0%	15.1%	NA
Las Vegas Convention & Visitors Authority Visitor Profile 2004 *LA Metro to LV*	2004	78%	8%	14%	NA
Las Vegas Convention & Visitor's Authority Visitor Profile 2015 *Southern CA to LV*	2015	90%[b]			
Las Vegas Convention & Visitor's Authority Visitor Profile 2018	2018	52%[c]		48%	
California High-Speed Rail Revealed Purpose Surveys 2016	2005; 2013-2014	82%	na	11%	7%
California State Highway Statistics	2012-2013	96.3%	1.1%	1.5%[d]	1.0%

NA = not applicable; na = not available. Shaded rows indicate California-wide statistics.
[a]References Steer Davies Gleave, 2019: see Table 7.5, pp 50.
[b]Also includes travel by recreational vehicle
[c]Also includes travel by recreational vehicle and motorcycle, and truck.
[d]Airplane mode shares for trips greater than 300 miles were shown to be 27%.

Number of Passengers per Transportation Mode

Vehicle passenger occupancy, HSR EER model parameter p, was identified from multiple sources shown in Table 3. Occupancy rates for passenger cars (light duty vehicles, or LDV), ranged from 1.2 for all travel purposes nationwide, to 3-plus passengers for about a third of travel along the Rancho Cucamonga to Las Vegas highway route. The 2016 XpressWest (DesertXpress) survey data (HDC JPA, 2017) were based on focus groups and direct response mail surveys and the 2005 XpressWest (DesertXpress) survey data (URS, 2005) were collected real-time from vehicles travelling on the I-15 corridor. Both surveys, conducted 10 years apart, used different methods to identify a value of 2.5 for LDV passenger occupancy. Such corroboration over time and methods lends greater weight to their results. This substantiated LDV passenger occupancy value is used in this EER model**.**

Table 3. Estimated Passenger Occupancy for Displaced Travel Modes and High-Speed Rail

	Passenger Occupancy			
Data Source	**Light Duty Vehicle**	**Motor Coach Bus**	**Airplane**	**HSR**
XpressWest (DesertXpress) Ridership and Revenue Study, 2005	2.46			
High Desert Corridor Joint Powers Authority 2017	2.5			
XpressWest (DesertXpress) Ridership & Revenue Study, 2019	2.5[a]			
U.S. DOT Federal Highway Administration Household Travel Survey, 2009 – Social/Recreational Purpose	2.02			
U.S. DOT Federal Highway Administration Household Travel Survey, 2009 – Avg across all travel purposes	1.2			
Private Charter Companies: # seats[b] (at 33.4% occupancy)[c]		55 (18)		
U.S. DOT Federal Highway Administration Los Angeles-Long Beach-Anaheim CA		33.4%		
Boeing 737-400: # seats (at 81% occupancy)[d]			160 (130)	
DesertXpress: # seats (at assumed 81% occupancy)				550[e] (468)
CA High Speed Rail: # seats (at assumed 81% occupancy)				900[f] (729)

[a]References Steer Davies Gleave, 2019: See Appendix C Behavioral Research, Table 3.2.
[b]Based on several private charter companies: Arrow Lines (54 seats), Earthlimos (55 seats), MCI Coach (57 seats).
[c]Based on USDOT Bureau of Transportation, 2019 – see Table 8, pp 23.
[d]Based on USDOT Bureau of Transportation Statistics for passenger load factor; represents the 2003-2019 average see Table 4 in this Study.
[e]Value chosen as approximate median of existing range: 500 to 596 depending on seat pitch chosen.
[f]Based on CHSR, 2019 Equivalent Capacity Analysis Report.

Motor coach passenger occupancy was based on the region-specific rate estimated by the U.S. Department of Transportation (DOT) Federal Highway Administration's (2019) methodology (2019) for the Los Angeles-Long Beach-Anaheim urban area.

Air passenger occupancy rate was estimated to be 81%, representing the average of U.S. Department of Transportation U.S. Air Carrier Traffic Statistics from 2003 – 2019 (Table 4). Using such a timespan is useful as it represents travel response to events such as post-9/11, post-2008 Recession, and thus captures response and rebound to calamitous events. Airlines typically design their routes and prices for high utilization rates. As passengers are drawn away from airlines, the airlines would be expected to cut routes and maintain a comparable high load factor.

The seating occupancy for the DesertXpress Velaro trainset has not yet been finalized, however, the range of seating is 500 to 596. Therefore, an approximate median value of 550 was selected for this analysis. Since HSR does not yet exist in the U.S. Southwest Region, the passenger occupancy rate estimated for airplane travel, per U.S. DOT statistics, was used to represent HSR occupancy rate.

Table 4. Airline Passenger Occupancy Rates 2003 - 2019

Year	% Passenger Occupancy	Year	% Passenger Occupancy	Year	% Passenger Occupancy
2003	73.5	2009	80.4	2015	83.8
2004	75.5	2010	82.1	2016	83.4
2005	77.6	2011	82.0	2017	82.5
2006	79.2	2012	82.8	2018	83.0
2007	79.9	2013	83.1	2019	85.0
2008	79.5	2014	83.4	**Average**	**81.0**

Source: U.S. Department of Transportation Bureau of Transportation Statistics, 2020

2.2.2 Energy Use Data

Data sources evaluated to represent energy use by transportation mode in the HSR EER model are described below. The associated data are summarized in Table 5, Table 6, and Table 8. These values provide the basis for determining the HSR EER model parameters related to vehicle energy use (parameter E in equation (4)) for passenger vehicles, motor coach buses, and airplanes. Decisions regarding data sources selected as model input parameters are discussed within respective sections below.

Passenger Car and Motor Coach

On-road fuel economy can be estimated from several sources endorsed by CARB, including fuel sales, EMFAC (CARB, 2021), and the California Vision 2.1 model (CARB, 2016c). Each data source has a different focus and specificity. Fuel sales alone are not informative with respect to vehicle types, which is important in this analysis. Fuel sales are a component of both EMFAC and the Vision 2.1 model. Fuel economy data from the Vision 2.1 model was compared to EMFAC data (Figure 7). EMFAC data provide the basis for this analysis (Table 5) because these values represent a more conservative approach to estimating fuel economy in the HSR EER, i.e., they represent higher fuel economy estimates than California Vision 2.1 (Figure 7). Values in Table 6 are specific to San Bernardino County[3], CA, and reflect on-road annual statistics for aggregated vehicle models and speeds using gasoline fuel. Vehicle fuel economy was estimated for vehicle types in EMFAC that correspond to the LCFS light duty vehicle (LDV) category, which is ≤8,500 lbs gross vehicle rated weight (GVRW): LDA, LDT1, LDT2, and MDV (CARB, 2021).

Table 5. Passenger Vehicle Types in the California LCFS and Emission Inventory

LCFS	LCFS GVWR (lb)	EMFAC	EMFAC GVWR (lb)	Fuel Economy (mi/gal)
LDV	<8,500	LDA	≤3,500	29.8
MDV	8,501-14,000	LDT1	0 - 3,750	24.6
		LDT2	3,751 - 5,750	24.2
		MDV	5,751 - 8,500	19.6

Source: CARB, 2020, §95481; CARB 2021

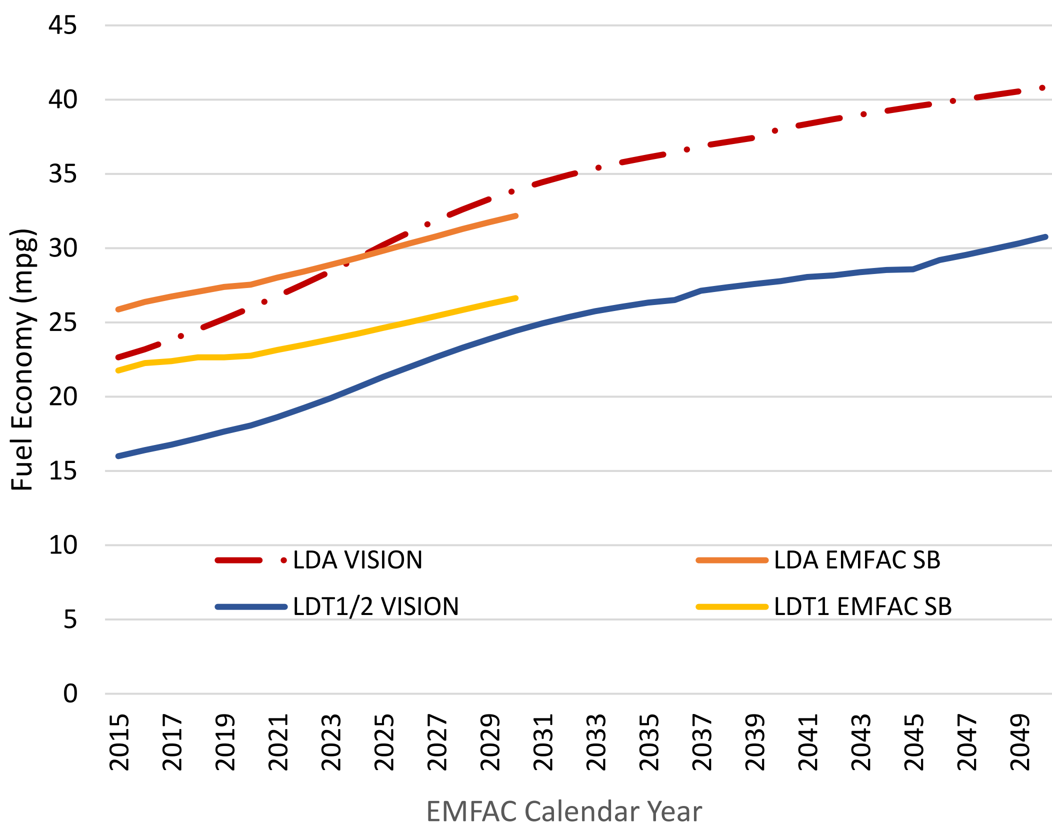

Figure 7. Passenger vehicle fuel economy per the EMFAC and Vision inventories
Source: CARB, 2016c; CARB 2016d

[3] EMFAC specifies two areas for San Bernardino County: SC and MD; MD covers the area from Rancho Cucamonga to the Nevada border and was used for this analysis.

Table 6. Energy Use by On-road Vehicle Type and Fleet Year

Fleet Year, Aggregate	Energy use (E) (mi/gal) LDA	LDT1	LDT2	MDV	Motor Coach
Fuel type	Gasoline	Gasoline	Gasoline	Gasoline	Diesel
2020	27.6	22.8	21.7	17.8	5.6
2021	28.0	23.2	22.2	18.2	5.6
2022	28.4	23.5	22.7	18.5	5.6
2023	28.9	23.9	23.2	18.9	5.6
2024	29.3	24.2	23.7	19.2	5.6
2025	**29.8**	**24.6**	**24.2**	**19.6**	**5.6**

Source: EMFAC2021, v1.0.0 online Emissions Inventory Tool, https://arb.ca.gov/emfac/emissions-inventory

Air Travel

Airplanes typically flown[4] for regional haul trips from Los Angeles to Las Vegas (LA to LV) are single aisle models including the Boeing 737-700, the Airbus A319/A320/A321, and the Embraer 175. Seating ranges, weighted average median seating values, and fuel economy based on landing and take-off (LTO), as well as cruise fuel use, are illustrated in Table 7. A weighted average seating capacity of 142.3 was calculated based on the median seating capacity and the number of flights scheduled on the Los Angeles to Las Vegas route.

Fuel use for each airplane model, for LTO and cruise modes, was based on values referenced in established emission inventory guidance (EMEP, 2019; CARB, 2016d). Fuel use during aircraft flight is modeled for the fuel used during LTO plus the fuel used during the cruise segment of flight. Total fuel use over the trip corresponds to the composite of these factors in Table 7.

Table 7. Airplane Models, Capacity, and Fuel Economy

Airplane Model	Seating Range		# Routes	# Seats	Fuel Economy			LTO[a]	Cruise[a]
	Min	Max	N=11	Median[b]	kg/mi[a]	gal/mi	mi/gal	mi/gal	mi/gal
Airbus A319	110	160	1	135	8.1088	2.70	0.37	688.81	5.02[c]
Airbus A320	140	170	4	155	8.0178	2.67	0.37	802.3	4.42
Airbus A321	185	236	2	210.5	8.0178	2.67	0.37	802.3[c]	4.42[c]
Embraer 175	78	88	3	83	7.6643	2.56	0.39	743.56	4.33
Boeing 737-700	137	143	1	140	8.7067	2.90	0.34	864.51	4.83
Weighted Average				142.3		2.67	0.38		

[a]Source: CARB, 2016d – Tables 26 and 27; EMEP, 2019 – Table 3.4.
[b] (Wikipedia, 2021)
[c] Represents Airbus A318 data (CARB, 2016d) since comparable data were not available for the A319 (EMEP, 2019).
[d] Represents Airbus A321 data (CARB 2016d) since comparable data were not available for the A320 (EMEP, 2019).

As illustrated in Table 8, the energy consumption (MJ/mi) for a jet operating on conventional petroleum fuel versus ultra-low sulfur fuel is similar (with a 1.2% difference in MPG and a 0.25%

[4] Airplane models identified through searches of online travel services for Los Angeles to Las Vegas Routes (Travelocity, Kayak, and Southwest Airline Website). Airline carriers included: Alaska, American, Delta, Frontier, Jet Blue, SouthWest, Spirit, and United.

difference in MJ/mi). Despite having disparate heating values, the fuel densities are similar, which contributes to comparable energy efficiency (Table 9). Airplane fuel economy in this study is based on conventional jet fuel.

Table 8. Airplane Energy Consumption and Fuel Density Comparison

Conventional Jet Fuel	Low Sulfur Jet Fuel	Units
	8.57	kg/mi
3,035.90	2,998.00	g/gal
2.82	2.86	gal/mi
0.354	0.350	mi/gal
131.15[a]	129.81[a]	MJ/gal
370.3	371.1	MJ/mi

[a]Source: CA-GREET3, Fuel_Specs Tab. Refer to table of GREET modifications, Appendix D.

Table 9. Jet Fuel Heating Values and Densities

	Heating Value			Density	
	LHV	HHV	LHV		
Fuel Properties from CA-GREET3[a]	MJ/kg	MJ/kg	MJ/gal	kg/L	g/gal
Conventional Petroleum Jet Fuel	43.2	46.2	131.15	0.802	3035.9
Low Sulfur Petroleum Jet Fuel (LSJ)	43.3	46.3	129.82	0.792	2998.0
Synthetic Paraffinic Kerosene (SPK)	44.1	47.2	126.37	0.757	2865.5
Renewable Jet, LCFS Regulation			126.37		

[a] Jet fuel heating values sourced from JetFuel_PTWa (Pump to Wake sheet, Rows 24-29).

HSR Power Consumption

Overview

Generally, the majority of the power supplied to the train during a journey is fed to the traction motors, while the rest is provided for ancillary services, such as controls, lighting, heating, and air-conditioning. Typically, 80-85% of the electrical energy supplied to the train at its current collector is consumed both at the wheel and by the ancillary services; the rest of the energy is lost as heat from components in the vehicle's propulsion system such as the motors and drive system. The energy consumed at the wheel is composed of three main components: A) energy consumed in accelerating the train's mass; B) energy consumed in overcoming the mechanical and aerodynamic resistance acting on the train; and C) energy consumed in overcoming the train's weight in relation to the route gradient.

The degree to which each of these components contributes to the total energy consumed at the train's wheels depends on the type of train and route. In general, a greater proportion of the total energy consumed at the wheel is used to overcome wind and tractive resistance acting on HSR trainsets than for conventional rail (CVR) trains, which have more stops and hence more energy used to accelerate the train's mass. The amount of energy used to overcome the train's weight in relation to route gradient depends upon a route's variation in altitude and the trainset's weight. Factors including the amount of curvature on a route, the prevalence of narrow tunnels, and the number of stops also influence energy consumption required to accelerate to resume high travel speeds. Regenerative braking systems recapture much of the kinetic energy during deceleration which otherwise would be lost as heat.

Drive cycle modeling as well as in-use data provide a basis for determining HSR power consumption. Drive cycle modeling includes route-specific details such as acceleration and deceleration profiles, track curvature, ambient temperature, and changes in elevation. Steady-state power is based on the power to overcome wind and rolling resistance, and generally provides an upper bound for power consumption, since actual route operations include the recouping of energy due to regenerative breaking and coasting during deceleration.

The data used to develop this EER are based on Siemens' dynamic model simulations that are aligned with in-use data. For comparative purpose, steady-state power consumption is also provided.

DesertXpress Power Consumption

Siemens calculates HSR energy consumption as a two-step process in order to enhance its accuracy. Step 1 calculates train driving dynamics based on data for the vehicle specifications, track alignment, and environmental conditions such as gradient. Step 2 calculates energy consumption, accounting for acceleration to operational speed, and deceleration via coasting to the destination. These models have been used by Siemens for years and have proven to provide reliable and verifiable data. For example, the DB AG German railway customer for the German inter-city train "ICx" of the Deutsche Bahn AG recalculated the modeled travel times with their own tool and derived the same results (Siemens, 2020a). Siemens' energy consumption model inputs and results are discussed below.

Siemens' energy consumption estimate for the DesertXpress Rancho Cucamonga to Las Vegas route was based upon the following assumptions:

- Preliminary track and trainset data:
    - Trainset length 658 feet with 8 railcars per trainset
    - Passenger seating capacity (excluding Bistro seats): 500 to 596 depending on chosen seat pitch
    - Curb weight: 450 tons (preliminary assumption)
    - Power
        - Power delivered by overhead contact line – trainset only uses electric energy during stabling (the corresponding term for electric trainset idling) for auxiliary systems and not for traction power equipment.
        - Traction power: 9,200 kiloWatt (kW)
        - Auxiliary power: 260 kW (preliminary assumption)
        - Voltage: AC 25 kV / 60 Hz
- Standard climate conditions
- Recuperative electrical brake is possible without restrictions (energy consumption estimated as a net value considering for recuperative energy during the electrical brake)
- Distributed traction over entire train length; 50% motorcars

Model results for the DesertXpress alignment (21.5 kWh/mile) are compared to other route simulations and steady-state data in Table 10. As indicated in Table 10, the route-based dynamic results by Siemens provide lower energy consumption values than the steady-state power requirements at the route's top speed.

Table 10. Simulated Energy Consumptions for DesertXpress and Comparative HSR Alignments.

Reference Number	Route Simulation	Top Speed mph	Route Length miles	Energy Consumption kWh/mile
Simulated Route Power Consumption				
1	Madrid – Barcelona	220	378	20.9
2	Victor Valley – Las Vegas	186	169	21.5
3	Ankara – Eskisehir	186	147	23.5
Steady-State Power Consumption and Example Routes				
4	Merced – Bakersfield	180	169	29.7
5	Gilroy – Burbank	220	367	33.2
Estimated Power Consumption for DesertXpress[5]				
	Rancho Cucamonga – Las Vegas	186	218	21.5

Source: Siemens, 2020a – page 2; California High Speed Rail Authority, 2020b

The tractive load of the trainset combined with its speed profile determines the power used over a route. Figure 8 illustrates the tractive load and power available at the trainset wheels. The force required to move the train is shown for different grade levels. Available force is greatest at zero-speed, and declines as speed increases, just as torque declines at higher speed with electric cars. The power at each speed is the product of force and speed.

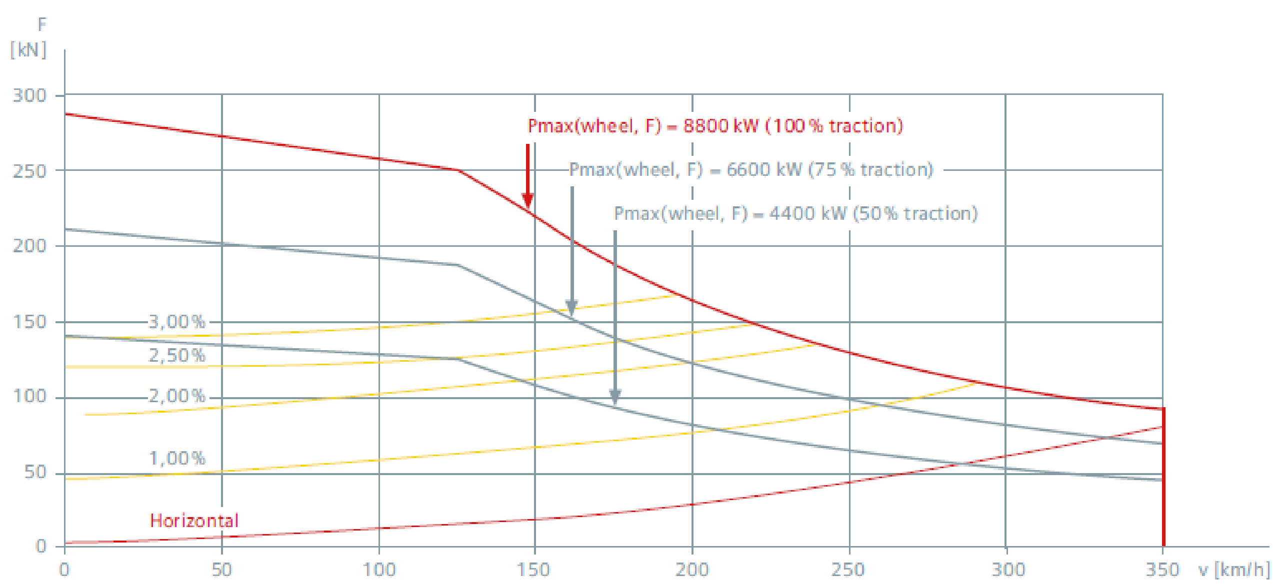

Figure 8. Tractive energy usage for trains at different speeds.
Source: Siemens, 2020b

[5] Calculated EERs are based on a 218 mi distance from RC to LV.

A calculation of power consumption and energy consumption based on rolling and wind resistance are shown in Figure 9. The steady state power (green dashed line in Figure 9) is the product of force and velocity described by the relationships in equation 5.

$$\text{Power} = \text{Energy/Time} = \text{Force} \times \text{Distance/Time} = \text{Force} \times \text{Velocity} \qquad \text{Eq (5)}$$

The energy consumption (solid yellow line in Figure 8) is the product of power and speed, as described by the relationship in equation 6.

$$\text{Power} = \text{Energy/Distance} = (\text{Power} \times \text{time})/\text{Distance} = \text{Power/ Velocity} \qquad \text{Eq (6)}$$

The power to overcome wind resistance increases with the square of speed, and the energy consumption per mile also grows with increased speed.

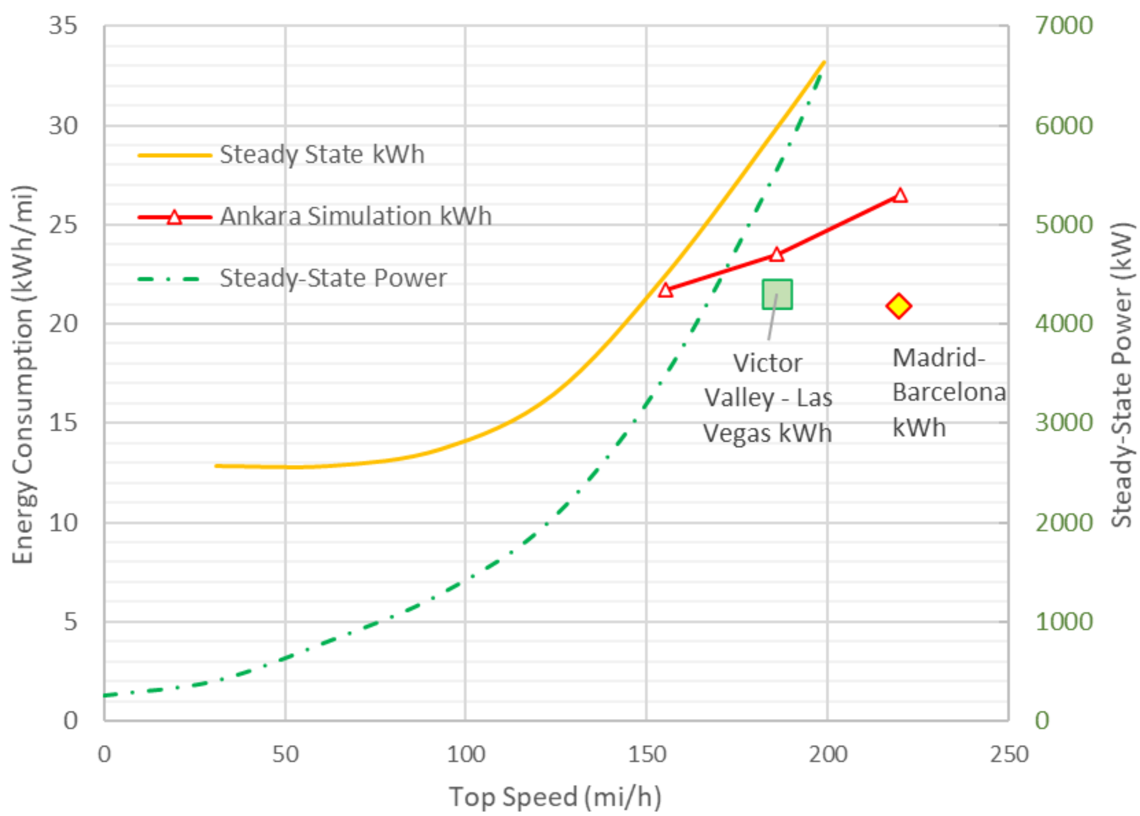

Figure 9. Comparison of energy consumption for selected routes
Source: Siemens, 2020b

As discussed above, many factors influence a train's energy consumption, including the vehicle specifications, the track configuration, environmental conditions, speed travelled, and the number of stops along a route. Therefore, disparate routes and trainsets exhibit different energy consumption values. Travel speed and approximate elevation for the DesertXpress route starting in Rancho Cucamonga, CA, are illustrated in Figure 10. Note that a portion of the travel speed is below 180 miles per hour, which results in the overall composite fuel consumption that is well below the steady-state power consumption in Figure 9.

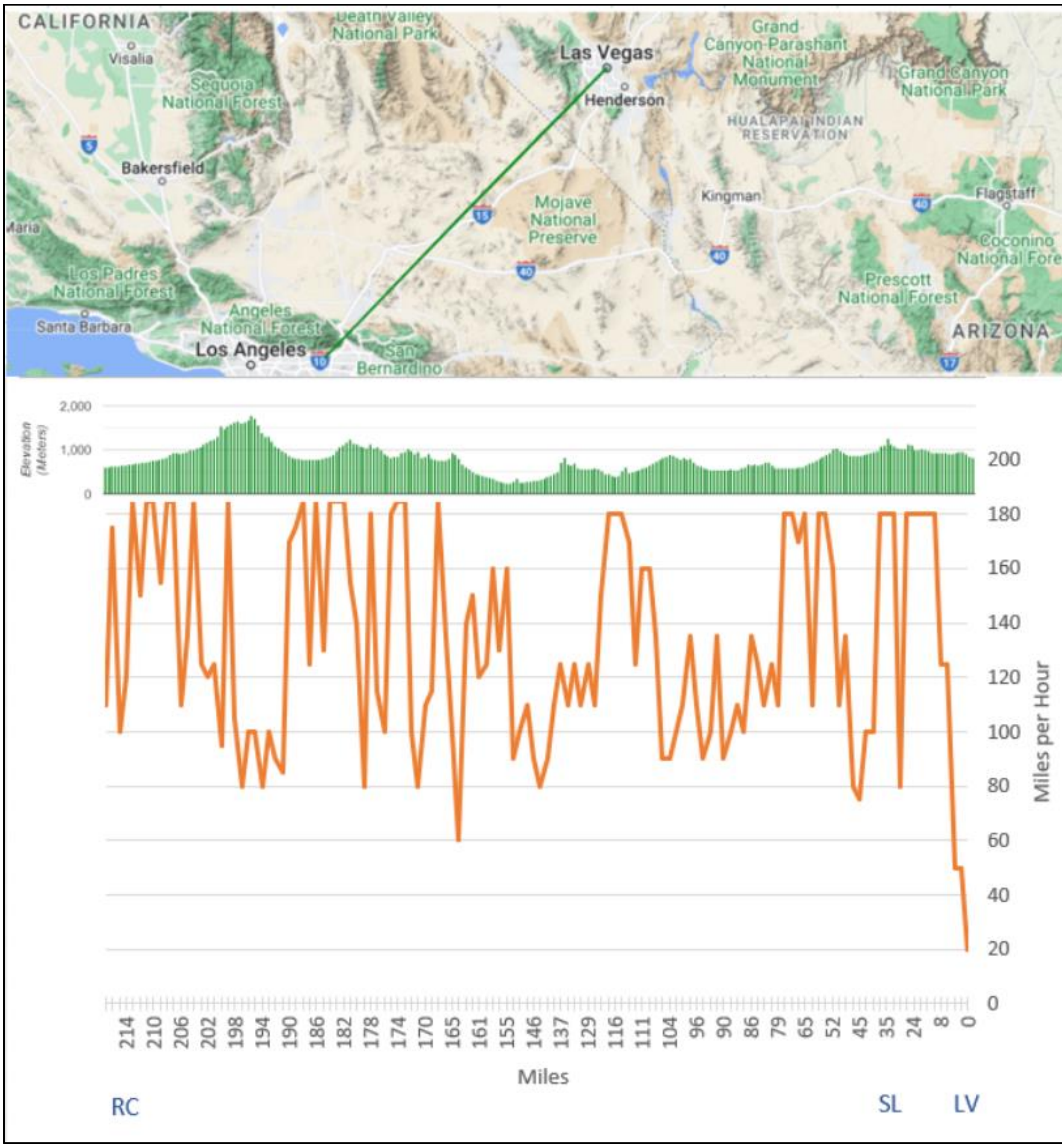

Figure 10. Proposed travel speed and approximate elevation for DesertXpress Route, shown as Las Vegas (LV) to Rancho Cucamonga (RC). State Line (SL) at mile 34.
Source: Siemens, 2020b; Distancesto.com, 2022

Fuel Density

Fuel density was calculated as miles per gallon equivalent (MPGe, e.g., megajoules/mile) to allow for comparison between vehicle efficiencies using traditional fuels, including gasoline and diesel, and HSR using electricity to provide transportation power (Table 11). Volumetric energy density or lower heating value (LHV) for liquid fuels provide the basis for determining the energy consumption per miles for automobiles, buses, and airplanes in Section 3.2. The LHV for gasoline and diesel are identified in the LCFS regulation (CARB, 2018a). This regulation includes an LHV for renewable jet fuel, however, the LHV for petroleum jet fuel in the GREET model is a more accurate and conservative representation of the energy content of the fuel. Using the greater LHV for conventional jet fuel results in a more conservative EER value for HSR.

Table 11. Fuel Economy (miles per gallon) for displaced travel modes and high-speed rail.

Data Source	LDV/LDT	Motor Coach	Airplane	HSR
Fuel Type	CA RFG	Diesel	Jet	Electricity
LHV, MJ/gallon, MJ/kW [a]	115.83	134.47	131.15[b]	3.6
Fuel Consumption per MOT				
Units	MPG	MPG	Passenger mi/gal	kWh/mi
Federal Highway Statistics, 2016	24.2			
EMFAC2021 average 2015-2020	23.3	5.6		
EMFAC2021, 2025	26.2	5.6		
CARB, 2016d; EMEP, 2019			43.2[c]	
Siemens, 2020a				21.5

[a] LCFS Regulation, Table 4. CA-GREET3 (CARB, 2018d) for conventional jet fuel LHV. Note that the LCFS regulation defines the LHV for renewable jet, which is lower per gallon than that of conventional jet.
[b] GREET1_2019 (Argonne National Labs, 2019) – see Fuel Specs Tab, cell B26. This is consistent with the aviation data in CA GREET3 (CARB, 2018d).
[c] Represents median # seats for LA-LV route*%seat occupancy (see Table 7 in this Study).

2.2.3 Data Quality

The data sources compiled for use in this HSR EER model derive from well-established and publicly reviewed sources. Where possible these sources have been comparatively evaluated to identify data that are most representative for developing this HSR EER. Discussion of selection criteria appear within respective data evaluation sections above. In many cases the data sources chosen for this HSR EER model are the same as those used by CARB, in consultation with the Authority, to develop the Quantification Methodology adopted under GGRF for estimating GHG emission reductions and air pollutant emission co-benefits associated with operation of an HSR system in California (CARB, 2018a).

The HSR Quantification Methodology utilized both CARB's EMFAC model and the Authority's Business Plan[6] Ridership and Revenue Forecasting Model based on industry-standard travel behavior survey methods and results. The CA GHG Emission Inventory adopted by CARB (2021) was also based on EMFAC and includes the estimation method for air travel.

The firm retained by DesertXpress to conduct the ridership and revenue forecasts, Steer Davies Gleave, rebranded as Steer in 2018, is a global consulting firm with expertise in the travel industry, including conducting several[7] ridership and revenue forecasts in the U.S. Based on their standing in the travel industry, the U.S. DOT Office of Inspector General retained Steer Davies

[6] The CHSR Business Plan is updated every two years.

[7] See https://www.steergroup.com/search?query=ridership+revenue+forecast&page_type=All&regions=All

Gleave (2011) to research and document best practices[8] for three main areas of HSR project development: ridership and revenue forecasting, operations and maintenance costs and public benefits.

2.2.4 Assumptions

Key inputs in the HSR EER model that have less data certainty can also have the greatest impact on the resulting EER value. Several model inputs fall into this category, including passenger loads, particularly for LDV/LDT and HSR, and the LDV/LDT fuel economy. LDV/LDT represents the greatest percentage of the DTM that affects parameter M in the model, therefore, factors influencing passenger occupancy and fuel efficiency have a relatively large influence on this model calculation compared to other DTMs. While the range is not large, e.g., 2 to 4, it nonetheless has considerable influence on the EER value. HSR passenger load also has a relatively large influence on the HSR EER model calculation as this transport mode has the greatest seating capacity of all vehicle types included in this analysis. The range for the seating capacity for the DesertXpress Velaro trainset is 500 to 596 seats.

[8] The full suite of reports describing best practice methods are available at http://www.oig.dot.gove/foiaelectronic-reading-room

3. EER MODEL ANALYSIS

This section provides a summary of the parameter inputs to the HSR EER model and presents the model's results.

3.1 Model Input Summary

HSR EER model parameter values presented in section 2.2 are summarized in Table 12. The parameters E, p, and M from equation (4) are derived directly from these values such that E = LHV/MPG. Equation (4) factors in all of the parameters for each displaced transportation mode as well as for the HSR application. The components are broken out by mode in the following analysis.

Table 12. HSR EER Model Parameter Values

Displaced Transportation Mode	Fuel Economy, 2025 (mi/gal)	Passenger Occupancy Rate (p)	% Displaced Mode (M)[f]
LDV/LDT	24.56[a]	2.5[c]	75.9%
Motor Coach	5.6[a]	33.4%[d]	9.0%
Airplane	0.38[b]	81%[e]	15.1%

[a] CARB, 2021.

[b] CARB, 2016d Tables 26, 27; EMEP 2019 Table 3.4; 194 kg Great Circle Calculator, 1.15078 = 223 mi (gcmap.com).

[c] Steer, 2019 – Table 3.2 in Appendix C.

[d] U.S. Department of Transportation, 2019 - Table 8, pp 23.

[e] U.S. Department of Transportation Bureau of Transportation Statistics 2003 – 2019; see Table 4 in this Study.

[f] Steer, 2019 – Table 7.5, pp50.

3.2 EER Model Results

Several scenarios were calculated for the HSR EER model. A baseline scenario was calculated using the parameter values identified in Table 12 and Table 13. Worst-case and best-case scenarios were calculated using the upper and lower end ranges identified from the data sources that were evaluated (see Section 2) for key parameters (per section 2.2.4): LDV/LDT passenger occupancy, HSR passenger occupancy, and LDV/LDT fuel economy.

Table 13. Baseline Results of the DesertXpress High-Speed Rail Energy Economy Ratio Model

Energy Input	LDV/LDT	Motor Coach	Airplane	Displaced Transport	Xpress-West HSR
Fuel Type	E10 Gasoline	Diesel	Jet		Electric
Lower Heating Value, LHV(MJ/gal)	115.83	134.47	131.15		3.6
% Mode (M)	75.9%	9.0%	15.1%		100%
Distance (mi)	218	218	223		218
# passengers/transport unit (p)	2.50	18.4	115		446
Fuel Efficiency (MPG)	24.56	5.6	0.38		
MPGe (MJ/mi)	4.72	26.2	349.6		77.4
MJ/passenger mi	1.887	1.42	3.035	2.018	0.17
MJ per HSR Trip[a]	312.08	27.95	102.27	442.3	37.87
			Displaced Distance EER		**11.68**
			Route Distance EER		**11.62**

[a]LHV/MPG /p × M

Table 14. HSR EER Model Key Parameter Inputs for Baseline, Worst- and Best-Case Scenarios

Key Assumptions	Baseline	Best Case	Worst Case
LDV/LDT Load	2.50	2	4
HSR Load	446	600	330
LDV/LDT Fuel Economy	24.56	20	40
EER - Displaced Distance	11.68	18.26	6.30
EER - Route Distance	11.62	18.18	6.25

4. Discussion

The results for the HSR EER model are robust, with the trainset power consumption representing the most significant variability compared to a petroleum baseline. As described in Section 3, three main factors in the model have the greatest impact on the EER value: LDV/LDT passenger occupancy, HSR passenger occupancy, and LDV/LDT fuel economy. The mode share for motor coach buses is low compared to air and LDV; moreover, due to the anticipated pricing difference between HSR and motor coach bus rides, the HSR capture rate for this component of the travel sector is projected to be minimal (Steer, 2019). Notably, even if the mode share for LDV and airplane are interchanged in the model, the EER only increases from 11.68 to 18.26 for the displaced distance method, and from 11.62 to 18.18 for the route distance method, demonstrating that the baseline HSR EER analysis is conservative.

4.1.1 Data Adequacy

Despite the fact that HSR is not considered to be a fixed guideway system, CARB's recommended approach for calculating an EER for a fixed guideway system provided a starting point for calculating an HSR EER. In this study, a simplified, revised version of CARB's recommended approach for fixed guideway systems provided several advantages:

- Fuel use data were derived from EMFAC (CARB, 2021) or established Inventories (CARB, 2016d; EMEP, 2019), all of which are highly vetted datasets and considered to provide industry-standard, high-quality data;
- Passenger loads represented in the model are consistent with actual experience, and extensive travel surveys conducted using industry standard methods (Steer, 2019; Cambridge Systematics, 2015);

The potential for future fuel economy to improve is accounted for in the methodology employed for this HSR EER model and for the proposed design-based pathway (Appendix C). CARB and other entities with low carbon fuel standards, including British Columbia, Canada, and Oregon, periodically update EER values as fuel economies of electric vehicles advance.

4.1.2 HSR EER Evaluation

To answer the question "How does HSR EER compare to its closest competitors?", one can look to the closest competing transportation vehicle, in this case, a diesel train. Currently, however, no EER exists for diesel trains. The closest competing transportation modes for which EERs do exist are electric buses, and fixed guideway light and heavy rail (Appendix A). CARB established an EER of 5.0 for electric buses. These buses, however, are battery-powered and not powered directly by lines as are HSR and light rail. The current EER for light-rail (overhead lines) is 3.3, which is based on the energy per person km traveled by electric light rail versus standard diesel bus as reported in the National Transit Database (Navius Research, 2018). The EER for electric fixed guideway, heavy rail is 4.6. The HSR EER for the DesertXpress RC-LV route is substantially higher than these existing EERs, in part because these trains are very energy-efficient, the displaced modes of transport often include multiple passenger occupancies, and because displaced air travel is represented. Currently HSR offers the only established low-carbon alternative to aviation, one of the most challenging sectors to decarbonize, for transport of large volumes of passengers for distances up to 1,000 km (IEA, 2019).

While it is impossible to compare the proposed DesertXpress HSR EER to any existing HSR in the U.S., it is possible to examine emissions-related statistics from other countries where HSR has been established for some time, as described in the Introduction. In Europe and Asia, HSR lines have been shown to decrease aviation transport by 20 to 80% along the same routes (IEA, 2019) (Figure 11). HSR has been found to be most competitive with competing travel modes for trips 1 to 3.5 hours in duration, and countries with established HSR lines typically have fewer short-haul flights along these routes than do countries without HSR (IEA, 2019).

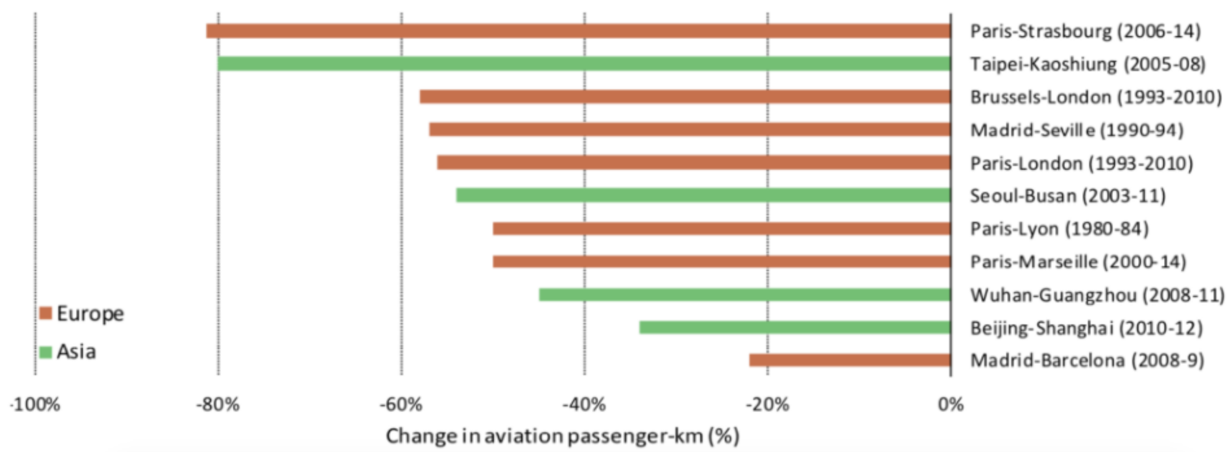

Figure 11. Average change in aviation passenger load after implementation of high-speed rail on same route
Source: (IEA, 2019)

HSR travel in Europe to date also indicates the following emissions reductions:

- Rail Europe's carbon calculator, associated with their booking tool, indicates that the typical HSR train generates up to ten times less CO_2 than an airplane (Mack, 2020).
- The International Transport Forum reports that the average CO_2 emissions of high-speed trains in Europe per passenger/km stand at less than 17g, compared with 153g for planes (Railway Technology, 2018).
- A Eurostar journey from London to Paris already emits 90% less greenhouse gas than the equivalent short haul flight and produces less carbon per passenger than a single car journey from central London to Heathrow Airport (Railway Technology, 2018).

In summary, the EER proposed for the DesertXpress HSR reflects the fact that these trains are highly energy-efficient and have great potential to displace multiple passenger occupancies in alternative modes of transport, including airplane travel, which is a challenging sector to displace. DesertXpress HSR, powered by zero-CI electricity, is well-situated to decrease GHG emissions, and assist in decarbonizing travel between Southern California and Las Vegas, Nevada.

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6. APPENDICES

APPENDIX A. HISTORY OF CALIFORNIA HIGH-SPEED RAIL

Source: Draft 2020 CA HSR Business Plan, Appendix D.

California has evaluated the potential for high-speed rail for several decades. The state first pursued the idea of a Southern California high-speed rail corridor working with Japanese partners in 1981 under Governor Edmund Gerald "Jerry" Brown Jr. In the mid-1990s, planning began in earnest as California's growing population put an increasing strain on its highways, airports, and conventional passenger rail lines.

At the federal level, as part of the High-Speed Rail Development Act of 1994 (https://www.govtrack.us/ congress/bills/103/hr4867), authored by then-U.S. Representative Lynn Schenk, California was identified as one of five corridors nationally for high-speed rail planning. The California Legislature created the Intercity High-Speed Rail Commission in 1993, charging the Commission with determining the feasibility of a system in California. In 1996, the Commission issued a report that concluded that such a project was indeed feasible.

California's Legislature passed the High-Speed Rail Act in 1996 (http://leginfo.ca.gov/pub/95-96/bill/ sen/sb_1401-1450/sb_1420_bill_960924_chaptered.html), a bill that created the High-Speed Rail Authority (Authority) and charged the Authority with preparing a plan and design for constructing a system to connect the state's major metropolitan areas. In 2002, following the release of the Authority's first business plan in 2000, Senate Bill 1856 (Costa) was passed and signed by Governor Gray Davis. The legislation authorized a $9.95 billion bond measure to fund the system but submitting that measure to the state's voters was delayed several years.

In the interim, the Authority, together with its federal partner, the Federal Railroad Administration (FRA), issued a Draft Program-Level Environmental Impact Report/Environmental Impact Statement (EIR/ EIS) that described the system and its potential impacts on a statewide scale. Through that process, the Authority received and reviewed more than 2,000 public and government agency comments on the draft document, which were used to determine the preferred corridors and stations for the system.

In November 2008, the state's voters approved Proposition 1A, a bond measure authored by then-assembly member Cathleen Galgiani and signed by Governor Arnold Schwarzenegger, making it the nation's first-ever, voter-approved financing mechanism for high-speed rail.

In 2009, $8 billion in federal funds were made available to high-speed rail projects nationwide as part of the American Recovery and Reinvestment Act (ARRA), which was passed to help stimulate the economy, create new jobs, and foster development of new rail manufacturing enterprises. California sought and successfully secured $3.3 billion in ARRA funds and other funds made available through federal appropriations and grants for planning and environmental work, as well as final design and construction of the first section in the Central Valley, which is underway.

In 2012, the Authority adopted its 2012 Business Plan, which laid out a framework for implementing the California high-speed rail system in concert with other state, regional and local rail investments, as part of a broader statewide rail modernization program. In that same year, the Legislature approved—and Governor Brown signed into law—Senate Bill 1029 (Budget Act of 2012) approving almost $8 billion in federal and state funds for the construction of the first high-speed rail investment in the Central Valley, to advance design and planning for Phase 1 and Phase 2 of the system and bookend and connectivity projects throughout the state.

In 2014, the Authority adopted its 2014 Business Plan, which built on and updated the 2012 Business Plan, implementing the requirements of Senate Bill 1029. Also in 2014, the Legislature and Governor Brown reaffirmed their commitment to the program by providing an ongoing funding stream through the state's Greenhouse Gas Reduction Fund.

In 2015, Governor Brown and supporters celebrated the historic groundbreaking of the high-speed rail program at the site of the future station in downtown Fresno, marking the beginning of what will be America's first true high-speed rail system.

The Authority adopted its 2016 Business Plan, which introduced the Silicon Valley to Central Valley Line and built on the 2014 Business Plan, implementing the requirements of Senate Bill 1029.

In July 2017, the Legislature voted to extend the Cap-and-Trade program through 2030, ensuring long-term state funding for the high-speed rail program from the state's Greenhouse Gas Reduction Fund.

In October 2017, the Authority met federal American Recovery and Reinvestment Act requirements by fully investing the more than $2.55 billion granted to the state to build the nation's first high-speed rail system.

Several years have passed since the official groundbreaking. As of late 2017, 119 miles of construction activities are underway in the Central Valley. In addition, design and environmental planning has advanced on the Phase 1 system between San Francisco and Los Angeles/Anaheim along with outreach to communities and stakeholders.

In 2018, under the direction of new Chief Executive Officer Brian Kelly, the Authority continued to make significant progress on the project. In October, the Authority's Board of Directors approved the Locally Generated Alternative—the 23-mile section that will bring high-speed rail into downtown Bakersfield. In October and November, the Board demonstrated its commitment to bringing high-speed rail to Southern California by moving the process forwards in selecting alignments from Bakersfield to the Los Angeles/Anaheim area.

Early 2019 was a busy time for high-speed rail. Newly-appointed Governor Newsom voiced his support of continuing with the high-speed rail program by focusing on completing a 171-mile line between Merced to Bakersfield that would run true, high-speed electric, clean trains, and would allow for connections to points to Sacramento, the Bay Area and Southern California. In addition, he committed to bringing new leadership and transparency to the Authority and announced the appointment of Lenny Mendonca to the Board. Shortly thereafter, the Board of Directors elected Mr. Mendonca as the new Board Chair. The beginning of the year also saw the completion of one of the major construction projects in the Central Valley, when the Authority and Caltrans celebrated the completion of the State Route 99 realignment project that moved the main artery through central Fresno 100 feet to the west in anticipation of high-speed rail tracks. This project replaced two overpasses and improved pedestrian access and traffic patterns.

In another major 2019 milestone, Governor Newsom and the Federal Railroad Administration (FRA) signed a Memorandum of Understanding (MOU), by which the Authority was assigned FRA's responsibilities as lead agency under the National Environmental Policy Act (NEPA). The NEPA Assignment MOU provides environmental review responsibilities under NEPA and other federal environmental laws with respect to projects in California's high-speed rail system and projects that directly connect to stations on the high-speed rail system, which include the Link Union Station (Link US) Project and West Santa Ana Branch Transit Corridor projects in Los Angeles. These federal responsibilities will be performed by the California High-Speed Rail Authority, with oversight by the California State Transportation Agency (CalSTA).

The Authority also saw major progress on the economic front when it crossed the 500 mark for certified small businesses playing a role in construction high-speed rail. And in early September 2019, the Authority announced that it had created more than 3,500 construction jobs since work began in the Central Valley.

In September, the Authority reaffirmed its commitment to progress in Southern California. Together with CalSTA and the Los Angeles County Metropolitan Transportation Authority (Metro), an agreement was reached to steer more than $400 million in Proposition 1A funds toward the transformative Link US project.

In late Fall, the Authority issued the Record of Decision for the final 23-mile route between Shafter and Bakersfield in the Central Valley. This completes the state's environmental review process between Fresno and Bakersfield and allows the Authority to move toward project construction into Bakersfield and was the first major environmental action taken under the State's newly granted federal National Environmental Policy Act (NEPA).

In December 2019, the Authority issued Request for Proposals for the Track and Systems procurement. This procurement will allow the Authority to start laying track in the Central Valley on top of the civil work and starts the process to electrify the system. Proposals are due to the Authority in September 2020 with award slated for December.

APPENDIX B. EER VALUES FOR FUELS USED IN LIGHT-, MEDIUM-, AND HEAVY-DUTY APPLICATIONS.

Source: California Air Resource Control Board's Low Carbon Fuel Standard Guidance, 2020.

Table 15. EER Value for Fuels Used in LDV, MDV and HDV Applications (Table 5 LCFS Regulation)

Light/Medium-Duty Applications (Fuels used as gasoline replacement)		*Heavy-Duty/Off-Road Applications (Fuels used as diesel replacement)*		*Aviation Applications (Fuels used as jet fuel replacement)*	
Fuel/Vehicle Combination	*EER Values Relative to Gasoline*	*Fuel/Vehicle Combination*	*EER Values Relative to Diesel*	*Fuel/Vehicle Combination*	*EER Values Relative to Conven-tional Jet*
Gasoline (incl. E6 and E10) Or E85 (and other ethanol blends)	1	Diesel fuel Or Biomass-based diesel blends	1	Alternative Jet Fuel	1
CNG/ICEV	1	CNG or LNG (Spark-Ignition Engines)	0.9		
		CNG or LNG (Compression-Ignition Engines)	1		
		Electricity/BEV or PHEV* Truck or Bus	5.0		
Electricity/BEV, or PHEV	3.4	Electricity/Fixed Guideway, Heavy Rail	4.6		
		Electricity/Fixed Guideway, Light Rail	3.3		
On-Road Electric Motorcycle	4.4	Electricity/Trolley Bus, Cable Car, Street Car	3.1		
		Electricity Forklifts	3.8		
		eTRU	3.4		
		eCHE	2.7		
		eOGV	2.6		

Appendix C. Tier 2 Design-Based Pathway Data Collection Plan for DesertXpress

The following describes procedures for collecting data pertaining to HSR EER model parameters for the DesertXpress HSR Design-Based Pathway once the Rancho Cucamonga-Las Vegas (RC-LV) HSR route is commercially operating. In accordance with LCFS Regulation §95488.9, data will be collected for the first three months of passenger-service operation to provide a basis for a Provisional Tier 2 Pathway, and annually thereafter per §95488.10.

A ramp-up period for adoption is commonly observed for new technologies and modes of transportation. Since HSR is a new form of advanced technology transportation in the U.S., a ramp-up period for ridership is anticipated, particularly as it represents a new service line and not an upgrade to an existing conventional rail line (Steer, 2019). As described in the DesertXpress Ridership and Revenue Forecasts Report (Steer, 2019) ridership ramp-up is expected to occur over a three-year period, with the ridership during the first year projected to represent 40-50% of that achieved by year-3 of operation (Table 16). Therefore, ridership during the initial three months of operation, which will inform the Provisional Tier 2 Pathway, is anticipated to be much lower than after 12 months of operation. Correspondingly, operations-associated emissions are anticipated to decrease proportional to increased passenger loads.

Table 16. Projected Ramp-up Passenger Demand Rates

Months of Operation	Projected Passenger Ramp-Up Rates
First 12 months	40-50%
Second 12 months	70-90%
Third 12 months	85-100%
>36 months	100%

Table 17 lists the design-based pathway parameters, their associated data sources[9], data quality, and approaches to update and refine model parameters for this design-based pathway. Source data quality was classified based on its accuracy, representativeness, and level of peer review. High-quality source data are associated with a statistically valid sample size that is relevant to the region of HSR operation, and robust peer-review. Moderate-quality source data do not meet one of these criteria, and low-quality source data do not meet two of these criteria. Data quality assessments for each of the model parameters and associated data refinement approaches are summarized here and are discussed in detail in the following sections C.1 and C.2.

Model parameters currently informed by high-quality data will be updated using the same data sources, as such updates become available, unless otherwise indicated. Model parameters based

[9] CARB Guidance (2020, pp3) states that "The applicant may clearly identify the displacement baseline and provide a justification along with all the data or references relied upon to make that determination. The applicant may rely on academic and market research, study, reports, surveys, etc., to make that determination".

on the California Emissions Factor Inventory, for example, can be readily updated for the scope of time represented in each submittal (EMFAC; CARB, 2021). Passenger occupancy for motor coach and airplane come from government sources and can be readily updated as such become available. A subset of the data sources assessed as being of high quality, however, do not require future update as they reflect established values that are not expected to change, i.e., lower heating values for stated fuels, and established air travel distance.

Model parameters currently informed by moderate- or low-quality data sources will be refined by field measurement. Such model parameters include those identified by CARB staff[10]: HSR fuel economy, displaced modes of transport, LDV/LDT passenger occupancy, and HSR passenger occupancy. HSR fuel economy can be readily calculated based on metered utility invoices for train operation, and HSR passenger occupancy can be readily calculated from ticket sales. Data for displaced modes of travel as well as LDV/LDT passenger occupancy can be ground-truthed by surveys designed to address these model inputs.

[10] Virtual Zoom meeting held September 17, 2020, with Jordan Ramalingam and Jim Duffy.

Table 17. DesertXpress EER Model Parameter Data Source, Quality, and Collection

EER Model Parameter	Data Source	Parameter Value	Data Quality	Data Refinement via	
				Update	Measurement
Distance: Highway	Google Maps	218 mi	High	Yes: per HSR Station Location	No
Distance: Air	Great Circle Calculator	223 mi	High	No Update Needed	No
Distance: HSR	Track Chart (Siemens, 2020b)	218 mi	Moderate	No	Yes: Odometer
LHV: CA Reformulated Gasoline	CA-GREET3 (CARB, 2018d, 2020b)	115.83 MJ/gal	High	From GREET No Update Needed	No
LHV: Diesel	CA-GREET3 (CARB, 2018d)	134.47 MJ/gal	High	In Regulation No Update Needed	No
LHV: Jet, Conventional	CA-GREET3 (CARB, 2018d)	131.15 MJ/gal	High	From GREET No Update Needed	No
Fuel Economy: LDV/LDT	EMFAC (CARB, 2021)	24.56 mi/gal	High	Yes, Potentially Update by Year	No
Fuel Economy: Motor Coach	EMFAC (CARB, 2021)	5.6 mi/gal	High	Yes, as available	No
Fuel Economy: Airplane	GHG Emission Inventory (CARB, 2016d)	0.38 mi/gal	High	Per CARB Inventory, No Update Needed	No
Fuel Economy: High Speed Rail	Train set (Siemens, 2020a); Track Chart (Siemens, 2020b);	77.4 MJ/mi	Moderate	No	Yes: Utility Invoices
Displaced MOT: LDV/LDT	XpressWest (DesertXpress) Ridership & Revenue Study (Steer, 2019)	75.9%	Moderate	No	Yes: Surveys
Displaced MOT: Motor Coach	XpressWest (DesertXpress) Ridership & Revenue Study (Steer, 2019)	9.0%	Moderate	No	Yes: Surveys
Displaced MOT: Airplane	XpressWest (DesertXpress) Ridership & Revenue Study (Steer, 2019)	15.1%	Moderate	No	Yes: Surveys
Passenger Occupancy: LDV/LDT	XpressWest (DesertXpress) Ridership & Revenue Study (Steer, 2019)	2.5	Moderate	No	Yes: Surveys
Passenger Occupancy: Motor Coach	U.S. DOT, 2019	18.4	High	Yes, as available	No
Passenger Occupancy: Airplane	U.S. DOT Bureau of Transportation Statistics (BOTS), 2020	115	High	Yes, as available	No
Passenger Occupancy: HSR	U.S. DOT BOTS, 2020	446	Low	No	Yes: Ticket Sales

C.1. Model Parameter Refinement via Data Source Update

Highway Distance

Highway distance for the RC-LV route is based on GoogleMaps distance calculations. Once the HSR stations are constructed, the comparable driving distances will be revised using GoogleMaps.

Air Travel Distance

Air travel distance from a nearby airport to Rancho Cucamonga (Burbank: Bob Hope Airport) to Las Vegas (McCarran International Airport) represents a common direct air travel route from Southern California to Las Vegas and is based on the Great Circle Mapper calculator (www.greatcirclemapper.net). This data source is widely accepted as providing accurate and representative data sources for determining travel distances, and therefore, no update for this model parameter is needed. The air travel distance entered in the model only reflects the miles travelled between the Burbank and Las Vegas airports and does not include the distance that passengers would need to travel from their travel-origin to the respective airport.

Lower Heating Values: CA Reformulated Gasoline, Diesel, Conventional Jet

CA Reformulated Gasoline:

The lower heating value for California reformulated gasoline is an established parameter represented in the CA GREET3 model (CARB, 2018d). Therefore, no update for this EER model parameter is necessary.

Diesel:

The lower heating value for diesel fuel is an established parameter represented in the California GREET3 model (CARB, 2018d). Therefore, no update for this EER model parameter is necessary.

Conventional Jet:

The lower heating value for conventional jet fuel is an established parameter represented in the California GREET3 model (CARB, 2018d). Therefore, no update for this EER model parameter is necessary.

Fuel Economy: LDV/LDT, Motor Coach, Airplane

LDV/LDT

LDV/LDT fuel economy was on based values published in the emission inventories that are established, vetted, and maintained by CARB – California Emission Factor Inventory (EMFAC) (2021), and the California GHG Emission Inventory (CARB, 2016d). The values included in Table 17 represent the year 2025, reflecting DesertXpress's plan to have the RC-LV line operational beginning that year. As policy and technology can be expected to drive fuel economy improvement relatively rapidly, this EER model parameter will be revised using these same sources when the fuel pathway application is submitted, following HSR operation, and on an annual basis per §95488.10.

Motor Coach

Motor coach fuel economy was on based values published in the emission inventories that are established, vetted, and maintained in EMFAC (CARB, 2021), and the California GHG Emission Inventory (CARB, 2016d). The values included in Table 17 represent the year 2025, reflecting DesertXpress's plan to have the RC-LV line operational beginning that year. As policy and technology can be expected to drive fuel economy improvement relatively rapidly, this EER model parameter will be revised using these same sources when the fuel pathway application is submitted, following HSR operation, and on an annual basis per §95488.10.

Airplane

Airplane fuel economy was based on conventional jet fuel for a subset of single aisle airplane models typically flown from Los Angeles to Las Vegas (Section 2.2.2). Immediately following fuel pathway application submittal and HSR operation, and on an annual basis per §95488.10, the jet fuel economy parameters will be evaluated to ensure that they represent current travel industry standards.

Passenger Occupancy:

Motor Coach

Motor coach passenger occupancy rates were established using statistical data collected and maintained by the U.S. Department of Transportation (2019) for motor coach transport. Immediately following fuel pathway application submittal and HSR operation, and on an annual basis per §95488.10, this same data source will be consulted and, as updated data become available, the motor coach passenger occupancy parameter will be accordingly revised.

Airplane

Airplane passenger occupancy rates were established using annual statistical data collected and maintained by the U.S. Department of Transportation (2020) for air carrier statistics. The airline passenger occupancy parameter in the EER model was calculated using the average passenger occupancy rate from this source for 2003 through 2019, applied to the weighted average median seating capacity for the airplane models typically flown from Los Angeles to Las Vegas. Immediately following fuel pathway application submittal and HSR operation, and on an annual basis per §95488.10, this parameter will be revised as updates to the associated data become available from this same source.

C.2. Model Parameter Refinement via Data Measurement

HSR Distance

The RC-LV track-chart (Siemens, 2019) estimates a 218-mile distance. This distance will be revised using train odometer readings upon operation post-construction.

HSR Fuel Economy

Data quality for HSR fuel economy is low since no HSR currently operates in the U.S., and current estimates are based on a route and trainset that have not yet been built or operated. Fuel economy data will be measured once the track construction is completed and commercial passenger service is operational. Such data will provide the basis of energy inputs to a Tier 2 Provisional Pathway Application.

Electricity supplied to the HSR trainsets will be metered independently from the electricity supplied to the train stations, thereby, clearly distinguishing electricity usage for trainsets from other station and maintenance-related usage. Specifically, the amount of electricity required to power the RC-LV line will be derived from utility-provided electricity bills for the two converter substations that are dedicated to trainset operation. The energy consumed in the California portion of the RC-LV Route will be measured by subtracting the energy consumed at the Nevada side (see Section C.3 for details).

Displaced Mode of Transport for LDV/LHV, Motor Coach, Airplane

To ground-truth the parameters for displaced modes of transport (MOT) in the EER model, DesertXpress plans to conduct passenger surveys to identify which MOT they would have taken had they not traveled by HSR, and the number of passengers if the LDV/LDT vehicle alternative is selected. Surveys will be designed to be statistically representative and take into account peak and seasonal tourism volume. In order to establish a provisional pathway, such surveys will initially be conducted during the first three months of the RC-LV HSR operation. As discussed above, ridership ramp-up may be expected to occur over a five-year period, with the ridership during the first year representing up to 50% of that achieved by year 5 of operation, and the steepest ramp-up occurring in years 2 and 3 of operation (CHSR, 2020c). Therefore, passenger surveys will be conducted in accordance with reporting requirements per §95488.10 in order to improve the quality of data representing displaced MOTs as well as HSR occupancy.

Survey questions will include those designed to inform model parameters pertaining to displaced mode of transport and associated passenger occupancy, e.g.,

1) Indicate which alternative mode of transportation would you have taken:
    a. light duty truck/SUV or light duty vehicle (car): y/n
    b. motorcoach bus: y/n
    c. airplane: y/n

2) If driving either a light duty truck/SUV or light duty vehicle (car), how many passengers would have travelled in this vehicle on this trip?
3) Would you have taken this trip if HSR had not been available as a transport mode, and you instead had to travel via an alternative mode of transportation, including either light duty truck/SUV or light duty vehicle (car), motorcoach bus, or airplane?

Passenger Occupancy: LDV/LDT

LDV/LDT passenger occupancy along the highway route between Los Angeles and Las Vegas (Interstate-15) was established based on data collected from two surveys conducted 10 years apart, using different methods. In 2015, (Steer Davies Gleave (2016, 2019) conducted an Investment Grade Ridership & Revenue Forecast for HSR rail service along a RC-LV line. For this survey, 4,072 respondents were either interviewed in focus groups or through mailed surveys. This ridership survey was designed to establish the current and future size of the "in-scope" travel market and identify traveler preferences. Based on survey responses, this study established a value of 2.5 passengers per LDV.

In 2005, a real-time in-situ survey of travelers along the RC-LV travel corridor was conducted by URS Corporation (2005) to refine estimates of the highway travel market between Southern California and Las Vegas due to inconsistencies observed between traffic count data from the State Departments of Transportation and the Las Vegas Convention and Visitors Authority. Specifically, these surveys were designed to better quantify the share of automobile travel along the I-15 corridor destined for Las Vegas, and the associated passenger occupancy. Three types of data were collected at Baker, California on November 10 – 14, 2005: mainline classification counts, ramp license plate counts and vehicle occupancy observation, and interviews at parking lots associated with service stations and restaurants (N=948). Survey results were evaluated by Cambridge Systematics (2008). Average passenger occupancy of vehicles surveyed was 2.46 persons, which has since been corroborated, as discussed above, by the 2015 Ridership and Revenue Forecasts (Steer Davies Gleave, 2016, 2019)

While the aforementioned data sources represent region-specific, measured passenger LDV/LDT occupancy, neither capture passenger occupancy rates for every day of the week, nor throughout the year (Cambridge Systematics, 2008). Therefore, the data informing this parameter will be compared to LDV/LDT passenger occupancy statistics measured through the HSR passenger surveys described above and accordingly updated for each pathway submittal. As well, DesertXpress will commission a peer-review of the Steer Davies Gleave Investment Grade Ridership and Revenue Forecast and submit it to CARB following initiation of HSR operation.

HSR Passenger Occupancy

As documented in the body of this report, the DesertXpress passenger occupancy rates that formed the basis of the HSR EER were derived from data collected and published by the U.S. DOT Bureau of Transportation Statistics for average occupancy in the airline industry between 2003 and 2019. This section describes a plan for collecting passenger occupancy data for the RC-LV

HSR route, once it is operational, to ground-truth those data. Operational passenger occupancy rates will be represented in the Provisional Pathway Application.

Passenger occupancy on the RC-LV line will be established by compiling data for all ticket sales in both directions for a one-year period. Ticket sales will be summarized on a daily, weekly, monthly, and annual basis. These data will be represented in each fuel pathway annual report.

C.3. Renewable Energy Requirements

Electricity Procurement

DesertXpress plans to purchase renewable energy credits (RECs) with a CI of zero (fuel pathway code ELCR), to power the RC-LV HSR line, and will consider CARB's recommendation to purchase Green-e[11]-certified renewable energy products during the REC-procurement process. DesertXpress could participate in CARB's Voluntary Renewable Electricity (VRE) Program. In this program[12], DesertXpress would purchase RECs that are subject to the Renewables Portfolio Standard (RPS), e.g., certified electricity that is shown to be generated or delivered to California, and are not used to meet any mandatory requirements, such as the RPS (CARB, 2020[13]). These RECS would be retired by CARB as Program allowances. Any RECs otherwise purchased will be retired through the Western Renewable Energy Generation Information System (WREGIS) (further described below).

Propulsion Electricity Measurement & Reporting

Electricity used to power the RC-LV line will be measured using a dedicated metering system of substations, converters, distribution lines, and switches. Three substations located in Hesperia, Barstow (Tortilla), and Ivanpah, CA, will be dedicated to powering the RC-LV Line (Figure 12). Transmission lines from these substations will convert the 115kv power provided by Southern California Edison to 25kv power required to power the trainsets. Per §95483.2(b)(8), the "converter" substations will each be registered as Fuel Supply Equipment (FSE) in the LRT-CBTS[14], in order to measure the quantity of electricity powering the RC-LV HSR line distinctly from any other FSE designated for other fueling purposes at the train stations, for example, parking lot EV-fueling. Monthly reports for trainset traction power supply will be generated from the substations in addition to utility invoices (Figure 14). Train station power usage will be separately metered and reported in energy procurement invoices pertaining to each FSE.

A smart power metering station installed at the CA-NV state line (Figure 14) will measure and provide an instantaneous and continuous record of the quantity of power consumed by trains

[11] https://www.green-e.org/

[12] https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/voluntary-renewable-electricity-program

[13] Guidance on Retiring Allowances from the Voluntary Renewable Electricity Reserve Account (LCFS Regulation sections 95831(b)(6), 95841.1, and 95870(c)).

[14] In the case of multiple FSEs, each will be registered separately.

along the portions of the track located in both states. Current and voltage meters[15] are placed on either side of the state boundary. These meters are capable of measuring both the amount and direction of current flow and voltages present, which vary depending on the number, direction, and speed of each train operating on the HSR track system.

On the California side of the RC-LV route, all current being used within the state will be measured, and on the Nevada side, all current being handed across (or back) from trains operating in Nevada will be measured. For the period of time when all trains are only operating in California, and not in Nevada, neither meter will record any current flow from California into Nevada. The smart metering system will record all the power being provided from each of the three California substations to the California portion of the RC-LV route. Once a train crosses the CA-NV boundary, a portion of the whole-line current is passed across the state boundary to power the trainset in Nevada. The net quantity of electricity supplied to power the trainset in California is determined by the smart metering system by subtracting the quantity of power supplied to power the trainset in Nevada from the total quantity of power supplied by the California substations. If a trainset is in Nevada, but approaching California and braking, it will produce power due to regenerative braking which will reverse the current flow. This self-generated quantity of power will also be measured by the smart system and subtracted from the overall power supplied from the California substations.

Therefore, regardless of the direction, speed and number of trainsets operating on each side of the CA-NV boundary, the proportion of power either being used or generated in Nevada is measured on a continuous basis and subtracted from the total quantity of power supplied from the three CA substations to provide a net quantity of power consumed by trainsets operating in California. Both the line voltage and current are measured and provide an accurate continuous measure of the total amount of power used within the state of California, regardless of whether trainsets are either using or generating power within the state of Nevada.

The data collected by the smart metering system is sent to the Power-SCADA network (Figure 14), which tracks all current flow at each of the substations and paralleling stations across the entire network. The Power SCADA system stores all of the power data measured by the smart metering system, calculates the total power usage, and produces a continuous record of the quantity of electricity used to power trainsets on the California portion of the track and on the Nevada portion of the track. only power usage and Nevada only power usage. These reports can be printed as frequently as required to provide a detailed record of power system usage across the entire network. The net electricity delivered by FSEs to power the trains for the California-

[15] A 2 x 25kV overhead catenary system is located on the state boundary line using a duplicated set of transformers – Current (CT), and Voltage (VT). The CT and VT are installed in both the negative and positive feeder. The energy measurement is directional to distinguish whether energy is flowing from CA to NV or from NV to CA. The energy flow can occur bi-directionally depending on the position of rolling stock, train acceleration or deceleration, and any potential degraded condition of the traction power system.

miles of the route will be reported quarterly in the LRT-CBTS, and annually for the purpose of annual LCFS fuel volume transaction reporting.

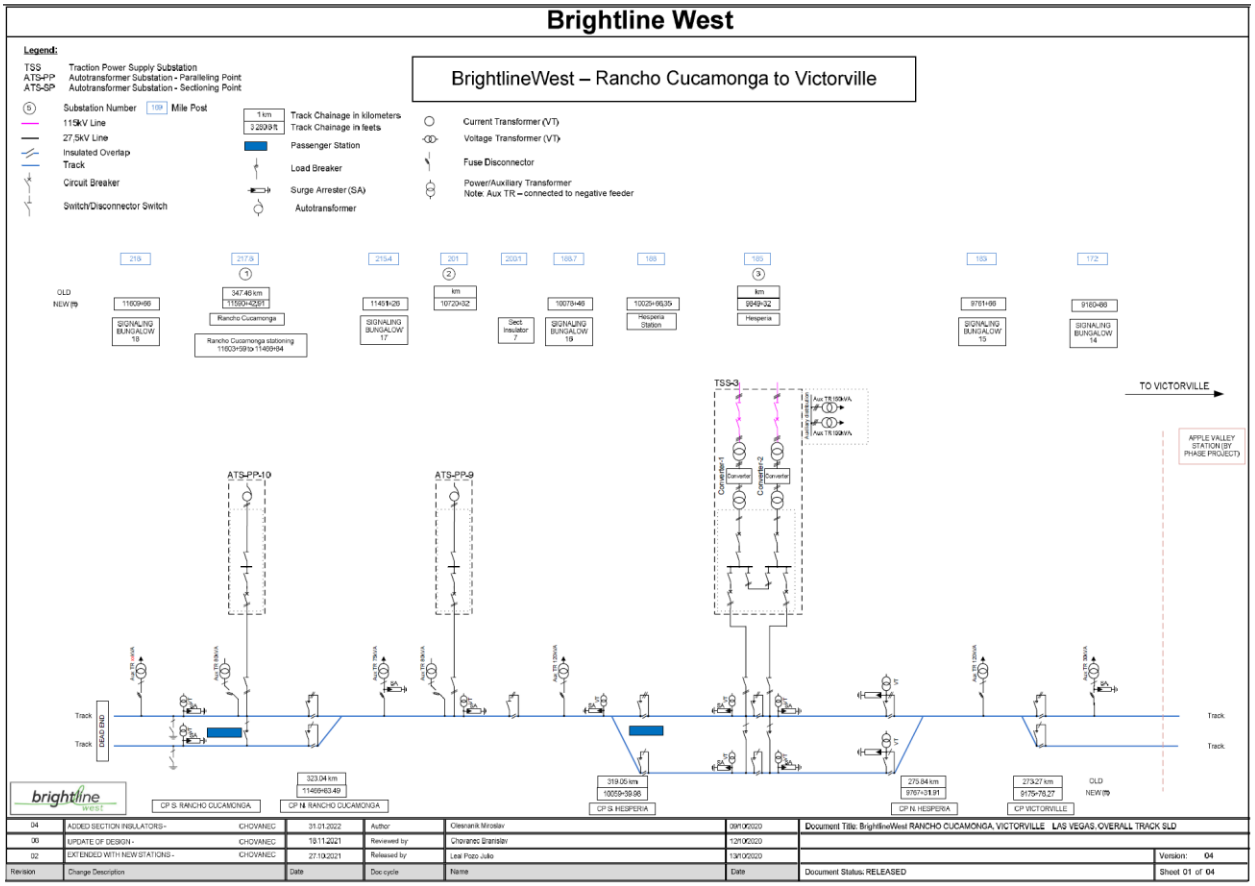

Figure 12. Power Traction Substation and Metering Locations.
Source: Siemens, 2022a

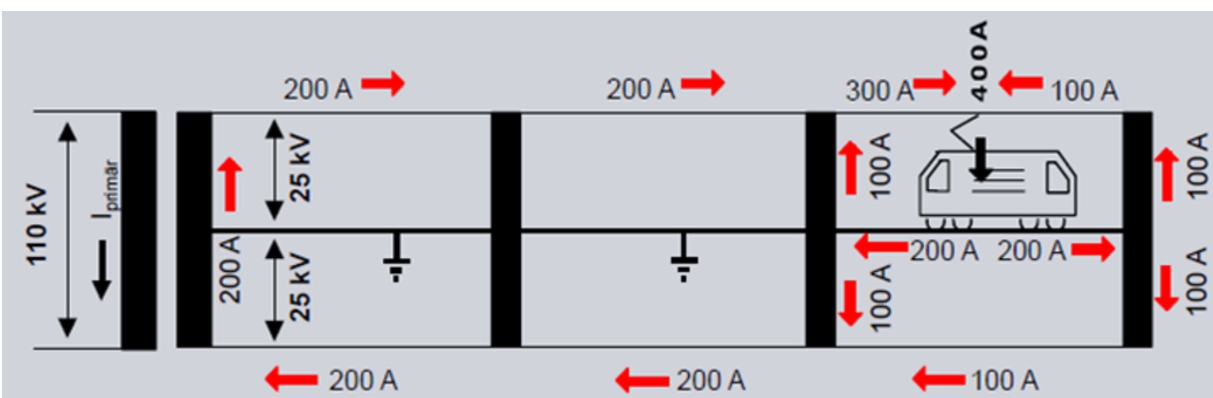

Figure 13. Example of current flowing in a two-pole system

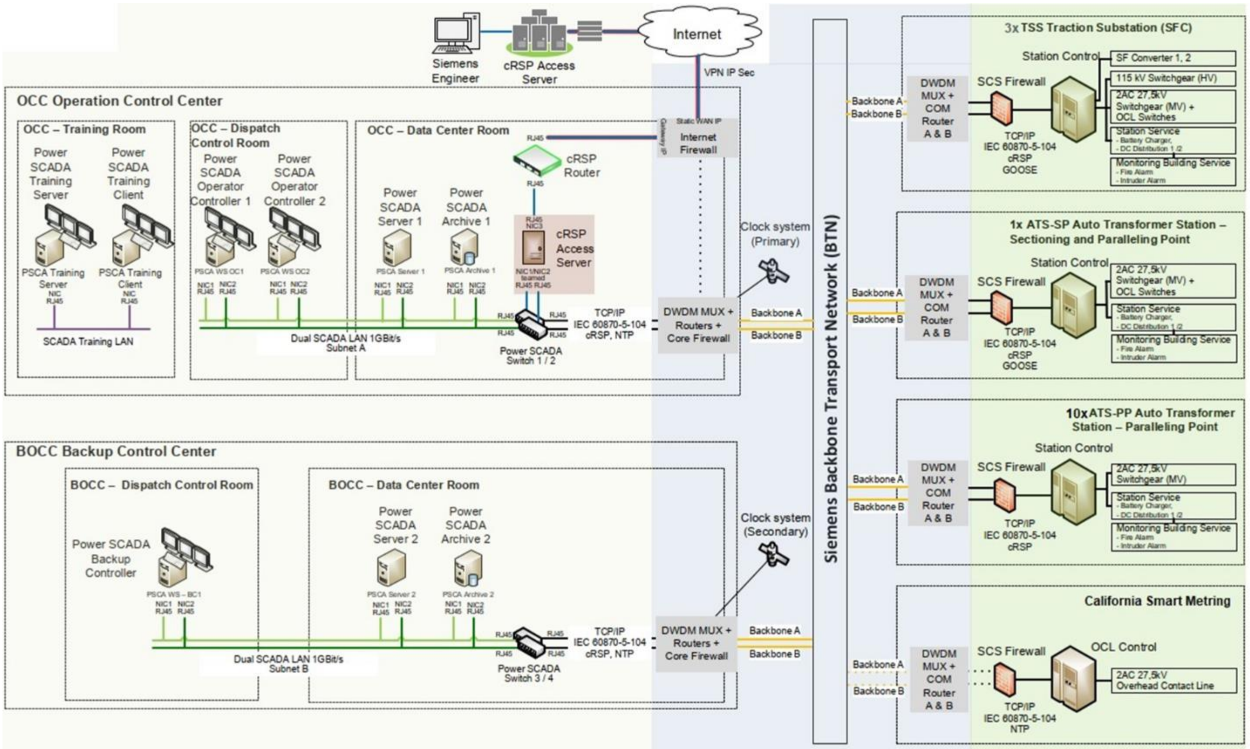

Figure 14. Energy Metering and Reporting System.

Source: Siemens, 2022b

Estimate of Operational Credit Potential

The number of LCFS credits estimated to be generated from operation of the California-portion of the RC-LV HSR line (184 mi), between 2025 and 2030, are represented in Table 18. These estimates are based on the model parameters, as represented in Table 17, with the addition of fuel economy values for 2026-2030 based on EMFAC data (CARB, 2021), and an estimated number of HSR trips/day (50 one-way, OW). The number of passengers per OW HSR trip reflects the anticipated ramp-up schedule presented in Table 16. The parameters that are most likely to change over time and influence the estimated credit volume are: percent mode represented for each displaced MOT, fuel economy, and number of HSR passengers per trip.

Table 18. Estimated LCFS Credit Generation[16], 2025-2030

	2025	2026	2027	2028	2029	2030
HSR #Trips/day	50	50	50	50	50	50
HSR Power (kWh)	197,800	197,800	197,800	197,800	197,800	197,800
HSR Power (MJ)	712,080	712,080	712,080	712,080	712,080	712,080
EER	6.5	11.3	11.3	11.2	11.1	11.0
HSR Displaced MJ	4,594,597	8,061,105	8,017,595	7,974,862	7,885,949	7,805,594
HSR CI	0	0	0	0	0	0
HSR Displaced GHG tonnes	**395.04**	**683.00**	**669.34**	**655.86**	**638.74**	**622.46**
Displaced Passenger mi	2,277,000	4,048,000	4,075,600	4,103,200	4,103,200	4,103,200
Displaced Energy						
Displaced Gasoline	3,259,661	5,693,183	5,639,296	5,586,272	5,503,063	5,427,537
Displaced Diesel	290,706	511,513	509,232	506,866	501,163	496,333
Displaced Jet	1,044,230	1,856,409	1,869,066	1,881,724	1,881,724	1,881,724
Total	4,594,597	8,061,105	8,017,595	7,974,862	7,885,949	7,805,594
Displaced GHG tonne/day						
Gasoline	279.6	481.2	469.6	458.3	444.6	431.8
Diesel	25.2	43.7	42.8	42.0	40.9	39.9
Jet	90.5	158.5	157.2	155.9	153.6	151.2
Total	395.24	683.37	669.72	656.24	639.13	622.86
LCFS Credits (tonne/yr)	**144,262**	**249,429**	**244,448**	**239,529**	**233,282**	**227,344**
Est.[a] LCFS Credit Value/yr ($)	**$25,967,100**	**$44,897,207**	**$44,000,565**	**$43,115,177**	**$41,990,726**	**$40,921,982**
[a]Based on a $180/tonne valuation						

Renewable Energy Credit Purchase & Retirement

DesertXpress is prepared to comply with the renewable energy requirements stated in the LCFS Regulation. Pursuant to paragraphs 5 and 7 in §95491(d)(3)(A) of the LCFS Regulation, all entities (load-serving (LSE) and non-LSE) generating credits from electricity pathways are required to submit an itemized summary of efforts and costs associated with meeting electricity credit proceeds requirement (CARB, 2020)[17]. This itemized summary must be submitted along with an Annual Compliance Report, due annually by April 30. Accordingly, utilities supplying electricity to DesertXpress HSR are also subject to requirements of the LCFS, §95488.8(c), pertaining to the use of book-and-claim accounting[18] for indirectly supplied low- and zero-CI electricity. This includes using the Western Renewable Energy Generation Information System (WREGIS) to retire renewable energy certificates (RECs) for low- and zero-CI electricity claimed in the LCFS once the energy associated with those RECs has been supplied to customers. CARB has also made

[16] LCFS Credits assuming 365 days/year operation.

[17] Draft LCFS Guidance 20-03 Electricity Credit Proceeds Spending Requirements.

[18] This refers to the chain-of-custody model in which decoupled environmental attributes, such as Renewable Energy Certificates, are used to represent the ownership and transfer of transportation fuel under the LCFS without regard to physical traceability. See section 95488.8(i) of the LCFS Regulation.

available[19] an information reporting template for electricity credits. The itemized summary would cover the following for the previous calendar year, e.g., January 1, 2019 – December 31, 2019:

1. Total number of credits carried over from the prior calendar year.
2. Total number of electricity credits carried over from the prior calendar year.
3. Total number of credits generated during the calendar year.
4. Total number of electricity credits generated during the calendar year.
5. Total number of credits sold during the calendar year.
6. Total number of electricity credits sold during the calendar year.
7. Total number of credits carried over to next calendar year
8. Total number of electricity credits carried over to next calendar year.
9. Total proceeds ($) resulting from credits sold during the calendar year.
10. Total proceeds ($) resulting from electricity credits sold during the calendar year.
11. Any electricity credit proceeds ($) carried over from prior calendar year.
12. Total electricity credit proceeds ($) used during the calendar year.
13. Any electricity credit proceeds ($) earmarked for future use. Provide a brief description of expected use and timeline, if available.
14. A brief description and breakdown of electricity credit proceeds ($) used during the calendar year to implement individual projects or programs to benefit EV drivers and customers, and to promote transportation electrification in California.

Paragraph 7 in §95491(d)(3)(A) of the LCFS regulation provides specific requirements for non-LSE (e.g., DesertXpress) use of electricity credit proceeds. These requirements apply to all credits generated using electricity pathways including incremental credits. Non-LSEs may use the electricity credit proceeds resulting from a specific category or sector of electric transportation to invest in transportation electrification projects in the same category or sector. For example, an entity generating electricity credits for public EV charging can use the proceeds to incentivize public EV charging or deploy additional EV charging infrastructure. Through the annual reporting, entities may demonstrate that they have exhausted opportunities to promote electric transportation in a specific category or sector and use credit proceeds to support transportation electrification in another category or sector. Examples that would meet the electricity credit proceeds spending requirements for a non-LSE include:

1. DesertXpress strongly supports a sector-specific approach to spending requirements to maintain sufficient flexibility in the use of proceeds to allow for both continued investment in capital projects for the fixed-guideway system, as well as day-to-day operational expenditures required to maintain a safe, reliable, and affordable passenger

[19] Draft Supplemental Information Reporting Template Electricity Template.xlsx, available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/lcfs-guidance-documents-user-guides-and-faqs.

rail system. Given its role as an operator of a publicly accessible intercity passenger rail system using low-carbon electricity to power its system, DesertXpress views these uses as tightly aligned with the goals of the LCFS Regulation and the state's broader objectives to reduce single-occupancy vehicle trips and decarbonization of the transportation sector.

2. Providing incentive support for purchasing/leasing of EVs or other electric transportation equipment (for example, electric forklifts, electric cargo handling equipment, electric transportation refrigeration units, electric buses, electric trucks, etc.).

3. Providing incentive or direct investment for installing EV charging infrastructure.

4. Providing rebates or other incentive for using electricity as a transportation fuel (for example, providing discounted or no-cost electricity for transportation applications, providing discounted or no-cost rides on electric public transit, etc.).

5. Marketing, education, outreach programs to provide information and material to inform the public on the benefits of electric transportation. This could include information regarding the environmental, health and economic benefits of electric transportation, including a comparison of the total cost of electric transportation mode versus other alternatives (including the cost of refueling, servicing and maintenance, etc.). The above list of examples is not exhaustive. Entities may use electricity credit proceeds to support other transportation electrification projects which are not included in the list but would meet the LCFS requirements. Entities may choose to spend all electricity credit proceeds in a single program or project.

APPENDIX D. DATA FROM LCFS REGULATION AND MODIFIED FROM CA_GREET3.0

Values referenced in the LCFS Regulation as well as those modified from CA_GREET3.0 are listed in Table 19.

Table 19. LCFS Regulation Data and Modifications to CA_GREET3.0

Parameter	GREET Cell Location	Units	Original GREET Value	Modification	Revised Value	Comment
From LCFS Regulation						
Diesel LHV	NA	MJ/gal	134.47	NA	N/A	LCFS Regulation, Table 4
CA RFG LHV	NA	MJ/gal	115.83	NA	N/A	LCFS Regulation, Table 4
Electric Power	NA	MJ/kWH	3.6	NA	N/A	LCFS Regulation, Table 4
GREET Modifications						
Jet LHV	Fuel_Specs!J 26	MJ/gal	none	=B26/MJ2BTU	131.15	Added calculation of LHV per MJ Jet
CI of Electric Power	Fuel_Prod_TS !U366	g CO_2e/MJ	100%	0%	0	Sets mix to 100% Renewable Power
Selection of Renewable Power	Region Selection!E8	g CO_2e/MJ	1. U.S. Avg Mix	2-User Defined Mix	0	

Feedback on DesertXpress Design-based Pathway for High Speed Rail

Revised application

Overview of remaining feedback items

- DesertXpress should commission a peer-review of the ridership study relied upon for the fuel pathway application that will be submitted after operation begins.
- Describe in more detail how electricity used for trainset propulsion will be measured and reported to CARB, including the methodology for isolating electricity consumed for operation in California.
- Fuel economy data sources for various vehicle/transport types should be updated when the fuel pathway application is submitted after operation begins.
- DesertXpress should consider including an option in their survey that captures induced trips, on page 47.
- Page 14, Eq (3) uses D_{air} instead of D_{bus} at the end of the numerator.

Next steps

- After satisfactorily revising the application to incorporate the bullet on measuring and reporting electricity used for operation in California, and the minor edit in the last bullet, staff can proceed to approval of the application.