



# Measuring the economic, equity, and environmental contributions of transit infrastructure

**Macroeconomic, Equity, Workforce,  
and Environmental Contributions**

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## Project background

- Public transit systems have seen significant declines in ridership and revenue during COVID-19 pandemic, but they remain vital to local, state, regional, and national economies.
- It is important to understand how transit drives economic, equity, workforce, and environmental outcomes, and how Metropolitan Planning Organizations (MPOs), Regional Planning Commissions (RPCs), Departments of Transportation (DOTs), and other agencies can leverage Federal funding to spur economic recovery in the short-term and transformational growth in the medium- and long-terms.
- KPMG and Regional Economic Models, Inc. (REMI) collaborated to explore these issues using the REMI model and rigorous quantitative analysis.
- This project conducted analysis on the benefits of transit investments:
  - Economic growth with a focus on the productivity and job growth from transit efficiencies.
  - Equity and workforce development benefits, including access to work and workforce training for lower-income and disadvantaged individuals and higher labor force participation.
  - Environmental benefits from the reduction in carbon emissions and air pollutants.
- It is important to note, however, that this project did not conduct a full cost-benefit analysis of transit investments.

## Use cases (Washington, DC Metropolitan Area)

### Selected Washington, DC Metropolitan Area due to its size and diversity of transit.

We analyzed three investment scenarios covering improvements to different transportation modes with varying degrees of costs and contributions in the key areas of interest. These scenarios are based on existing infrastructure and proposed improvements, allowing for realistic measures of contributions.

### Investment 1: Bus electrification

- Replace Washington Metropolitan Area Transit Authority (WMATA) bus fleet entirely with electric buses and expand service to account for the implementation of Bus Rapid Transit (BRT) along critical routes.
- As of Q1 FY2020, WMATA's bus fleet consists of 61% hybrid diesel buses, 29% compressed natural gas (CNG) buses, 9% clean diesel buses, and 1% diesel buses.
- Fleet electrification is expected to yield a substantial reduction of emissions and operating costs.

### Investment 2: Fixed guideway transit

- Complete the Purple Line project, which will result in a 16-mile-long east-west transit connection between Maryland's Montgomery and Prince George's counties.
- 21 stations connecting major residential and employment centers in the two counties to provide a transit option that bypasses the urban core.
- Divert car trips to transit and reduce the negative externalities from car travel.

### Investment 3: Improved bicycle infrastructure

- A significant expansion of the bicycle trail and lane network in the Washington, DC MSA as outlined in the 2015 Bicycle and Pedestrian Plan for the National Capital Region.
- Expected to result in a shift of some of the car trips to bicycles.
- While cycling has many benefits, this scenario focuses on the transportation contributions, and some user and non-user benefits. It does not account for possible health benefits or increases in property values.

#### STEP 1



#### STEP 2



#### STEP 3



#### STEP 4



#### STEP 5



## Study approach

### Conduct background research to determine transit investments and geographic areas to study

- Select scenarios that are representative of transit investment in reality, particularly:
  - The types of transit investments to model.
  - Reflect grants that MPOs and similar organizations may be looking to apply for, given the infusion of Federal dollars; may involve building new infrastructure or rehabilitating existing assets.

### Analyze the macroeconomic contributions of transit investments

- Estimate the short-term economic contributions of transit investments (e.g., GDP, jobs, disposable income per household). Present the employment impacts by industry sector, income groups, and race/ethnicity.

### Analyze the equity contributions of transit investments

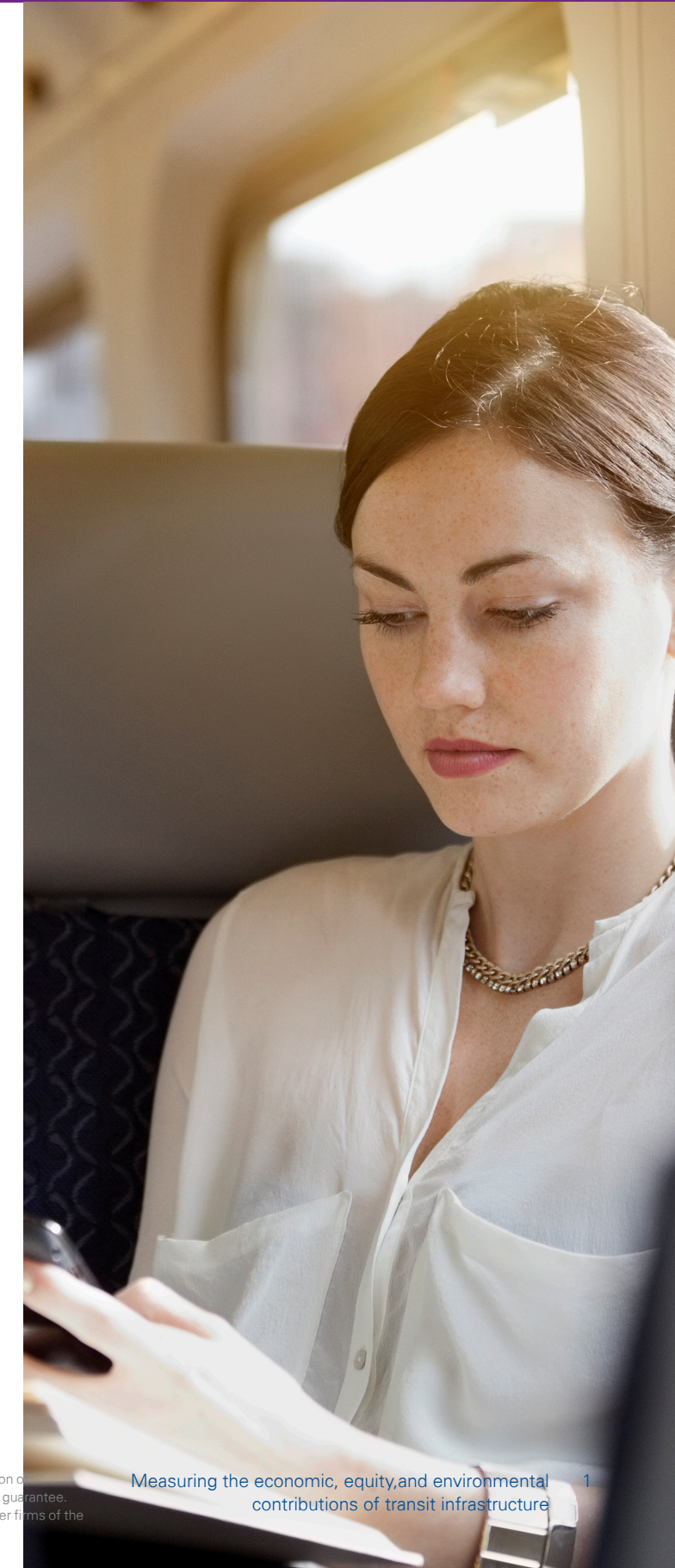
- Quantify the economic benefits for households with varying levels of income.
- Characterize the distributional impacts.

### Estimate the workforce development benefits of transit investments

- The labor impacts (e.g., labor force participation, unemployment rate, and wages).

### Analyze the environmental contributions of transit investments

- The reduction in carbon emissions and air pollutants.







**Data and Approach**

**Model input and assumptions:  
Bus electrification**

Assumptions	
Timeline	<ul style="list-style-type: none"> <li>— Analysis period: 2022-2031</li> <li>— Electrification completed in 5 years (2022–2026)</li> <li>— Construction of BRT conducted concurrently</li> </ul>
Funding	Entirely paid for with Federal funding
Initial Costs	Expended evenly through the five-year fleet replacement period
Input	Components
Manufacturing costs (2020\$)	Vehicle and charging facility costs
Construction costs (2020\$)	Charging facility installation and BRT construction costs
O&M cost savings (2020\$)	Difference between the O&M costs of the existing fleet and the costs of operating an expanded electric bus fleet (fossil fuel annual operating costs—electric annual operating costs—fast charger O&M and fossil fuel annual fueling costs—electric annual fueling costs—BRT operating costs)
Change in energy consumption (billions of BTU)	Difference between the fuel consumption (CNG/hybrid/clean diesel/diesel/electric fuel economy x share of revenue miles) for the existing fleet and the fuel consumption for an electric bus fleet

**Model input and assumptions:  
Fixed guideway transit**

Assumptions	
Timeline	<ul style="list-style-type: none"> <li>— Analysis period: 2022–2031</li> <li>— Construction completed in 2023 and revenue service starts in 2024</li> <li>— Ramp-up in ridership in the first two years of operation (one half of projected first year ridership)</li> </ul>
Funding	Entirely paid for with Federal funding
Costs	Expended evenly through the two-year construction period
Input	Components
Capital costs (2020\$)	Vehicle acquisition, engineering and design, transportation structure, and terminal construction costs
O&M costs (2020\$)	Ongoing operations and maintenance and rehabilitation costs
Vehicle trips change, VHT and VMT change	Difference between the vehicle trips, vehicle hours traveled (VHT), and vehicle miles traveled (VMT) totals with and without the Purple Line
Ridership change, PHT and PMT change	Difference between the ridership, passenger hours traveled (PHT), and passenger miles traveled (PMT) totals with and without the Purple Line

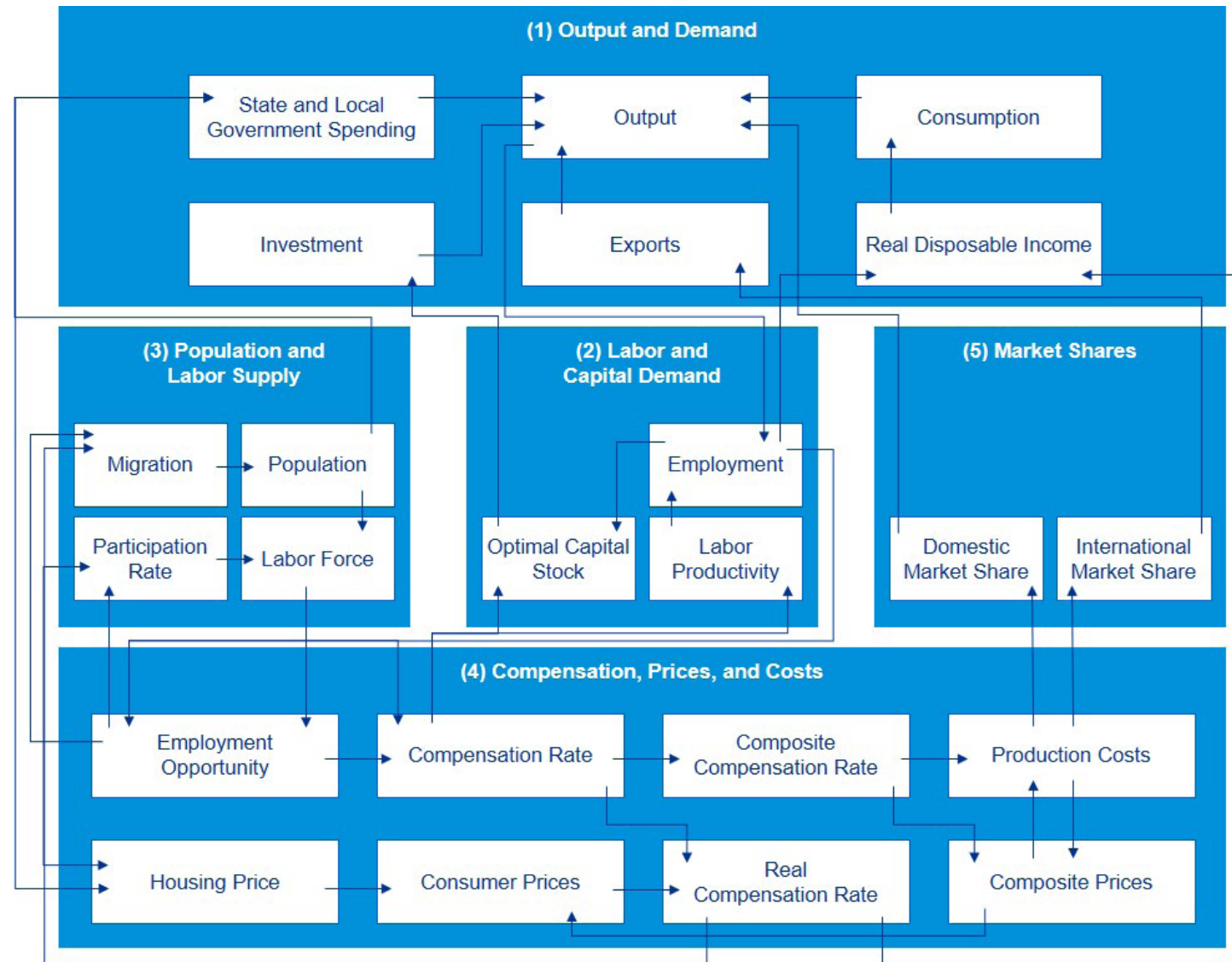
**Model input and assumptions:  
Bicycle infrastructure**

Assumptions	
Timeline	<ul style="list-style-type: none"> <li>— Analysis period: 2022–2031</li> <li>— Construction completed in 2040 (after the analysis period)</li> </ul>
Funding	Entirely paid for with Federal funding
Costs	Construction costs expended evenly through the 2015–2040 build period, no maintenance costs
Input	Components
Construction costs (2020\$)	Bicycle lane and shared use path construction costs
VMT change	Reduction in VMT from the increased bicycle network.*
Option value (2020\$)	Transportation diversity value (halved) applied to the VMT reduction
User benefits (2020\$)	Willingness to pay for use of a bicycle trail applied to the number of trips shifted from automobiles to bicycles

\*% change in VMT = (-1) x % change in bikeway miles x elasticity x existing bike mode share x bike trip length

Existing auto mode share x auto trip length

### Model input and assumptions: Bus electrification



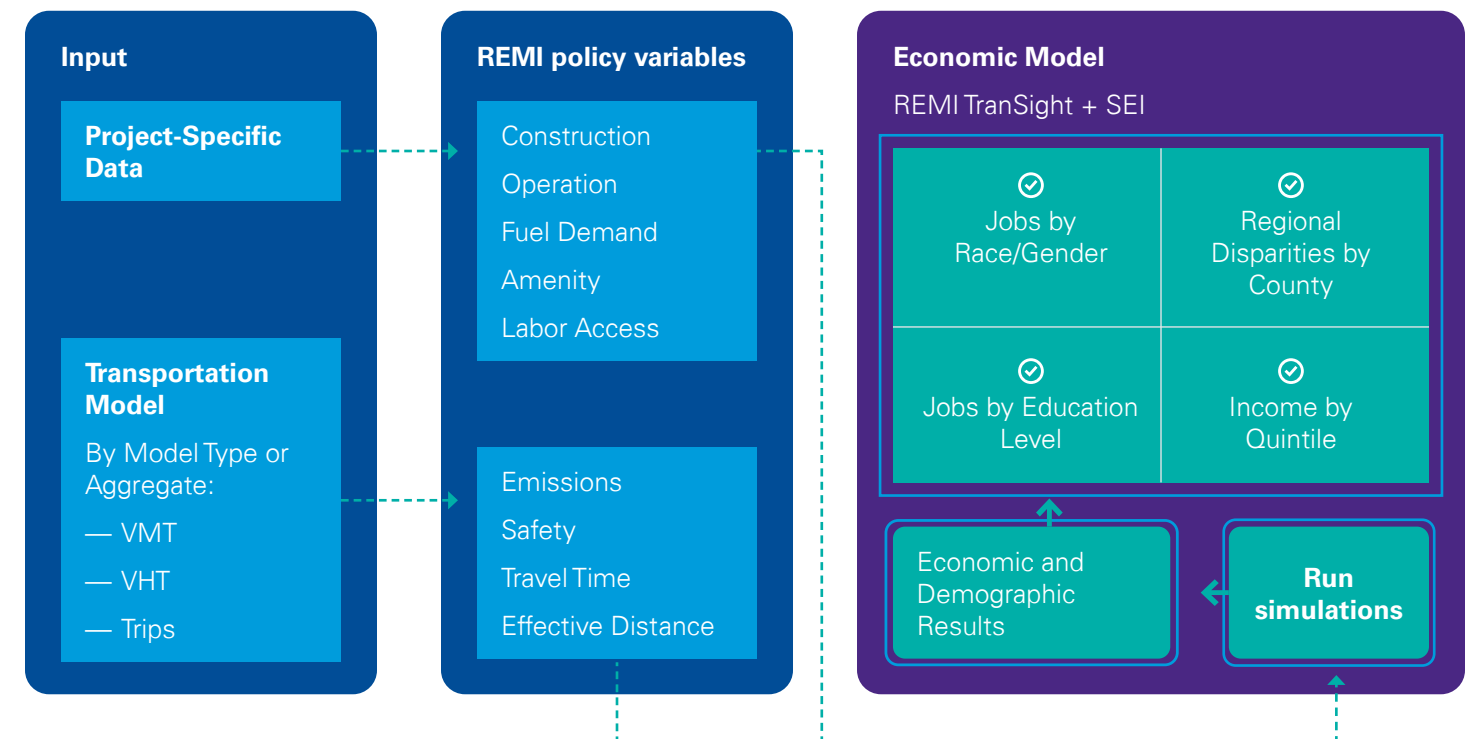
REMI PI+ consists of thousands of simultaneous equations representing geographic regions, industries, and many other economic and demographic categories, whose structure can be summarized in five major blocks:

- 1** Output and Demand
- 2** Labor and Capital Demand
- 3** Population and Labor Supply
- 4** Compensation, Prices, and Costs
- 5** Market Shares.

### Models used: REMI TranSight & REMI Socioeconomic Indicators (SEI)

- This analysis customized the PI+ model (figure below) to integrate the Travel Demand Module from the REMI TranSight model and the REMI Socioeconomic Indicators (SEI) module.
- The Travel Demand Module translates the key outputs generated by the transportation models (i.e., VMT, VHT, trips between regional origin-destination pairs) into a series of cost and amenity variables, including changes in emissions, safety, travel time, and effective distance

- (e.g., commuting costs). Collectively, this information is transferred into PI+ model, which produces multi-year forecasts of economic and demographic trends and compares them with a baseline forecast to determine net impacts.
- The SEI Module can display various results, including employment and labor force participation by race and gender, jobs by education level, income by quintile, and more.







## Bus electrification

### Macroeconomic contributions



#### Job creation

Supports an average of 1,159 jobs annually



#### GRP growth

\$184 million increase in GRP in year 2031



#### Labor income

A total increase of \$980 million in Disposable Personal Income

### Economic benefits of bus electrification

Category	2031	2031 percent of region	Cumulative, 2022-2031
Change in regional total employment	1,468	0.031%	11,590
Change in Gross Regional Product (\$millions, 2020)	184	0.028%	1,306
Change in Disposable Personal Income (\$millions, 2020)	155	0.030%	980

**Note:** Cumulative total employment contributions are measured in job years instead of jobs.

- The maintenance and construction sectors benefit the most from infrastructure construction and bus operations
  - 611 jobs supported annually.
  - Electrification is assumed to take 5 years (2022-2026). After 2026, the construction and manufacturing is complete and then the ongoing maintenance and repair work begins. This creates a bigger jump in employment in 2027.

### Change in employment by industry

Industry	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
All Industries	1,066	985	910	805	691	1,323	1,408	1,460	1,473	1,468	1,159
Construction	669	672	660	637	610	134	169	181	176	163	407
Repair and maintenance	7	(41)	(87)	(132)	(177)	506	500	494	488	483	204
State and local government	31	44	50	50	48	70	86	97	105	110	69
Retail trade	53	46	43	37	31	83	87	90	90	90	65
Ambulatory health care services	34	26	23	20	16	86	84	83	82	81	54
Professional, scientific, and technical services	42	38	35	30	25	44	53	60	65	68	46
Food services and drinking places	25	25	26	25	23	62	64	67	68	69	45
Real estate	29	25	25	23	19	53	57	61	62	63	42
Administrative and support services	30	25	23	19	15	47	51	54	55	56	38
Personal and laundry services	13	11	10	9	7	36	34	34	32	31	22
All other	133	114	102	87	74	202	223	239	250	254	167

- Direct and induced employment are the major components
- The project supports 485 direct jobs annually on average
- Increased labor income, improved labor access, and other dynamic economic responses create 628 more jobs on average

### Direct + Indirect + Induced effects

Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
Total employment	1,066	985	910	805	691	1,323	1,408	1,460	1,473	1,468	1,159
Direct employment	587	533	481	432	385	497	492	487	482	478	485
Indirect employment	66	61	56	52	47	36	35	34	34	34	46
Induced employment	413	391	372	321	259	790	881	939	956	957	628
Employment multiplier	1.82	1.85	1.89	1.86	1.8	2.66	2.86	3	3.05	3.07	2.39

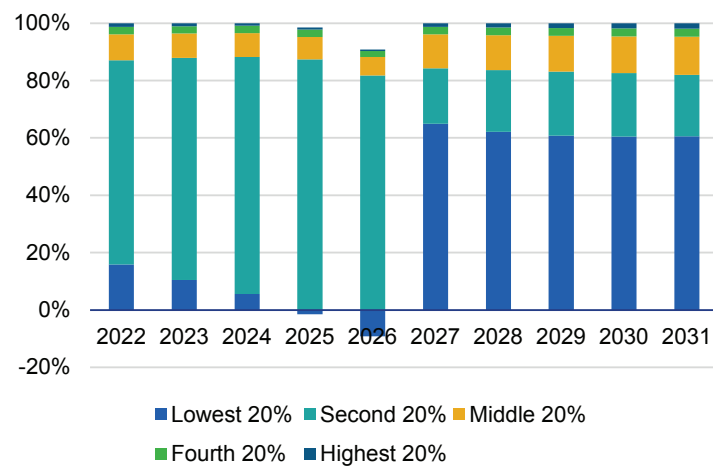
**Findings**

**Bus electrification (Cont...)**

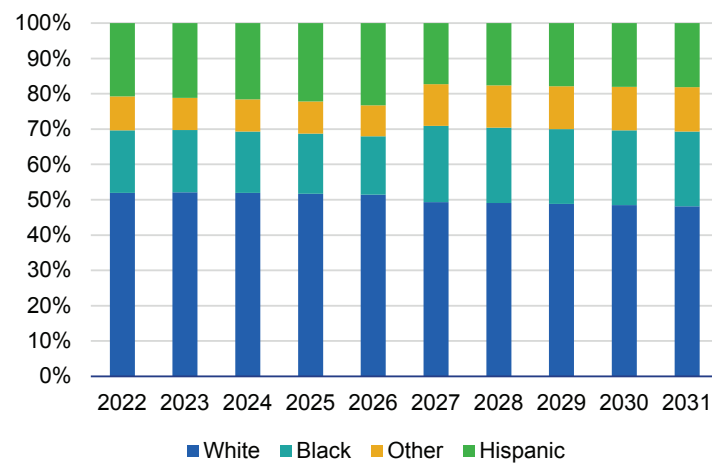
**Equity contributions**

- Approximately 50% of new jobs to benefit ethnic and racial minorities
- More job opportunities for low-income and Hispanic workers
  - 80% of employment gains to benefit workers in the lowest two income quintiles
  - Among minority groups, Hispanics benefit from over 20% of the total jobs gained during construction phase, exceeding population share in MSA. During the operation phase, Black workers are expected to have the largest gains in employment among minority groups, accounting for approximately 21% of all new jobs.

**Supported employment by income quintiles**

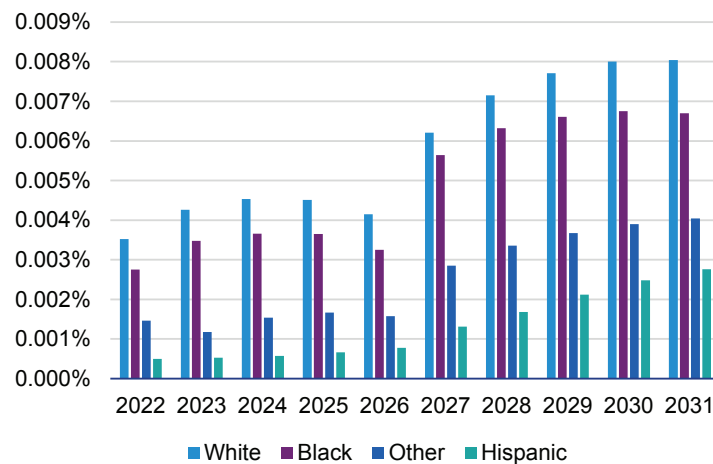


**Supported employment by race/ethnicity**

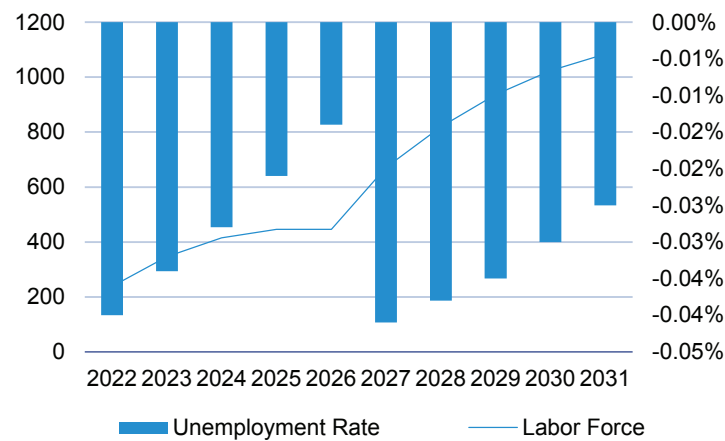


- A larger labor market with diverse demographic groups
- An expanded labor pool with the unemployment rate dropping by 0.03% on average
- Higher labor participation rate for all races/ethnicities, especially White and Black workers

**Change in participation rate by race/ethnicity**

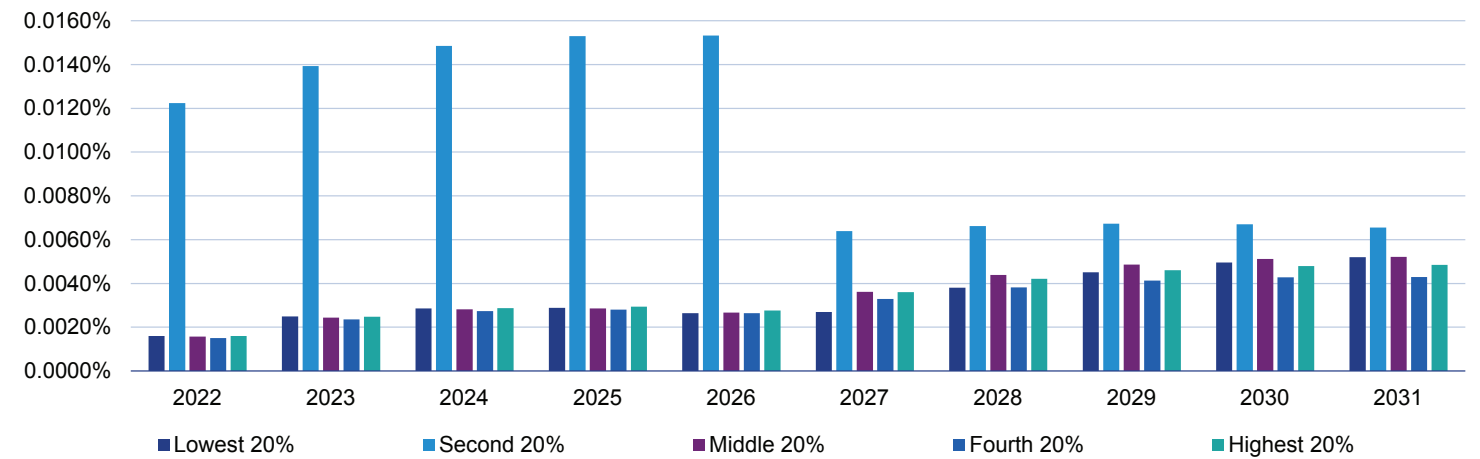


**Change in labor force and unemployment rate**



- Higher compensation rate for all income groups
- Largest growth for the second quintile ranging from 0.012% to 0.015%, which includes the construction sector, during the construction period
- More evenly distributed among quintiles after construction, buoyed by improved labor access

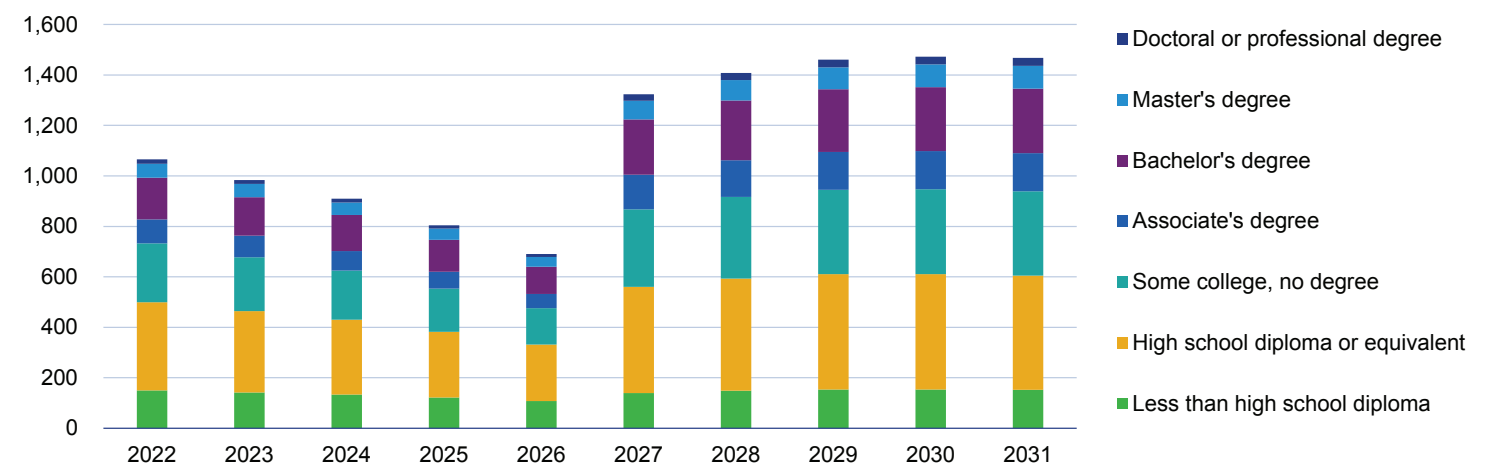
**Change in compensation rate by income quintile**



**Workforce development contributions**

- More job opportunities for workers with at most a high school degree.
  - By 2031, about 400 jobs would be added for workers with a high school degree.
- 76.1% of the newly employed will not need a bachelor's degree (relative to 62.5% of the overall workforce)

**Additional jobs by educational attainment**





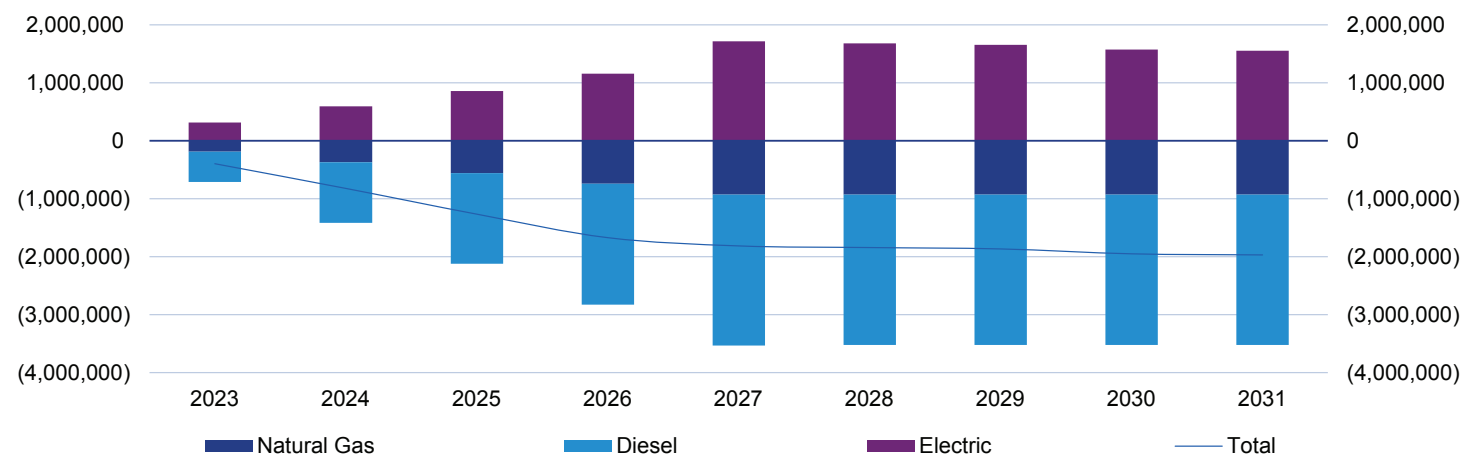
Findings

## Bus electrification (Cont...)

### Environmental contributions

- Lower CO2 emissions: \$1.5 million in annual monetized benefit (25,403 metric tons) on average, and approaching \$2 million by 2031
- Largest reduction in diesel fuel, which results in \$2.02 million average monetized benefit

### Co2 emissions avoided (\$)





Findings

 Fixed guideway transit

Macroeconomic contributions



**Job creation**

Supports an average of 3,275 jobs annually



**GRP growth**

\$386 million increase in Gross Regional Product in year 2031



**More labor income**

A total increase of \$1.9 billion in Disposable Personal Income

Economic benefits of fixed guideway transit

Category	2031	2031 Percent of region	Cumulative, 2022-2031
Change in regional total employment	3,644	0.077%	32,748
Change in Gross Regional Product (\$millions, 2020)	386	0.059%	3,297
Change in Disposable Personal Income (\$millions, 2020)	268	0.051%	1,924

**Note:** Cumulative total employment contributions are measured in job years instead of jobs.

Findings

Fixed guideway transit (Cont...)

Macroeconomic contributions ( Cont...)

- The repair and maintenance and construction sectors benefit the most from infrastructure construction and transit operations
- Support 1,494 jobs annually

Change in employment by industry

Industry	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
All Industries	1,885	1,906	3,465	3,576	3,642	3,665	3,661	3,656	3,648	3,644	3,275
Repair and maintenance	12	12	1,270	1,249	1,234	1,221	1,206	1,193	1,182	1,170	975
Construction	1,250	1,267	304	353	371	369	353	332	309	287	519
State and local government	66	100	217	296	345	377	398	414	426	435	307
Retail trade	83	79	195	193	196	197	196	197	197	197	173
Food services and drinking places	40	44	113	131	147	160	169	177	183	188	135
Administrative and support services	48	45	158	153	149	145	142	141	140	140	126
Professional, scientific, and technical services	64	63	119	114	110	106	103	102	103	105	99
Real estate	46	44	78	90	101	109	115	120	123	127	95
Performing arts, spectator sports, and related industries	9	8	92	90	89	89	88	89	89	89	73
Wholesale trade	25	24	83	82	81	80	80	80	79	79	69



### Macroeconomic contributions (Cont...)

- Direct and induced employment are the major components
- The project supports an average of 1,193 direct jobs annually
- Increased labor income, improved labor access, and other dynamic economic responses create 1,986 more jobs on average

### Change in employment by industry

Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
Total employment	1,885	1,906	3,465	3,576	3,642	3,665	3,661	3,656	3,648	3,644	3,275
Direct employment	1,111	1,099	1,261	1,247	1,233	1,221	1,208	1,196	1,185	1,173	1,193
Indirect employment	119	116	96	94	93	91	89	87	86	85	96
Induced employment	655	690	2,109	2,235	2,316	2,353	2,364	2,373	2,377	2,386	1,986
Employment multiplier	1.7	1.73	2.75	2.87	2.95	3	3.03	3.06	3.08	3.11	2.73



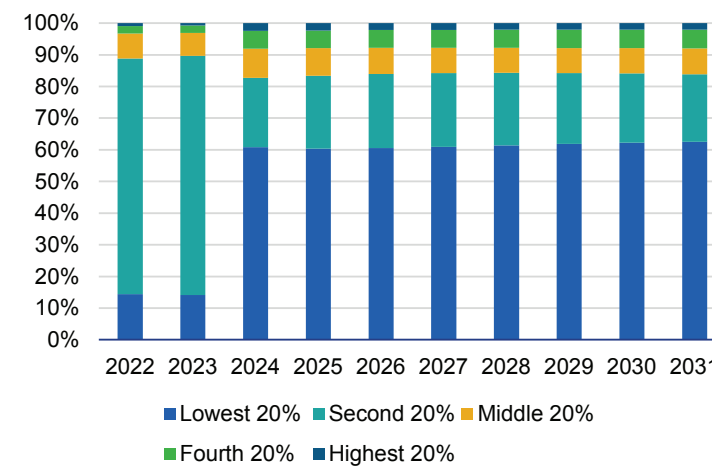
### Findings

### Fixed guideway transit (Cont...)

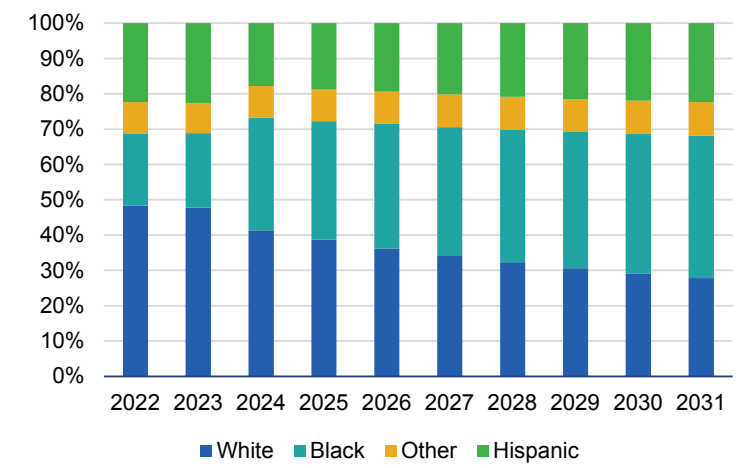
#### Equity contributions

- Approximately 65% of new jobs to benefit ethnic and racial minorities, exceeding the share of population in MSA
- More job opportunities for low-income and Black workers
  - 77% of employment gains to benefit workers in the lowest two income quintiles
  - An average of 35% of employment gains to benefit Black workers, with more gains in the operations phase
- Hispanic workers to benefit from 21% of the jobs gained, on average

#### Supported employment by income quintiles

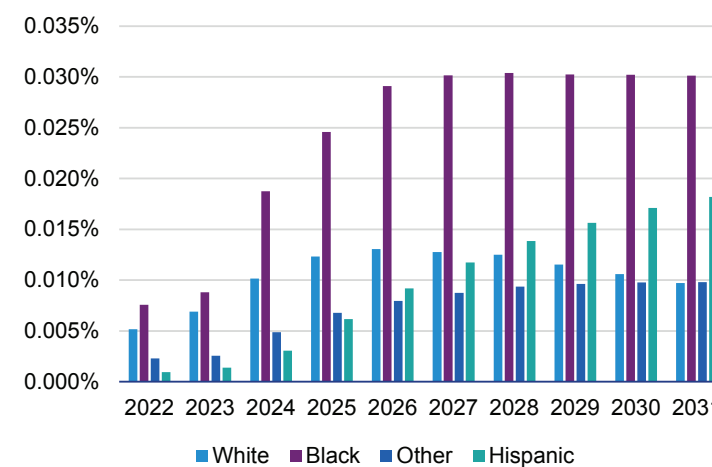


#### Supported employment by race/ethnicity

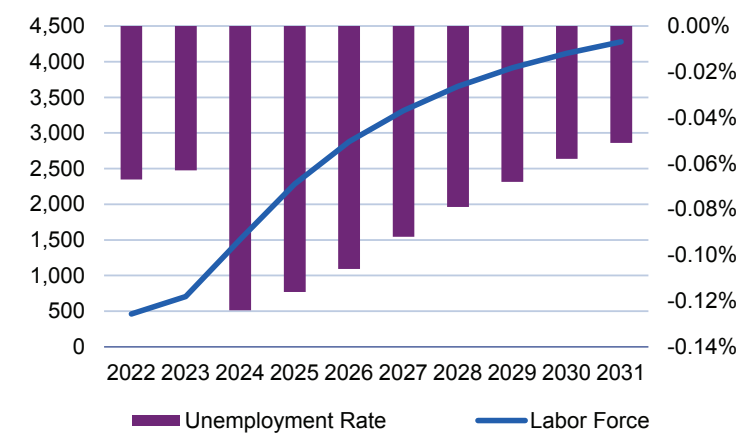


- A larger labor market with diverse demographic groups
- An expanded labor pool with the unemployment rate dropping by 0.08% on average
- Higher labor participation rate for all races/ethnicities, especially Black workers

#### Change in participation rate by race/ethnicity



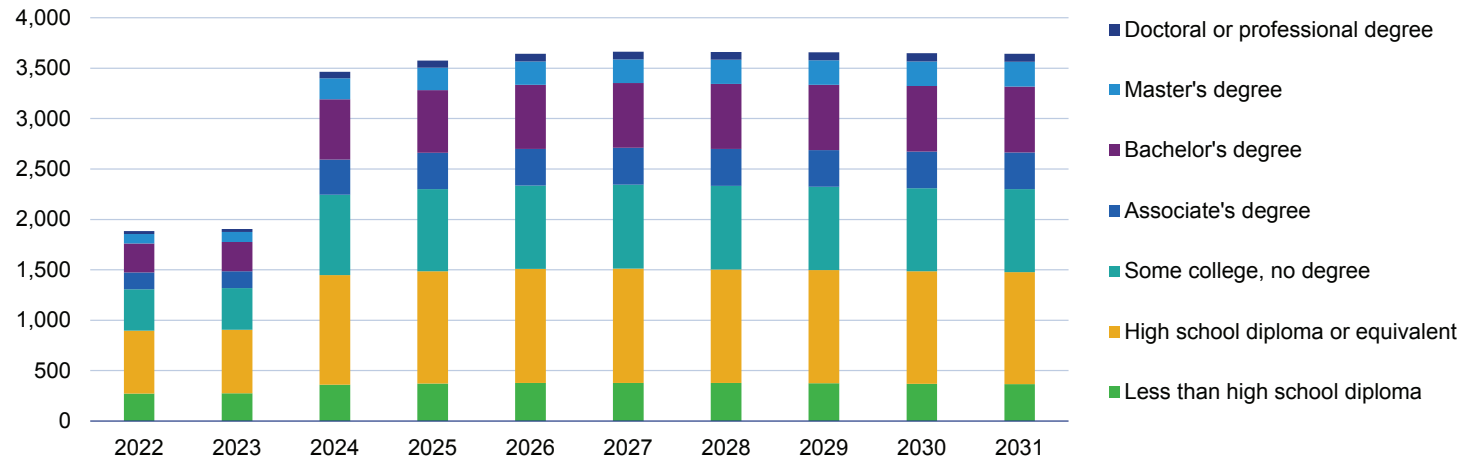
#### Change in labor force and unemployment rate



**Workforce development contributions**

- More job opportunities for workers with at most a high school degree
- 74.7% of the newly employed will not need a bachelor's degree (relative to 62.5% of the total workforce)

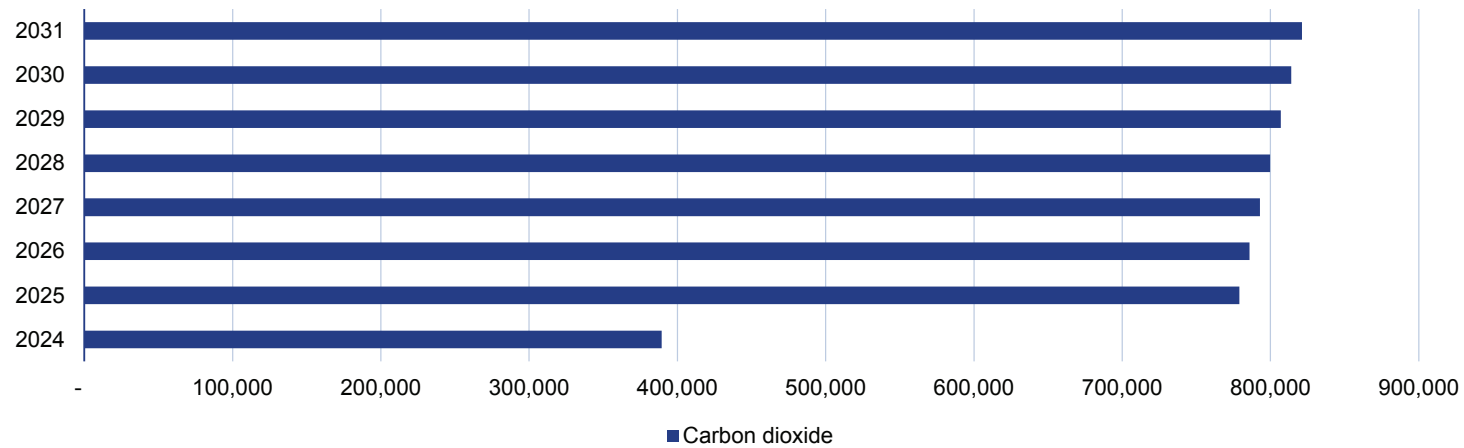
**Additional jobs by educational attainment**



**Environmental contributions**

- Lower CO2 emissions: an average of \$0.75 million in annual monetized benefit (10,081 metric tons)
- Benefits from the reduction in other pollutants (e.g. sulfur dioxide, nitrogen oxides, fine particulate matter)

**Emissions reduction benefit (\$)**



**Environmental contributions (Cont...)**

**Fixed guideway transit: monetized benefit by pollutant (2020\$)**

Category	2024	2025	2026	2027	2028	2029	2030	2031
Carbon dioxide	389,491	778,982	785,873	792,826	799,840	806,916	814,054	821,256
Sulfur dioxide	726	1,452	1,465	1,478	1,491	1,504	1,517	1,513
Nitrogen oxides	5,712	11,425	11,526	11,628	11,731	11,835	11,939	12,045
Fine particulate matter	1,981	3,963	3,998	4,033	4,069	4,105	4,141	4,178
Particulate matter	104	208	210	212	214	216	218	219
<b>Total</b>	<b>\$398,015</b>	<b>\$796,030</b>	<b>\$803,072</b>	<b>\$810,177</b>	<b>\$817,344</b>	<b>\$824,575</b>	<b>\$831,870</b>	<b>\$839,229</b>







**Findings**

**Bicycle infrastructure**


**Macroeconomic contributions**



**Job creation**  
Support an average of 782 jobs annually



**GRP growth**  
\$75 million increase in GRP in year 2031



**More labor income**  
A total increase of \$515 million in Disposable Personal Income

Economic benefits of bicycle infrastructure			
Category	2031	2031 percent of region	Cumulative, 2022-2031
Change in regional total employment	687	0.015%	7,819
Change in Gross Regional Product (\$millions, 2020)	75	0.012%	830
Change in Disposable Personal Income (\$millions, 2020)	52	0.01%	515

**Note:** Cumulative total employment contributions are measured in job years instead of jobs.



### Macroeconomic contributions (cont...)

- The construction sector benefits the most with a 508 job increase on average
  - Accounts for 65% of the total new employment

### Change in employment by industry

Industry	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
All industries	840	848	854	835	806	776	746	723	703	687	782
Construction	541	550	547	536	520	504	488	474	463	454	508
State and local government	25	38	45	49	51	51	50	50	49	48	46
Retail trade	42	40	40	38	36	34	31	30	28	26	35
Food services and drinking places	20	21	24	26	26	27	27	27	26	26	25
Professional, scientific, and technical services	28	28	27	25	23	20	19	17	16	16	22
Real estate	23	22	24	24	23	22	21	20	19	19	22
Ambulatory health care services	26	22	21	20	18	17	16	15	14	14	18
Administrative and support services	22	21	21	20	18	17	16	15	14	14	18
Wholesale trade	12	11	11	10	10	9	8	8	8	7	9
Personal and laundry services	10	9	10	9	8	8	7	7	7	6	8

- Direct and induced employment are the major components
- Supports an average of 461 direct jobs annually
- Increased population and household spending create 273 more jobs on average

### Direct + indirect + induced effects

Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
Total employment	840	848	854	835	806	776	746	723	703	687	782
Direct employment	477	472	468	464	462	459	456	454	451	449	461
Indirect employment	52	51	50	49	48	47	46	45	44	42	48
Induced employment	310	325	336	321	296	270	244	225	208	196	273
Employment multiplier	1.76	1.8	1.83	1.8	1.75	1.69	1.64	1.59	1.56	1.53	1.69

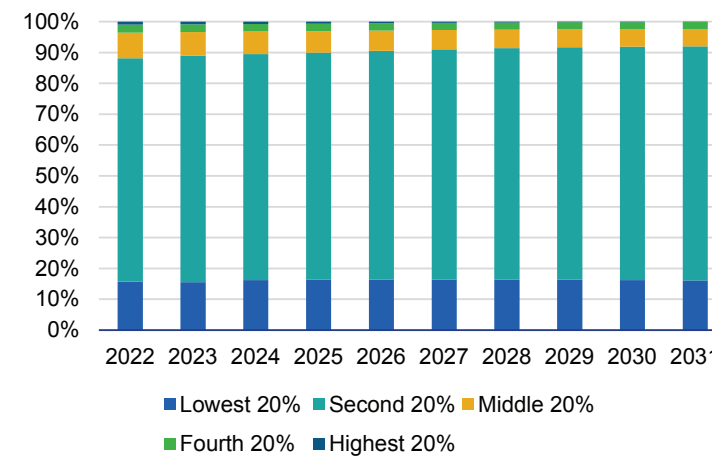
### Findings

### Bicycle infrastructure (Cont...)

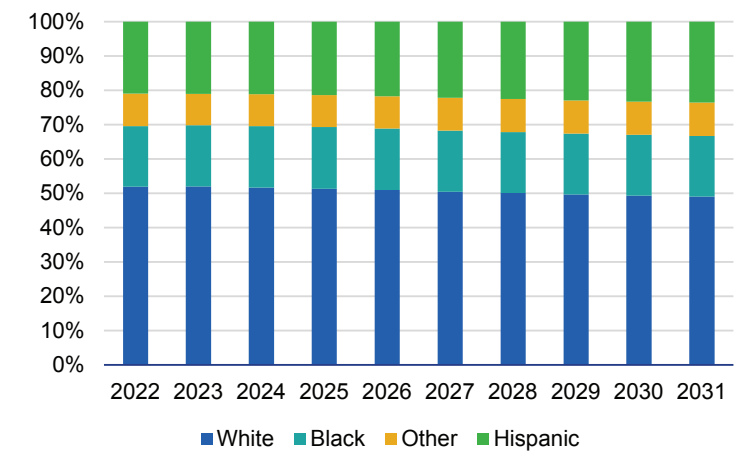
#### Equity contributions

- Approximately 49% of new jobs to benefit ethnic and racial minorities
- More job opportunities for low-income and Hispanic workers
  - 70% of employment gains to benefit workers in the second lowest income quintile
  - 22% of new jobs expected to benefit Hispanic workers, exceeding population share in MSA
- Black workers expected to benefit from 18% of the jobs gained

#### Supported employment by income quintiles

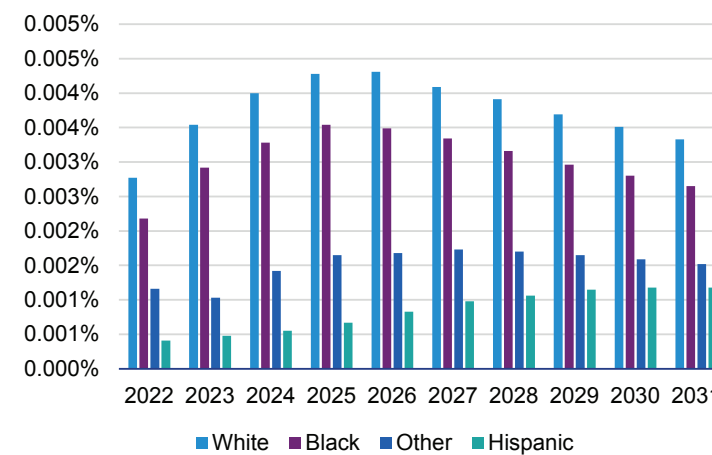


#### Supported employment by race/ethnicity

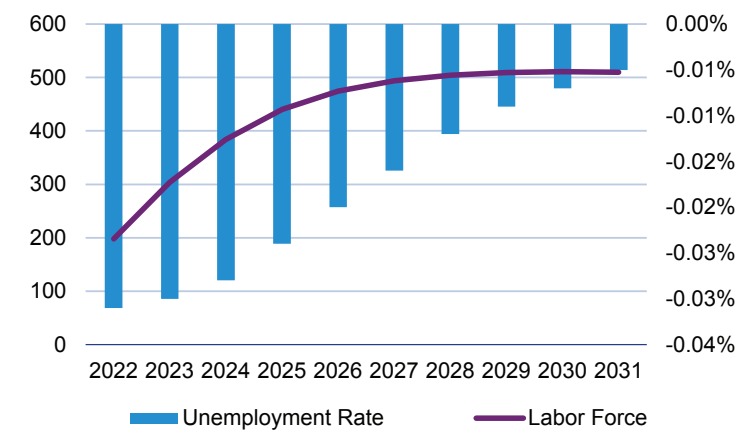


- A larger labor market with diverse demographic groups
- An expanded labor pool with the unemployment rate dropping by 0.02% on average
- Higher labor participation rate for all races/ethnicities, especially for White and Black workers

#### Change in participation rate by race/ethnicity



#### Change in labor force and unemployment rate





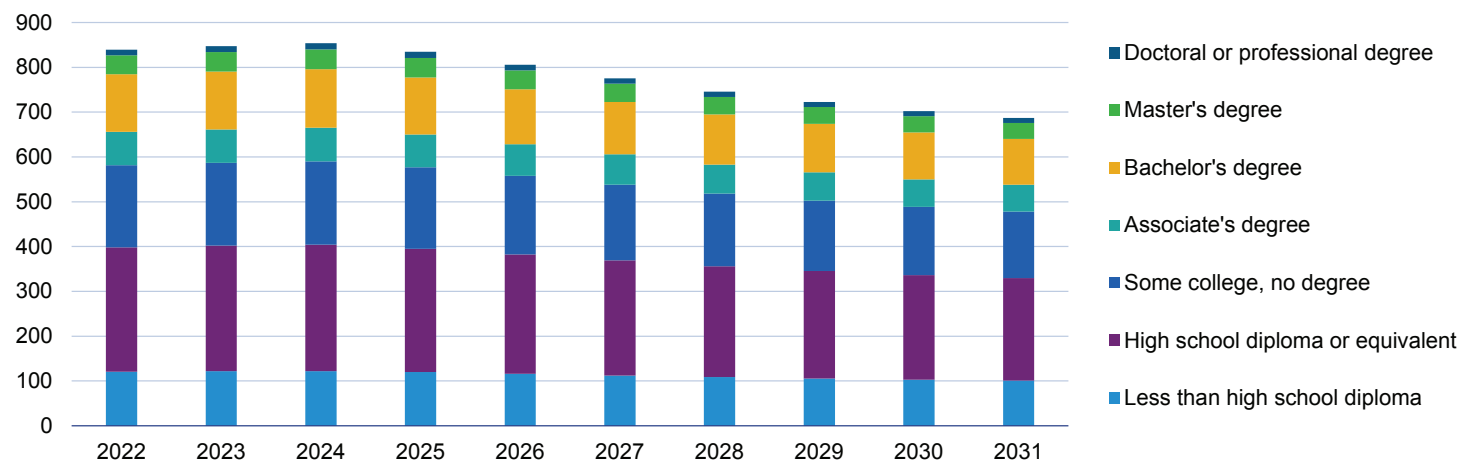
**Findings**

**Bicycle infrastructure (Cont...)**

**Workforce development contributions**

- More job opportunities for workers with at most a high school degree
- 78.1% of the newly employed will not need a bachelor's degree (relative to 62.5% of the total workforce)

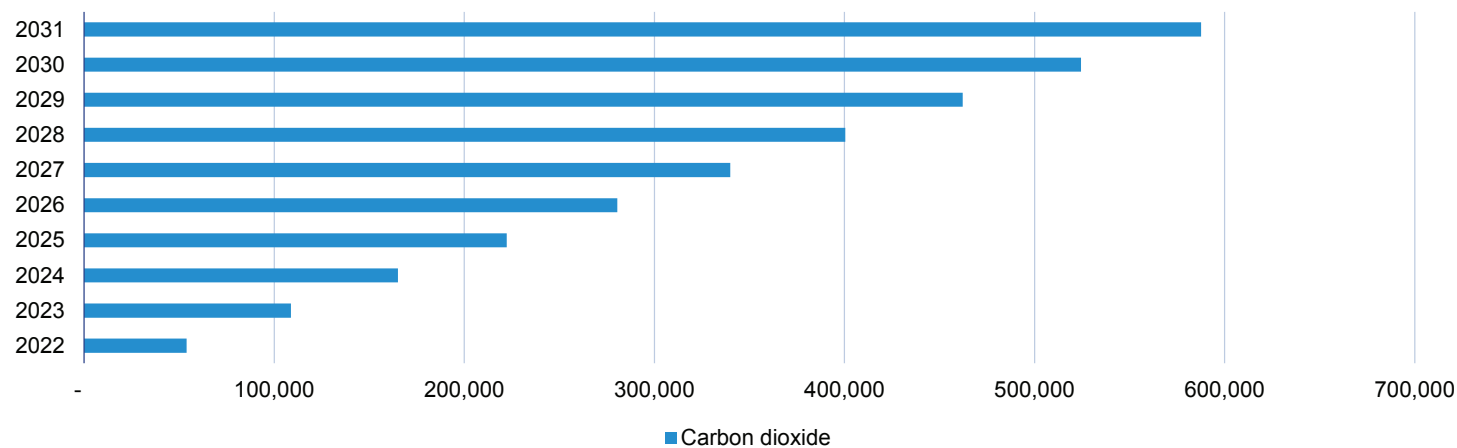
**Additional jobs by educational attainment**



**Environmental contributions**

- Lower CO2 emissions: \$0.31 million average annual monetized benefit (5,294 metric tons), approaching \$0.6 million by 2031
- Benefits from reduction in other pollutants (e.g. sulfur dioxide, nitrogen oxides, fine particulate matter)

**Emissions reduction benefit (\$)**



**Improved bicycle infrastructure: Monetized benefit by pollutant (2020\$)**

Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Carbon dioxide	53,854	108,874	165,081	222,263	280,550	339,957	400,500	462,197	524,407	587,644
Sulfur dioxide	100	203	308	414	523	634	746	861	977	1,095
Nitrogen oxides	790	1,597	2,421	3,260	4,115	4,986	5,874	6,779	7,691	8,619
Fine particulate matter	274	554	840	1,131	1,427	1,729	2,037	2,351	2,668	2,990
Particulate matter	14	29	44	59	75	91	107	124	140	157
<b>Total</b>	<b>\$55,032</b>	<b>\$111,257</b>	<b>\$168,694</b>	<b>\$227,128</b>	<b>\$286,690</b>	<b>\$347,396</b>	<b>\$409,265</b>	<b>\$472,312</b>	<b>\$535,883</b>	<b>\$600,505</b>

# Conclusion

## Comparison of scenario outcomes

### Contributions by scenario

	Bus Electrification		Fixed Guideway Transit	Bicycle Infrastructure
	Construction and O&M Only	Full Scenario		
Net Capital Cost (\$M)	\$1,983	\$1,983	\$489	\$833
Net O&M Cost (\$M)	\$179	\$179	\$1,299	\$0
Total Cost (\$M)	\$2,161	\$2,161	\$1,788	\$833
<b>Contributions</b>				
Jobs created (total, job-years)	8,122	11,590	32,748	7,819
Jobs created (annual average)	812	1,159	3,275	782
Share of jobs without Bachelor's degree	78.59%	76.14%	74.72%	78.08%
Share of jobs benefiting ethnic/racial minorities	49.04%	50.04%	64.60%	49.27%
Increase in GRP (\$M)	\$858	\$1,306	\$3,297	\$830
Increase in Disposable Personal Income (\$M)	\$515	\$980	\$1,924	\$515
Emissions Avoided (monetized average)	\$1,500,000	\$1,500,000	\$750,000	\$310,000
Emissions Avoided (monetized, 2031)	\$2,000,000	\$2,000,000	\$839,000	\$600,000
<b>Contributions per dollar spent</b>				
Jobs created per \$1 million in spending	3.76	5.36	18.31	9.39
GRP per dollar spent	\$0.40	\$0.60	\$1.84	\$1.00
Labor Income per dollar spent	\$0.24	\$0.45	\$1.08	\$0.62
Average wage per job created	\$63,408	\$84,556	\$58,752	\$65,865
Emission reduction efficiency	0.09%	0.09%	0.026%*	0.07%
Emission reduced per \$1 million in spending, 2031	\$925	\$925	\$255*	\$720

\* Emission reduction efficiency calculation includes total capital costs of \$1.99 billion

## What we learned



### Bus electrification

- Of the scenarios evaluated, most effective for reducing emissions.
- Supports 1,159 jobs annually, a total increase of \$1.3 billion in GRP, and adds a total of \$980 million in Disposable Personal Income.
- Expands the labor force and lowers the unemployment rate by 0.03%.
- Provides substantial job opportunities to minority groups, with 50% of jobs created benefitting racial and ethnic minorities. Hispanic workers see largest employment gains.
- Increases compensation for all workers, especially the second lowest quintile (from the expansion in construction).
- Provides more job opportunities for workers with lower educational attainment: 76.1% of the newly employed will not need a bachelor's degree (relative to 62.51% of the total D.C. Metro Area workforce).
- Cuts down carbon emissions by 25,403 metric tons (\$1.5 million) per year.

### Fixed guideway transit

- Of the scenarios evaluated, provides the largest regional economic contribution and creates the largest share of jobs that benefit racial and ethnic minorities.
- Supports 3,275 jobs annually, a total increase of \$3.3 billion in GRP, and adds a total of \$1.9 billion in Disposable Personal Income.
- Expands labor force and reduces unemployment rate by 0.08%.
- Provides substantial job opportunities to minority groups, with 65% of jobs created benefitting racial and ethnic minorities. Black workers see the largest employment increases.
- Provides more jobs to workers with lower educational attainment: 74.7% of the newly employed will not need a bachelor's degree.
- Cuts down carbon emissions by an average of 10,081 metric tons per year, which is equivalent to \$0.75 million.

### Bicycle infrastructure

- Of the scenarios evaluated, offers a less expensive way of reducing emissions while providing an effective regional economic boost.
- Supports 782 jobs annually, a total increase of \$830 million in GRP, and adds \$515 million in Disposable Personal Income.
- Expands labor force and reduces unemployment rate by 0.02%.
- Provides substantial job opportunities to minority groups, with 49% of jobs created benefitting racial and ethnic minorities. Hispanic workers see largest employment increases.
- Provides more jobs to workers with lower educational attainment: 78.1% of the newly employed will not need a bachelor's degree.
- Cuts down carbon emissions by 5,294 metric tons (\$0.31 million) per year.



# Appendix

## Literature review

Paper	Research question	Data/Tools	Findings
Michigan Department of Transportation, 2018-2022 Five-Year Transportation Program	What are the economic impacts of investments in transportation infrastructure programs?	<ul style="list-style-type: none"> <li>— The Michigan Benefits Estimation System for Transportation Tool</li> <li>— The REMI TranSight model</li> </ul>	<ul style="list-style-type: none"> <li>— The \$8.2 billion investment in the Five-Year Highway and Bridge Program would support an average of 20,780 jobs annually. It would also result in a total increase of \$6.4 billion in real personal income and \$8.7 billion in gross state product.</li> <li>— The \$1.6 billion investment in the Five-Year Transit Program would support an average of 5,521 jobs annually. It would also result in a total increase of \$1.7 billion in real personal income and \$2.3 billion in gross state product.</li> </ul>
Economic Impact Analysis for HGAC's High Capacity Transit (HCT) Project	What are the economic impacts of investment in candidate HCT projects?	<ul style="list-style-type: none"> <li>— Project construction and O&amp;M costs</li> <li>— Finance Options</li> <li>— VMT, VHT and VTT</li> <li>— The REMI TranSight model</li> </ul>	<ul style="list-style-type: none"> <li>— The six scenario projects, with a range of costs from \$48.1 billion to \$154.4 billion, would result in total impact benefits of \$45.1 billion to \$926.3 billion, respectively.</li> <li>— Economic benefits consist of personal user benefits and increases in personal income, total employment, annual average job growth, GDP, and output.</li> </ul>
South California Association of Governments, Economic and Job Creation Analysis	What are the economic impacts of the 2020 Regional Transportation Plan and Sustainable Communities Strategies?	<ul style="list-style-type: none"> <li>— Project construction and O&amp;M costs</li> <li>— VMT, VHT and number of trips from the Connect SoCal travel demand model</li> <li>— Reductions in commuting costs, accessibility costs, transportation costs and operating costs, and improvements in amenities or reductions in externalities</li> <li>— The REMI TranSight model</li> </ul>	<ul style="list-style-type: none"> <li>— The \$603+ billion on transportation improvement projects would create an average of 432,900 jobs a year over the FY2020-21 through FY2044-45 period.</li> <li>— Out of the 432,900 average annual jobs, 168,400 would be a result of the job growth from building, operating and maintaining the projects, while 264,500 would be a result of the increases in economic competitiveness and improved economic performance from congestion reduction and improvements in regional amenities.</li> </ul>





Paper	Research question	Data/Tools	Findings
Costs and Benefits of Electrifying and Automating Bus Transit Fleets	What are the costs and benefits of electrifying and automating bus transit fleets?	<ul style="list-style-type: none"> <li>— Bus capital and infrastructure costs</li> <li>— Bus O&amp;M costs</li> <li>— VMT</li> <li>— Fuel price effects</li> </ul>	<ul style="list-style-type: none"> <li>— Battery-electric buses will become lifecycle cost-competitive in or before 2030 at existing U.S. fuel prices, with rising diesel prices resulting in immediate cost savings before reaching \$3.30 per gallon.</li> <li>— The benefits of converting to electric propulsion include a reduction in greenhouse gas emissions and public health benefits from eliminating diesel bus emissions and reducing noise and heat to those near bus stops.</li> </ul>
Regional Economic Studies Institute, Economic and Fiscal Impact of Class I Railroads in 2017	What is the economic impact of Class I railroads on the U.S. economy?	<ul style="list-style-type: none"> <li>— Class I railroad operations and capital investments</li> <li>— IMPLAN model</li> </ul>	<ul style="list-style-type: none"> <li>— Direct economic effects include an increase in employment to support railroad operations, as generated from operations and capital investments.</li> <li>— Indirect economic effects arise from an increase in goods and service purchases from other firms.</li> <li>— Induced economic effects driven from the increase in employment and thus household income, resulting in households increasing purchases at local businesses.</li> </ul>
National Institute for Transportation and Communities, Understanding Economic and Business Impacts of Street Improvements for Bicycle and Pedestrian Mobility: A Multi-City, Multi-Approach Exploration	What are the economic impacts of bicycle and street improvements in the U.S.?	<ul style="list-style-type: none"> <li>— Employment, wage, and retail sales tax data</li> <li>— Aggregated trend analysis, Difference-in difference (DID) analysis, Interrupted time series (ITS) analysis</li> </ul>	<ul style="list-style-type: none"> <li>— Street improvements have either positive or non-significant impacts on corridor employment and sales.</li> <li>— The food service industry benefits the most from the addition of active transportation infrastructure.</li> <li>— The retail industry generally benefits from the addition of active transportation structure (in most case studies, retail sales and/or employment were positively impacted, while in some case studies there was either no impact or a mixed result).</li> </ul>



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