Evaluation of the Baltimore Washington Maglev Environmental Benefits Assessment

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University of Maryland, CES No.: 07-4-32340
Sponsor #: U00P3600388
Task II.D Draft Report

December 11, 2023

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EXECUTIVE SUMMARY

This report provides a review, conducted by the University of Maryland Center for Environmental Science Environmental Economics lab (UMCES-EE), of the environmental benefits assessment completed for the Baltimore-Washington (BW) Maglev project. UMCES-EE evaluated the methods and results of the BW Maglev environmental benefits assessment and the underlying ridership model. UMCES-EE also considered whether all sources of air pollution emissions were included, and compared the results to studies for similar projects.

The BW Maglev environmental benefits assessment used methods that generally follow common practices for environmental benefit assessments, but likely overestimated short-term air emission reductions resulting from project implementation, due to evaluating a narrow set of effects. The BW Maglev analysis estimated air pollution reductions due to personal vehicle miles being diverted to train ridership. However, UMCES-EE compared the net air emissions of the *without* and *with project* conditions by expanding the scope of analysis to include air emissions associated with construction and increased energy use for train operation. An analysis of the direct and indirect greenhouse gas (GHG) impacts during construction estimated total emissions of about 2.6 million metric tons (MT) of CO_2e and thousands of MT of criteria pollutants over the 7-year construction period. Based on conditions of the current electrical grids in Maryland and Washington, DC, UMCES-EE estimated that train operations would emit about 12.4 million MT of CO_2e over the analysis period (2030-2060), compared with about 2.1 million MT of CO_2e avoided when travelers divert from passenger vehicles to the BW Maglev over the same period, yielding net GHG emissions of about 10.3 million MT by 2060. However, these estimates of future GHG emissions have high uncertainty over the full 2030–2060 analysis period because the rate that the power grid transitions to renewable energy is not represented in these calculations and the faster the rate, the lower the future GHG emissions. Even if the projected annual increase in ridership (and VMT avoided) doubled in the *without project* scenario and emissions from Maglev operations were halved by 2060 (i.e., due to a greener grid) in the *with project* scenario, there would still be a net annual CO_2e emissions by the end of the analysis period.

The BW Maglev environmental benefits assessment included estimates of project-related air pollution emission reductions made using well-established EPA MOVES models and federal damage cost estimates. The analysis estimated that diversion of trips from passenger vehicles to the BW Maglev would result in the avoidance of emissions of about 2.1 million MT of CO_2e, 30 MT VOC, 118 MT NO_x, 15 MT SO_2 and 89 MT $PM_{2.5}$ from 2030-2060. These reductions in CO_2e and criteria pollutants had an estimated economic benefit of $17.38 million due to health impacts avoided and $76.64 million from GHG avoided. However, a unit conversion error meant that reported criteria pollutant reductions and associated damage costs were about 9% too high. Additionally, since the BW Maglev analysis was completed, changes to EPA's MOVES models that incorporate electric vehicles and more stringent federal fuel efficiency policy may result in lower estimates of project-related criteria pollutant and GHG emissions avoided.

Ridership projections were used to estimate reductions in personal vehicle miles traveled (VMT) due to the BW Maglev project. Louis Berger International conducted the ridership analysis, and their methods follow common procedures and empirical data were used. However, the report reviewed for this analysis was heavily redacted to protect proprietary data. As a result, UMCES-EE was unable to fully evaluate their methods and results.

UMCES-EE also identified studies completed in recent years for similar projects. Environmental benefits assessments were identified for 3 similar projects (California High Speed Rail, Cascadia Ultra High Speed Ground Transportation and Illinois High Speed Rail), and Environmental Impact Statements (EIS) were identified for another 5 projects (including BW Maglev). Benefits assessments for each project reported estimates of avoided VMT and GHG. UMCES-EE calculated annual GHG avoided per VMT avoided, and compared this metric across the 3 studies and the BW Maglev. The range across studies was 159-984 MT GHG avoided/million VMT avoided and the value for the BW Maglev was at the low end of the range (164 MT GHG avoided/million VMT avoided).

1 INTRODUCTION

Baltimore-Washington Rapid Rail (BWRR) proposes to build a Superconducting Maglev high speed rail system providing passenger service between Washington, DC and Baltimore, MD (BW Maglev). The project will require new tunnels, aboveground track and maintenance structures. Some construction impacts will occur in or near watersheds that are designated as Tier II or high quality waters of Maryland.

BWRR has applied for a permit from the Maryland Department of the Environment (MDE) for approval of the BW Maglev project. That application included an assessment of the project's environmental benefits that accompanied its analyses of economic impacts of the project (WSP 2021), compensatory mitigation plan (WSP 2020), and other related materials. The scope of the BW Maglev environmental benefits assessment included changes in air pollution and greenhouse gas (GHG) emissions due to passenger car trips diverted to rail. The specific air emissions analyzed in the report included estimates of reductions in criteria pollutants (i.e., VOC (ozone precursor), NO_x, SO_2 and $PM_{2.5}$) and GHG (as CO_2e), including carbon dioxide (CO_2), methane (CH_4) and dinitrogen oxide (N_2O) emissions.

The environmental economics team at the University of Maryland Center for Environmental Science (UMCES-EE) reviewed the methods and scope of the BW Maglev environmental benefits analysis and compared them to similar projects. The evaluation considered whether appropriate assumptions and methods were used and whether all major sources of air emissions were included. UMCES-EE conducted an alternative air emissions analysis that incorporated sources of air pollution other than cars to provide a broader assessment of net air emissions than provided by the BW Maglev analysis. Results of the BW Maglev analysis were also compared to similar projects where an environmental benefits assessment was available. UMCES-EE did not evaluate other environmental effects as those have been assessed in an environmental impact statement (USDOT FRA and MDOT 2021a).

2 ASSESSMENT OF BW MAGLEV REPORT ASSUMPTIONS, METHODS & CONCLUSIONS

The BW Maglev analysis estimated the quantity and monetary value of air pollution emissions avoided that resulted from car trips diverted to the Maglev passenger rail system (WSP 2021). Environmental benefits assessments typically compare a *with project* scenario to a *without project* scenario to estimate a range of benefits due to the project, in the context of ongoing trends and other sources of change. The BW Maglev analysis evaluated changes in criteria pollutants and GHG due to the project, based on an estimate of the reduction in private vehicle miles traveled (VMT) that would be converted to rail trips. The total air emissions were measured as the total change in VMT multiplied by average air emissions per vehicle, over the period of 2030-2060. The diverted VMT were estimated using detailed models of commuter flows and estimates of air emissions were based on current data and trends of passenger vehicle characteristics. The total health and other benefits of air emissions avoided were estimated by applying national average damage cost values per unit of air pollution.

The next sections provide additional description of methods and results and any implications of methodological choices for the accuracy of the air pollution estimates.

2.1 Ridership projection methods

Louis Berger International was contracted to create a ridership forecast and estimate the changes in vehicle miles traveled due to the BW Maglev project. UMCES-EE reviewed a version of the ridership model report in which some data and results were redacted. The model of future ridership is based on: 1) a review of regional data, 2) economic growth projections and 3) a stated preference survey. Regional socioeconomic and demographic data were used to establish base levels of travel demand and origin/destination patterns for the base year (not clearly defined). Future changes in intercity passenger levels were forecast using economic growth projections and other data. A stated preference survey established characteristics of travel demand and willingness to pay for travel time savings in the Baltimore Washington area. The contractor performed sensitivity tests on model results to quantify the impacts of alternative assumptions, and, finally, included a peer review process.

Based on the available information, the methods for estimating ridership changes appear to follow common procedures and use empirical data. However, many methodological details were redacted, preventing a full evaluation. Redacted pieces included survey results, much of the ridership model results, sensitivity testing, and peer review comments. Some sources of uncertainty of the ridership model results that could not be addressed due to redactions include, 1) Has the Covid19 pandemic changed the willingness of drivers to divert to high-speed rail? And if so, how long are such effects likely to persist given increasing road congestion?; 2) Were the results of the ridership surveys that were conducted at rail stations properly transferred to the general car driving population to estimate willingness to choose rail travel?; and 3) Are the expected ticket prices for Maglev travel consistent with the potential riders' expressed willingness to pay?

2.2 Criteria air pollution emissions methods

The MOVES14b model was used to estimate air emission rates per vehicle mile traveled (VMT) at 10-year increments (2020-2050), in the BW Maglev analysis. This model was developed by US EPA for calculating mobile source emissions and is in widespread use. The model provides national scale data that can be used to estimate effects at finer scales, although model users can also modify the model by adding local data.

The BW Maglev analysis used the national scale default option for Prince George's County and the latest model version available at the time of their analysis (MOVES14b, released in Aug 2018). Currently, these estimates are somewhat out of date because the MOVES14b model did not reflect changes in federal policy that are expected to alter the future vehicle fleet and reduce emissions per VMT from passenger vehicles in the decades ahead. More recent air emission model versions that were released in January 2021 and August 2023 (MOVES3 and MOVES4) include newer estimates of expected trends in type of fuel and energy use efficiency per vehicle. MOVES3 incorporated the impacts of the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for model years 2021-2026 passenger cars and light trucks that promotes faster adoption of higher fuel efficiency vehicles. That rule was subsequently revised by the Light-Duty (i.e., passenger car) Greenhouse Gas rule (LD GHG 2023 rule) for model years 2023 and later and MOVES4 incorporates the expectations that this rule will lead to a higher proportion of electric vehicles (EVs) in the future (US EPA 2023b).

While MOVES14 has the capacity to model EVs, due to the small market share of EVs during model development, all passenger cars (through model year 2050) are assumed to be gasoline, diesel or flex-fuel (US EPA 2016, 2020a). In contrast, MOVES4 includes forecasts of increasing numbers of EVs in the car fleet in response to new federal rules. MOVES4 also applies updated energy consumption rates for light-duty ICEs and incorporates energy consumption estimates for EVs.[1] The effect of the BW Maglev analysis having modeled criteria air pollution and GHG emissions with a model developed prior to these policy changes is that the lack of EV representation and the lower mandated fuel efficiency of ICE vehicles suggests that GHG emissions will be overestimated in the MOVES14b analysis of emissions avoided during the 2030-2060 time period.

Avoided VMT from the ridership model was combined with estimates of air pollution emissions per VMT from MOVES to generate estimates of emission reductions due to diversion of passenger vehicles to the BW Maglev. From 2030-2060, ridership is expected to ramp up for 2 years before reaching a “steady-state” during which time ridership is expected to grow 1.8% annually (Louis Berger 2018). During the same period, MOVES model outputs show emissions per VMT decreasing each decade. By BW Maglev analysis estimates, the VMT avoided due to the project result in the reduction of more than 2 million metric tons (MT) of carbon dioxide equivalents (CO_2e)[2] from 2030-2060 (Table 1). The magnitude of reductions in criteria pollutants from the project are much smaller in magnitude than the CO_2e emissions but are still potentially meaningful in terms of human health benefits.

[1] MOVES does not account for “upstream” emissions from producing the fuels required to operate vehicles (e.g., gasoline, diesel fuel, electricity).

[2] CO_2e is a common unit that incorporates the global warming potential (GWP) of GHG other than CO_2. GWP is the measure of how much energy (heat) a ton of gas will absorb over a certain period of time relative to a ton of CO_2. Methane has a GWP of 27-30 over 100 years, and dinitrogen oxide has a GWP of 273 over 100 years (US EPA 2023d).

Table 1. Estimated pollution reductions in the *with project* scenario, 2030-2060
Source: WSP (2021) Figure 12

Air pollutant	Emission reduction due to decreased VMT (MT)
CO_2e	2,119,369
VOC	30
NO_x	118
SO_2	15
$PM_{2.5}$	89

2.3 SOCIAL VALUE OF AIR POLLUTION REDUCTIONS

The BW Maglev analysis monetized the emission reductions in Table 1 by applying damage cost estimates per ton from federal government sources. Values for criteria pollutants were drawn from the US Department of Transportation (US DOT) Benefit Cost Analysis Guidance (US DOT 2020), which derives values largely from health effects avoided but also other harms. For CO_2, dollar estimates of damages were from the 2016 Interagency Working Group (IWG) Technical Support Document on the Social Cost of Carbon (SCC) (IWG 2016), which represents expected global damages to property, human health, and crop production, among other harms due to climate change, per ton of CO_2 emitted.

Although the sources of monetary values appear sound, the calculated total damage cost values in the BW Maglev report (Table 2, Column A) appear to be overestimated for VOC, NO_x, $PM_{2.5}$ and SO_2, apparently due to a unit conversion error. In the source document for criteria pollutant costs (US DOT 2020), values are shown as $/short ton in 2018$ (Table 2, Column B). In the BW Maglev report, values are reported to be $/metric ton in 2020$, but the conversion from short tons to metric tons appears not to have been done. Column C of Table 2 shows that when the US DOT values are converted from 2018$ to 2020$ the resulting values are similar to what the BW Maglev analysis reported (Column A). When UMCES-EE also converted values to metric tons (Table 2, Column D), the damage cost estimates for VOC, NO_x, SO_2 and $PM_{2.5}$ were 9% lower than the values used in the BW Maglev report (Table 2 column A). Applying the correct conversion value to the damage cost estimates yields a total of $15.8 million in emission reduction benefits from non-CO_2 pollutants, compared with the $17.4 million shown in the BW Maglev report (Table 3). Values for CO_2 appear to have been appropriately applied to generate the estimates of harms avoided.

Table 2. Unit conversion correction to BW Maglev analysis estimates for criteria air pollutants

	A	B	C	D
Pollutant*	BW Maglev report value (Fig 4) ($/metric ton (2020$))	USDOT value ($/short ton (2018$))	USDOT value converted to 2020$ ($/short ton (2020$))	USDOT value converted to metric tons ($/MT (2020$))
VOC	$2,161	$2,100	$2,166	$1,966
NO_x	$8,849	$8,600	$8,869	$8,051
SO_2	$51,549	$50,100	$51,664	$46,904
$PM_{2.5}$	$398,501	$387,300	$399,392	$362,589

* Damage cost estimates for CO_2 came from a different source and did not have the same error

Table 3. Comparison of the present value of emission reduction benefits in the BW Maglev report with corrected damage cost assessment

Pollutant	Present Value of Emission Reduction Benefit from BW Maglev report ($M) (Fig 12)	Corrected Present Value of Emission Reduction Benefit ($M)
VOC	$0.03	$0.03
NO_x	$0.53	$0.48
SO_2	$0.44	$0.40
$PM_{2.5}$	$16.38	$14.90
Total	**$17.38**	**$15.81**

3 OTHER SOURCES OF AIR POLLUTION

The reductions in VMT and associated criteria air pollutants estimated above represent emissions that would be generated *without* the project, and would be avoided in the *with project* scenario when passenger vehicles are diverted from roadways in favor of the Maglev. However, there are other sources of air emissions in the *without* and *with project* scenarios that were not accounted for in the BW Maglev environmental benefits assessment. UMCES-EE conducted scenario analyses of air pollution emissions from Maglev construction and operations (i.e., *with project*), relative to the emissions from VMT occurring in the *without project* scenario (Table 4) to estimate net air emissions. Each project phase in each scenario represents a potential increase in air emissions.

Air pollution will be generated during Maglev construction from the manufacture of material inputs and during building activities. In terms of net emissions, these *with project* emissions could be partially offset if the *without project* scenario had higher amounts of road maintenance and construction than the *with project* scenario. However, the BW Maglev project is estimated to reduce VMT 9-12% in the Baltimore-Washington region (USDOT FRA and MDOT 2021a), relative to *without project* conditions over time. This difference in VMT was deemed insufficient to require substantial new road construction or maintenance in the *without project* scenario, according to the Environmental Impact Statement and Section 4(f) Evaluation (USDOT FRA and MDOT 2021b). UMCES-EE used this same assumption that the *without project* scenario would not generate substantial additional road maintenance or construction.

Table 4. Sources of air pollution emissions in the BW Maglev *without* and *with project* scenarios

Phase	Without Project	With Project
Construction	Road maintenance and construction (deemed insignificant)	Concrete manufacturing and system construction (Section 3.1)
Operations	VMT that would be diverted to Maglev (Section 2.2)	Energy generation for system operation (Section 3.2)

3.1 AIR POLLUTION EMISSIONS FROM PROJECT CONSTRUCTION

Construction of a Maglev rail system will require a substantial amount of concrete. Cement, which is a major component of concrete, generates high levels of CO_2 because fossil fuels are used during manufacturing to generate the high temperatures needed in the manufacturing process, and because

CO_2 is a byproduct of the chemical reaction that creates cement. By one estimate, as much as 600 kg of CO_2 is released for every metric ton of cement produced (Nature Publishing Group 2021).

UMCES-EE used tools within the IMPLAN economic model (IMPLAN 2019 Data) to estimate the effects of project spending on pollution emissions. IMPLAN provides industry-specific estimates of emissions for a variety of pollutants per dollar of industry output, as part of its model results. The industry-specific estimates are derived from EPA's Environmentally-Extended Input-Output model data, and are available only at the national level. IMPLAN's pollution emission model includes criteria pollutants and GHG emissions (CO_2e).

The same economic models created to estimate jobs and other impacts were leveraged to estimate construction-related air emissions. Estimates were derived for the Local Study Area and the state of Maryland models (economic model specification details in Wainger and Price 2023). Emissions were estimated using the BW Maglev analysis of construction-phase spending estimates with 2019 IMPLAN model data (Scenario 1b in Wainger and Price 2023).[3] Some EPA-derived pollution estimates represent emissions from a broader economic sector than the one specified in the economic model, such as the energy generation sector. However, the Construction sector was represented at the same level of aggregation in the economic and air emission models.

To generate a conservative estimate, UMCES-EE limited air pollution emissions estimates to only those associated with spending in the construction sector, thereby omitting direct spending in other sectors (e.g., insurance, marketing, architecture and engineering). The results include emissions from direct and indirect construction sector purchases, but exclude emissions from induced spending because these household-related impacts (e.g., purchases of utilities such as electric power) may have occurred regardless of whether the BW Maglev project was constructed. Using this approach, CO_2e emissions during the 7-year construction phase are estimated at about 2.6 million MT (Table 5) and for the various criteria air pollutants they range from 1,200 MT (VOC) to 7,900 MT (NOx).

Table 5. IMPLAN estimates of emissions associated with seven-year construction phase (using 2019 IMPLAN data, 2020$)

Pollutant	Direct and indirect emissions from construction industry spending only (MT)
CO_2e	2,595,838
VOC	1,241
NO_x	7,864
SO_2	1,632
$PM_{2.5}$	1,681

3.2 EMISSIONS FROM PROJECT OPERATIONS (GHG ONLY)

After construction, substantial amounts of energy will be required to operate the Maglev train, train stations and associated facilities. The Federal Railroad Administration (FRA) estimated that total annual

[3] The Maglev analysis used 2018 data in its IMPLAN analysis, but UMCES-EE showed that 2018 is an anomalous data year relative to 2019 (Wainger and Price 2023). Using 2019 model data to estimate emissions yields a more conservative estimate than 2018 data because 2019 has lower Output estimates, and therefore lower emission estimates, for the key construction sector (i.e., new non-residential construction).

energy consumption for Washington, DC to Baltimore Maglev operations would be about 1.26 million megawatt hours (MWh) (Table 6; USDOT FRA and MDOT 2021b), which is assumed to come from power sources serving the Maryland and Washington, DC markets.

Table 6. Total annual BW Maglev system consumption (MWh/year)
Source: USDOT FRA and MDOT (2021b), Table D.4-42

Use	MWh/year
SCMAGLEV train	644,644
Train stations	315,360
Ancillary facilities	81,505
TMF and MOW facilities	220,000
Total	1,261,509

Air pollution emission rates vary by state because a mix of energy sources are used in each state. State-specific GHG emission rates from EPA eGRID year 2021 (the most recent year available), were used to estimate total emissions of operating the BW Maglev (Table 7).[4] The estimate uses a weighted sum of Maryland (92%) and DC (8%) sources. Multiplying the estimate of annual energy consumption from BW Maglev operation for each state (e.g., 105,714 MWh/yr for DC) and the average state-specific emission rates (e.g., 0.293 MT/MWh for DC) and then summing the results yields an annual estimate of about 400,000 MT CO_2e emissions from operating the Maglev system (Table 8).

Table 7. Average annual state-specific GHG emission rates (lbs/MWh), 2021
Source: EPA eGRID (US EPA 2023a)

Greenhouse Gas	Washington, DC	Maryland
CO_2	651.672	698.189
CH_4*	0.018	0.058
N_20**	0.002	0.008
CO_2e	652.731	702.026
CO_2e (MT/MWh)***	0.296	0.319

* The global warming potential (GWP) of CH_4 is 27-30 times that of CO_2 (US EPA 2023d). The midpoint was used to convert to CO_2e.
** The GWP of N_2O is 273 times that of CO_2 (US EPA 2023d)

[4] EPA eGRID does not provide emission rates of other non-GHG air pollutants, so UMCES-EE was unable to estimate emissions for VOC, NO_x, SO_2 and $PM_{2.5}$ for the operations phase.

Table 8. Estimated increases in GHG emissions from annual BW Maglev operations

	Washington DC	Maryland
Total annual BW Maglev system consumption (MWh/yr) (see Table 6)	1,261,509	
% of Total Maglev energy provided	8.38%	91.62%
Maglev energy consumption (MWh/yr)	105,714	1,155,795
CO_2e (MT/MWh)	0.2961	0.3184
CO_2e (MT/yr)	31,299	368,044
Total CO_2e (MT/yr)*	**399,343**	

* FRA included two alternative routes and terminals (Cherry Hill and Camden Yards). DC to Cherry Hill values shown here.

3.3 Net Emissions

UMCES-EE compared estimates of GHG pollution emissions generated during the 7-year construction period and 31-year operation period of the BW Maglev rail system with estimates of air pollution emissions avoided from diverted car trips over the 31-year operation period. Estimated emissions generated in the *without project* scenario are considered emissions avoided *with* the project, so net emissions for the Maglev project are calculated by taking the difference between scenarios.

Construction of the BW Maglev system generates about 2.6 million MT CO_2e over 7 years.[5] In the *without project* scenario, no additional construction emissions are anticipated (Table 9). Therefore, a net increase in emissions is expected with the project, particularly in the short term.

During the operations phase (2030-2060), energy required to run the BW Maglev system is expected to generate about 400,000 MT CO_2e annually, or 12.4 million MT CO2e over the analysis period (Table 9). An estimated 2.1 million MT CO_2e would have been generated from vehicle trips *without* the project.[6] Assuming BW Maglev ridership reaches and maintains forecasted levels and the power grid remains unchanged from its 2021 energy mix,[7] the sum total net increase in CO_2e emissions over the operation phase (2030-2060) would be about 10.3 million MT CO_2e. As long as there are net GHG emissions from Maglev system operation, GHG emissions from construction will never be offset.

Uncertainty of net emissions increases over time. If the market share of EVs continues to increase, the predicted emissions in the *without project* scenario would be lower. And, if the electric grid increases its share of renewable energy sources, the *with project* emissions would also decrease over time. As a result of commitments to increase renewable energy sources within the Maryland and DC power grids, and a current trend of EV adoption by consumers, both point and mobile source emissions are likely to be overestimated for both scenarios over the 31-year analysis period. Also, future ridership (and

[5] Criteria air pollutants from construction and operation are also important considerations for human health, but there was insufficient information to compare across all project phases.

[6] As described in Section 2.2, *without project* emissions estimates are based on VMT avoided (derived from Maglev ridership) and pollution emissions per VMT from MOVES. From 2030-2060, ridership is expected in increase at an average annual rate of 1.8% (Louis Berger 2018), while emissions per VMT are expected to decrease (WSP 2021). Therefore, average annual GHG emissions in the operations phase of the *without project* scenario are a rough estimate.

[7] An assumption of an unchanged power grid was used to make projections because no reliable estimates of rates of renewable energy adoption were available.

resulting VMT avoided) is highly uncertain and if ridership were higher than predicted, it would result in higher *without project* emissions due to higher VMT avoided. Net emissions with the project will tend to decrease as ridership increases, all else equal.

Given these sources of uncertainty, the results can best be stated as, without major changes in the grid or EV adoption, and without major increases in ridership (e.g., due to rail expansion), the BW Maglev project results in net increases in CO_2e in the region over the 31 years of operation that was used for analysis purposes. Even if the projected annual increase in ridership (and VMT avoided) doubled in the *without project* scenario and emissions from Maglev operations were halved by 2060 (i.e., due to a greener grid) in the *with project* scenario, there would still be a net annual CO_2e emissions by the end of the analysis period (Figure 1).

Table 9. Total GHG emissions (annual MT CO_2e) per scenario

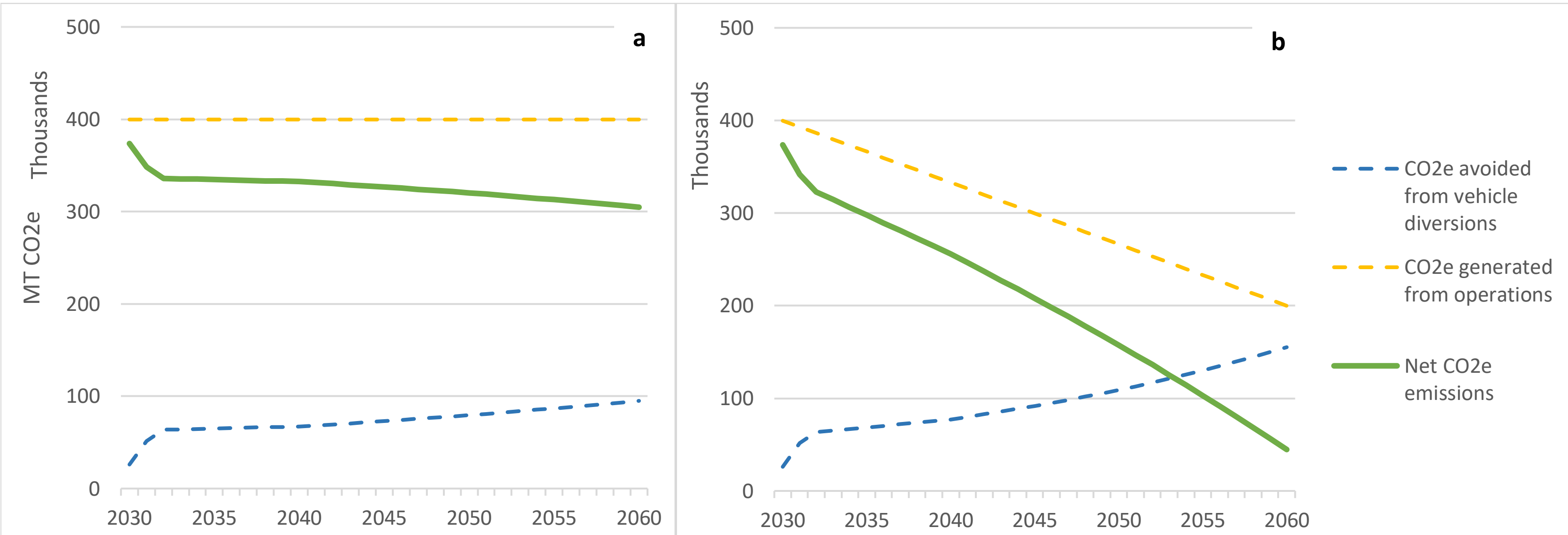
Phase	Increases in emissions *Without Project*		Increases in emissions *With Project*	
	Total	**Average Annual**	**Total**	**Annual**
Construction (7-year)	NA	NA	2,595,838[a]	370,834
Operations (31-year)	2,119,369[b]	68,367	12,379,633	399,343[c]

[a] from Table 5
[b] from Table 1
[c] from Table 8

Figure 1. Comparison of estimated net emissions using a) difference between *without* and *with project* and b) scenario difference given increased ridership/greener grid scenarios.

The left graph (a) shows a slightly decreasing trend in net CO2e through 2060 using the baseline assumptions of increasing CO_2e emissions avoided (blue dashed line) as ridership increases at 1.8% annually and operations emissions are constant (yellow dashed line).

The right graph (b) shows the potential for net CO2e emissions to decline much faster if ridership grows at twice the baseline rate (3.6% - blue dashed line) and renewable energy sources increase in the power grid such that emissions decrease by 50% between 2030 and 2060, resulting in lower emissions from operations (yellow dashed line). Under the alternative assumptions of graph b, net annual CO2e emissions are still positive in 2060.



4 COMPARISON WITH SIMILAR STUDIES

UMCES-EE reviewed analyses of the air quality impacts of similar projects using various performance metrics. Of the five rail and six major regional infrastructure projects identified in the economic analysis review (Wainger and Price 2023), three projects were similarly designed to provide a regional transportation alternative and had some form of environmental benefits assessment available for review (bolded studies in Table 10). Four highway projects were excluded from this analysis because they were not designed to remove cars from the road. For the remaining projects, including the BW Maglev, Environmental Impact Statements (EIS) as required by NEPA (National Environmental Policy Act) were available and included air quality analyses to ensure compliance with National Ambient Air Quality Standards (NAAQS) under the Clean Air Act. These results are shown separately from the stand-alone benefits assessments due to non-parallel data structure.

Table 10. Projects reviewed for environmental benefits analyses

Project	Benefits Analysis Status
CA High Speed Rail (CA HSR)	**2022 Sustainability Report describes reduced GHG**
Cascadia Ultra High Speed Ground Transportation (Cascadia UHSGT)	**Business Case report (2019) describes reduced VMT and GHG**
Texas Central High Speed Rail	EIS
Illinois High Speed Rail (IL HSR)	**Preliminary Feasibility Study (2013) estimates value of reduced Person Miles Traveled (PMT)**
Atlanta to Charlotte Passenger Rail	EIS
Metro Purple Line	EIS
Capital Beltway HOT Lanes	Highway project
I-495 & I-270 Toll Lanes and New American Legion Bridge	Highway project
Intercounty Connector	Highway project
Metro Silver Line	EIS
Transform 66 Outside the Beltway	Highway project
BW Maglev	EIS

4.1 AIR QUALITY ANALYSES CONDUCTED BY PROJECT PLANNERS

The three environmental benefits assessments that are reviewed in this section were developed by project planners to tout the benefits or assess the feasibility of the proposed projects and are distinct from the EIS documents that follow NEPA guidelines (following section). All project planner studies used similar air emission metrics as the BW Maglev analysis. Similar to the BW Maglev study, the Cascadia and Illinois studies limited environmental benefits analyses to emission reductions, while the California study included discussion of some other environmental benefits (e.g., water use, habitat). Only one (CA High Speed Rail) used a broader scope (similar to the analysis in Section 3) that encompassed construction and operation phases of the project. One project (Cascadia) used similar models and valuation methods, including the same sources of benefits per ton of air pollutants to estimate net present value of benefits.

The estimated GHG reductions per VMT of the proposed BW Maglev are within the range of the other projects, but fall at the low end (Table 11). The four projects reported in Table 11 include comparable estimates of annual or cumulative VMT and cumulative GHG emissions avoided through diverted car trips. Whereas, criteria pollutants are omitted from the comparison because of inconsistent reporting. High levels of emissions avoided were associated with projects that had long enough rail systems to substitute for flights (Cascadia) or long time frames of analysis (CA HSR).

Table 11. Comparison of similar projects for avoided GHG per VMT

Project	Timeline (yrs)	VMT avoided		GHG avoided (MT)		Annual MT GHG/ Million VMT
		Cumulative	Annual	Cumulative	Annual	
CA HSR[1]	50		5,000,000,000	92,995,000	1,859,900	372
Cascadia[2]	40	6,100,000,000	152,500,000	6,000,000	150,000	984
IL HSR[3]	10	8,307,457,214	830,745,721	1,318,140	131,814	159
BW Maglev	31	12,500,000,000	416,666,667	2,119,369	68,367	164

[1] The 93 million MT cumulative GHG emissions avoided is the midpoint of reductions estimated from two scenarios (84 and 102 M) in the CA HSR report.
[2] Estimated value is high because some avoided GHG emissions come from an estimated 27 million avoided flight miles.
[3] Rates of PMT avoided were similar across scenarios. High driving cost scenario values shown here. GHG avoided converted from tons to metric tons.

4.2 Air Quality Analysis Conducted for EISs

For NEPA review, various environmental impacts (harms and benefits) are characterized, including air quality, water quality, noise, hazardous materials, aesthetics, land use, socioeconomics, recreational facilities and environmental justice, among others. This analysis considers only the air quality analyses, to enable comparison with BW Maglev analysis results. The NEPA process requires that the air quality impacts be evaluated in terms of compliance with NAAQS and such analyses generally compare emissions under *no build* and *build* scenarios. Emissions during the project construction and operations phases are included but some analyses ignore temporary impacts (<5 years). Project-related emissions that occur off-site (e.g., cement manufacturing) are not included.

The BW Maglev was similar to four comparable projects in that the levels of emissions during project development were generally found to comply with NAAQS (Table 12). UMCES-EE compared air emission reduction benefits using the same four projects used for comparison in the economic assessment. However, data limitations prevented a quantitative comparison due to limited details or omissions.

Table 12. Results of air quality and GHG analyses in EISs of reviewed projects
Values reported are pollutants avoided. Negative values represent emissions.

Project	VMT avoided	Phase	Avoided VOC	Avoided Criteria Pollutants			Avoided GHG
				PM	SO_2	NO_x	
Texas Central HSR[1]	820M (2026) to 1.3B (2040)	Construction[2]	(5) tons			(39) tons	(100,500) MT CO_2e annually
		Operations (2040 emissions)	14 tons	49 tons PM_{10}	(8) tons		175,000 MT CO_2e
Atlanta to Charlotte Passenger Rail[3]	Not described	Construction	Minimal, short-term impacts; no expected violation of NAAQS				Not described
		Operations	No expected increase in criteria pollutants				Not described
Purple Line[4]	91,000 in 2040	Construction	Minimal, short-term impacts, especially PM due to fugitive dust				Not described
		Operations (2040 emissions)	0.01 tons	0.3 tons $PM_{2.5}$		0.03 tons	22,550 tons CO_2e
Silver Line[5]	Not described	Construction	Minimal, short-term impacts; no expected violation of NAAQS				Not described
		Operations	No expected increase in criteria pollutants				Not described
BW Maglev[6]	285-316M (2030) to 393-437M (2045)	Construction	Minimal, short-term impacts; no expected violation of NAAQS				Not described
		Operations	Some localized and regional increases in criteria pollutants from vehicle traffic to/from stations, but overall compliance with NAAQS				Expected reduction in GHG from reduced VMT in region; Likely increase in GHG from power plants

[1] US DOT FRA 2020
[2] Estimated emissions in DFW non-attainment area in Year 4 of construction of 5-year construction period (non-attainment area with highest emissions in year of greatest emissions)
[3] GDOT and FRA 2021
[4] MDOT, MTA and FTA 2013
[5] US DOT et al. 2004
[6] USDOT and MDOT 2021

5 CONCLUSIONS

The BW Maglev environmental benefits assessment was comparable in scope and methods to assessments for many similar projects and appears to use common assessment techniques to estimate criteria air emissions, GHG emissions, and monetized social benefits of those emission reductions. Comparing the air emission reductions due only to VMT avoided, the BW Maglev project has GHG emissions near the low end of the range for three similar projects. Criteria air pollutant ranges could not be directly compared due to data limitations. UMCES-EE found that the monetary benefits of avoiding emissions of criteria pollutants appeared to have been overestimated by 9%, due to a minor error in converting units; no similar concerns were identified with the GHG emissions estimates. A caveat to the methods review is that details of the ridership model, which provides inputs to all air emission calculations, could not be fully assessed since the assumptions, methods, results of VMT diverted, and sensitivity analyses were not provided (due to proprietary business information).

The BW Maglev environmental benefits analysis was less comprehensive than a few EIS documents that included air emissions from construction and operation phases, rather than only examining emissions avoided from car trips diverted to rail. Examining the total air emissions from Maglev operation and passenger vehicle trips diverted, UMCES-EE estimates a total net increase in GHG emissions of about 10.3 million MT CO_2e for the BW Maglev project from 2030-2060. This estimate assumes no changes in the 2021 power grid. As the power grid transitions to renewable energy sources, these emissions will decrease over the operational lifespan. The UMCES-EE analysis suggests that a net increase in annual GHG emissions will persist with the project through 2060, even under a scenario where the power grid emissions are decreased by 50%, due to conversion to renewable sources of energy.

As a result of the project being unlikely to achieve net reductions in emissions during the operation phase, the estimated 2.6 million MT of CO_2e emitted during the 7-year construction period will not be offset, unless or until the power grid becomes dominated by renewable energy sources. In terms of criteria air pollutants, the EIS analyses of the BW Maglev that included the construction and operations impacts, showed that the BW Maglev, like most of the similar projects, were expected to have short-term, minimal impacts that complied with NAAQS. Other social benefits, such as reduced congestion and time savings for travelers, were not considered.

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