Measuring the Economic, Equity, and Environmental Contributions of Transit Infrastructure

Macroeconomic, Equity, Workforce, and Environmental Contributions

August 26, 2021

Introduction

Disclaimer: In providing our services, KPMG professionals have undertaken no view and have not undertaken any role that could be fairly interpreted as public policy advocacy and the firm's work is not intended to be used as such or in that context.

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 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 WMATA's 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.

Use Cases (Washington, DC Metropolitan Area) (continued)

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.

Data and Approach

Study Approach

Step 1: 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.

Step 2: Analyze the macroeconomic contributions of transit investments and 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.

Step 3: Analyze the equity contributions of transit investments

— Quantify the economic benefits for households with varying levels of income.

— Characterize the distributional impacts.

Step 4: Estimate the workforce development benefits of transit investments

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

Step 5: Analyze the environmental contributions of transit investments

— The reduction in carbon emissions and air pollutants.

Model Input and Assumptions: Bus Electrification

Assumptions	
Timeline	Analysis period: 2022-2031 Electrification completed in 5 years (2022-2026) Construction of BRT conducted concurrently
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

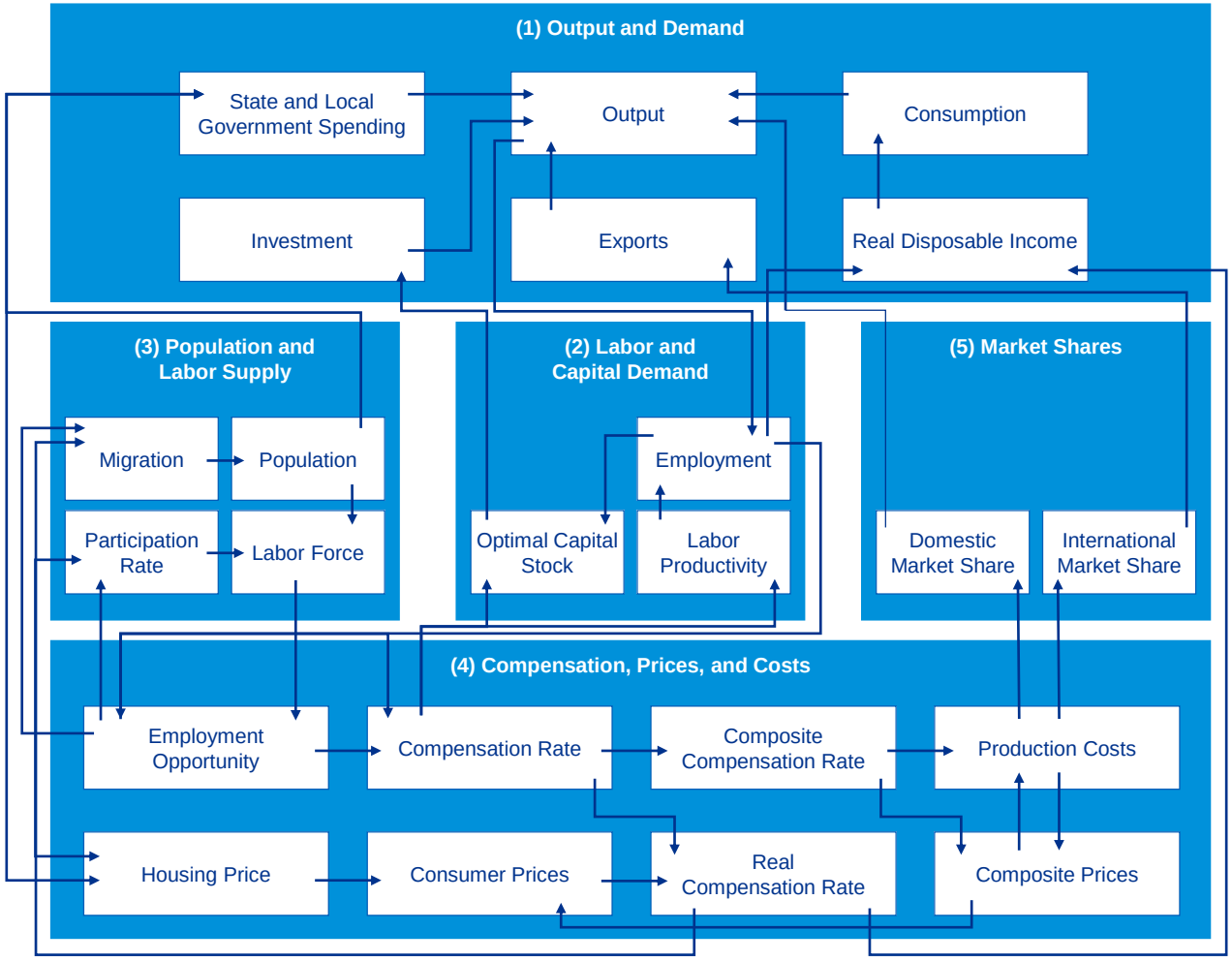
Model Input and Assumptions: Fixed Guideway Transit

Assumptions	
Timeline	Analysis period: 2022-2031 Construction completed in 2023 and revenue service starts in 2024 Ramp-up in ridership in the first two years of operation (one half of projected first year ridership)
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	Analysis period: 2022-2031 Construction completed in 2040 (after the analysis period)
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: $\%\ change\ in\ VMT = \frac{(-1)\ \times \%\ change\ in\ bikeway\ miles\ \times elasticity\ \times existing\ bike\ mode\ share\ \times bike\ trip\ length}{existing\ auto\ mode\ share\ \times auto\ trip\ length}$
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

REMI Model Framework: Linkages



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

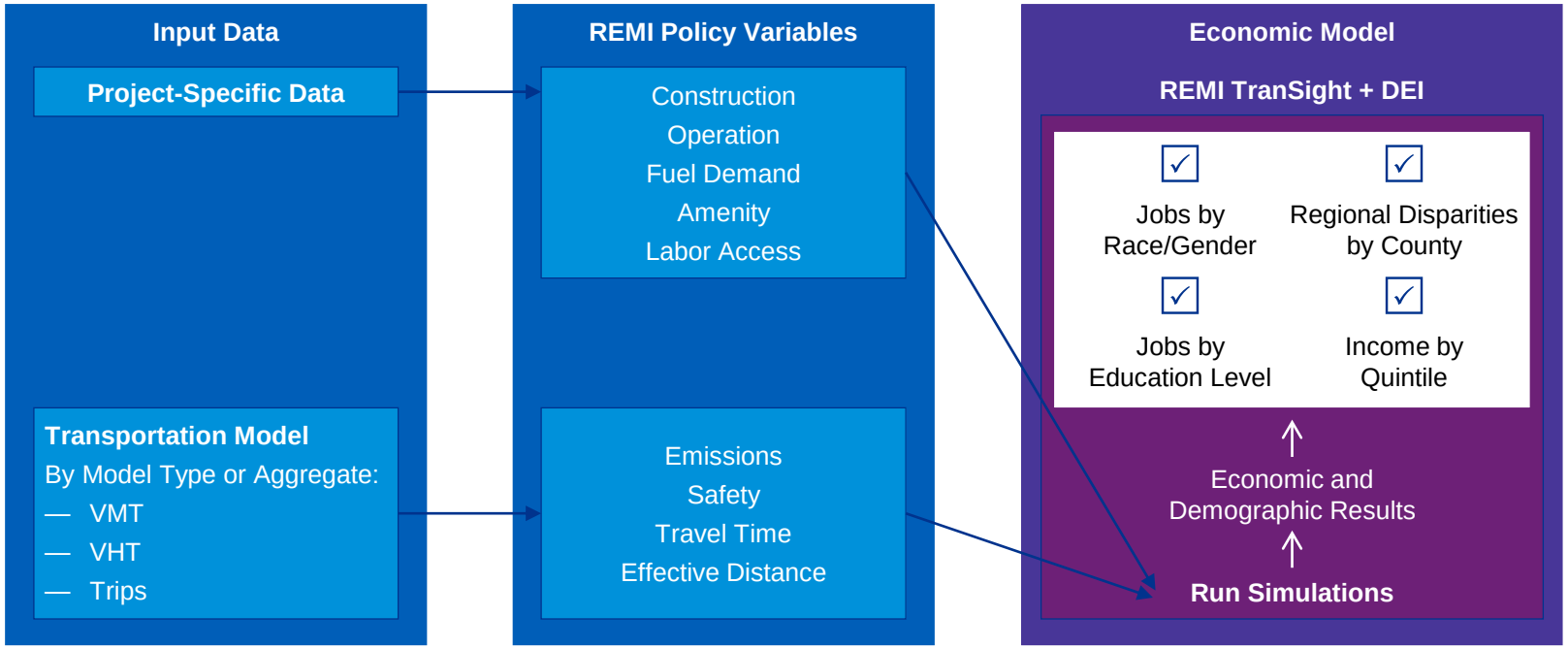
(3) Population and Labor Supply

(4) Compensation, Prices, and Costs

(5) Market Shares.

Models Used: REMI TranSight & REMI Diversity, Equity, and Inclusion (DEI)

- This analysis customized the PI+ model (figure below) to integrate the Travel Demand Module from the REMI TranSight model and the REMI Diversity, Equity, and Inclusion (DEI) 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 DEI Module can display various results, including employment and labor force participation by race and gender, jobs by education level, income by quintile, and more.



Findings

Bus Electrification

Macroeconomic Contributions

- Job creation: 1,159 additional jobs annually on average
- 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.			

Bus Electrification (continued)

Macroeconomic Contributions (continued)

— 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

Bus Electrification (continued)

Macroeconomic Contributions (continued)

- 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	1.80	2.66	2.86	3.00	3.05	3.07	2.39

Bus Electrification (continued)

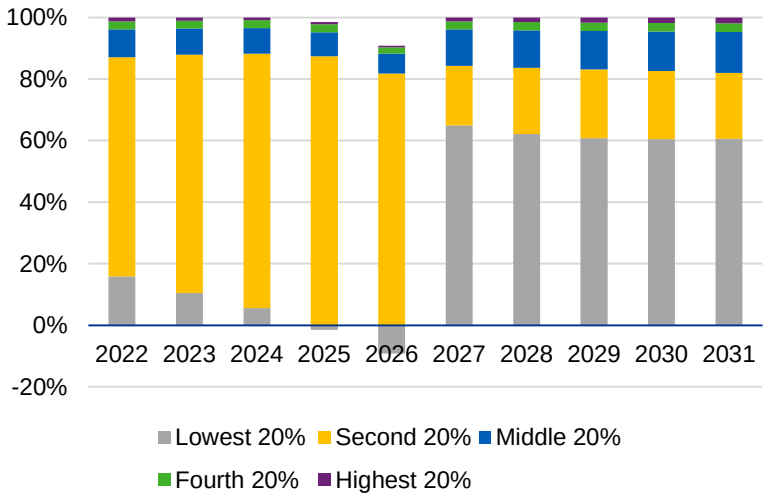
Equity Contributions

— Approximately 50% of new jobs to benefit ethnic and racial minorities

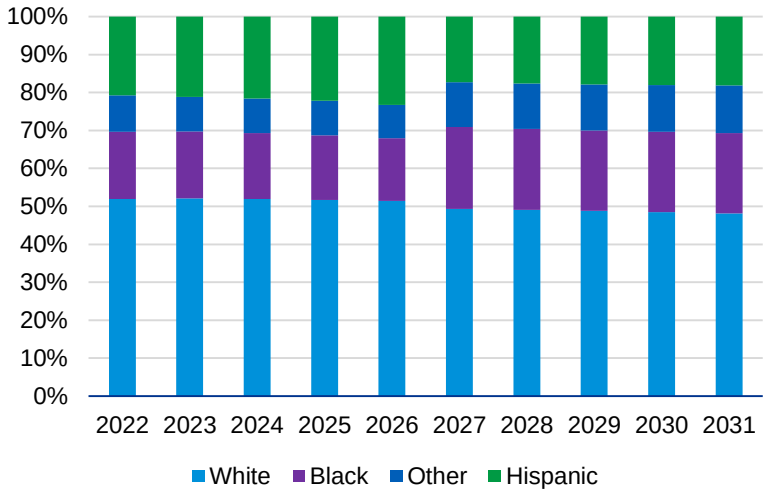
— More job opportunities for low-income and Hispanic workers

- 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.

Employment by Income Quintiles



Employment by Race/Ethnicity

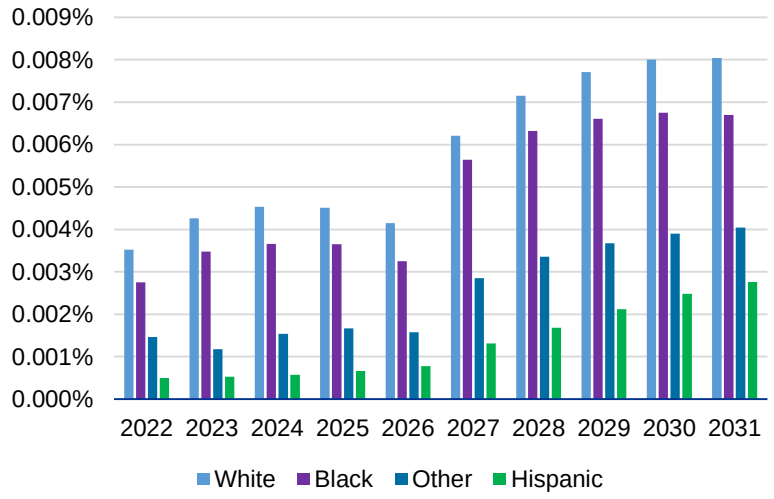


Bus Electrification (continued)

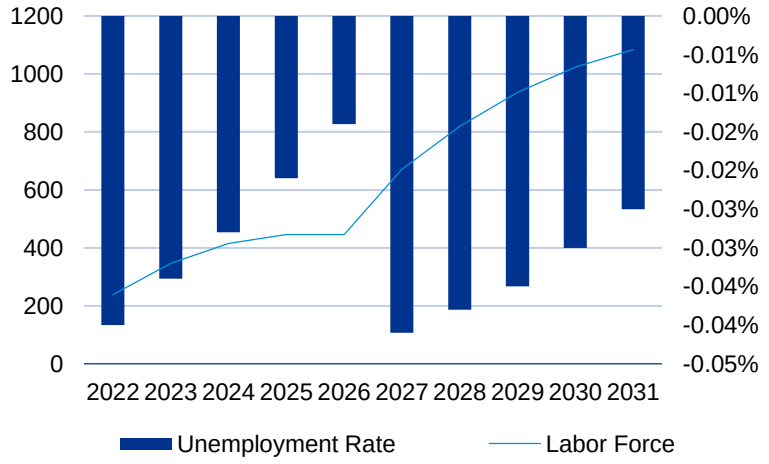
Equity Contributions (continued)

- 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

Participation Rate by Race/Ethnicity



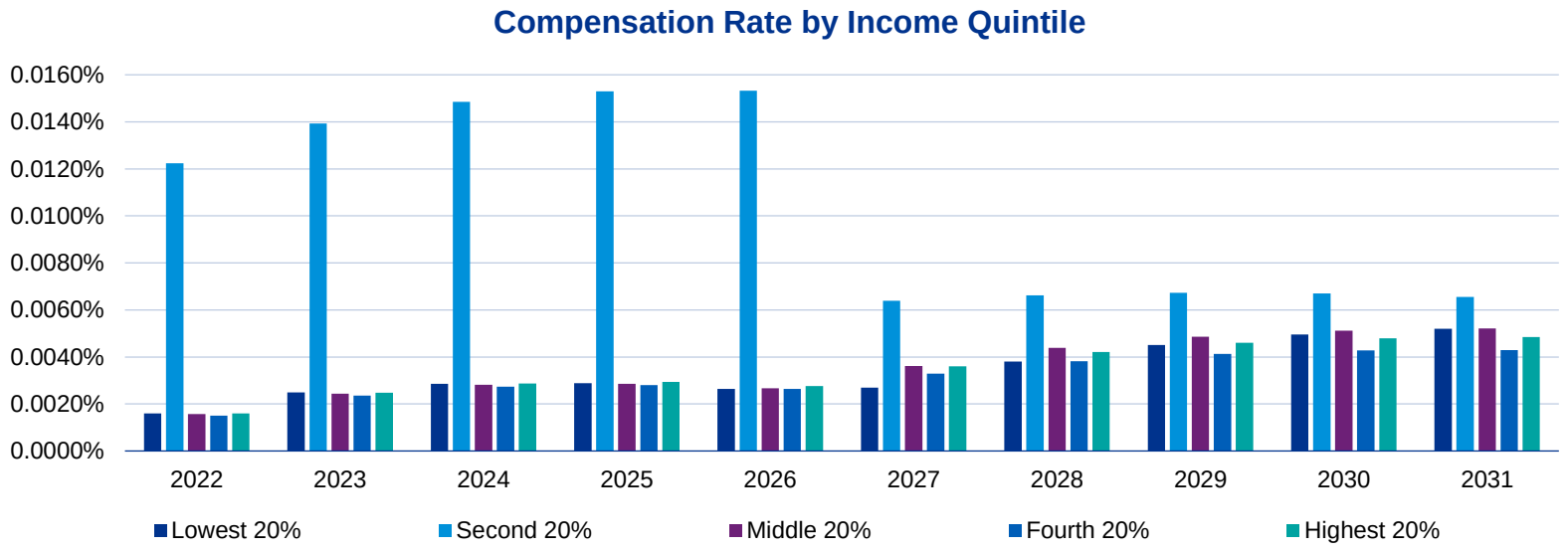
Change in Labor Force and Unemployment Rate



Bus Electrification (continued)

Equity Contributions (continued)

- 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

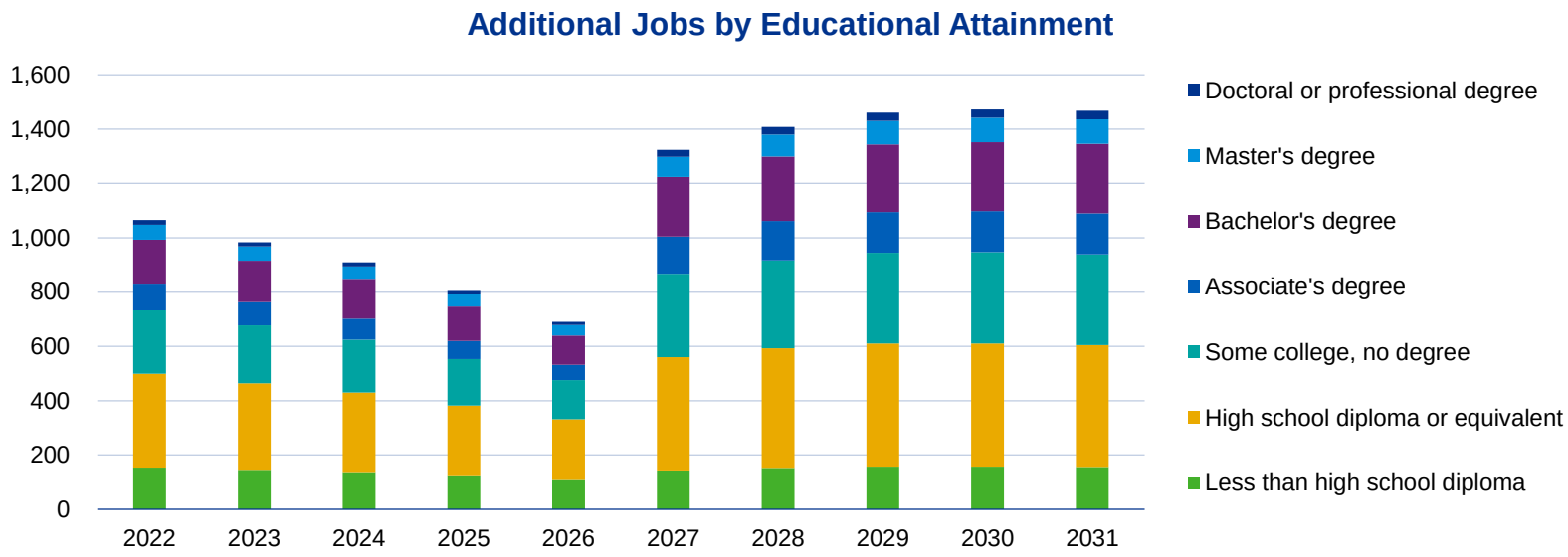


Bus Electrification (continued)

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.

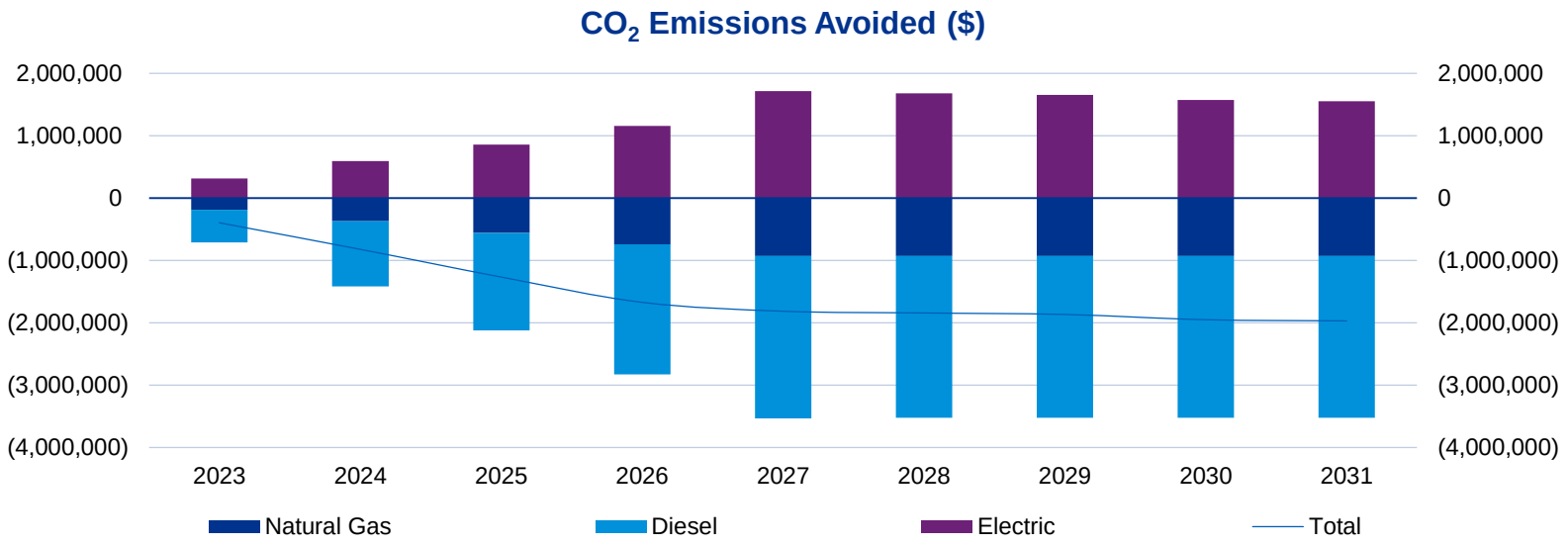
— 76.1% of the newly employed will not need a bachelor's degree (relative to 62.5% of the overall workforce)



Bus Electrification (continued)

Environmental Contributions

- Lower CO_2 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



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	$833
Contributions				
Jobs created (total, job-years)	8,122	11,590	32,748	7,819
Jobs created (annual average)	812	1,159	3,275	782
Share of jobs without Bachelor's degree	78.59%	76.14%	74.72%	78.08%
Share of jobs benefiting ethnic/racial minorities	49.04%	50.04%	64.60%	49.27%
Increase in GRP ($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
Contributions per Dollar Spent				
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	0.093%	0.093%	0.026%*	0.072%
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 add a total of $980 million in Disposable Personal Income.
- Expand the labor force and lower the unemployment rate by 0.03%
- Provide 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)
- Provide 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).
- Cut down carbon emissions by 25,403 metric tons ($1.5 million) per year.

What We Learned (continued)

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, with 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.

What We Learned (continued)

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, with 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.

Questions?

Please feel free to email any additional questions about this presentation to:

INFO@REMI.COM

Appendix

Background and objectives

Many of President Biden's proposals fall into several of the four areas of Federal policy intervention that environmental research institution Resources for the Future has identified as necessary for a fair transition to greener technology: workforce development and labor standards, economic development, and environmental remediation and infrastructure. These areas of focus include:

- **Workforce Development and Labor Standards:** As evident by the name of President Biden's infrastructure proposal, the American Jobs Plan, workforce development is a key focus. The proposal focuses on two areas — (1) job creation and training and (2) labor standards — especially as it invests in low-income communities and communities of color.
- **Economic Development:** President Biden's plan calls for several programs aimed at promoting the economic development of low-income communities and communities that may be economically impacted by a transition to greener technologies. Examples include closing the racial and gender gap in research and development in various fields.

Background and objectives (continued)

- **Environmental Remediation and Infrastructure:** Many of President Biden's proposals are specifically aimed at remediation efforts. These programs include: eliminating 100 percent of lead pipes and service lines in the country, increasing infrastructure resilience to flooding and extreme weather events cause by climate change, modernizing drinking water, wastewater, and stormwater systems, building high-speed broadband infrastructure to reach 100 percent coverage, plugging orphan oil and gas wells and cleaning up abandoned mines, and remediating and redeveloping brownfield and Superfund sites.

These investments in infrastructure will advance racial equity by providing better jobs and better transportation options to underserved communities. These investments also will extend opportunities to small businesses to participate in the design, construction, and manufacturing of new infrastructure and component parts.

Source: [1] ttps://www.natlawreview.com/article/biden-infrastructure-proposal-prioritizes-equity-and-environmental-justice; accessed 5/31/2021

[2] https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/, accessed 6/6/2021

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?	— The Michigan Benefits Estimation System for Transportation Tool — The REMI TranSight model	— 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. — 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.
Economic Impact Analysis for HGAC's High Capacity Transit (HCT) Project	What are the economic impacts of investment in candidate HCT projects?	— Project construction and O&M costs — Finance Options — VMT, VHT and VTT — The REMI TranSight model	— 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. — Economic benefits consist of personal user benefits and increases in personal income, total employment, annual average job growth, GDP, and output.

Appendix

Literature review (continued)

Paper	Research question	Data/Tools	Findings
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?	— Project construction and O&M costs — VMT, VHT and number of trips from the Connect SoCal travel demand model — Reductions in commuting costs, accessibility costs, transportation costs and operating costs, and improvements in amenities or reductions in externalities — The REMI TranSight model	— 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. — 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.
Costs and Benefits of Electrifying and Automating Bus Transit Fleets	What are the costs and benefits of electrifying and automating bus transit fleets?	— Bus capital and infrastructure costs — Bus O&M costs — VMT — Fuel price effects	— 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. — 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.

Appendix

Literature review (continued)

Paper	Research question	Data/Tools	Findings
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?	— Class I railroad operations and capital investments — IMPLAN model	— Direct economic effects include an increase in employment to support railroad operations, as generated from operations and capital investments. — Indirect economic effects arise from an increase in goods and service purchases from other firms. — Induced economic effects driven from the increase in employment and thus household income, resulting in households increasing purchases at local businesses.
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?	— Employment, wage, and retail sales tax data — Aggregated trend analysis, Difference-in difference (DID) analysis, Interrupted time series (ITS) analysis	— Street improvements have either positive or non-significant impacts on corridor employment and sales. — The food service industry benefits the most from the addition of active transportation infrastructure. — 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).

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