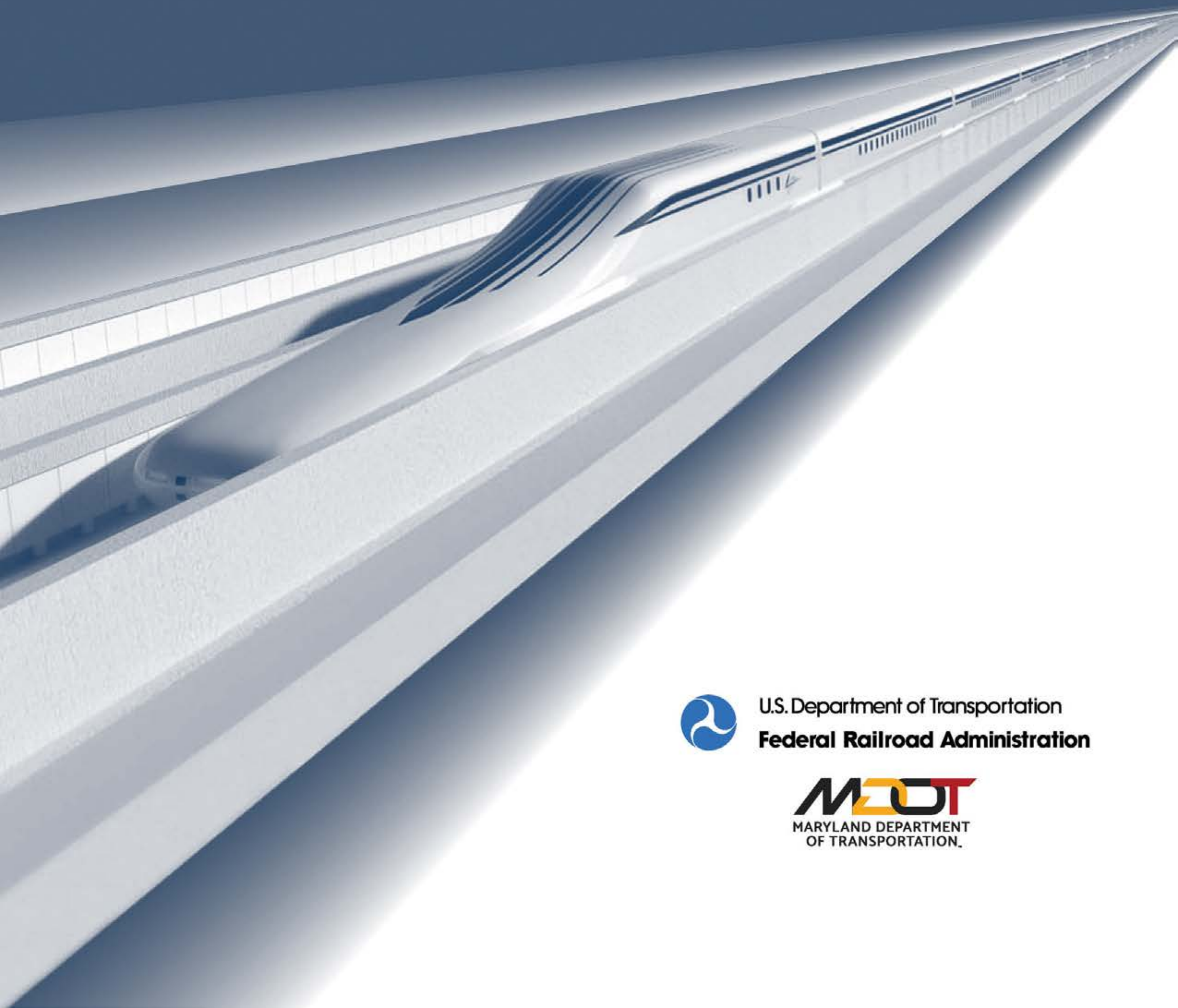
Section 4.19

Energy

BALTIMORE-WASHINGTON SUPERCONDUCTING MAGLEV PROJECT

DRAFT ENVIRONMENTAL IMPACT STATEMENT AND
SECTION 4(f) EVALUATION



U.S. Department of Transportation
Federal Railroad Administration

MARYLAND DEPARTMENT OF TRANSPORTATION

4.19 Energy

This section provides an assessment of the anticipated net changes in energy consumption between the No Build and Build Alternatives. It considers the direct energy consumption of the Superconducting Magnetic Levitation Project (SCMAGLEV) system and ancillary facilities, indirect energy impacts from construction, as well as projected changes in other transportation modes such as passenger vehicles, rail, and buses. This analysis also provides an overview of expected impacts of the SCMAGLEV system to the reliability of the regional power grid, and a discussion of potential strategies to mitigate any adverse impacts.

4.19.1 Regulatory Context and Methodology

4.19.1.1 Regulatory Context

In accordance with the National Environmental Policy Act (NEPA), 42 U.S.C. § 4321 et seq., the Council on Environmental Quality (CEQ) regulations, 40 C.F.R. Parts 1500 - 1508, and the Federal Railroad Administration's (FRA) Procedures for Considering Environmental Impacts, 64 Fed. Reg. 28545 (May 26, 1999), FRA assessed any irreversible or irretrievable commitments of energy resources likely to be involved in each alternative and any potential energy conservation.

4.19.1.2 Methodology

The SCMAGLEV system may impact the availability and reliability of existing energy supply chains and infrastructure in the Superconducting Magnetic Levitation Project (SCMAGLEV Project) Affected Environment described in Section 4.19.2. Given the lack of more localized data, FRA reasonably assessed the impacts of SCMAGLEV Project to energy consumption at the state level for this evaluation.

FRA compared the No Build Alternative against two scenarios of Build Alternatives. The No Build Alternative accounts for projected 2045 growth of existing transportation options. These options include auto and/or bus transportation via I-95, US 1, US 29, and MD 295/BWP, and by the passenger rail services Maryland Area Regional Commuter (MARC) and Amtrak. Changes in air travel were included in the ridership projections, but only in terms of changes in auto trips to and from Baltimore-Washington International Thurgood Marshall Airport (BWI Marshall Airport). Given this data gap, FRA did not analyze the energy impacts of changes to air traffic. The No Build Alternative includes transportation improvements adopted in the Regional Constrained Long-Range Plan for the Baltimore and Washington, D.C. areas and selected planned major rail improvements identified in the NEC FUTURE Record of Decision (ROD).[1] FRA used estimates of Passenger-Miles Traveled (PMT) provided by the Project Sponsor to calculate the combined projected energy use of auto, bus, and rail in 2045

[1] https://www.fra.dot.gov/necfuture/tier1_eis/rod/

under the No Build Alternative.[2] These estimates are based on modeling of ridership which is valid within the Washington, D.C.-Baltimore corridor.

The variance between the various Build Alternatives in direct energy consumption of the SCMAGLEV system and ancillary facilities is minimal given that the different alternatives have similar track lengths, track gradients, and number of stations served by SCMAGLEV. However, the ridership data provided by the Project Sponsor indicates that there are differences in passenger diversion from other travel modes depending on the location of the SCMAGLEV terminal station in Baltimore. As such FRA groups the Build Alternatives into the following two scenarios for the energy analysis: 1) Build Alternatives with a terminal station in Cherry Hill, and 2) Build Alternatives a terminal station in Camden Yards. FRA's estimate of energy consumption accounts for growth in existing transportation modes, changes in ridership of auto, bus, and rail transportation modes caused by the availability of SCMAGLEV Project as a transportation option, and the future demands of the SCMAGLEV system. FRA estimates the energy consumption of this system in terms of the following direct and indirect use categories:

- Direct energy consumption by SCMAGLEV trains and ancillary facilities (i.e., fresh air and emergency egress (FA/EE) facilities, stations, maintenance of way (MOW), and trainset maintenance facility (TMF) facilities).
- Indirect energy expenditure associated with the construction of physical infrastructure.

The SCMAGLEV Project will also use natural gas to heat offices and work areas. At present the available information is insufficient to estimate total natural gas consumption for these facilities. However, FRA estimates that total energy consumption attributable to natural gas for heating will be small relative to SCMAGLEV Project's other operational energy needs.

FRA measures energy in terms of million British thermal units (MMBtu) and megawatt-hours (MWh). **Table 4.19-1** describes the units of measurement used to document energy consumption and demand. Passenger-miles were converted to energy consumption using estimates from the Energy Information Administration (EIA) on 2045 passenger mode energy intensities. Energy intensity is the energy required to move one passenger one mile. For auto, bus, and passenger rail, these values are 2,000, 1,100, and 1,250 British thermal units (Btus) per passenger-mile, respectively.[3]

[2] BWRR provided estimates of auto travel in vehicle-miles traveled. To convert to passenger-miles traveled a conversion factor of 1.5 passengers per trip was applied, calculated based on the average party size provided by the Project Sponsor in a ridership forecast.
[3] Energy intensity value for passenger rail is assumed to be applicable both to commuter rail and intercity passenger rail.

Auto travel is considerably more energy intensive per person, given that light-duty vehicles carry on average fewer passengers than bus or rail.

Table 4.19-1: Units of Measurement

Unit	Description
Energy Consumption	
MMBtu	One million British thermal units. A Btu is defined as the amount of heat required to raise the temperature of one pound of water by one-degree Fahrenheit. 1 MMBtu = 1 million Btu.
MWh	A megawatt-hour is equivalent to 1,000,000 watts for one hour. 1 MWh = 1 million Wh.
MMBtu/year; MWh/year	MMBtu and MWh are shown as MMBtu/year and MWh/year to represent energy consumption on an annual basis.
Energy Demand (also referred to as power)	
MW	Megawatt (MW) measures the rate of energy transfer.
Transportation Metrics	
PMT	Passenger-miles traveled (PMT) represents the movement of one passenger for one mile. This metric is used to estimate the energy expenditure of different transportation modes.
VMT	Vehicle-miles traveled (VMT) represents the total number of miles traveled by vehicles. In this analysis, VMT refers to light-duty vehicles.
Energy Intensity	
Btu/PMT	Conversion factor unit for mode energy intensity to convert PMT to transportation energy consumption.

4.19.2 SCMAGLEV Project Affected Environment

As of 2018, Washington, D.C. and Maryland rank below the national average in energy consumption per capita. However, in terms of the percentage of total energy consumption which is *transportation-related,* Washington, D.C. is well below the national average of 28 percent at 12 percent. For Maryland, this figure is slightly above the national average at 32 percent. **Table 4.19-2** provides an overview of the energy profile for both geographies and a comparison to the national average.

Table 4.19-2: State Energy Overview and Consumption by Sector

Geography	Total Consumption (trillion Btu/year)	Energy Consumption Per Capita (MMBtu/year/ person)	Percent of Energy Consumption by Sector			
			Transportation	Industrial	Commercial	Residential
Washington, D.C.	175	241	12	3	61	24
Maryland	1,361	218	32	8	30	30
National Average	1,983	347	28	32	18	21

Source: Energy Information Agency (EIA), Energy Consumption Estimates by End-Use Sector, Ranked by State, 2018

According to the Bureau of Transportation Statistics the U.S. transportation sector consumed 26,600 trillion Btus in 2018. Light duty vehicles[4] accounted for 61 percent of this consumption; more than all other transportation modes combined, as shown in **Table 4.19-3**.

Table 4.19-3: U.S. Energy Consumption by Transportation Mode

Mode	Consumption (trillion Btu)	% of Total
Air	1,872	7
Light Duty Vehicles	16,097	61
Medium/Heavy Trucks	5,801	22
Bus	312	1
Rail (Freight)	507	2
Rail (Passenger)[a]	11	0
Watercraft	970	4
Pipeline	890	3

Source: Bureau of Transportation Statistics, Table 4-6: Energy Consumption by Mode of Transportation, 2018
[a] Passenger rail represents Amtrak operations only.

In Washington, D.C. and Maryland, the transportation sector accounts for 78 percent and 85 percent of total petroleum consumption, respectively.[5] Gasoline and diesel consumption emit more pounds of CO_2 per Btu of energy produced when compared with the other energy source except for coal.[6] See **Table 4.19.4**.

[4] Light Duty Vehicles include cars, sport utility vehicles, and small trucks.
[5] https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_fuel/html/fuel_use_pa.html&sid=US&sid=DC (last visited on **July 2, 2020**)
[6] https://www.eia.gov/tools/faqs/faq.php?id=73&t=11 (last visited on **July 2, 2020**)

Table 4.19-4: Energy Consumption by Source

Geography	Percent of Annual Consumption (%)					
	Coal	Natural Gas	Petroleum[a]	Nuclear	Renewables[b]	Interstate Flows[c]
Washington, D.C.	0	19	11	0	2	69
Maryland	9	23	33	12	7	17

Source: Energy Information Agency, Maryland and Washington, D.C. Energy Consumption Estimates, 2018
[a] Petroleum combines the EIA categories of motor gasoline, distillate fuel oil, jet fuel, Hydrocarbon Gas Liquids (HGL), residual fuel, and other petroleum.
[b] Renewables combines EIA categories of hydroelectric power, biomass, and other renewables.
[c] Interstate flows refer to energy generated outside of the state and delivered via interstate transmission lines.

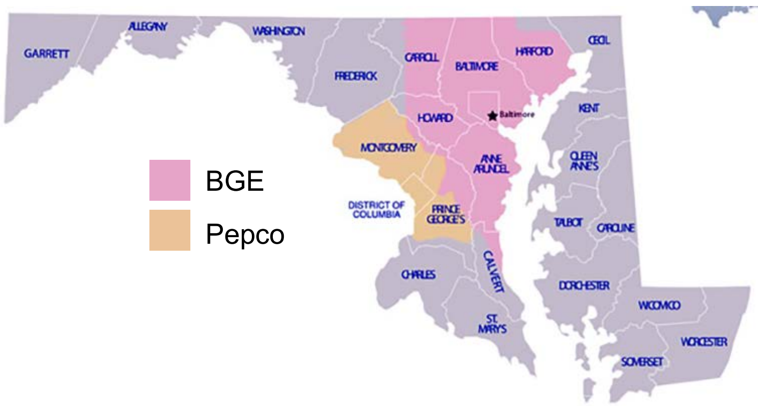
The proposed SCMAGLEV system and its ancillary facilities would draw power from two electric utilities: Potomac Electric Power Company (PEPCO) and Baltimore Gas and Electric Company (BGE). PEPCO and BGE provide electric energy transmission and distribution services for all areas included in the SCMAGLEV Project Affected Environment, as shown in **Figure 4.19-1**. PEPCO has over 883,000 customers in Washington, D.C. and surrounding Maryland counties. BGE serves more than 1.25 million customers across its 2,300 square mile service area, which encompasses Baltimore and most of the Baltimore-Washington Parkway (BWP) corridor.

Both PEPCO and BGE belong to the Pennsylvania-New Jersey-Maryland Power Pool (PJM) which is a regional transmission organization responsible for coordinating the delivery of electricity in the Mid-Atlantic region. Interstate energy flows, which provide 69 percent of the total energy consumed in Washington, D.C. as shown in **Table 4.19-4**, are managed by PJM. PJM is one of the largest power pools in the U.S. with over 65 million customers in 13 states and Washington, D.C. and a generating capacity of over 197,485 megawatts.[7]

The SCMAGLEV Project would also utilize natural gas to heat offices, ventilation buildings, maintenance facilities, and passenger stations. BGE and Washington Gas would provide natural gas service to SCMAGLEV Project. The small volume of natural gas needed for heating ancillary spaces should be easily serviceable by the local utilities with no adverse impact to existing customers.

[7] https://learn.pjm.com/-/media/about-pjm/newsroom/fact-sheets/pjm-statistics.ashx

Figure 4.19-1: BGE and PEPCO Service Areas in the Baltimore-Washington Corridor[8]



Source: https://oasisenergy.com/maryland/

4.19.3 Environmental Consequences

The following sections compare the energy consumption of auto, bus, rail, and SCMAGLEV transportation modes in 2045 in the No Build Alternative and for Build Alternatives.[9]

4.19.3.1 No Build Alternative

Under the No Build Alternative, auto travel between Baltimore and Washington, D.C. would account for 96.5 percent of total transportation energy consumption at almost 7.6 trillion Btus annually. The energy consumption of bus travel is projected to account for a negligible percentage (0.3 percent) of energy consumption, with rail making up the remaining 3.1 percent. (See **Table 4.19-5**)

[8] https://oasisenergy.com/maryland/

[9] For this chapter FRA considers two groups of Build Alternatives: those with a terminal station in Cherry Hill, and those with a terminal station in Camden Yards. Energy consumption varies between these two groups because of differences in ridership projections depending on the location of the Baltimore terminal.

Table 4.19-5: 2045 Projected Transportation Energy Consumption for No Build Alternative

Transportation Mode	2045 Projected Transportation Consumption			
	Passenger-Miles Traveled (in 000s)	Mode Energy Intensity in Btu per PMT	Energy Use (MMBtu)	Percent of Total
Auto Travel	3,775,499	2,000	7,550,998	96.5
Bus Travel	24,638	1,100	27,102	0.3
Rail Travel[a]	195,220	1,250	244,025	3.1
		Total	**7,822,125**	**100**

Source: BWRR 2020
[a] Passenger rail only, does not include freight rail.

4.19.3.2 Build Alternatives

Total energy consumption of the SCMAGLEV system requires an estimated 4.0 trillion Btus per year for its operations (including trains, stations, ancillary facilities, TMF and MOW facilities). This is a preliminary estimate that will be refined as planning for the project progresses. The preliminary estimate is based on public information about the Chuo Shinkansen and other high-speed maglev technologies, as well as input from the Project Sponsor. To contextualize this estimated energy consumption, FRA compared the SCMAGLEV energy consumption against comparable trains. Energy intensity for maglev trains can be evaluated in two ways: (1) In energy per passenger-mile (Btu/seat-mile), or (2) in energy per usable area per distance (Btu/m^2-mile). Energy per passenger-mile is the standard for benchmarking transportation energy efficiency and measures the amount of energy necessary to move one passenger a distance of one mile. In the case of maglev trains, usable area is also helpful as it omits variables related to ridership and allows for a more direct comparison of the efficiency of the train system design. Usable area is a measure of the space within the train which can be used to accommodate cargo or passengers. [10]

Both metrics are provided in **Figures 4.19-2** and **4.19-3** along with figures for maglev and traditional trains of comparable speed and size in Japan (Chuo Shinkansen), Germany (ICE3 and Transrapid), and France (TGV Duplex).

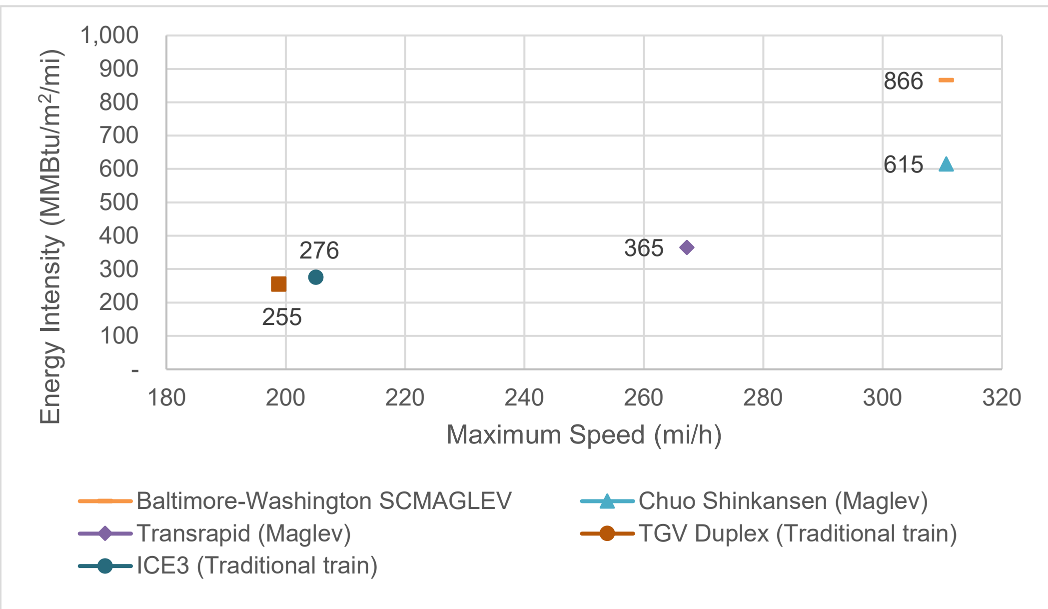
The SCMAGLEV Project's projected energy intensity is the highest of all trains for which data is available. FRA estimates that the energy intensity of the SCMAGLEV system is 866 Btu/m^2-mile – 41 percent larger than Chuo Shinkansen which has an efficiency of 615 Btu/m^2-mile. In terms of per seat energy intensity, SCMAGLEV Project is 53 percent larger than Chuo Shinkansen at 831 Btu/seat-mile. The relative inefficiency of

[10] This calculation is per the methodology of Fritz et al. 2018, available at https://www.researchgate.net/publication/328733747_Energy_Consumption_of_Track-Based_High-Speed_Transportation_Systems_Maglev_Technologies_in_Comparison_with_Steel-Wheel-Rail. The usable area is equivalent to the train length times the train width, multiplied by a factor of 0.75 to account for space that is exclusively dedicated to mechanical areas and cannot be used to carry people or cargo.

SCMAGLEV Project is likely due to the short distances between the three planned stations which will require frequent periods of acceleration[11].

Figure 4.19-3 is provided in units of energy per seat rather than energy per passenger to match the data available for comparable trains. Taken in terms of energy per passenger transported per mile, this figure increases to 1,672 Btu/passenger-mile for Build Alternatives with a terminal station in Cherry Hill and 1,506 Btu/passenger-mile for Build Alternatives with a terminal station in Camden Yards. SCMAGLEV's energy consumption more efficient than personal vehicles, which the EIA estimates at 2,000 Btu/passenger-mile but less efficient than passenger rail or bus at 1,250 and 1,100 Btu/passenger-mile, respectively.

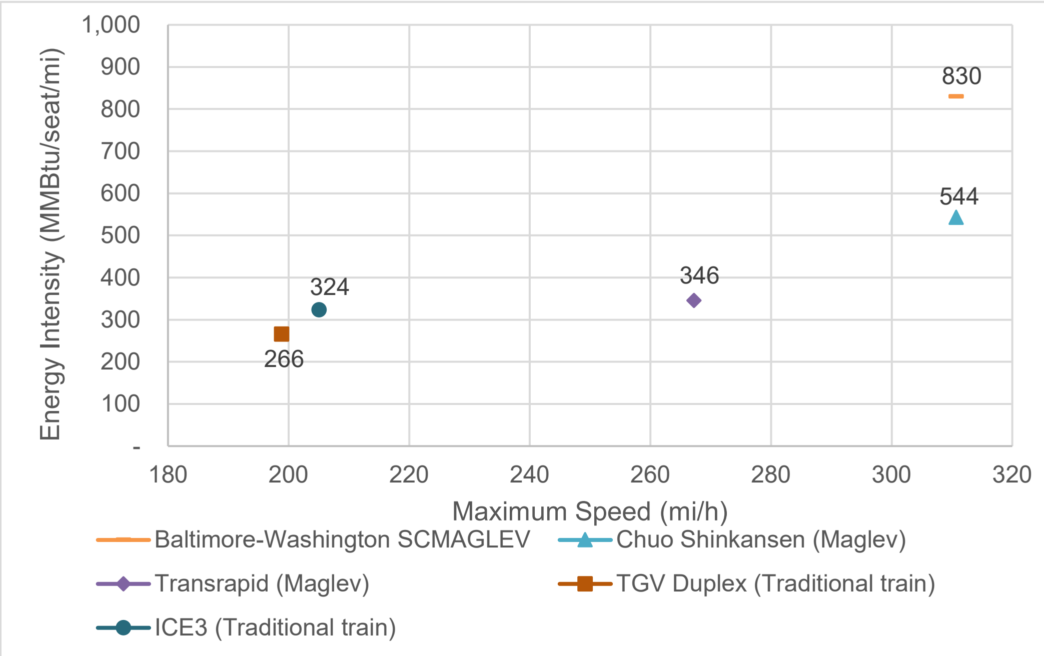
Figure 4.19-2: Benchmarking Projected SCMAGLEV Energy Intensity to Comparable Trains on a Usable Area Basis



Source: FRA calculation based on data and methodology of Fritz et al. 2018

[11] Trains are most energy efficient when cruising at top speed. Acceleration is the most energy intense part of maglev train operation. Therefore, a track design which requires frequent stops followed by periods of acceleration decreases the train's energy efficiency.

Figure 4.19-3: Benchmarking Projected SCMAGLEV Energy Intensity to Comparable Trains on a Seat Basis



Source: FRA calculation based on data and methodology of Fritz et al. 2018

Auto travel between Baltimore and Washington, D.C. will continue to increase by 2045, though the SCMAGLEV Project would offset 393 million auto passenger-miles for Build Alternatives with a terminal station in Cherry Hill and 437 million auto passenger-miles for Build Alternatives with a terminal station in Camden Yards. In 2045, auto travel will account for 60 percent of total transportation energy consumption for both groups of Build Alternatives, compared to 97 percent in the No Build Alternative. The SCMAGLEV Project would be the next greatest energy consumer at nearly 4.0 trillion Btus annually and 38-39 percent of total energy consumption. Energy consumption of bus and rail travel are 0.1 percent and 1 percent, respectively, for both groups of Build Alternatives. **Table 4.19-6** provides a summary of the annual energy consumption per mode for both groups of Build Alternatives.

Table 4.19-6: 2045 Projected Transportation Energy Consumption for Build Alternatives

Build Alternative	Transportation Mode	2045 Projected Transportation Consumption			
		Passenger-Miles Traveled (in 000s)[a]	Mode Energy Intensity in Btu per Passenger-Mile Traveled	Energy Consumption (MMBtu)	Percent of Total
Terminal station in Cherry Hill	Auto Travel	3,382,350	2,000	6,764,700	62
	Bus Travel	11,185	1,100	12,304	>0
	Rail Travel	92,883	1,250	116,104	1.0
	SCMAGLEV	2,517,185[b]	1,671[c]	4,000,000	37
			Total	**10,893,108**	**100**
Terminal station in Camden Yards	Auto Travel	3,338,993	2,000	6,677,866	62
	Bus Travel	10,657	1,100	11,723	>0
	Rail Travel	85,880	1,250	107,350	1
	SCMAGLEV	2,793,521[b]	1,506[c]	4,000,000	37
			Total	**10,796,939**	**100**

Source: FRA calculation except where otherwise cited
[a] Passenger-miles traveled are shown in thousands and are valid for the Baltimore-Washington corridor.
[b] SCMAGLEV PMT calculated using estimates of maximum number of passengers estimated for 2045.
[c] Energy intensity of SCMAGLEV is taken as average value of Cherry Hill and Camden Yards alternatives on a Btu/passenger-mile basis.

In terms of energy intensity per PMT, SCMAGLEV compares favorably with auto travel but unfavorably with existing bus and rail transportation modes for both terminal station alternatives. At 1,506 Btu per PMT for the Camden Yards scenario, SCMAGLEV is nearly 25 percent more efficient than auto travel, but 37 and 20 percent less efficient than existing bus and passenger rail, respectively.

Table 4.19-7 presents a comparison of energy consumption per mode for the No Build and two groups of Build Alternatives. For Build Alternatives with a terminal station in Cherry Hill, there is an expected net increase in energy consumption of 3.0 trillion Btus. This represents a 39 percent increase from the No Build Alternative despite offsetting 929 million Btus from auto, bus, and passenger rail travel modes. Build Alternatives with a terminal station in Camden Yards are nearly equivalent with a net increase in energy consumption of 2.9 billion Btus, representing a 38 percent increase in total transportation energy consumption.

Table 4.19-7: 2045 Comparison of Changes in Energy Use

Transportation Mode	No Build Energy Consumption (MMBtu)	Energy Consumption of Build Alternatives with Terminal Station in Cherry Hill	Net Consumption of Build Alternatives with Terminal Station in Cherry Hill (MMBtu)	Energy Consumption of Build Alternatives with Terminal Station in Camden Yards (MMBtu)	Net Consumption of Build Alternatives with Terminal Station in Camden Yards (MMBtu)
Auto Travel	7,550,998	6,764,700	-786,298	6,677,866	-873,132
Bus Travel	27,102	12,304	-14,798	11,723	-15,379
Rail Travel	244,025	116,104	-127,921	107,350	-136,675
SCMAGLEV Travel	0	4,000,000	4,000,000	4,000,000	4,000,000
		Total	**3,070,983**	**Total**	**2,974,814**

Source: FRA calculation except where otherwise cited

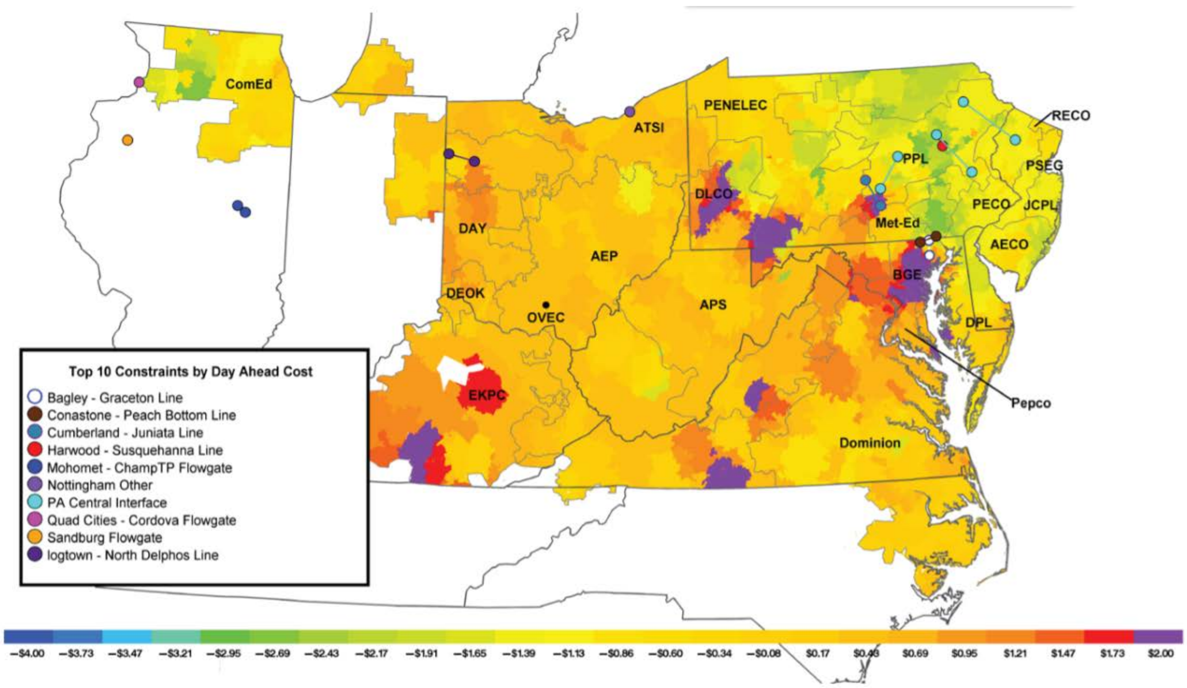
As indicated in **Table 4.19-7**, the SCMAGLEV system and ancillary facilities will increase net transportation energy consumption by approximately 3.0 trillion Btus. For context, this would be enough energy to power around 88,900 average homes for one year.[12] The anticipated decrease in energy expenditure from the diversion of auto, bus, and rail traffic to the SCMAGLEV Project is not expected to offset the increase in energy consumption from the SCMAGLEV system.

PJM had a total generation capacity of 197,485 MW as of 2020. In comparison, the optimum power requirement for a single SCMAGLEV train during acceleration is 35 MW – equivalent to 0.02 percent of PJM's total generation capacity. In the Southern Mid-Atlantic region specifically, which encompasses the Washington-Baltimore corridor, PJM projects peak annual demand to be 12,537 MW.[13] An SCMAGLEV train operating during this period of peak demand would add an additional 0.2 percent to peak demand. FRA does not consider this additional demand to be problematic for grid reliability given that PJM maintains a "reserve margin" of extra generation capacity which can be turned on in periods of extremely high demand. From 2020 through 2024, PJM projects a reserve margin of 31-36 percent of expected summer peak demand.[14] Beyond 2024, PJM has planning processes to regularly update their reserve margin in accordance with the Reliability Assurance Agreement, which defines PJM's obligations in maintaining grid reliability.[15] Even with the estimated 208 SCMAGLEV trips per day, FRA estimates that PJM's existing generation resources will be sufficient to meet SCMAGLEV's energy demands.

[12] https://www.eia.gov/tools/faqs/faq.php?id=97&t=3
[13] https://www.pjm.com/-/media/library/reports-notices/load-forecast/2020-load-report.ashx?la=en
[14] https://www.pjm.com/-/media/planning/res-adeq/20200219-forecasted-reserve-margin-graph.ashx?la=en
[15] https://www.pjm.com/library/governing-documents.aspx

A more critical constraint is the capacity of the current transmission infrastructure to handle the power demands of the SCMAGLEV system. Transmission congestion occurs when the capacity of the physical infrastructure (such as transmission lines and transformers) is insufficient to transport power from generators to customers and is of particular concern during periods of high demand. Congestion in urban centers is common and is usually managed effectively through dynamic pricing schemes and long-term planning processes. However, more severe congestion can lead to high electricity prices and, in the worst case, outages. The Washington, D.C.-Baltimore corridor, which lies within BGE's service area, is among the most congested in PJM. This is visible in **Figure 4.19-4,** which shows the average day-ahead congestion costs in millions of dollars in PJM for the first three months of 2020.

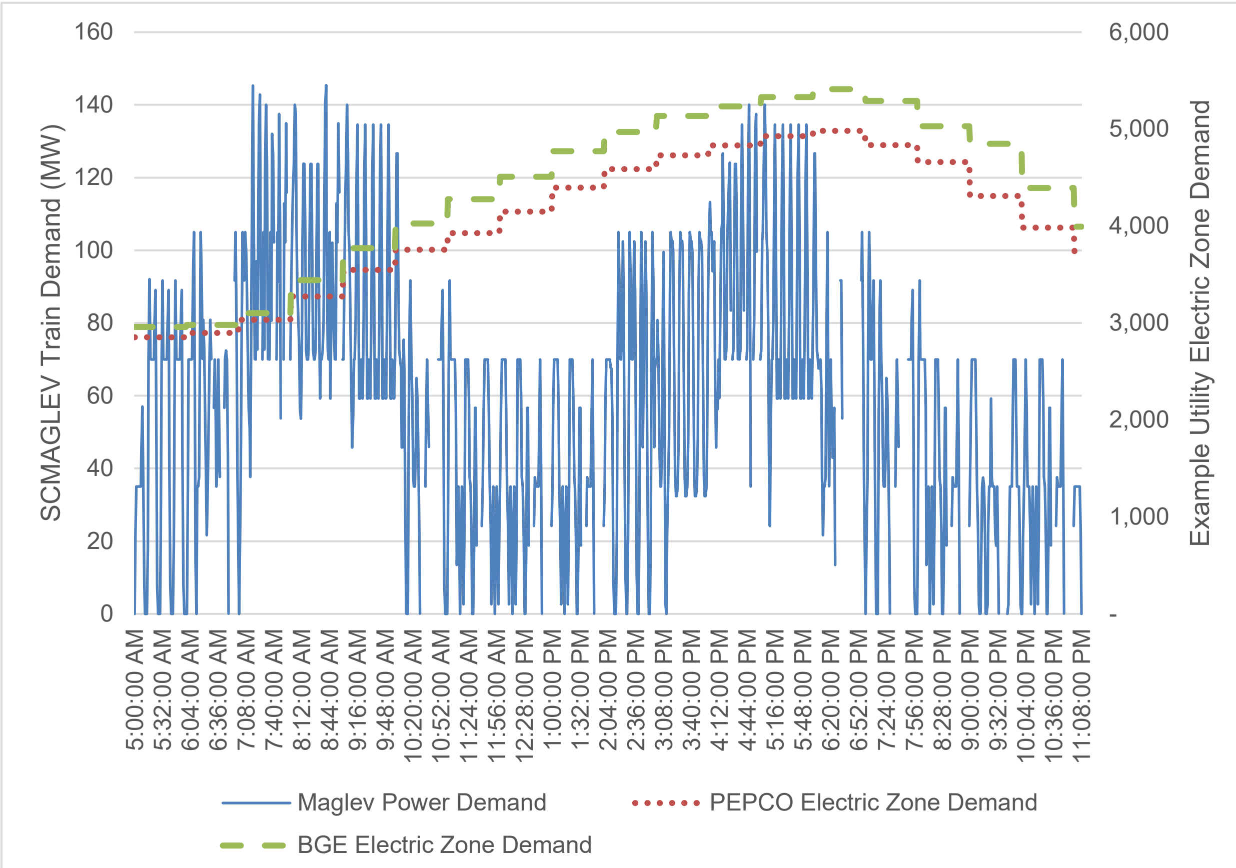
Figure 4.19-4: PJM Day-Ahead Congestion Costs[16]



SCMAGLEV's power needs are particularly complex given the minute-to-minute fluctuations in demand during operations. **Figure 4.19-5** visualizes the power demands of the SCMAGLEV trains during a standard weekday operating schedule. Demand cycles rapidly as trains accelerate; these fluctuations are largest where several trains are accelerating simultaneously. The period of largest demand for SCMAGLEV Project is from 4:00 to 6:00 PM, which coincides with the period of peak demand for the local utilities.

16 http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2020/2020q1-som-pjm-sec11.pdf

Figure 4.19-5: Demand Profile on Standard Weekday



PJM has established procedures for accommodating the interconnection of new, high-consumption customers.[17] The Project Sponsor would apply through PJM for long-term transmission service, which will initiate a Transmission Feasibility Study (TFS). This study uses power flow models and other sophisticated modeling tools to determine whether sufficient transmission capability exists to accommodate the requested service. If this analysis indicates that service cannot be granted with existing grid infrastructure, PJM initiates a System Impact Study (SIS) and Facility Studies. The SIS is a comprehensive regional analysis of the impact of the customer's demand on the deliverability of electricity in the immediate area where the project is located. It identifies specific system constraints and any upgrades necessary to accommodate the requested service. The SIS also provides a comprehensive estimate of cost responsibility and construction lead times to complete upgrades.[18] As a final step, the results of the SIS are incorporated into PJM's Regional Transmission Expansion Plan (RTEP). The RTEP is PJM's process for managing and documenting transmission upgrades necessary to ensure operational and economic reliability over a 15-year

[17] See PJM Manual 2: Transmission Service Request, Revision 14 dated April 1, 2018. https://www.pjm.com/~/media/documents/manuals/m02.ashx
[18] https://www.pjm.com/~/media/documents/manuals/m14a.ashx

horizon.[19] Any adverse impacts of the SCMAGLEV system to regional grid reliability will be appropriately identified and mitigated through PJM's planning process, in close cooperation with the local utilities PEPCO and BGE.

4.19.3.3 Short-Term Construction Impacts

The SCMAGLEV Project would have temporary indirect energy impacts resulting from the construction of the terminus stations, guideway, tunnels, and ancillary facilities. FRA estimates that tunnel boring, worker transportation, and construction trucking –will consume 6 trillion Btus. Additional energy will be needed to operate equipment, power lighting, and cool working areas, among other uses. Though the energy consumption of these activities is excluded from this estimate due to data in-availability, FRA expects them to make up only a small percentage of total construction energy use relative to transportation and operation of the TBMs.

The most energy intense construction activity is tunnel boring. The Project Sponsor estimates that it will use 8-9 tunnel boring machines (TBM) during the construction phase, each requiring around 14 MW of power. As demonstrated in **Table 4.19-8**, boring activities alone will consume 4.9 trillion MMBtus during construction activities. BWRR has stated that it plans to meet this demand with temporary standby generation facilities, which will most likely be diesel-powered.[20] **Table 4.19-9** and **Table 4.19-10** present estimates of energy consumption from worker transportation and construction-related truck use.[21]

Table 4.19-8: Boring Machine Energy Consumption

Months of Construction[a,b]	Working Days per Month[b]	Hours of TBM Operation per Day[b]	Power per TBM (MW/TBM)	Total Annual Energy Consumption (MWh | MMBtu)	
172	25	24	14	1,440,600	4,915,327

[a] Represents the collective months from all eight boring sites.
[b] Source: BWRR, Construction Planning Memorandum, May 14, 2020.

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19 https://www.pjm.com/planning/rtep-development.aspx
20 Electrical Coordination Technical Memorandum dated May 8, 2020.
21 These estimates assume 17.1 miles per trip for each worker, based on the average commute distance in the D.C. metro region published by the National Capital Region Transportation Planning Board's 2019 State of the Commute Survey Report.[21] FRA assumes an average light-duty vehicle fuel economy of 22.3 miles per gallon of gasoline based on 2017 statistics from the Bureau of Transportation Statistics.[21] For construction vehicles, 6.2 miles per gallon of diesel is assumed based on a 2019 report by the International Council on Clean Transportation

Table 4.19-9: Energy Consumption from Worker Transportation

Worker Vehicle Trips[a,b]	Average Miles per Trip	Energy Intensity of Transportation (miles/gallon gasoline)	Energy Intensity of Fuel (Btu/gallon gasoline)	Total Annual Energy Consumption (MWh | MMBtu)	
3,464,300	17.1	22.3	120,286	93,651	319,537

[a] Represents all worker trips needed throughout the duration of construction activities.
[b] Source: BWRR, Construction Planning Memorandum, May 14, 2020.

Table 4.19-10: Energy Consumption from Construction Trucking

Worker Vehicle Trips[a,b]	Average Miles per Trip[c]	Energy Intensity of Transportation (miles/gallon diesel)	Energy Intensity of Fuel (Btu/gallon diesel)	Total Annual Energy Consumption (MWh | MMBtu)	
3,605,466	10	6.8	137,381	234,148	798,912

[a] Represents all worker trips needed throughout the duration of construction activities.
[b] Source: BWRR, Construction Planning Memorandum, May 14, 2020.
[c] Estimate based on distances to spoil disposal and laydown sites indicated in the Construction Planning Memorandum.

Energy use for construction purposes are often benchmarked as a percentage of energy consumption over the lifetime of the project. Assuming that the SCMAGLEV Project would have a minimum service life of at least 50 years, the energy consumption from construction activities quantified in this analysis constitutes less than three percent of lifetime energy consumption.

The impacts from all construction activities will be temporary and geographically distributed across several sites. Much of the construction-related energy needs will be met with gas or diesel rather than electricity from the grid.[22] For construction energy needs which do require electricity, the Project Sponsor will submit temporary electric service requests to the utilities. This allows the utilities to take the energy needs of construction into account in their own planning processes and to ensure that there will be no negative impact on grid reliability from the added construction demand.

4.19.4 Potential Mitigation Strategies

FRA estimates that all Build Alternatives will increase overall energy consumption by 3.3-3.4 trillion MMBtu. Energy will be sourced from the regional electricity pool. In order to offset the increase in associated emissions, the Project Sponsor may pursue renewable energy projects to offset any increases in power generation-related emissions. Other mitigation strategies should look to increase SCMAGLEV's energy

[22] See Sharrard et al. 2007, Environmental Implications of Construction Site Energy Use and Electricity Generation

efficiency through operational improvements, including increasing train utilization, optimizing number of train cars to ridership demands, and offering a direct Washington-Baltimore route option. Furthermore, an extension of the track northwards to New York City and the New England region would likely improve the overall energy efficiency of the system, provided that the spacing of stations allow the train to reach and maintain its optimum cruising speed for more extended periods of time.

Innovative engineering approaches could also decrease SCMAGLEV's energy consumption. Regenerative braking is an approach commonly used with rail systems to recover kinetic energy that is dissipated during deceleration. Similar to hybrid vehicles, energy is recovered in a regenerative braking system by using an electric motor during braking. This motor is run in reverse during braking, generating electricity which is stored in an on-board energy storage system. This energy is then released during acceleration and offsets electricity which would otherwise be supplied by the grid. Though the magnitude of energy recovered through regenerative braking is often only a fraction of total system energy consumption, the key benefit of this technology is its ability to reduce the system's peak demand.