Low Carbon Prosperity Institute CLIMATE XCHANGE

BUILDING BACK BETTER

INVESTING IN A RESILIENT RECOVERY FOR WASHINGTON STATE

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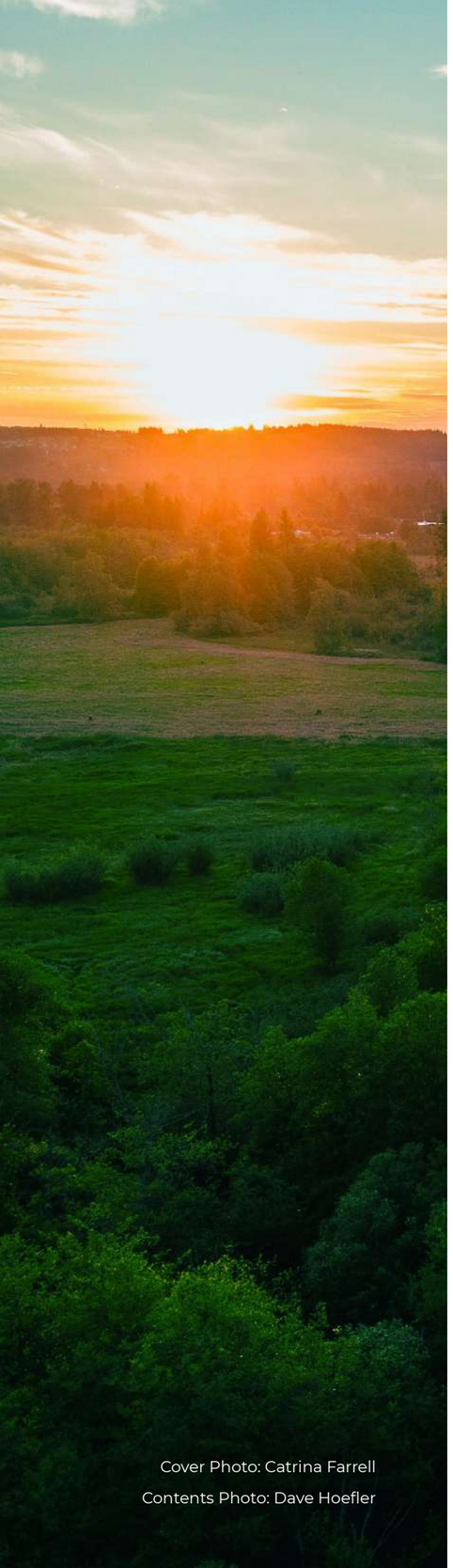

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The Low Carbon Prosperity Institute (LCPI) was established in 2014 as a project of the Washington Business Alliance's PLAN Washington. Our goal is to guide Washington to a double win — achieve greenhouse gas reduction commitments and build a thriving shared economy. LCPI provides system design based on data and science working collaboratively with others and informing policies to make our goals come to life.

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Climate XChange (CXC) is a 501(c)(3) nonpartisan, nonprofit organization with a mission to advance the transition towards the low-carbon economy of the future in states across the United States. With a three-pronged approach of research, media, and advocacy, and a State Carbon Pricing Network with over 7,500 members nationwide, CXC is at the forefront of state-level emissions reductions policy. For more information visit climate-xchange.org.

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I. EXECUTIVE SUMMARY

ABSTRACT

This report analyzes the potential jobs and community health benefits created by a sample portfolio of investments in Washington State. We find that investing in clean transportation, forest conservation and ecosystem restoration, clean energy, water and energy efficiency, low carbon agriculture, and sustainable industry supports over ten jobs per million dollars invested. By comparison, the state's ten largest industries support 4.3 jobs per million dollars invested. Additionally, we find that every million dollars invested in these programs accrues $2.4 million in clean air and climate benefits. These findings can help state policymakers design an economic recovery plan in response to the COVID-19 crisis that maximizes both job creation and the long-term health of Washington communities.

Washington has been hit hard by the COVID-19 health and economic crises. According to the Washington State Department of Health, over 1,300 Washingtonians have died of COVID-19 between February and June of this year.[1] This is roughly equivalent to the number of deaths the Puget Sound Clean Air Agency attributes to outdoor air pollution each year in Washington State.[2] Additionally, a record 1.1 million Washington workers filed for unemployment in the first few months of the crisis, with unemployment reaching a record-high 16.3 percent in April.[3]

The ability of Washington communities to bounce back from these crises will hinge on the short and medium-term policy choices of the state and federal government. Incoming stimulus dollars, whether from the federal government or elsewhere, need to be efficiently deployed for maximum high-quality job creation and long-term durable health and climate benefits. This report is intended to help guide a smart direction towards achieving these outcomes through well-crafted stimulus programs.

Solar canopy atop the Bullitt Center in Seattle, Washington. Photo Stephen Coffrin.

1 | Washington State Department of Health, 2020." COVID-19 Data Dashboard." t.ly/o9BW
2 | Puget Sound Clean Air Agency. "Air Pollution and Your Health." https://pscleanair.gov/161/Air-Pollution-Your-Health
3 | Bureau of Labor Statistics, 2020. https://www.bls.gov/web/laus/lauhsthl.htm

BUILDING A *RESILIENT RECOVERY PORTFOLIO* FOR WASHINGTON

This study is motivated by the urgent need to rebuild and create new economic growth and healthier communities in Washington State. To meet this challenge, Climate XChange and the Low Carbon Prosperity Institute analyzed the economic and health impacts of 14 different investment programs. The programs were analyzed for their job creation, wage and benefit levels, and value added to the state economy using IMPLAN economic modeling. They were subsequently evaluated for community health and climate benefits per million dollars invested.

Based on our analysis, the most effective path to economic recovery prioritizes investments in what we refer to as the *Resilient Recovery Portfolio*, which includes programs in clean transportation, forest conservation and ecosystem restoration, clean energy, water and energy efficiency, low carbon agriculture, and sustainable industry. We find that the co-benefits derived from these investments greatly outweigh their upfront costs, and provide robust job creation and significant community health benefits. These programs will also help the state build the jobs, industries, and services that will help it prosper in the thirty-plus year transition towards a net zero-emissions future.

This analysis provides a screening tool for Washington policymakers and stakeholders to use in constructing a recovery plan at the nexus of jobs and community health. However, while the *Resilient Recovery Portfolio* examined in this report is built with an emphasis on Washington State, the broader takeaways hold up across state lines, even if the specific portfolio may need to be tailored to best suit local strengths and opportunities. The quantitative methodology we developed can empower and inform subsequent strategies and support a healthier, more sustainable, and prosperous future for all Americans.

***THE RESILIENT RECOVERY PORTFOLIO* CONSISTS OF**

CLEAN TRANSPORTATION

- HIGH-SPEED RAIL
- LIGHT RAIL — SOUND TRANSIT EXPANSION FEDERAL WAY
- LOW CARBON BUSES & TRUCKS
- CLEAN VEHICLE PROGRAMS
- TRANSIT-ORIENTED COMMUNITY DEVELOPMENT

WATER, POWER, & ENERGY EFFICIENCY

- HOME ENERGY EFFICIENCY & RENEWABLES
- 100% CLEAN POWER READINESS
- WATER-ENERGY PROGRAMS

FOREST CONSERVATION & ECOSYSTEM RESTORATION

- WILDFIRE PREVENTION & PREPAREDNESS
- URBAN & COMMUNITY FORESTRY
- YAKIMA BASIN ECOSYSTEM RESTORATION

LOW CARBON AGRICULTURE

SUSTAINABLE INDUSTRY

- ELECTRIC FERRIES
- LOW CARBON FREIGHT OPERATIONS

KEY FINDINGS

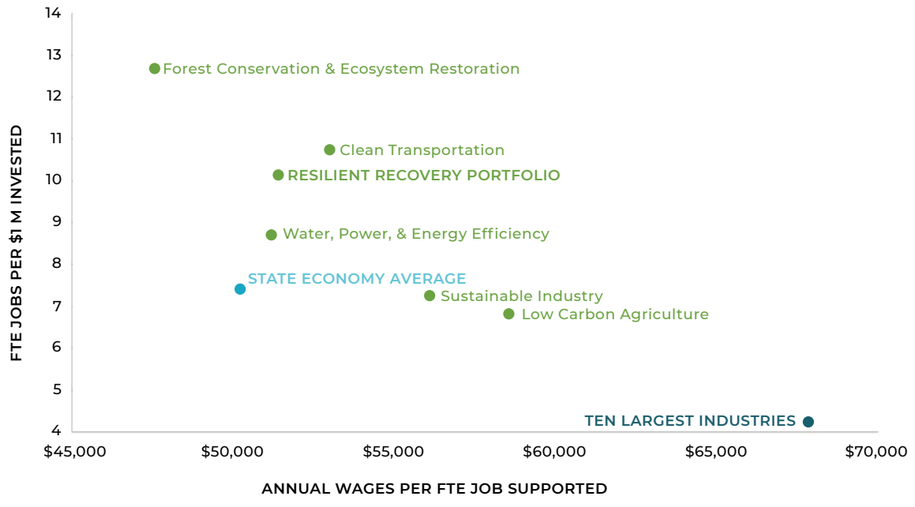
JOBS AND ECONOMIC BENEFITS

We find that every million dollars invested in the *Resilient Recovery Portfolio* creates 10.1 full-time-equivalent jobs, compared to 4.3 full-time-equivalent jobs created per million dollars invested in the state's largest industries. The investments also outperform the broader state economy benchmark, which supports 7.4 full-time-equivalent jobs per million dollars invested. This is because the *Resilient Recovery Portfolio* supports labor-intensive businesses that conduct most of their economic output and activities within the state's economy.

Across all 14 programs included in the portfolio, the job potential ranges from 6.4 to 15 full-time-equivalent jobs created per million dollars invested. The jobs supported by these investments are diverse and cut across many different industries and economic sectors, with particularly strong job creation in construction, support activities for agriculture and forestry, transit and ground transportation, and individual and family services. For example, we find that *Yakima Basin Ecosystem Restoration*, *Sound Transit Expansion*, *Wildfire Prevention and Preparedness*, *Urban and Community Forestry*, and *Low Carbon Buses and Trucks* provide the most robust job performance per dollar invested.

FIGURE 1.1 Job creation from the *Resilient Recovery Portfolio* compared to economy benchmarks

FIGURE 1.2 Job creation and earnings by investment program



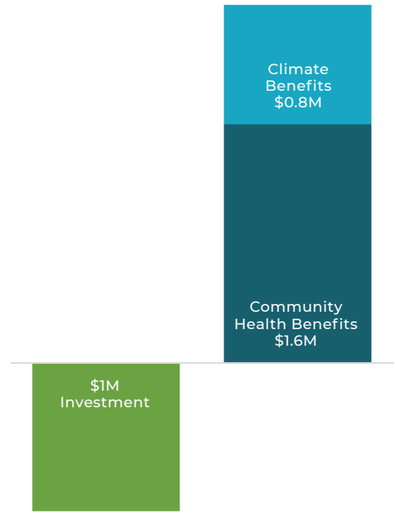
These investments support labor-intensive productive businesses in the state with $0.64 of each dollar invested supporting employee compensation, compared to $0.40 in the state's ten largest industries. They also provide robust broader economic value, both in terms of gross state product ($0.94 for every dollar spent versus $0.50 for the state's largest industries), as well as overall productive output ($1.75 for every dollar invested versus $1.59 for the state's largest industries). Jobs in the *Resilient Recovery Portfolio* average a wage and salary level of $51,400 per year. This is slightly higher than the broader state economy, although no investment programs in the portfolio match the average wage levels of the ten largest industries.

Every million dollars invested in the *Resilient Recovery Portfolio* creates 10.1 full-time-equivalent jobs, compared to 4.3 full-time-equivalent jobs created per million dollars invested in the state's largest industries.

COMMUNITY HEALTH AND CLIMATE BENEFITS

Beyond the job creation potential of the programs identified, the *Resilient Recovery Portfolio* also results in significant community health benefits through cleaner air. These investments work to improve the state's energy security by reducing the drain on the local economy from importing fossil fuels while removing damaging pollutants from the air we breathe. Every million dollars invested in the *Resilient Recovery Portfolio* offers $2.4 million in health and climate benefits, including $1.6 million in clean air benefits. The results are particularly accentuated by the projected impact of the *Wildfire Prevention and Preparedness* Program, which avoids over $12 million in health and climate damages for every million dollars spent.

FIGURE 1.3 Community Health and Climate Benefits from the *Resilient Recovery Portfolio*



Community health benefits are likely to be enduring and improve over time as Washington moves towards a net zero-emissions future. Sustaining and expanding these programs in order to meet the state's climate goals would unlock net health and climate benefits of $46 billion through 2050 while continuing demand for the types of jobs highlighted in this report.

NEXT STEPS & POLICY MAKING

We present findings throughout this report as comparative "multipliers," which normalize all benefits to a million dollar investment. To complement our findings, we offer two additional factors: investment scale and deployment speed (see Table 1.1). Investment scale refers to the size of funding required to exhaust available investment opportunities from the *Resilient Recovery Portfolio*, whereas deployment speed refers to the pace at which projects can be feasibly implemented to facilitate rapid employment.

This report and the *Resilient Recovery Portfolio* are intended to provide a data-driven starting point for discussions about recovery measures in Washington. IMPLAN does not provide a comprehensive picture of job quality, and that metric is, therefore, outside the scope of this study. We recommend additional analysis be conducted to carry these findings forward, emphasizing:

- Social justice, community engagement, and analysis of the distributional economic and health outcomes of selected recovery measures.
- Job quality, career advancement opportunities, local and diverse access, and other occupation-specific components of jobs supported.
- Expansion of the *Resilient Recovery Portfolio* to additional programs that have the potential to deliver community benefits at the nexus of quality job creation and community health.
- Potential contributions and compatibility of stimulus measures with Washington's long-term climate goals, and the net benefits of achieving those goals.
- Further work to bridge this portfolio to a workable policy, assess optimal investment scale, and identify possible financing mechanisms.

TABLE 1.1 Overview of Findings by Investment Area

INVESTMENT AREA	INVESTMENT SCALE	DEPLOYMENT SPEED	FTE JOBS/$M	HEALTH BENEFITS	CLIMATE BENEFITS
CLEAN TRANSPORTATION	$$$	MIXED	10.7	+++	+++
WATER, POWER, & ENERGY EFFICIENCY	$$$	MEDIUM TO FAST	8.7	+++	++
FOREST CONSERVATION & ECOSYSTEM RESTORATION	$$$	FAST	12.7	+++	+++
LOW CARBON AGRICULTURE	$$$	MEDIUM	6.8	NOT QUANTIFIED	+++
SUSTAINABLE INDUSTRY	$$$	MEDIUM	7.1	++	+++

INVESTMENT SCALE *Lower opportunity* ($) | *Medium opportunity* ($$) | *Higher opportunity* ($$$)
DEPLOYMENT SPEED *Within 2 years* (Fast) | *Within 5 years* (Medium) | *5+ years* (Slow)
HEALTH AND CLIMATE BENEFITS *Low* (+) | *Medium* (++) | *High* (+++)

Yakima Basin Ecosystem Restoration, Sound Transit Expansion, Wildfire Prevention and Preparedness, Urban and Community Forestry, and *Low Carbon Buses and Trucks* provide the most robust job performance per dollar invested. **(A)** Yakima River Canyon, Bureau of Land Management **(B)** Light rail track near Tukwila, Washington, Oran Viriyincy **(C)** USDA employees in Gifford Pinchot National Forest, Kristen Chadwick **(D)** A student tour of Seattle parks, Seattle Parks **(E)** C-Tran hybrid bus serving Clark County, Steve Morgan

CONCLUSION

This report and the *Resilient Recovery Portfolio* addresses the dual challenges exacerbated by the COVID-19 pandemic: economic recovery and community health. The job creation potential and investment returns through the local economy are compelling, firmly outpacing both the largest industries in the state and economy-wide benchmarks. These programs also collectively offer a positive return on investment in clean air benefits and avoided climate damages.

This type of jobs portfolio and investment mindset can kick-start both short-term and long-term job growth, shared economic prosperity, and cleaner air. By developing and investing with this type of approach, Washington can lead the transformation America needs to recover from the current crisis and build a healthier, more resilient future.

II. INTRODUCTION

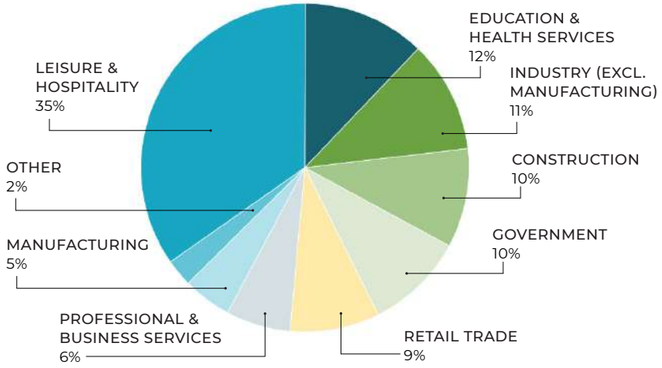
EMPLOYMENT AND EQUITY IN THE COVID-19 CONTEXT

The COVID-19 public health and economic crises have left American families, businesses, and institutions financially vulnerable and uncertain about the future. The federal unemployment rate peaked at 14.7 percent in April, with more than 20 million Americans out of work — a number unprecedented since the Great Depression.[4] While May unemployment numbers indicated the potential start of economic recovery, with the net unemployment rate falling to 13.3 percent, the Federal Reserve projects that unemployment will stay between nine and ten percent by the end of 2020 and remain high for the next few years.[5] Other forecast models aren't as optimistic, projecting the U.S. unemployment rate to persist upward to 20 percent by January of 2021.[6]

Black, Indigenous and People of Color (BIPOC) across the U.S., who already face systemic challenges to employment, have yet to see employment rates bounce back. While the unemployment rate of White workers fell to 12.4 percent, Black unemployment continued to rise, hitting 16.8 percent, and Asian unemployment increased to 15 percent in May.[7] Despite unemployment rates falling from 18.9 to 17.6 percent between April and May, Latinx unemployment remains the highest among all racial and ethnic groups.

Furthermore, Black and Latinx workers are more likely to have jobs in service industries, which were hit first and worst by stay-at-home measures. At the same time, those who haven't lost their jobs are more likely to be working on the frontlines in essential services, increasing exposure to COVID-19 and risking their health to earn a living — often without paid sick days or health insurance.[8] Black workers make up 17 percent of frontline jobs, despite making up just under 12 percent of the labor force.[9] Yakima County, with an agriculture and food processing workforce made up largely of People of Color, has the highest rate of COVID-19 cases and deaths per capita in Washington State as of June 2020.[10,11]

FIGURE 2.1 Washington Job Losses by Industry Sector[12]



The burden of job losses and resulting financial hardship has therefore clearly fallen disproportionately on BIPOC communities. These disparities also impact energy security. Among the 37 million households struggling to pay their energy bills nationally, over 60 percent of Native American households, 50 percent of Black households, and 40 percent of Latinx households experience some level of energy insecurity.[13] Washington State has not been immune to these employment and health disparities. Since the beginning of the pandemic, BIPOC workers have filed a disproportionate share of unemployment claims.[14]

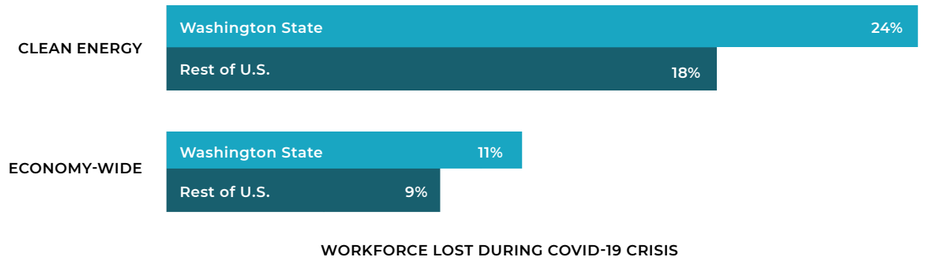
Statewide, unemployment skyrocketed to a record-high of 16.3 percent in April 2020, after hitting a record low in February 2020, with more than 1.1 million workers filing for unemployment benefits or related assistance.[15] Leisure and Hospitality, Education & Health Services, and Construction have experienced the largest volume of job losses.[16]

CLEAN ENERGY EMPLOYMENT AND JOB LOSSES

Despite growth well above statewide trends in recent years, Washington's clean energy industries have also been hit hard. Energy efficiency, renewable energy, clean vehicles, clean fuels, and grid and storage employed more than 85,000 workers in Washington prior to the COVID-19 crisis, compared to 7,300 employees in the fossil fuel industry.[17] In just three months, more than 21,200 clean energy workers lost their jobs, constituting 24 percent of the state's clean energy workforce. Thousands more were furloughed or underemployed. King County has been particularly hard hit, with more than 7,600 clean energy workers unemployed through May, the second highest level of clean energy job loss of any county in the nation.[18]

The experience of clean energy industries in Washington aligns with national trends. More than 620,000 clean energy workers have lost their jobs, which constitutes 18 percent of the industry's workforce.[19] In Washington, 70 percent of pre-COVID clean energy workers were employed by businesses with fewer than 20 employees.[20] These small firms are less resistant to financial shocks than larger counterparts and are disproportionately impacted by the slowdown in commerce.[21]

FIGURE 2.2 Job Loss in Washington vs Rest of United States



4 | U.S. Bureau of Labor Statistics, May 2020. https://www.bls.gov/news.release/pdf/empsit.pdf
5 | U.S. Federal Reserve Board. "Economic Projections for Monetary Policy, June 2020." t.ly/X1LV
6 | Trading Economics, 2020. https://tradingeconomics.com/united-states/unemployment-rate
7 | Elise Gould, Valerie Wilson, 2020. https://www.epi.org/publication/black-workers-covid/
8 | Center for Economic Policy Research. https://cepr.net/a-basic-demographic-profile-of-workers-in-frontline-industries
9 | Elise Gould, Valerie Wilson, 2020. https://www.epi.org/publication/black-workers-covid/
10 | The New York Times, 2020. "Coronavirus in the U.S.: Latest Map and Case Count." t.ly/Np09
11 | Yakima Health District, 2020. COVID-19 Data Summary. https://www.yakimacounty.us/2404/Data-Summary
12 | "Industry" includes Wholesale Trade, Transportation, Warehousing & Utilities, and Mining & Logging, and "Other" includes Other Services, Financial Activities, and Information determined by the Bureau of Labor Statistics.
13 | U.S. Energy Information Agency, 2018. https://www.eia.gov/todayinenergy/detail.php?id=37072
14 | Washington State Employment Security Department, 2020. "Initial claims demographics report." t.ly/P5qU
15 | Bureau of Labor Statistics, 2020. https://www.bls.gov/web/laus/lauhsthl.htm
16 | Washington State Employment Security Department. "Monthly Employment Report for May 2020." t.ly/Xue2
17 | A majority of Washington clean energy jobs are in the energy efficiency sector, which particularly features electricians and construction workers, sales and marketing associates, and technicians. E2, April 2020. "Clean Jobs America 2020." https://e2.org/reports/clean-jobs-america-2020/
18 | E2, 2020, "May 2020 Unemployment Analysis." https://e2.org/reports/clean-jobs-covid-economic-crisis-may-2020/
19 | E2. "May 2020 Unemployment Analysis." https://e2.org/reports/clean-jobs-covid-economic-crisis-may-2020/
20 | E2, 2019. "Clean Jobs Washington." https://e2.org/reports/clean-jobs-washington-2019/
21 | E2, April 2020. "Clean Jobs America 2020." https://e2.org/reports/clean-jobs-america-2020/

Pike Place Market at sunset. Photo: Cherly Boyd

BUILDING BACK BETTER

The economic and public health crises have increased the sense of urgency to invest in a way that promotes job-centric industries and delivers positive health outcomes.[22] Research has demonstrated a substantive connection between air pollution hotspots, BIPOC communities, and high mortality and infection rates of COVID-19.[23,24] On top of high unemployment rates and energy insecurity burdens, BIPOC communities face an inequitable public health reality stemming from decades of structural racism through the built environment and the disproportionate zoning of polluting industries and activities.[25]

Existing literature on economic recovery strategies can help inform this unique moment. According to a global survey of economic experts, clean physical infrastructure investment, efficiency spending for existing buildings, education and training programs, natural capital investments for ecosystem resilience and regeneration, and clean R&D spending rank as top-performing recovery measures from COVID-19.[26] The co-benefits of these investments are cited as key drivers of long-term economic benefits, including reduced waste, reduced congestion and inefficiencies, improved health outcomes, preserved biodiversity, and ecosystem sustainability.[27]

In the U.S., the Rocky Mountain Institute identifies building retrofit programs, transportation expansion and electrification, sustainability-tied debt forgiveness, and new finance mechanisms for clean energy and transportation as key programs for an adequate and equitable federal recovery strategy. For example, a national low-carbon financing bank capitalized at $5 billion would create 388,000 jobs and reduce energy costs for nearly 800,000 homes. However, the success of these programs hinges on how policymakers prioritize job creation potential, cleaner air, and economic, energy, and climate resilience.[28]

The American Recovery and Reinvestment Act of 2009 (ARRA), the largest single investment in clean energy in U.S. history,[29] provides key lessons for utilizing clean energy and ecosystem restoration investments as tools for efficient economic recovery. Investments enabled by the ARRA laid the groundwork for unprecedented growth in clean energy and energy efficiency in the decade following.[30,31]

22 | Mikael Andersen, 2017. https://www.sciencedirect.com/science/article/pii/S1470160X17301693

23 | The COVID Tracking Project, June 2020. "The COVID Racial Data Tracker." https://covidtracking.com/race

24 | Xiao Wu et al., 2020. https://projects.iq.harvard.edu/files/covid-pm/files/pm_and_covid_mortality_med.pdf

25 | Esther Min et al., 2019. "Washington Environmental Health Disparities Map." t.ly/aqTc

26 | Jennifer Allan et al., 2020. https://www.smithschool.ox.ac.uk/publications/wpapers/workingpaper20-02.pdf

27 | Other top ranked "non-climate" measures for economic recovery include liquidity support for households and small and medium enterprises, healthcare

28 | Ben Holland et al., Rocky Mountain Institute, 2020. t.ly/xLgr

29 | The ARRA allocated more than $90 billion in clean energy investments and tax incentives, and leveraged an additional $150 billion in private and other non-federal capital for these investments.

30 | Executive Office of the President of the United States, 2016. t.ly/piZQ

31 | Solar electricity generation increased by more than 30 times between 2008 and 2016, adding workers at a pace 12 times faster than the overall economy, and wind generation more than tripled during that time period. The Department of Energy estimates that more than 1.6 million homes have benefitted from energy efficiency improvements between 2009 and 2015 as part of the Weatherization Assistance Program.

Notable investments and job creation from the American Recovery and Reinvestment Act of 2009 (ARRA):

> Clean energy-related programs supported 900,000 job-years between 2009 and 2015, and were some of the most cost-effective job creators across all ARRA measures.[32]

> Nearly $60 million for weatherizing homes in Washington was accessible within weeks, leading to money-saving improvements for 7,000 low-income homes and hundreds of new jobs.[33,34]

> Shovel-ready habitat restoration projects from $167 million in funding to NOAA created more than 1,400 jobs within 18 months of administering the projects.[35]

> Each dollar invested in public transit supported nearly twice as many jobs as each dollar invested in new roads. However, most states prioritized building new roads instead of repairing deteriorating infrastructure and building out public transit.[36] In Washington, 95 percent of flexible transportation funding was spent on highways and roads, as opposed to 0.3 percent spent on public transit and three percent spent on active transportation.[37]

A key element of ARRA clean energy-related investments was a focus on "shovel ready" projects, as 80 percent of all clean energy jobs created from ARRA investments occurred within the first three years of spending. Within weeks of funding, Washington State took advantage of the immediate job creation potential from the Weatherization Assistance Program (WAP), utilizing nearly $60 million for weatherizing 7,000 low-income homes to save homeowners money and create hundreds of jobs.

If anything, the ARRA has been criticized for excessive fiscal austerity, resulting in slower than necessary economic recovery.[38] However, early rescue packages to deal with COVID-19 fall-out have been much larger than the ARRA. The Coronavirus Aid, Relief and Emergency Security (CARES) Act provided Washington with more than $6 billion in funds for state and local governments, childcare and education, housing protection, and expanded unemployment benefits.[39] The U.S. Federal Reserve maintains a policy rate of 0 to 0.25 percent.[40] Real government bond rates in developed countries are near zero or negative, reflecting limited concerns at present about devaluation or default. These indicators point to greater 'fiscal space' for government borrowing and short-term public debt to inject the capital necessary for this recovery.[41]

Whether from further federal government packages or other revenue sources, Washington will soon need to implement rescue and recovery stimulus measures at a scale far beyond the ARRA and build a comprehensive vision for what a post-COVID Washington could look like.

This report places an analytical lens to these principles by modeling what a specific, instructive portfolio of clean jobs and healthy community investments would mean in terms of sustainable job creation and community well-being for recovery. How can we help Washingtonians restore their livelihoods, enjoy substantial public health and climate benefits, and collectively share the prosperity of building back better?

32 | Executive Office of the President of the United States, 2016. t.ly/piZQ

33 | Office of Governor Chris Gregoire, 2009. t.ly/2obg

34 | Office of Governor Chris Gregoire, 2010. t.ly/dKib

35 | P.E.T. Edwards, A.E. Sutton-Grier, G.E. Coyle, 2013. https://doi.org/10.1016/j.marpol.2012.05.020

36 | Smart Growth America, 2020. https://smartgrowthamerica.org/resources/learning-from-the-2009-recovery-act/

37 | Smart Growth America, 2011. https://smartgrowthamerica.org/app/legacy/documents/lessons-from-the-stimulus.pdf

38 | Josh Bivens, 2016. https://www.epi.org/publication/why-is-recovery-taking-so-long-and-who-is-to-blame/

39 | Office of Governor Jay Inslee, 2020. "Inslee statement on federal stimulus package." t.ly/roXD

40 | U.S. Federal Reserve Board, 2020. https://www.federalreserve.gov/monetarypolicy/openmarket.htm

41 | Jennifer Allan et al., 2020. https://www.smithschool.ox.ac.uk/publications/wpapers/workingpaper20-01.pdf

III. STUDY OVERVIEW

This report analyzes full-time-equivalent (FTE) jobs created, community health benefits, and climate outcomes from an investment portfolio of 18 projects across 14 program areas, as listed in Table 3.1.[42] Within the portfolio, seven projects pull from existing financial data on major programs proposed, planned, or underway across the state: *Wildfire Prevention and Preparedness*, *Sound Transit Expansion*, *Yakima Basin Ecosystem Restoration*, *High-Speed Rail*, *Electric Ferries*, and *Low Carbon Freight Operations* sub-projects for Sustainable Industrial Manufacturing Zones (SIMZ) and Rail-Bed Replacement. Programs lacking available in-state financial documentation were approximated using data from the UCLA Luskin Center for Innovation and National Renewable Energy Laboratory with Washington-specific adjustments.[43] This study consists of three stages:

1 | All 18 projects were deconstructed into line-item expenditures using available budgetary data and run through IMPLAN — an economic input-output model that maps the flow of economic activity between 546 sectors and institutions in the state of Washington. IMPLAN allows each dollar invested to ripple throughout the state economy and measures resulting employment, output, labor income, and fiscal impacts.[44]

2 | A cost-benefit model was constructed that compares the health and climate benefits of each investment to upfront costs. This was achieved using a combination of county-level air pollution databases, reduced-complexity models (RCMs) to calculate down-wind health impacts of air pollution, and project-specific literature on pollution reduction potential. Of 18 total projects, 14 have sufficient data to derive metric tons of CO_2 equivalent ($mtCO_2e$) reduced per million dollars invested, and 10 have sufficient data to derive statewide health benefits, in dollar terms, per million dollars invested.[45]

3 | To supplement our ground-up health and climate models, we conducted a top-down system analysis of health and climate benefits from deep decarbonization in Washington. Using recent literature from Energy and Environmental Economics (E3) and the Clean Energy Transition Institute, we derived a detailed decarbonization pathway and the approximate net energy system costs of achieving it. We applied air pollution data and RCMs from step two to this decarbonization scenario to derive cumulative health and climate outcomes in comparison to a business-as-usual projection of state emissions through 2050.

These investment programs were weighted and aggregated into a sample *Resilient Recovery Portfolio* with significant flexibility for adjustments and future iterations. Each program was assigned its respective share of the portfolio through a combined weighting of job impacts, community health outcomes, and climate benefits.[46]

This portfolio is not intended to prescribe a precise allocation for Washington policymakers but is instead designed to be illustrative of what this type of investment approach could achieve in Washington.

Not all projects initially examined made the cut for inclusion. For example, a program mirroring California's Clean Vehicle Rebate Program (CVRP) for electric vehicles was an outlier in terms of low jobs potential. It was excluded from the final portfolio on the grounds of being an insufficient stimulus measure.[47]

42 | Jobs in this study are measured as full-time-equivalent (FTE) job-years, which are the equivalent of one person working full-time for one year. These are not permanent jobs and are tied to continued funding.

43 | Luskin Center for Innovation, 2018. "Employment Benefits from California Climate Investments and Co-Investments." t.ly/vwfh

44 | See the methodology section for details on the jobs impact methodology and IMPLAN.

45 | See the methodology section for details on the health and climate benefit multipliers.

46 | Jobs impacts were given a 50 percent weighting, of which 65 percent is tied to relative rank FTE job creations and 35 percent tied to relative rank in employee compensation. Community health multipliers and greenhouse gas reduction potential were given 25 percent weighting respectively. For more information on portfolio assembly, see the methodology section.

47 | The CVRP created only 1.2 FTEs per million dollars invested, largely due to the lack of any clean vehicle manufacturing in the state.

The 14 investment programs in the *Resilient Recovery Portfolio*, with denotations for where health and climate multipliers were constructed, are shown in Table 3.1.

TABLE 3.1 *Resilient Recovery Portfolio* Investment Programs

INVESTMENT AREA	INVESTMENT PROGRAMS	HEALTH BENEFIT DATA AVAILABLE?	CLIMATE BENEFIT DATA AVAILABLE?
CLEAN TRANSPORTATION	HIGH-SPEED RAIL	YES	YES
	LIGHT RAIL — SOUND TRANSIT EXPANSION FEDERAL WAY	YES	YES
	LOW CARBON BUSES & TRUCKS	YES	YES
	CLEAN VEHICLE PROGRAMS	YES	YES
	TRANSIT-ORIENTED COMMUNITY DEVELOPMENT	YES	YES
WATER, POWER, & ENERGY EFFICIENCY	HOME ENERGY EFFICIENCY & RENEWABLES	YES	YES
	100% CLEAN POWER READINESS		
	GRID RESILIENCY & OPTIMIZATION	NO	NO
	HYDRO EXPANSION & UPGRADES	YES	YES
	WATER-ENERGY PROGRAMS	NO	YES
FOREST CONSERVATION & ECOSYSTEM RESTORATION	WILDFIRE PREVENTION & PREPAREDNESS	YES	YES
	URBAN & COMMUNITY FORESTRY	NO	YES
	YAKIMA BASIN ECOSYSTEM RESTORATION	NO	NO
LOW CARBON AGRICULTURE	LOW CARBON AGRICULTURE		
	AGRICULTURE WATER EFFICIENCY	NO	YES
	DAIRY DIGESTERS	NO	YES
SUSTAINABLE INDUSTRY	ELECTRIC FERRIES	YES	YES
	LOW CARBON FREIGHT OPERATIONS		
	MULTI-SOURCE FACILITY PROJECTS	YES	YES
	SUSTAINABLE INDUSTRIAL MANUFACTURING ZONES	NO	NO
	RAIL-BED REPLACEMENT	NO	NO

CLEAN TRANSPORTATION INVESTMENTS

INVESTMENT SCALE: $$$
DEPLOYMENT SPEED: MIXED
FTE JOBS/$M: 10.7
HEALTH BENEFITS: +++
CLIMATE BENEFITS: +++

High-Speed Rail

The *High-Speed Rail Program* looks at existing proposals for Ultra-High-Speed Ground Transportation (UHSGT) in the Cascadia megaregion. The project, upon completion, would provide the ability to travel between Seattle, Portland, and Vancouver, B.C., in less than one hour per segment. The project is currently still in the "project initiation" phase (two to three years), requiring further project development (approximately three years) prior to construction and subsequent operation and maintenance.

Light Rail — Sound Transit Expansion Federal Way

The *Sound Transit Expansion* Program specifically looks at the ongoing extension of the existing light rail network to Federal Way from just south of Sea-Tac airport.[48] The Federal Way extension serves one of the most diverse corridors in the light rail system, including a high proportion of low-income and communities of color along the busy Interstate 5 corridor. This extension is currently scheduled to open in 2024 with three new stations in a 7.8 mile stretch of light rail. The concept and rationale for including this specific portion of light rail are to ensure that the timeline does not lapse, and if possible, to accelerate construction such that the Federal Way extension can open earlier than currently scheduled.

Low Carbon Buses and Trucks

The *Low Carbon Buses and Trucks* Program focuses on expanding low-emission and zero-emission heavy-duty vehicle use in Washington, particularly in public transit. This includes funding for transit agencies to establish new or expanded bus services, expanded intermodal transit facilities, vouchers for the purchase of hybrid and zero-emission trucks and buses, and competitive grants to truck and bus operators to replace or expand their fleets with commercially available vehicles in strategic hubs.

Clean Vehicle Program

The *Clean Vehicle Program* expands the adoption of zero-emission vehicles (ZEV) and low-emission vehicles (LEV) in the state. This includes funding to lending institutions, auto dealerships, community groups, and other organizations that help low-income individuals finance the cost of cleaner vehicles. The program also includes financial assistance for lower-income individuals who replace their vehicles with cleaner ones, new or used. In addition, this program provides funding for the establishment of plug-in hybrid vehicles (PHEVs) and ZEV car-sharing fleets and mobility options in disadvantaged communities.

Transit-Oriented Community Development

The *Transit-Oriented Community Development* Program provides grants and loans for development and land-use projects that increase the accessibility of affordable housing, employment centers, and key destinations via low-carbon transportation. This includes transit-oriented development of affordable housing and transportation-related infrastructure, as well as both urban and rural integrated connectivity projects that provide high-quality transit access to existing affordable housing.

48 | Sound Transit. "Federal Way Link Extension." t.ly/xALP

WATER, POWER, AND ENERGY EFFICIENCY INVESTMENTS

INVESTMENT SCALE: $$$
DEPLOYMENT SPEED: MEDIUM TO FAST
FTE JOBS/$M: 8.7
HEALTH BENEFITS: +++
CLIMATE BENEFITS: ++

Water-Energy Program

The *Water-Energy Program* provides funding for local governments and organizations to implement water efficiency projects that reduce water use, energy use, and greenhouse gas emissions for residential, commercial, and institutional consumers. The program also funds consumer-facing rebate programs to reduce cost barriers for efficient household appliances, bathroom fixtures, and commercial and institutional cooking equipment.

Home Energy Efficiency and Renewables

The *Home Energy Efficiency and Renewables* Program provides weatherization, energy efficiency, and localized renewable energy installations for single and multi-family homes. Efficiency and weatherization improvements include weather stripping, insulation, caulking, water heater blankets, fixing or replacing windows, refrigerator replacement, water heater repair/replacement, heating and cooling system repair/replacement, and solar water heater installation. The program also provides low-income households and large apartment buildings with solar photovoltaic (PV) systems to lower cost barriers to adopting renewable solar energy, using a barn-raising model to give volunteers and job trainees hands-on experience which can be used to help start careers in the solar industry.

100% Clean Power Readiness

With the legislated Clean Energy Transformation Act of 2019 (CETA), each utility in the state must transition off of coal power by 2025, move to net carbon neutral electricity by 2030, and reach carbon-free without offsets by 2045 as long as certain cost constraints are not exceeded.[49] While not exhaustive, these sub-projects are envisioned as part of the enabling environment to ensure the CETA goalposts can be reached:

Grid Resiliency and Optimization

The Grid Resiliency and Optimization Project provides expanded transmission lines, battery storage, and microgrid funding to improve the connectivity and resilience of the state's electricity grid. This project solely focuses on capital costs of building new grid infrastructure, rather than future operation and maintenance costs.

Hydro Expansion and Upgrades

The Hydro Expansion and Upgrades Project provides funding for new high-efficiency turbines to replace or add to existing capacity at Washington's hydroelectric generating plants. This includes the purchase of new turbines, engineering and scoping services, as well as construction and installation of the new turbines and associated grid infrastructure.

49 | Washington State Department of Commerce, 2019. "Clean Energy Transformation Act (CETA)." T.ly/XK5Q

FOREST CONSERVATION AND ECOSYSTEM RESTORATION

INVESTMENT SCALE: $$$
DEPLOYMENT SPEED: FAST
FTE JOBS/$M: 12.7
HEALTH BENEFITS: +++
CLIMATE BENEFITS: +++

Wildfire Prevention and Preparedness

The *Wildfire Prevention and Preparedness Program* provides funding towards the Department of Natural Resources' 20-year strategic plan for wildfire preparedness and prevention, and has been requested through proposed House Bill 2413. The plan includes the following major program buckets by share of funding: Staffing and Aircraft for Fire Preparedness (39 percent), Treating Unhealthy Forests (22 percent), Local Fire Service Capacity and Fire Prevention (18 percent), Resilient Communities and Landscapes (16 percent), Landscape Risk Assessment (three percent), and Post-wildfire recovery (two percent).

Yakima Basin Ecosystem Restoration

The *Yakima Basin Integrated Plan* is a 30-year water restoration and conservation plan for the Yakima Basin watershed in central Washington.[50] The phased implementation plan includes significant state as well as leveraged federal funds among other sources. The following seven key elements are part of the plan: fish passage, fish habitat enhancement, modification of existing irrigation structures and operations, surface storage, groundwater storage, enhanced water conservation, and market-based water reallocation. This report focuses on the nearly $400 million in planned funding for 2020-2023, based on the Department of Ecology's 2018 Cost Estimate and Financing Plan.

Urban and Community Forestry

The *Urban and Community Forestry Program* provides funding for projects to optimize the benefits of green space in urban settings. This includes expanding urban forestry, implementing forward-thinking green infrastructure, reclaiming and restoring abandoned land, establishing new forestry management practices, and diverting dead urban trees from landfills to new wood products or biomass energy. The projects can be administered by local governments and nonprofits organizations.

LOW CARBON AGRICULTURE

INVESTMENT SCALE: $$$
DEPLOYMENT SPEED: MEDIUM
FTE JOBS/$M: 6.8
HEALTH BENEFITS: NOT QUANTIFIED
CLIMATE BENEFITS: +++

Agriculture Water Efficiency

The *Agriculture Water Efficiency Program* provides competitive grants to implement irrigation systems that save water and reduce greenhouse gas emissions. Qualified water-saving measures include micro-irrigation drip systems, irrigation sensors that are responsive to soil moisture and weather, energy-efficient pump replacement, fuel-switching to renewable sources, switching to lower pressure pumping systems, variable frequency drives, and improved irrigation scheduling.

Dairy Digesters

The *Dairy Digester Program* provides competitive grants to support projects that reduce methane emissions from dairy waste. Applicants can use funds to install new covered lagoon digesters, which funnel produced methane through a gas line to be burned to generate electricity or stored as a transportation fuel. The program also provides research and demonstration grants to examine scientific and technical methods to enhance the efficiency and economic viability of dairy digester technology.

50 | Washington State Department of Ecology. "Yakima River Basin Integrated Plan." t.ly/NmuB

SUSTAINABLE INDUSTRY

INVESTMENT SCALE - $$$
DEPLOYMENT SPEED - MEDIUM
FTE JOBS/$M - 7.1
HEALTH BENEFITS - ++
CLIMATE BENEFITS - +++

Low Carbon Freight Operations

Multi-Source Facilities

The *Multi-Source Facilities* Project provides competitive grants that support the adoption of low-emission or zero-emission technologies at freight facilities with multiple sources of emissions. Eligible facilities include distribution centers, warehouses, ports, intermodal rail yards, or other similar freight support facilities. The project aims to accelerate the deployment of pre-commercial clean technologies and improve local air quality.

Sustainable Industrial Manufacturing Zones

The *Sustainable Industrial Manufacturing Zones (SIMZ)* Project funds areas zoned for light manufacturing supported by rail. Rail replaces heavy-duty truck transportation of goods. The budget is based on capital material and construction costs associated with buildings, new rail spurs, and associated infrastructure to transfer goods on and off of rail cars. It is supported by construction to connect the SIMZ with long haul rail.

Rail-Bed Replacement

The Rail-Bed Replacement Program provides funding for re-constructing existing rail lines to accommodate a wider array of train cars, top speeds, and both passenger and industrial freight transportation use. Funds are predominantly directed to construction and capital material costs associated with re-laying rock rail beds, fixing ditches, installing new ties, and installing new rails in order to improve the functionality of vintage rail. It takes advantage of existing rights of way and land ownership, which is a typical financial and administrative obstacle of new rail projects.

Electric Ferries

The *Electric Ferries Program* accelerates the first wave of Washington State ferry retirements to be replaced with hybrid-electric ferries and ferry terminal electrification. The ferries are contracted to be built locally by Vigor Shipyards. This report considers six new ferry builds and two conversions along with ferry terminal electrification projects currently scheduled through 2027, with the intent of accelerating the $1.5 billion budget to complete those builds earlier than scheduled.

SUMMARY-LEVEL OUTCOMES

This section of the report provides an overview of outcomes at the portfolio level and outlines how we constructed comparative benchmarks to the state's economy. Subsequent sections provide greater detail on inter-program and individual project findings.

ECONOMIC IMPACTS OF THE *RESILIENT RECOVERY PORTFOLIO*

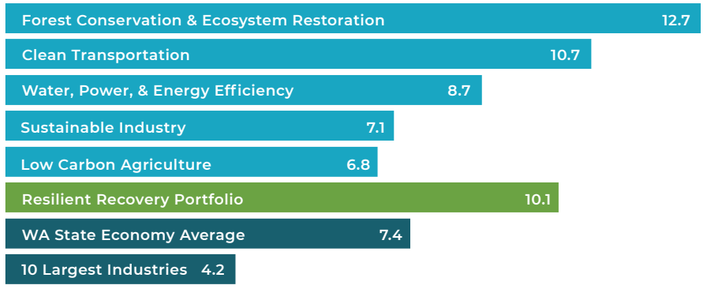
Overall Portfolio vs. Benchmarks

Every million dollars invested in the *Resilient Recovery Portfolio* supports 10.1 full-time equivalent (FTE) jobs either directly, indirectly, or induced. We report FTE jobs in order to normalize across industries that may have variable part-time or seasonal jobs.

To better understand these findings, we constructed benchmark investments into the Washington economy, both broadly and targeted at the state's ten largest industries. We did so by running a million-dollar "investment" which is treated in IMPLAN as a million dollar increase in industry output, across all 546 sectors available in Washington. By weighing these results by industry output size, we found that a diffuse million dollar investment across the state's entire economy would support 7.4 FTE jobs.

As a more targeted benchmark, we isolated the ten largest industries in Washington, which together generated 32 percent of the state's economic output in 2018.[51] Together, an output-weighted million dollar investment into these top ten industries supports 4.3 FTE jobs, which is less than half the job creation efficiency of the *Resilient Recovery Portfolio*. None of the ten largest industries generated as many jobs per million dollars as the *Resilient Recovery Portfolio*.

FIGURE 3.1 Comparison of FTE Jobs Created per Million Dollars Invested



WHAT ARE DIRECT, INDIRECT, AND INDUCED EFFECTS?

DIRECT EFFECTS are the result of direct payments to industries to carry out a given program (i.e., paying construction firms to build public transit).

INDIRECT EFFECTS are the result of how direct industries then subsequently pay money to other industries to conduct their business (i.e., a construction firm subsequently purchasing heavy-duty equipment for the project).

INDUCED EFFECTS are the result of how households spend new income across the economy (i.e., construction workers subsequently spend income on food, services, housing, and other non-work expenses).

51 | Industry size is defined as the sum of the industry's economic output in Washington State. In order of size, these industries are aircraft manufacturing, software publishing, other real estate, nonstore retailers, scientific research and development services, internet publishing and broadcasting, petroleum refineries, tenant-occupied housing, hospitals, and wireless telecommunications carriers.

The portfolio outcomes are somewhat sensitive to the relative share of funds directed to each program. We constructed multiple portfolios that individually prioritize FTE jobs, job wages, health benefits, and climate benefits (see Table 3.2). Isolating for each of these criteria widens the range of potential job creation from 8.3 FTE to 11.1 FTE jobs per million dollars invested, depending on whether wage levels or gross FTE jobs are prioritized. This partially inverse relationship between wage levels and scale of job creation is an expected outcome of input-output models like IMPLAN and does not necessarily capture fully the comprehensive wage and benefit characteristics of the occupations supported by these investments. However, it does suggest the need for policymakers to avoid designing a recovery strategy that maximizes job creation at the expense of sufficient job quality, or vice versa.

Additional portfolios that prioritized health benefits and greenhouse gas reductions respectively landed within the range of job creation established by the wage and job-focused portfolios. To construct the *Resilient Recovery Portfolio*, these four priorities were weighted and combined.

While not the focal point of our analysis, IMPLAN provides additional measures on Wage and Benefit levels, output multipliers, and value added to the state economy. The *Resilient Recovery Portfolio*:

> Results in $51,400 in average wages across all jobs supported, which is slightly above the statewide average of $50,200, although lower than the top ten industry average of $67,900 (as of 2018).

> Increases state economic output by $1.75 for every dollar invested, which outperforms both the broad economy ($1.73) and the ten largest industries ($1.59).[52]

> Provides $0.94 in value added for every dollar invested, which is nearly double that of the ten largest industries ($0.50).[53]

TABLE 3.2 IMPLAN Outcomes per Million Dollars Invested — Portfolio Comparison

ECONOMIC INDICATOR	RESILIENT RECOVERY PORTFOLIO	WAGES PORTFOLIO	FTE JOBS PORTFOLIO	HEALTH BENEFIT PORTFOLIO	CLIMATE BENEFIT PORTFOLIO
FULL-TIME EQUIVALENT (FTE)	**10.1**	8.3	11.1	9.5	9.3
WAGES PER FTE	**$51,400**	$55,800	$49,200	$52,500	$51,400
OUTPUT MULTIPLIER	**1.75**	1.71	1.81	1.65	1.73
EMPLOYEE COMPENSATION	**$644,000**	$668,000	$575,000	$628,000	$586,000
VALUE ADDED	**$942,000**	$839,000	$1,002,000	$915,000	$943,000

52 | Output is the total measure of all economic activity in a state. In IMPLAN, output is described as the total economic activity required across all industries in the region to satisfy a given level of final-use expenditures. (See t.ly/wBs5)

53 | Value Added is equivalent to gross state product. IMPLAN defines value added as "gross output (sales or receipts and other operating income, plus inventory change) minus intermediate inputs (consumption of goods and services purchased from other industries or imported)." (See t.ly/xgQb)

Job Creation and Economic Output by Industry

The impacts of investing in a *Resilient Recovery Portfolio* will be felt stronger in certain industries, with a smaller and more diffuse indirect and induced impact spread broadly across the economy at large.

The top ten industries for job creation, measured in FTE jobs, represent nearly 50 percent of all new jobs supported by the portfolio. Construction activities for new infrastructure are a significant portion, with industries ranging from shipbuilding to landscape and horticulture as well as service and state government jobs, including local passenger transit, rounding out the list.

TABLE 3.3 Top Ten Jobs Created per 100 Million Dollars Invested in *Resilient Recovery Portfolio*

INDUSTRY	FTE JOBS
Construction of other new nonresidential structures	101
Local government passenger transit	88
Support activities for agriculture & forestry	85
Employment & payroll of state government, other services	49
Individual & family services	41
Landscape & horticultural services	32
Construction of new power & communication structures	27
Construction of new multifamily residential structures	24
Maintenance & repair construction of nonresidential structures	23
Shipbuilding & repairing	21

The next ten are a wider array of industry types, including management consulting, architectural, engineering and related services, retail, restaurants, real estate, and civic organizations.

In terms of the amount of economic output resulting from each million dollars invested in the *Resilient Recovery Portfolio*, the top ten beneficiary industries account for just over one-third of all new economic output. There is substantial overlap with the top ten industries for job creation.

TABLE 3.4 Top Ten Industry Outputs per Million Dollars Invested in *Resilient Recovery Portfolio*

INDUSTRY	OUTPUT
Construction of other new nonresidential structures	$103,100
Petroleum refineries[54]	$76,100
Maintenance & repair construction of nonresidential structures	$66,800
Ship building & repairing	$64,600
Owner-occupied dwellings	$57,900
Employment & payroll of state governmet, other services	$54,600
Local government passenger transit	$54,000
Construction of new power & communication structures	$49,000
Support activities for agriculture & forestry	$44,700
Construction of new highways & streets	$36,200

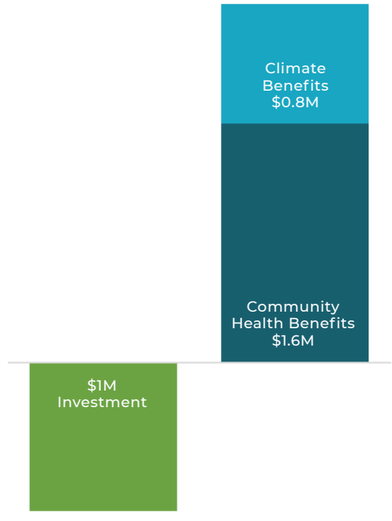
54 | The increase in output for petroleum refineries is due to limitations with the economic modeling. IMPLAN maps historical relationships between industries and doesn't reflect how technology changes over time. In the case of the *Low Carbon Buses and Trucks* Program, IMPLAN assumes that a strong increase in diesel fuel purchases is needed to meet the demand of an expanded transit system. However, were this program to fund hybrid or electric heavy-duty vehicles, rather than fuel-intensive internal combustion engines, these diesel fuel purchases would be significantly limited. Additionally, the reduced use of personal vehicles, and subsequently fossil fuel, is not captured in this study.

CLEAN AIR AND CLIMATE BENEFITS OF THE *RESILIENT RECOVERY PORTFOLIO*

In addition to jobs and broader economic gains, the co-benefits unlocked by these programs are critical to understanding their value. When weighted according to the *Resilient Recovery Portfolio*, we find that these 14 programs combined provide $2.4 million in health and climate benefits, including cleaner air resulting in $1.6 million in avoided losses associated with increased mortality, for every million dollars invested.[55] This is particularly influenced by the *Wildfire Prevention and Preparedness* Program, which avoids over $12 million in health and climate damages for every million dollars invested.

Beyond significant community health benefits, there are inherent benefits from reducing greenhouse gas emissions, reflected through the social cost of carbon. The economic value of avoided damages stemming from climate change incorporates impacts such as reduced agricultural production, damages from extreme weather events, and property loss.

FIGURE 3.2 Community Health and Climate Benefits from *Resilient Recovery Portfolio*



A conservative social cost of carbon estimate from the U.S. Interagency Working Group, adjusted to 2020 dollars, finds that avoided emissions have a societal benefit of $52 per metric ton of carbon dioxide.[56,57] This amounts to approximately one-third of total pollution benefits as calculated in this study, with the other two-thirds coming from cleaner air.

These portfolio-level benefits are despite four projects that lacked sufficient data and specificity to attribute meaningful community health results, even though the projects reduce pollution. Significant additional co-benefits beyond cleaner air, such as reduced traffic fatalities, reduced expenditures on fossil fuel imports, and increased active transportation, are not quantified. We therefore expect total co-benefit returns, in dollar terms, to be far higher than our analysis indicates.

Our study uses county-level pollution data where appropriate, but remains generalized to the state level. There is important local context that may increase or decrease these community health benefits when put in practice. Location and efficacy of the given program largely determines where and how pollution reductions occur, and who are the local or downwind beneficiaries. When these programs transition from hypothetical proof of concept to concrete, location-specific proposals, more granular community health analysis is essential for prioritizing and maximizing benefits on the ground. Subsequent sections of this report will discuss the potential clean air and climate benefits of each program.

55 | The statistical value of life (VSL) is an economic measure of mortality in dollar terms. We use a VSL of $9.4 million in our analysis, mirroring estimates used by the EPA adjusted to inflation.

56 | Interagency Working Group on Social Cost of Greenhouse Gases, 2016. t.ly/U4mo

57 | By comparison, other studies project the social cost of carbon as high as $417 per metric ton of carbon dioxide equivalent. This would result in climate benefits from these investments 8 times higher than reported in our model. https://www.nature.com/articles/s41558-018-0282-y.

IV. JOBS AND ECONOMIC IMPACT ANALYSIS

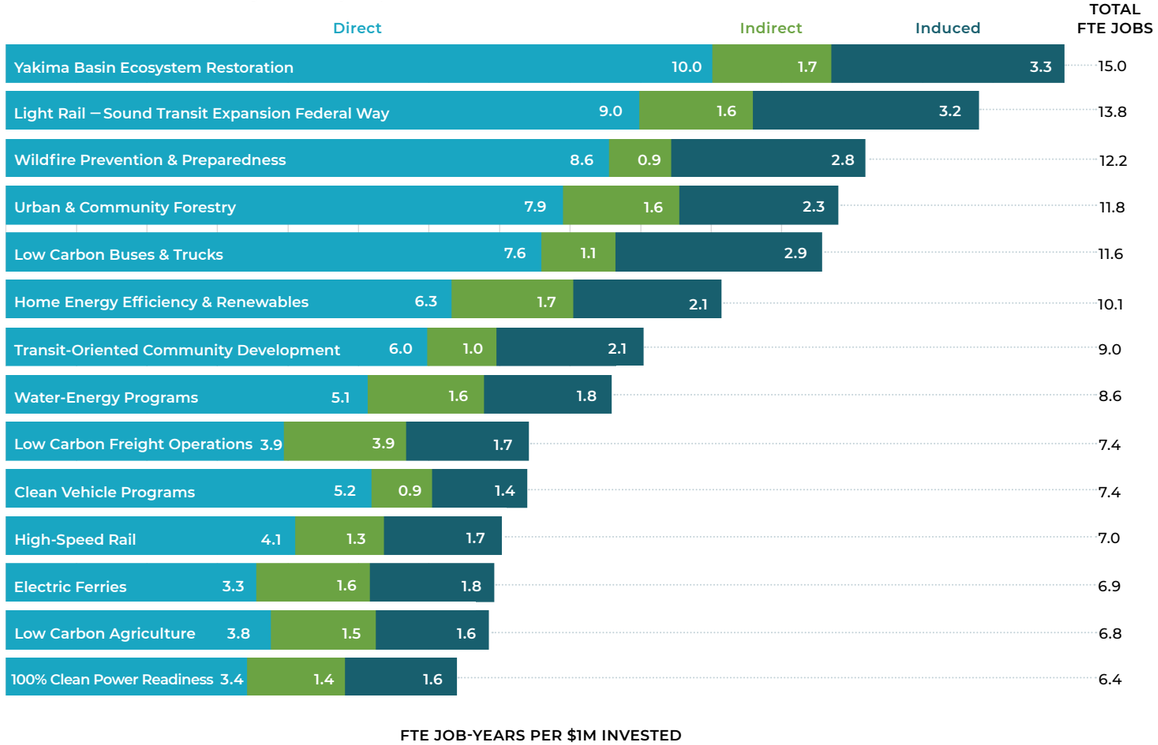
OVERVIEW OF JOBS MODELING APPROACH

Each program and sub-project in the *Resilient Recovery Portfolio* was deconstructed into line-item expenditures using available budgetary data and run through the 2018 Washington State IMPLAN package. IMPLAN maps the flow of economic activity between 546 sectors, with each dollar tracked throughout the state economy with resulting employment, output, labor income, and fiscal impacts estimates.

While economic input-output models provide meaningful insights into economy-wide employment and useful forecasting metrics, they are not without limitations. Industries in this model are constructed as single, snapshot-level relationships rather than time-sensitive and evolving. Investment impacts scale linearly without sensitivity to the magnitude of investment and the dataset used lacks geographic specificity to the location of investments, as well as additional metrics on job quality that are described elsewhere in this section.

A widely-used output from IMPLAN is the employment multiplier, often expressed as the number of job-years per million dollars spent. A job-year, due primarily to part-time or seasonal employment, is slightly less than a "full-time-equivalent" or FTE. Throughout this report, the term "FTE job" is used as a short-hand for full-time-equivalent job-years.

FIGURE 4.1 *Resilient Recovery Portfolio* jobs per million dollars of investment



JOB CREATION POTENTIAL

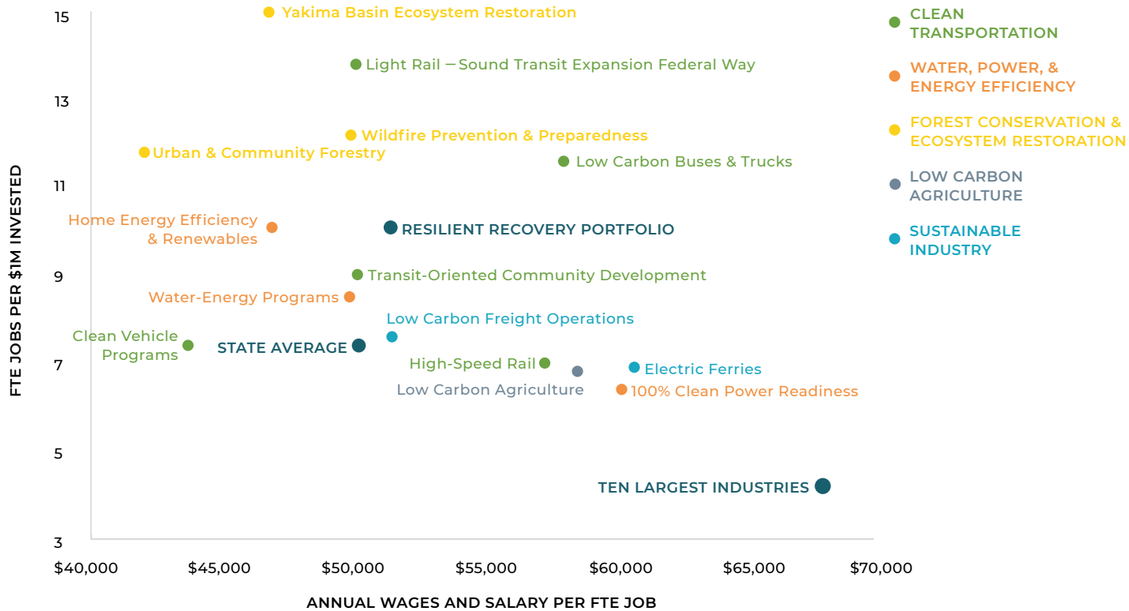
The 14 programs analyzed individually support between 6.4 and 15 FTE jobs per million dollars invested. The Yakima Basin Ecosystem Resilience Program (15 FTE jobs), *Sound Transit Expansion* (13.8 FTE jobs), and *Wildfire Prevention and Preparedness* Program (12.2 FTE jobs), are the most compelling job creators and are also shovel-ready for rapid deployment.

All programs in the *Resilient Recovery Portfolio* support more FTE jobs than the state's ten largest industries (4.3 FTE jobs). Out of 14 programs, ten match or outperform the economy-wide benchmark of 7.4 FTE jobs per million dollars invested. Programs that perform lower on FTE job creation tend to be manufacturing heavy (i.e., Sustainable Industry, *Electric Ferries*, *100% Clean Power Readiness*), or have large shares of direct inputs flowing to out-of-state purchases (*Clean Vehicle Programs*).

Average annual wages per FTE job supported across these programs ranges from $42,000 (*Urban and Community Forestry*) to $60,700 (*Electric Ferries*). Nine out of 14 programs provide wages higher than the economy-wide average ($50,200). All programs considered provide lower average wages than investing in the state's top ten industries ($67,900 per FTE job supported).

As observed in the construction of aggregate portfolios, IMPLAN suggests a partial inverse relationship between the scale of FTE job creation and wage levels. Holding other factors constant, an industry with lower wage levels supports more jobs per dollar of output than an industry with higher wage levels. However, the inverse relationship is only partial, due to the additional key factors influencing job creation by industry — namely labor-intensity (the proportion of industry output that is dedicated to paying for labor as opposed to capital costs) and leakage rates (the proportion of industry output that flows out of the state economy creating jobs elsewhere). Maximizing both job creation and job quality requires prioritizing industries that lead to greater labor intensity and lower leakage.

FIGURE 4.2 Jobs and Wage Projections of *Resilient Recovery* programs



BROAD ECONOMIC INDICATORS

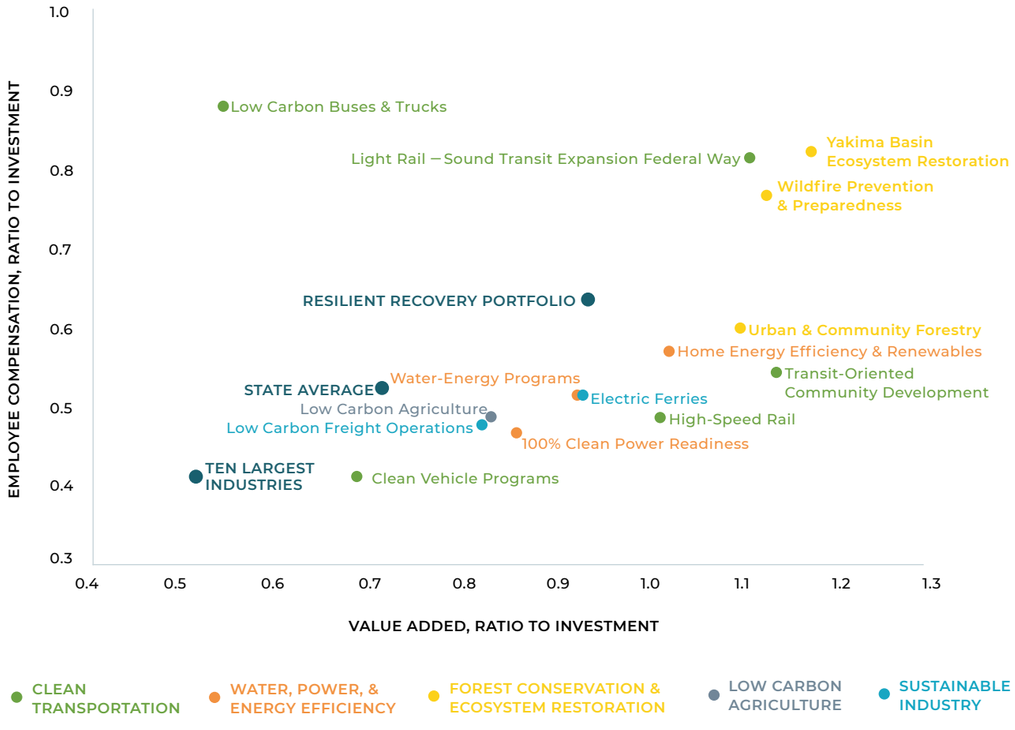
At a broader economy-wide level, the portfolio investments score well on two key metrics: the total value added per million dollars and share of employee compensation.

Value added is the sum of all aspects of industry output except for material production costs. This includes labor income (LI), other property income (OPI), and taxes on production and imports (TOPI).[58] Value added is also interchangeably described as gross domestic product (GDP), which is a standard measure of economic growth, and helps measure to what degree investment programs are prioritizing valuable industries to the in-state economy, as opposed to leakage-prone industries.

Employee compensation is the specific portion of value added that is directed to employee labor costs, including wages, benefits, and payroll taxes. This helps measure to what degree investment programs are prioritizing labor-intensive industries as opposed to capital-intensive industries.

All *Resilient Recovery Portfolio* programs are significantly above the value added rates from the ten largest industries, and all but two provide greater value added than the state average benchmark. Out of the 14 programs, 13 provide a greater share of money to employee compensation than the ten largest industries, while seven have higher employee compensation rates than the broader economy.

FIGURE 4.3 Valued Added and Employee Compensation Rates from *Resilient Recovery* programs



58 | For more information on IMPLAN's definition of value added, see t.ly/xgQb


View of downtown Spokane from Cliff Drive. Photo: J Dubman

Not every program scores strongly on every metric. Due in particular to the portion of funds sent to out-of-state car manufacturers, the *Clean Vehicle Program* performs relatively poorly on both employee compensation share and value added. The *Low Carbon Buses and Trucks* program provides exceptional job creation, wage levels, and employee compensation, but measures poorly on value added to the state economy.[59] Other shovel-ready labor-intensive programs, such as *Sound Transit*, *Wildfire Prevention and Preparedness*, and the *Yakima Basin Ecosystem Restoration* Program, all perform strongly on both employee compensation, and value added.

LIMITATIONS OF JOB ANALYSIS

Although our analysis is detailed and customized for each of the 14 programs, the analysis necessarily has limited application, summarized below.

JOB LONGEVITY, TIMING, AND LOCATION — We cannot say precisely when the jobs identified in this report are created, for how long those created jobs last, or where within the state they will be located. Those results depend on when stimulus measures are enacted and implemented, over what duration those stimulus measures occur, and where the activity occurs. Some programs involve small, rapidly-deployed projects (such as home energy efficiency measures), whereas others require spending for many years (such as large infrastructure projects like *High-Speed Rail*). A project's unique timeline and location will affect when, where, and for how long its supported jobs occur.

JOB QUALITY — While IMPLAN provides preliminary data on wages and benefits, comprehensive job quality is beyond its abilities. Actual wage levels and job quality vary widely within an industry depending on the occupation. Additional engagement, research, and policy considerations are necessary to ensure these programs have sufficient pay and benefits, training and career advancement opportunities, local and diverse access, and other key components of job quality.

Our study does quantify the in-state industries with the greatest employment impacts, so this data can be used as a springboard for robust analysis of the kind of occupations that are typically supported within these industries, as well as job quality metrics associated with these occupations. The challenge before policymakers is to actively support these occupations in a just manner using prevailing wages, local and diverse hiring requirements, and additional policies to ensure benefits reach those who need them most.

59 | In the IMPLAN model, a large portion of funds in the *Low Carbon Buses and Trucks* program are directed to local government passenger transit, which derives significant revenue from budgetary allocations rather than sales of products or services. As such, IMPLAN measures one component of value added from this institution — Other Property Income — as an exceptionally negative value which greatly reduces the total value added from the program.

V. COMMUNITY HEALTH AND CLIMATE BENEFIT ANALYSIS

AIR POLLUTION PRIMER

In the U.S., more than 100,000 people die each year from overexposure to airborne pollutants such as fine particulate matter ($PM_{2.5}$), at a societal cost of $886 billion per year.[60,61] Acute exposure to $PM_{2.5}$ can cause lung irritation and exacerbate pre-existing respiratory diseases. Chronic prolonged exposure to $PM_{2.5}$ and other air pollutants, such as nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOCs),[62] and ammonia (NH_3), can cause decreased lung function and other respiratory diseases, diabetes, hypertension and increased risk of heart attack or stroke, cancer, and premature death.

Children and infants are particularly vulnerable to air pollution, which can harm lung development. Exposure to air pollutants has consistently been linked to higher rates of asthma, which affects more than six million American children.[63] Prenatal exposure to air pollution can also impact fetal development and has been linked to low birth weight and premature birth, which further decreases lung function.[64]

In the U.S., communities of color and low-income communities bear the overwhelming burden of air pollution and its health impacts, despite contributing significantly less to air pollution emissions.[65] Black and Latinx Americans bear the burdens of pollution at a rate that is 60 percent higher on average, than their contribution to pollution; White Americans experience 17 percent less air pollution than what they produce.[66] Asthma "hotspots" around the country are most often found in communities of color, and Black children have a 250 percent higher hospitalization rate and 500 percent higher death rate from asthma compared to White children nationwide.[67] Analyzing the distributional impacts of pollution across geography, demographics, and socioeconomic status is therefore critical to a comprehensive understanding of air pollution and community health.[68]

The Puget Sound Clean Air Agency estimates that poor air quality causes around 1,100 deaths annually in Washington State.[69] Using current EPA estimates, these mortality damages exceed $10 billion per year.[70] Wildfire smoke is a notable contributor to compromised air quality across the state, emitting a wide range of compounds harmful to human health, including $PM_{2.5}$ and VOCs.[71] The U.S. Forest Service found that the most at-risk Washington cities from wildfire damages are located in Central and Eastern Washington, and that $PM_{2.5}$ concentrations reach "very unhealthy" levels in many sites.[72,73] As Washington continues to feel the impacts of global climate change, more frequent and larger fires pose greater health risks to Washingtonians.[74]

RELATION TO COVID-19 INFECTION AND MORTALITY RATES

The definitive link between air pollution and higher mortality rates from respiratory illnesses has been known for decades. As with the Severe Acute Respiratory Syndrome (SARS) outbreak,[75] research has shown that individuals suffering from pre-existing conditions caused by air pollution, including asthma, diabetes, and heart disease, are the most at risk of fatality from COVID-19. Researchers from the Harvard T.H. Chan School of Public Health quantified this relationship, citing that a one microgram per cubic meter increase in long-term exposure to $PM_{2.5}$ leads to an eight percent increase in the COVID-19 death rate.[76,77] The study also notes that African Americans are more likely than other racial and ethnic groups to live in counties with elevated levels of $PM_{2.5}$.

Approximately 1,300 Washingtonians have died from COVID-19 between February and June 2020.[78] Many of these deaths have been concentrated in communities identified as the most overburdened by environmental risks.[79,80] Latinx individuals constitute 44 percent of total confirmed cases and 28 percent of hospitalizations in the state, despite constituting only 13 percent of the state's population.[81] Yakima County, for example, where 46 percent of the population is Latinx and one-fifth of all residents live in poverty, has the highest COVID-19 cases and deaths per capita in the state, approaching the infection rate of New York City.[82,83]

Cleaner air is crucial when it comes to the world's ability to respond better to future public health crises and alleviate the pollution burden on vulnerable communities. The *Resilient Recovery Portfolio* demonstrates that prioritizing investments to stimulate job creation can also support these goals and result in healthier communities.

60 | "$PM_{2.5}$" is any floating particle or droplet under 2.5 microns in width, which is small enough to penetrate the lungs and enter the bloodstream.

61 | Andrew Goodkind et al., 2019. https://www.pnas.org/content/116/18/8775.short

62 | Ground-level ozone, commonly known as "smog", is created by chemical reactions between NO_x, VOCs and sunlight. Exposure to ground-level ozone can trigger asthma attacks and other respiratory issues by irritating lungs and airways.

63 | Allison Burbank, David Peden, 2018. https://dx.doi.org/10.1097%2FACI.0000000000000422

64 | Xiaoli Sun et al., 2016. https://doi.org/10.1016/j.envpol.2015.12.022

65 | Robert Brulle, David Pellow, 2006. https://doi.org/10.1146/annurev.publhealth.27.021405.102124

66 | Christopher Tessum et al., 2019. https://doi.org/10.1073/pnas.1818859116

67 | Lara Akinbami, Center for Disease Control, 2006. https://www.cdc.gov/nchs/data/ad/ad381.pdf

68 | Esther Min et al., 2019. "Washington Environmental Health Disparities Map." t.ly/aqTc

69 | Puget Sound Clean Air Agency. "Air Pollution and Your Health." https://pscleanair.gov/161/Air-Pollution-Your-Health

70 | The statistical value of life (VSL) is an economic measure of mortality in dollar terms that governments use for cost-benefit analysis purposes. We use a VSL of $9.4 million in our analysis, mirroring estimates used by the EPA adjusted to inflation.

71 | EPA, 2017. "National Emissions Inventory." https://www.epa.gov/air-emissions-inventories/

72 | USDA Forest Service — Region 6, 2018. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd611322.pdf

73 | Daily average U.S. $PM_{2.5}$ Air Quality Index readings above 150 units are considered "very unhealthy." Readings between 101-150 units are "unhealthy for sensitive groups" including young children and older adults.

74 | Jessica Halofsky, David Peterson, Brian Harvery, 2020. https://link.springer.com/article/10.1186/s42408-019-0062-8

75 | Cui, Y., Zhang, Z., Froines, J. et al, 2003. https://doi.org/10.1186/1476-069X-2-15

76 | Xiao Wu et al., 2020. "Exposure to air pollution and COVID-19 mortality in the United States." t.ly/oLm5

77 | The United States Environmental Protection Agency established the National Ambient Air Quality Standards to improve air quality and public health. The long-term standard (annual average) for a "safe" level of exposure to $PM_{2.5}$ is 12 micrograms per cubic meter, however even this level can cause lung and eye irritation. t.ly/6kwm

78 | Washington State Department of Health, 2020. "COVID-19 Data Dashboard."

79 | Esther Min et al., 2019. "Washington Environmental Health Disparities Map." t.ly/aqTc

80 | The hardest hit counties in Washington State are located in Eastern and Central regions of the state, where wildfire smoke is most damaging to air quality and public health. The Washington State Department of Natural Resources is predicting the state will have the worst wildfire season in the country, which could worsen COVID-19 health outcomes.

81 | Washington State Department of Health, 2020. "Novel Coronavirus Outbreak 2020 (COVID-19)."

82 | As of June 2020. https://datausa.io/profile/geo/yakima-wa/#

83 | Danny Westneat, Seattle Times, June 17, 2020. https://www.seattletimes.com/seattle-news/westneat-17/

COMMUNITY HEALTH MODELING APPROACH

To evaluate the community health and climate benefits of the *Resilient Recovery Portfolio*, we constructed a custom health and climate benefit calculator for each project based on available pollution databases and project-specific literature. Of 18 total projects, ten had sufficient data to derive statewide health benefits from the investment, and 14 had sufficient data to derive climate benefits. Our conceptual modeling approach follows five steps:

1 | Using the EPA's National Emissions Inventory (NEI), we extracted annual levels of local pollutants ($PM_{2.5}$, SO_2, NO_x, VOCs, and NH_3) emitted across 36 different activity sources at the state and county level in Washington.[84]

2 | Using reduced-complexity models (RCMs), we calculated pollutant-specific, geographically sensitive annual health damages, in dollar terms, associated with each pollutant from each activity source in Washington.[85]

3 | Using Washington greenhouse gas inventory data, we aggregated and mapped the health damages from each activity source to specific types of fossil fuel usage and/or greenhouse gas inventory emissions (i.e., light-duty vehicle gasoline, heavy-duty vehicle diesel, home natural gas heating, etc.).

4 | Using project-specific literature and quantification tools, we derived the expected reduction in fossil fuel use and/or greenhouse gases per million dollars spent on each project, which were then converted to potential health benefits, in dollar terms, using the public health estimates by emissions source outlined above.[86]

5 | Using a modest $52 per metric ton CO_2e estimate of the social cost of carbon, we converted greenhouse gas reductions to a dollar estimate of avoided climate damages per million dollars invested.

These steps allowed us to estimate both the potential community health benefits and climate benefits from any program where greenhouse gas or fuel reduction estimates per dollar invested are available. However, this is a screening tool, not a comprehensive environmental impact analysis. Community health outcomes are highly dependent on the local context, and require intense modeling exercises that closely examine geographic proximity, seasonal and daily intensity of pollution sources, demographics, and other complex interactions between humans and the built and natural environment. A majority of programs considered in the *Resilient Recovery Portfolio* are hypothetical and lack the concrete data necessary for such analysis.

COMMUNITY HEALTH AND CLIMATE BENEFITS

The value of avoided air pollution deaths in Washington State from programs in the *Resilient Recovery Portfolio* ranges from $9,000 to $9 million per million dollars invested in each program. Once avoided climate damages are included, total health and climate benefits from these programs jump to between $20,000 and $12.6 million, as shown in Table 5.1. We find that programs in the *Resilient Recovery Portfolio* provide an average of $2.4 million in health and climate benefits for every million dollars invested.

84 | U.S. Environmental Protection Agency. "2017 National Emissions Inventory (NEI)." t.ly/6oFp

85 | Reduced Complexity Models are commonly used tools to screen for health impacts from air pollution. They use geographic data on population density, wind patterns, and point source behavior to estimate the mortality impacts from air pollution. For more details on the RCMs used in this study, see CACES.us.

86 | Some programs, such as the *Wildfire Prevention and Preparedness* Program, required alternate methods to appropriately derive health benefits (see Methodology section).

TABLE 5.1 Program-Level Health and Climate Benefits per Million Dollars Invested

INVESTMENT AREA	INVESTMENT PROGRAMS	AVOIDED GHG EMISSIONS, $MTCO_2E$	CLIMATE BENEFITS**	COMMUNITY HEALTH BENEFITS	TOTAL CO-BENEFITS
CLEAN TRANSPORTATION	HIGH-SPEED RAIL	180	$9,400	$17,800	$27,200
	LIGHT RAIL — SOUND TRANSIT EXPANSION FEDERAL WAY	130	$6,900	$12,900	$19,800
	LOW CARBON BUSES & TRUCKS	1,530	$79,200	$121,300	$200,500
	CLEAN VEHICLE PROGRAMS	710	$36,700	$69,000	$105,700
	TRANSIT-ORIENTED COMMUNITY DEVELOPMENT	490	$25,500	$48,000	$73,500
WATER, POWER, & ENERGY EFFICIENCY	HOME ENERGY EFFICIENCY & RENEWABLES	2,420	$125,900	$49,000	$174,800
	100% CLEAN POWER READINESS				
	GRID RESILIENCY & OPTIMIZATION*	—	—	—	—
	HYDRO EXPANSION & UPGRADES	770	$40,000	$9,000	$49,000
	WATER-ENERGY PROGRAMS*	9,190	$477,100	—	$477,100
FOREST CONSERVATION & ECOSYSTEM RESTORATION	WILDFIRE PREVENTION & PREPAREDNESS	70,040	$3,637,500	$9,000,000	$12,637,500
	URBAN & COMMUNITY FORESTRY*	4,760	$247,000	—	$247,000
	YAKIMA BASIN ECOSYSTEM RESTORATION*	—	—	—	—
LOW CARBON AGRICULTURE	LOW CARBON AGRICULTURE				
	AGRICULTURE WATER EFFICIENCY*	7,320	$380,300	—	$380,300
	DAIRY DIGESTERS*	39,920	$2,073,100	—	$2,073,100
SUSTAINABLE INDUSTRY	ELECTRIC FERRIES	2,310	$105,300	$677,500	$782,800
	LOW CARBON FREIGHT OPERATIONS				
	MULTI-SOURCE FACILITY PROJECTS	130	$6,600	$32,800	$39,500
	SUSTAINABLE INDUSTRIAL MANUFACTURING ZONES*	—	—	—	—
	RAIL-BED REPLACEMENT*	—	—	—	—

**Denotes programs where health benefits were not quantified due to insufficient data.*
***Climate benefits are evaluated using a social cost of carbon estimate of $52/metric ton CO_2e. Benefits are undiscounted.*

The community health and climate results vary widely depending on how efficiently a dollar spent translates to reduced greenhouse gas and fossil fuel use, as well as the point source of emissions they diminish. In particular, the *Wildfire Prevention and Preparedness* program has the greatest return on investment, avoiding $12.6 million in wildfire damages from substantial amounts of greenhouse gas, $PM_{2.5}$ and VOC emissions prevented for every million dollars invested.

Due to high upfront capital costs, clean transportation programs generate community health benefits between approximately $20,000 (*Sound Transit Expansion*) and $200,000 (*Low Carbon Buses and Trucks*) for every million dollars invested through reduced gasoline and diesel consumption. Though they generate low health and climate benefits relative to the scale of investment, these programs score highly on job creation and create other substantial co-benefits such as reduced congestion, reduced traffic fatalities, increased economic development and lower transportation costs. For example, a 2019 study of the Transportation and Climate Initiative (TCI) by Cambridge Systematics finds that the health benefits of increased physical activity and avoided traffic injuries/fatalities from clean transportation investment were over 21 times greater, in dollar terms, than the health benefits from cleaner air.[87]

The *Electric Ferries* program has higher health benefits than all other sustainable industry programs, estimated at $782,000 per one million dollars invested, because of high $PM_{2.5}$ and NO_x damages associated with Washington's diesel-powered ferry system.[88]

There are four *Resilient Recovery Investment* programs that do not have sufficient data to make community health estimates but have quantifiable climate benefits from emissions reductions. The *Dairy Digesters* program, which would help to reduce methane emissions from agricultural practices, creates nearly $2.1 million in climate benefits for every million dollars invested in the program, second to the *Wildfire Prevention and Preparedness* program.[89] The remaining three programs create between $247,000 to $477,000 in climate benefits each.

CAVEATS TO COMMUNITY HEALTH AND CLIMATE ANALYSIS

Although our community health and climate analysis is custom-built for each program, it has limitations as summarized below:

GEOGRAPHIC SPECIFICITY — Many of the programs included in the portfolio lack concrete proposals that include geographic specificity. As noted above, comprehensively modeling the actual community health benefits of these programs requires far greater geographic detail than we have available. This methodology is meant to serve as an illustrative screening tool for the comparative co-benefit potential of these programs, rather than a prediction of final investment outcomes.

TIMING OF BENEFITS — Our methodology does not capture precisely when the community health and climate benefits from a given program will occur, which varies widely depending on the program. Some investments can be rapidly deployed and provide immediate clean air benefits, such as home energy efficiency and renewable energy projects. Other investments, such as high-speed rail construction, are part of a long-term transition that may take many years to fully complete, and accrue health benefits slowly over time. Health and climate benefits in our analysis are undiscounted, due to the various timelines of program deployment and project lifetimes.

87 | The Transportation and Climate Initiative (TCI) is a regional program under consideration on the east coast to reduce transportation emissions and fund public transit and clean vehicles. t.ly/M7zp

88 | Puget Sound Maritime Air Forum, 2018. "Puget Sound Maritime Air Emissions Inventory." t.ly/pDmu

89 | Due to data limitations, our analysis treats methane according to the Intergovernmental Panel on Climate Change's (IPCC) fourth assessment report (AR4), which finds that methane has a global warming potential (GWP) 25 times higher than that of carbon dioxide. The IPCC's fifth assessment report (AR5) finds that methane has a GWP 28 to 36 times higher than carbon dioxide over 100 years, meaning releasing one metric ton of methane is equivalent to releasing 28 to 36 metric tons of CO_2. Intergovernmental Panel on Climate Change, 2014. "Global Warming Potential Values." t.ly/05D2

NON-MORTALITY HEALTH BENEFITS — The reduced-complexity models we use to quantify health benefits are only able to quantify the health damages associated with mortality. While mortality constitutes the majority of quantifiable community health damages from air pollution, there are non-fatal health costs that this study does not capture, such as increased hospitalization, asthma incidence, and other healthcare costs associated with long-term lung and heart damage.

ADDITIONAL CO-BENEFITS — Our methodology does not consider additional co-benefits beyond cleaner air and climate, such as reduced traffic fatalities, reduced congestion, reduced expenditures on fossil fuel imports, increased active transportation, accelerated technological deployment, among others. Measuring these benefits is highly project-dependent and outside the scope of this study, but is an essential and potent aspect of comprehensive cost-benefit analysis when designing an investment strategy. As such, it is fair to assume the real net benefits of the investments in the *Resilient Recovery Portfolio* exceed what our study indicates.

LEVERAGED FUNDING NOT CONSIDERED — True cost-benefit analysis depends on the degree to which these programs leverage funds from federal, private, or other out-of-state sources, should they be implemented. For example, every state dollar invested in California Climate Investments leverages an additional $3.70.[90] Were the *Resilient Recovery Portfolio* programs to leverage this scale of funding from out-of-state sources, it would unlock community health and climate benefits of up to $11 million per million dollars invested by the state, as opposed to our current estimate of $2.4 million. This is particularly important when evaluating stimulus recovery measures, which may leverage significant funds from the federal government.[91]

SUSTAINED BENEFITS OF DEEP DECARBONIZATION

Washington State residents and leaders have repeatedly expressed ambition to tackle a deep reduction in carbon pollution. With the passage of House Bill 2311 during the 2020 legislative session, the state's emissions limits were updated to mandate a 45 percent reduction by 2030 and a 95 percent reduction by 2050, relative to 1990 levels.[92] The investments in the *Resilient Recovery Portfolio* represent programs that can help contribute to the deep infrastructural changes needed to meet these limits, as well as the requirements outlined in the Clean Energy Transformation Act, passed in 2019, which transitions the state to 100 percent carbon-free electricity by 2045.[93]

By combining existing research on deep decarbonization pathways and costs for Washington State with our clean air modeling methodology outlined above, we find billions of dollars in net benefits. Meeting Washington State's climate goals offers health and climate benefits that are nearly 90 percent of energy system costs through 2030 and 175 percent of energy system costs through 2050, equal to net benefits of $46 billion.

Failing to achieve net-zero carbon emissions by mid-century would be a huge missed opportunity to build a healthier and more resilient state. The potential rewards are myriad, including saved lives, billions of dollars retained in the state's economy, improved energy security and self-reliance, and opportunities for employers and workers to capitalize on growth of new globally relevant industries.

90 | This estimate excludes the High-Speed Rail program, and does not differentiate between funds leverage in-state versus out-of-state. California Air Resources Board, 2020. t.ly/ERzo

91 | The term "leverage" assumes a direct causality between in-state investment and out-of-state assistance. If a specific state proposal directly results in additional federal funds that otherwise would not have occured, then those federal funds qualify as leveraged and could be omitted from upfront costs for the purpose of state-level cost-benefit analysis.

92 | Washington State Legislature, 2020. HB 2311. t.ly/ZTor

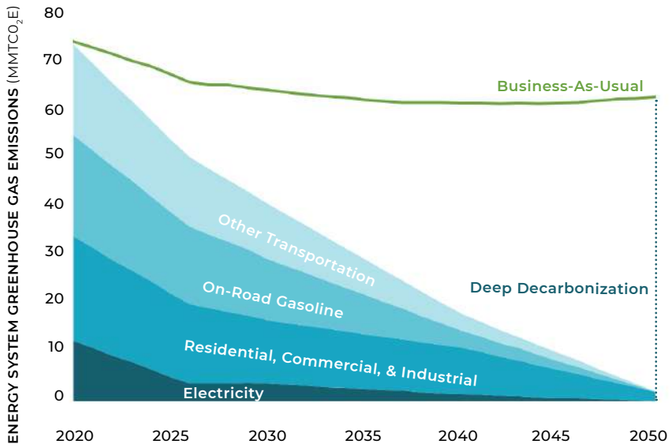
93 | Washington State Department of Commerce, 2019. "Clean Energy Transformation Act (CETA)." t.ly/XK5Q

SUMMARY OF MODELING APPROACH

A handful of energy-system scenarios for the state and region have been released over the last few years examining greenhouse gas emission reductions.[94] To provide a full energy system perspective of achieving the state's legislated carbon reduction aims, we apply the screening methodology in this report for community health benefits to two recent deep decarbonization studies: *Pacific Northwest Pathways to 2050* by Energy and Environmental Economics (E3) and the Clean Energy Transition Institute's *Meeting the Challenge* report for net energy system costs.[95,96] We compare the emissions trajectories for a 95 percent reduction relative to 1990 emissions by mid-century, including 45 percent by 2030, to a business-as-usual emissions scenario, which is derived from the state's Carbon Tax Assessment Model (CTAM).[97]

We compare the business-as-usual scenario to a "deep decarbonization" emissions trajectory extracted from the Pacific Northwest Pathways to 2050 study, which was scaled to match the state's updated emissions limits from 2020.[98] This comparison yields a sector and fuel-specific trajectory for deep decarbonization versus expectations with no additional action. Thus, we can calculate our expected greenhouse gas reductions from achieving long-term decarbonization targets, by sector, as the difference in emissions trajectories between our business-as-usual scenario and our "deep decarbonization" scenario. We then converted these expected emissions reductions to health and climate benefits using the methodologies outlined in the previous section.

FIGURE 5.1 Business-As-Usual and Deep Decarbonization Projections for Washington State



We subsequently derived the system-level costs of decarbonizing beyond baseline emissions from the Clean Energy Transition Institute's (CETI) *Meeting the Challenge of Our Time* report.[99] *Meeting the Challenge* covers Idaho, Montana, Oregon, and Washington, modeling several scenarios of an 86 percent economy-wide reduction in greenhouse gases below 1990 levels. This includes a roughly 45 percent reduction by 2035, approximately five years later than the current legislation for Washington requires.[100] Washington's share of system costs are assumed to scale proportional to share of regional emissions (45.5 percent).[101] We estimate net present value (NPV) costs for Washington under the Central Case of *Meeting the Challenge* to be roughly $22 billion through 2035 (when emissions fall to approximately 45 percent below 1990 levels) and $52 billion through 2050. Scaled to a 45 percent reduction by 2030 and a more than 95 percent reduction by 2050, we determine NPV costs of $25 billion through 2030 and $59 billion through 2050 as a direct point of comparison to net health and climate benefits.

We also added in an estimate of avoided forest fire costs and benefits by applying the methodology described above to the Department of Natural Resources (DNR) 20-year *Forest Health Strategic Plan*[102] and assuming the program costs are sustained through 2050. *Wildfire prevention* adds NPV costs of $0.5 billion through 2030 and $1.1 billion through 2050.[103]

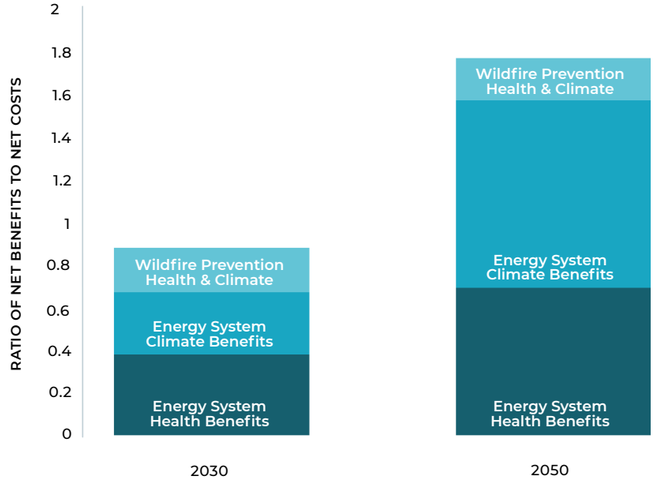
RESULTS

Including a social discounting rate of three percent for future costs and benefits, the avoided emissions and wildfires return a NPV benefit of $46 billion through 2050, equal to 175 percent of the net costs. This includes $106 billion in health and climate benefits minus the net costs. Through 2030, nearly 90 percent of net costs are balanced by $22 billion health and climate benefits.[104,105]

The long-term air quality benefits are mainly projected to come from decreased fuel consumption of on-road gasoline ($2.8 billion through 2030, $16 billion through 2050), marine vessels ($4.1 billion through 2030, $11 billion through 2050), on-road diesel ($2.6 billion through 2030, $9.8 billion through 2050), and wildfires ($3.7 billion through 2030, $8.4 billion through 2050).

Long-term climate benefits are mainly projected to come from on-road gasoline ($1.8 billion through 2030, $14 billion through 2050), on-road diesel ($2.0 billion through 2030, $11 billion through 2050), natural gas in buildings and industry ($1.8 billion through 2030, $9.1 billion through 2050), and jet fuel and aviation ($1 billion through 2030, $8.7 billion through 2050).

FIGURE 5.2 Benefit-cost ratio for Deep Decarbonization in Washington State, net present value



94 | These have covered a mix of states, sectors, and ambition levels and, aside from the two used for this report, include: Governor's Office Deep Decarbonization study for WA (2016, with less ambitious greenhouse gas reduction targets based on now updated legislation), E3's electricity sector and electricity sector reliability studies from 2018 and 2019, Climate Solutions electricity sector only study from 2018, the 7th Northwest Power Plan, and the NW Natural Gas Company 2019 study covering all sectors but optimizing only for the electricity sector.

95 | E3, 2018. "Pacific Northwest Pathways to 2050." t.ly/BNxo

96 | Clean Energy Transition Institute, 2019. "Meeting the Challenge of Our Time: Pathways to a Low-Carbon Future for the Northwest." t.ly/o8T0

97 | Specifically, we derive the business-as-usual pathway from CTAM's "Adjusted Emissions" scenario, which reflects policies in place through the 2019 legislative session with no carbon price applied.

98 | E3, 2018. "Pacific Northwest Pathways to 2050." t.ly/BNxo

99 | Clean Energy Transition Institute, 2019. "Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest" t.ly/o8T0

100 | To align the two studies in terms of scale of carbon reduction, we assume the net costs from Meeting the Challenge through 2035 for a 45 percent reduction versus the net benefits using the E3 Pathways analysis through 2030 only. We also scale up the costs in Meeting the Challenge proportionally from an 86 percent reduction to a 97.5 percent energy-sector reduction.

101 | Washington State's share of emissions in 2020 annual net costs every fifth year through 2020 for the 4-state region were provided in personal communication by the Meeting the Challenge study authors.

102 | Washington State Department of Natural Resources. https://www.dnr.wa.gov/ForestHealthPlan

103 | The NPV calculation assumes a 10-year average lag in avoided wildfires and a 5-year average lag in expenditures from the beginning of each decade.

104 | At a fixed social cost of carbon of $52/tCO$_2$e for 2020. Computationally, holding the social cost of carbon constant is the equivalent of applying a social discount rate on future benefits of 3 percent.

105 | The net costs in 2050 are scaled proportional to ambition to a 97.5 percent reduction from the 86 percent reduction in the Meeting the Challenge Central Case.

VI. SUMMARY AND NEXT STEPS

The *Resilient Recovery Portfolio* offers an investment template for Washington to build back better, delivering compelling results: enhanced well-being for communities and families through clean air and climate benefits linked to above-average job creation, wages, and economic performance. Below we offer two additional pieces of analysis that synthesize previous findings with additional components for the consideration of policymakers and stakeholders.

INVESTMENT SCALE AND DEPLOYMENT SPEED

We present findings throughout this report as comparative "multipliers", which normalize all benefits to a million dollar investment. However, in reality, the various investment areas identified as part of the *Resilient Recovery Portfolio* require different scales of funding. Additionally, not all programs can be deployed immediately — some programs require years of upfront planning and scoping work prior to implementation, others may not require such drawn out steps, while others may be shovel-ready. The speed at which programs can be deployed is an important factor in an effective, rapid recovery plan. Our *Resilient Recovery Portfolio* does seek to emphasize a suite of programs that can generate jobs and other benefits starting in the near-term.

To complement our findings, we offer two additional considerations: investment scale and deployment speed (see Table 6.1). Investment scale refers to the size of funding required to exhaust available investment opportunities considered in the *Resilient Recovery Portfolio*, and deployment speed refers to the anticipated pace at which projects can be feasibly implemented to facilitate rapid deployment.

TABLE 6.1 Overview of Findings by Investment Area

INVESTMENT AREA	INVESTMENT SCALE	DEPLOYMENT SPEED	FTE JOBS/$M	HEALTH BENEFITS	CLIMATE BENEFITS
CLEAN TRANSPORTATION	$$$	MIXED	10.7	+++	+++
WATER, POWER, & ENERGY EFFICIENCY	$$$	MEDIUM TO FAST	8.7	+++	+++
FOREST CONSERVATION & ECOSYSTEM RESTORATION	$$$	FAST	12.7	+++	+++
LOW CARBON AGRICULTURE	$$$	MEDIUM	6.8	NOT QUANTIFIED	+++
SUSTAINABLE INDUSTRY	$$$	MEDIUM	7.1	++	+++

INVESTMENT SCALE *Lower opportunity* ($) | *Medium opportunity* ($$) | *Higher opportunity* ($$$)
DEPLOYMENT SPEED *Within 2 years* (Fast) | *Within 5 years* (Medium) | *5+ years* (Slow)
HEALTH AND CLIMATE BENEFITS *Low* (+) | *Medium* (++) | *High* (+++)

Our evaluation of these two criteria remains qualitative, as concrete program details are required for all programs in Washington State to quantitatively assess both investment scale and deployment speed. Notably, clean transportation has a wide array of deployment speeds depending on the project in question. Large infrastructural projects, such as *High-Speed Rail*, require several additional years of planning and scoping work prior to beginning construction. However, ongoing *Sound Transit Expansion* qualifies as a "fast" potential deployment speed. The Federal Way extension has already entered construction phase, and cash flow is the predominant limiting factor on hastening broader system expansion.[106]

Main Program Areas of the *Resilient Recovery Portfolio*. **A. CLEAN TRANSPORTATION** Electric vehicle charging stations, Sarah Corrice **B. WATER, POWER, AND ENERGY EFFICIENCY** Home powered by solar panels and wind generator in West Olympia, Wonderlane **C. FOREST CONSERVATION AND ECOSYSTEM RESTORATION** Washington Office of the USDA employees gather to inspect the health of a forest , Richard Sniezko **D. LOW CARBON AGRICULTURE** Hydroponic irrigation decreases water usage in greenhouse agriculture, Lance Cheung, USDA **E. SUSTAINABLE INDUSTRY** A ferry in Anacortes Washington, Michael Feist

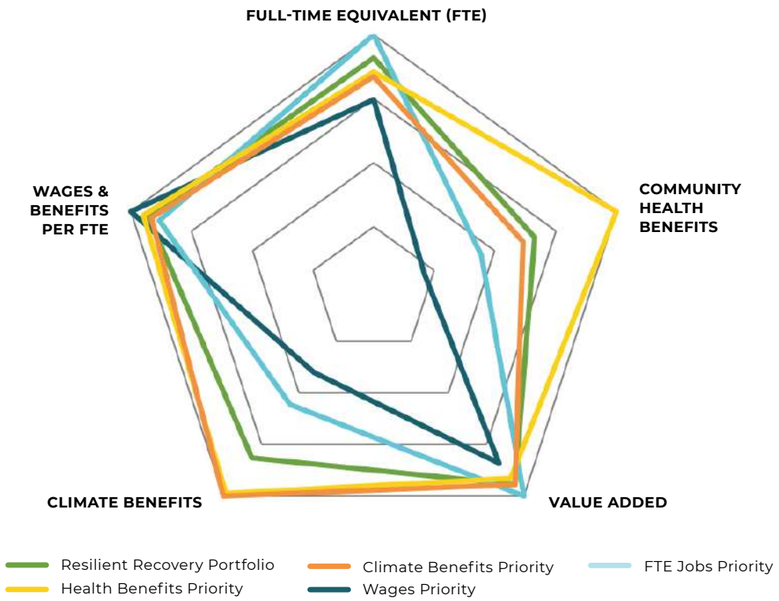
106 | Sound Transit blog states: "Taxpayers are paying for this massive transit expansion in installments over a 25-year period. Meanwhile, by policy we limit the amount of debt we can carry and maintain minimum cash reserves. This means we have to build projects over time as the money comes in. That might seem like an eternity in Twitter Time, but it's how we ensure we are good stewards of taxpayer money." t.ly/Yjz2

BALANCING BENEFITS IN THE RESILIENT RECOVERY PORTFOLIO

The *Resilient Recovery Portfolio* is the weighted composite of four priorities: FTE jobs supported, wage levels, community health benefits, and climate benefits. Four corresponding portfolios were assembled that weigh programs according to their rank performance on each priority. The *Resilient Recovery Portfolio* is a balanced composite of these four portfolios. The five different color lines in Figure 6.1 illustrate the performance of the *Resilient Recovery Portfolio* in relation to its four priority portfolio components: higher wages, more jobs, greater community health benefits, or greater climate benefits. Each portfolio scenario is shown on a relative scale of five metrics examined in this report, with the outermost edge representing the highest scoring portfolio scenario.

Combining and weighting these priorities leads to increased funding for the programs that provide the most holistic and balanced benefits, and creates a *Resilient Recovery Portfolio* that scores highly on all metrics. Large gains in community health and climate benefits, creating a compelling return-on-investment, result in only marginal decreases to up-front jobs, employee compensation, and added economic value. At least 65 percent of Washingtonians in every county view protecting the environment as a higher priority than economic growth.[107] The *Resilient Recovery Portfolio* shows that these do not have to be at odds, with well above average performance on jobs and economic value added. Decision makers who wish to build holistic recovery plans can undergo a similar data-driven approach, including the methods and programs highlighted in this report, to balance job creation, community health, climate benefits, and other key priorities in the state.

FIGURE 6.1 Performance of different investment prioritization of the portfolio's programs



107 | Yale Climate Opinion Maps, 2018. Washington State Response to the question: Which do you think is more important? (a) Protecting the environment, even if it costs jobs or economic growth? (b) Economic growth, even if it leads to environmental problems. t.ly/ugVq

NEXT STEPS

Future work should build on this report and add critical dimensions of analysis to take the *Resilient Recovery Portfolio* outlined here and convert it into actionable policy. Additional work areas that we see as crucially important include:

> Social justice, community engagement, and analysis of the distributional economic and health outcomes of selected recovery measures.

> Job quality, occupational analysis, career advancement opportunities, diverse and local access, and other components of jobs supported.

> Expansion of the *Resilient Recovery Portfolio* to additional programs that have the potential to deliver community benefits at the nexus of quality job creation and community health.

> Deep analysis of the potential contributions and compatibility of stimulus measures with Washington's long-term climate goals, and the net benefits of achieving those goals.

> Further work to bridge this portfolio to a workable policy by assessing optimal investment scale, phasing, and project readiness, and identifying possible financing mechanisms including those that leverage other funding.

This work is evolving, with more programs to consider, more states to assess, and additional dimensions to evaluate and engage. With the *Resilient Recovery Portfolio*, we establish a framework for building back better Washington. As we envision stretching that framework into a meaningful stimulus for change, we offer a look forward with a non-exhaustive list of additional investment programs worth examining.

TABLE 6.2 Additional Recovery Programs to Consider

INVESTMENT AREA	ADDITIONAL PROGRAMS TO CONSIDER
CLEAN TRANSPORTATION	EV Charging Infrastructure, Broadband Connectivity Infrastructure, Active Transportation
WATER, POWER & ENERGY EFFICIENCY	Commercial & Institutional Retrofits, Utility-Scale Power Generation, Transmission, & Energy Storage
FOREST CONSERVATION & ECOSYSTEM RESTORATION	Fish Passage Barrier Removal, Floodplain & Coastal Restoration, Natural Lands Carbon Sequestration
LOW CARBON AGRICULTURE	Soil Sequestration & Nutrient Management, Regenerative Annual Cropping, Biochar
SUSTAINABLE INDUSTRY	Energy Efficiency & Electrification (Industrial & Marine), Methane Leak Reduction, Biofuel Production
OTHER INVESTMENT AREAS	Waste Reduction Programs, Circular Economy Interventions, Healthy & Low-GHG Food Programs

VII. METHODOLOGY

JOBS AND ECONOMIC IMPACT ANALYSIS

IMPLAN OVERVIEW

Obtaining a complete picture of jobs and economic impacts requires tracking the direct, indirect, and induced impacts of each investment, which is nearly impossible with observational methods, as it would require verifying the unique supply chain of every impacted firm, as well as the unique spending pattern of every impacted worker.

For each program described in this report, we collected detailed project-level expenditures that we entered into an economic input-output model called IMPLAN (Version 5). IMPLAN is a commonly used tool on job creation, including technical reports for government agencies and academic papers in peer-reviewed journals. Economic input-output models such as IMPLAN are often used to evaluate the impact of a policy of investment, particularly when empirical data gathering is difficult or impossible.

IMPLAN maps the flow of economic activity between 546 industries and institutions, with each dollar tracked throughout the state economy with resulting employment, output, labor income, and fiscal impact estimates. All 18 projects in this study were deconstructed into line-item expenditures using available budgetary data and run through IMPLAN's 2018 Washington State dataset to subsequently ripple throughout the state economy.

SCOPE OF STUDY

Proper application of our jobs and economic analysisrequires a careful understanding of the scope of the study. Economic input-output models provide meaningful insights into economy-wide employment, but are not without limitations.

Static and Linear Industry Relationships

Industries in this model are constructed as single, snapshot-level relationships rather than time-sensitive evolving businesses with ever changing conditions. Thus, changing technologies and supply chains may lead to different employment outcomes in particular industries compared to what this study estimates.

Investment impacts scale linearly without sensitivity to the magnitude of investment. Thus, in IMPLAN's economic flows, a dollar investment and a billion dollar investment in a given industry will lead to the same proportional outcomes, even if an investment of such size exceeds the production or workforce capacity of the region in question. Evaluating capacity constraints is outside the scope of this study, as our investment programs are normalized to a million dollar scale.

Geographic Detail

All job estimates provided in this study are located within Washington. Jobs supported out of state or abroad are excluded from the study's results. Distributional analysis at the county level is possible in IMPLAN, but requires geographic specificity to the projects implemented and where each line item expenditure occurs. This information is outside the scope of this study and a key focal point of future research as investment programs become rooted in location-specific proposals.

Direct and Indirect Savings

Investment programs in this study, in most cases, result in financial savings for consumers and grantees. Those savings increase the spending power of the state economy, and are used on a variety of goods and services to support additional jobs. Our IMPLAN analysis includes direct financial savings for consumers and grantees, but not indirect financial savings, as defined below:

> Direct savings occur immediately as a direct result of the investment program — for example, the *Low Carbon Buses and Trucks* Program provides funds for transit agencies to offer free fare days to encourage ridership. These funds do not necessarily generate new economic activity within the transit sector, but they do create financial savings for transit riders who otherwise would have paid for their trip that day. IMPLAN can direct these financial savings to typical household expenditures, which leads to additional captured job numbers in our study.

> Indirect savings are those which occur due to the cost efficiency that programs achieve over time. For example, the *Low Carbon Buses and Trucks* Program also provides funds for local transit agencies to expand service, which will lead to decreased personal vehicle use and savings on fuel costs. Some households will spend these indirect savings on other goods and services. Quantifying these cost savings is important for comprehensively analyzing the benefits of investment, and is an important aspect of future work, but is outside the scope of this study.

Net vs Gross Impacts

This study strictly looks at the gross number of jobs that are supported by investment programs, not whether these jobs are net positive jobs. When modeling these programs in IMPLAN, the model assumes that each investment is a new additional influx of spending into the Washington State economy. In reality, these funds must originate from somewhere. If the source of revenue of these programs comes from within the state, those revenues would have otherwise been circulated in some way that supports jobs as well. Depending on where revenue comes from, some of the jobs identified in this study may represent a transfer of jobs from one sector of the economy to another, rather than an overall gain in employment.

Such analysis would require counterfactual scenarios of how investment funds would have been used if left to their original sources. Absent details on a funding mechanism, we use an average economy-wide benchmark, as well as a comparison to the ten largest industries in the state, in order to inform the relative effectiveness of the *Resilient Recovery Program* compared to typical spending patterns in the state.

COMMUNITY HEALTH AND CLIMATE BENEFIT ANALYSIS

METHODOLOGY OVERVIEW

To evaluate the community health and climate benefits of the Resilient Recovery Portfolio, we constructed a custom health and climate benefit calculator for each project based on available pollution databases and project-specific literature. Of 18 total projects, ten had sufficient data to derive statewide community health benefits from the investment, and 14 had sufficient data to derive climate benefits from the investment. Our conceptual modeling approach follows five steps:

> 1 | Using the EPA's National Emissions Inventory (NEI), we extracted annual levels of local pollutants ($PM_{2.5}$, SO_2, NO_x, VOCs, and NH_3) emitted across 36 different activity sources at the state and county level in Washington.

> 2 | Using Reduced-Complexity Models (RCMs), we calculated pollutant-specific, geographically-sensitive annual public health damages, in dollar terms, associated with each of these activity sources in Washington.[108]

> 3 | Using Washington GHG inventory data, we aggregated and mapped the public health damages from each activity source to specific fossil fuel uses and/or greenhouse gas inventory sources (i.e., light-duty vehicle gasoline, heavy-duty vehicle diesel, home natural gas heating, etc.).

> 4 | Using project-specific literature and quantification tools, we derived the expected reduction in fossil fuel use and/or greenhouse gases per million dollars spent on each project, which can be bridged to potential community health benefits, in dollar terms, using the steps outlined above.[109]

108 | Reduced Complexity Models are commonly used tools to screen for public health impacts from air pollution. They use geographic data on population density, wind patterns, and point source behavior to estimate the health impacts from pollution. For more details on RCMs used in this study, see CACES.us.

109 | Some programs, such as the *Wildfire Prevention and Preparedness* Program, required alternate methods to appropriately derive public health savings (see Methodology section).

5 | Using a modest estimate of the social cost of carbon, we converted GHG reductions to a dollar estimate of avoided climate damages per million dollars invested.

EPA NATIONAL EMISSIONS INVENTORY (NEI)

The EPA National Emissions Inventory (NEI) is a comprehensive and detailed estimate of air emissions of criteria pollutants, criteria precursors, and hazardous air pollutants from air emissions sources. The NEI is released every three years based primarily on data provided by State, Local, and Tribal air agencies for sources in their jurisdictions and supplemented by data developed by the US EPA.[110]

This study uses 2017 NEI data, which was released in April 2020. The dataset includes pollutant emissions from five pollution sources:

1 | Point sources, which include emissions estimates for larger sources at fixed, stationary locations such as power plants and industrial facilities.

2 | Nonpoint sources, which include sources that are too small to individually report, such as residential and commercial building heating.

3 | On-road sources, which include emissions from on-road vehicles that use gasoline, diesel, and other fuels, such as light duty and heavy duty vehicles.

4 | Non-road sources, which includes off-road mobile sources that use gasoline, diesel, and other fuels, such as construction equipment, locomotives, and marine vessels.

5 | Event sources, which include unique sources of emissions, particularly wildfires and prescribed burns.

Emissions data for particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and ammonia (NH_3) across 36 different sources were extracted from the NEI dataset. The 36 sources of pollution typically span sources of fossil fuel combustion, but also included industrial processes, leakage of uncombusted fossil fuels, and wildfires. Each pollutant from each source was aggregated to the statewide level, with the exception of pollutants from wildfires.[111]

ESTIMATING ANNUAL MORTALITY FROM POLLUTION

In order to assess the health damages associated with each pollutant from each source, we used publicly available data from the Center for Air, Climate, and Energy Solutions (CACES).[112] CACES uses three different reduced complexity models (RCMs) to estimate the public health damages associated with emitting a unit of $PM_{2.5}$, SO_2, NO_x, VOCs, or NH_3. RCMs connect emissions of local air pollution to ambient concentrations, exposures, physical health and environmental effects, and monetary damage.

CACES allows the user to specify location, spatial resolution, stack height,[113] statistical value of life, and C-R function.[114] We use the EPA's estimates for the statistical value of life (VSL), which is $7.4 million in 2006 dollars. Adjusted to 2020, this gives us a VSL of $9.4 million. For a majority of emissions sources and pollutants, we derived CACES data at the state level, although in some cases we weighted CACES damages with county-level NEI to reflect the unique pollution characteristics of wildfires and agriculture. The CACES model provides geographic resolution on the source of pollution, but no geographic resolution on the location of mortality impacts. Since RCMs capture downwind effects of pollution, some of the health impacts captured in this study may be happening outside of Washington State.

110 | https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei

111 | See below for special methodology required in our wildfire analysis.

112 | https://www.caces.us/

113 | Stack height refers to the height at which pollutants are emitted into the air, which changes where the pollutant subsequently concentrates.

114 | C-R function refers to the assumed impact of a given unit of pollution on mortality. For a majority of emissions sources, we used a blend of two mortality estimates provided by the American Cancer Society (ACS) and Harvard 6-Cities cohort. For more information, visit the CACES RCM User Guide at CACES.us.

These CACES mortality damage estimates, which are provided in dollar terms, were applied to the NEI dataset in order to calculate the total mortality damages associated with each source of pollution in Washington State.

To prepare for subsequent project-level health and climate analysis, the 36 NEI pollution sources were aggregated and mapped to 17 pollution sources as defined in Washington State's 2017 Greenhouse Gas Inventory.[115] This resulted in a set of 17 "GHG-NEI-CACES" conversions, which allows us to derive local health costs of co-pollutants associated with emitting GHGs. A metric ton of carbon dioxide equivalent ($mtCO_2e$) from any of these 17 pollution sources can be translated to a corresponding scale of co-pollutants, which then can be translated into projected health damages from those co-pollutants.[116]

PUBLIC HEALTH AND CLIMATE INVESTMENT CALCULATORS

Using the GHG-NEI-CACES conversions, we can derive community health benefits from any investment project, as long as two questions are answered - (a) which of the 29 pollution sources will be impacted; and (b) what level of GHG emissions and/or fuel combustion will the investment avoid. To do this, we analyzed existing resources on expected GHG/fuel reductions from 14 Resilient Recovery programs, and compared them to capital program costs.

Ten programs were modeled after existing programs in California. For these programs, we looked at the quantified emissions reductions from programs administered through California Climate Investments (CCI), which are estimated using calculators from the California Air Resources Board.[117]

Using the CCI project database, we extracted data on total funding and expected GHG emissions

TABLE 7.1 GHG-NEI-CACES Conversions for Washington State

SECTOR	POLLUTION SOURCE	COMMUNITY HEALTH DAMAGES/ $MTCO_2E$ ($2020)
ELECTRICITY GENERATION	COAL	$15
ELECTRICITY GENERATION	NATURAL GAS	$12
ELECTRICITY GENERATION	OIL	$3
RESIDENTIAL, COMMERCIAL, & INDUSTRIAL HEATING	COAL	$268
RESIDENTIAL, COMMERCIAL, & INDUSTRIAL HEATING	NATURAL GAS	$26
RESIDENTIAL, COMMERCIAL, & INDUSTRIAL HEATING	OIL	$8
TRANSPORTATION	ON-ROAD GASOLINE	$98
TRANSPORTATION	ON-ROAD DIESEL	$80
TRANSPORTATION	MARINE VESSELS	$177
TRANSPORTATION	JET FUEL & AVIATION	$12
TRANSPORTATION	RAIL	$339
INDUSTRIAL PROCESSES	CEMENT MANUFACTURING	$84
INDUSTRIAL PROCESSES	OTHER MANUFACTURING	$222
AGRICULTURE	AGRICULTURAL MANURE	$374
AGRICULTURE	AGRICULTURAL SOILS	$109
OTHER	NATURAL GAS DISTRIBUTION	$51
OTHER	SOLID WASTE MANAGEMENT	$138

115 | Washington State Department of Ecology. "2017 Greenhouse Gas Data." t.ly/ZZOR

116 | Wildfire pollution remained as a 18th standalone source, as it was used in subsequent analysis but is not a present emission source in Washington's GHG latest GHG inventory.

117 | https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials

reductions for all projects administered between 2015 and 2019. Project data that lacked funding or quantifiable emissions reductions was excluded from our estimates. Using only the projects with quantified GHG emissions reductions, we calculated the ratio of total project funding to a quantity of GHG reductions, and subsequently scaled this ratio to calculate the expected GHG emissions ($mtCO_2e$) avoided per one million dollars invested in each CCI program.

For programs in the *Resilient Recovery Portfolio* that encompass more than one CCI program (*Low Carbon Buses and Trucks*, *Clean Vehicle Programs*, and *Home Energy Efficiency and Renewables*) each GHG multiplier was calculated using a weighted average of sub-project GHG reductions per one million dollars invested.

The programs using these greenhouse gas reduction calculators include:

> *Low Carbon Buses and Trucks*
>
> *Clean Vehicle Programs*
>
> *Transit-Oriented Community Development*
>
> *Home Energy Efficiency and Renewables*
>
> *Water-Energy Programs*
>
> *Urban and Community Forestry*
>
> *Low Carbon Agriculture*
>
> *Agricultural Water Efficiency*
>
> *Dairy Digesters*
>
> *Low Carbon Freight Operations*
>
> *Multi-Source Facility Projects*

For Washington-based programs, we looked at existing studies to determine the greenhouse gas reductions per one million dollars invested. The following 4 programs relied on project-specific methods, rather than the CCI project database:

HIGH-SPEED RAIL — To determine the health and climate benefits per $1 million invested for the High-Speed Rail program, we used the project cost and expected emissions reductions from the Washington State Department of Transportation's (WSDOT) 2019 Business Case Analysis for UHSGT.[118] The UHSGT is expected to avoid 6 million $mtCO_2e$ over the system's lifetime through reduced passenger vehicle use.

Capital costs for this project ranges from $24 to $42 billion, so we used the average of $33 billion for our analysis. Combining average capital costs and expected emissions reductions, we found that the High-Speed Rail program would reduce 182 $mtCO_2e$ for every $1 million invested.

SOUND TRANSIT EXPANSION FEDERAL WAY — The Federal Way Link Extension Final Environmental Impact Statement (EIS) released in 2016 provides expected net emissions reductions from the light rail system.[119] The avoided emissions from reduced VMTs would be slightly offset by the expected emissions from operating this system, however the Central Puget Sound Regional Transit Authority estimates that the Federal Way Extension project will produce a net decrease of 11,590 $mtCO_2e$ annually. Scaled through 2050, cumulative net emissions avoided are 324,500 $mtCO_2e$.

There is just over $2.4 billion in remaining capital costs for the Federal Way Expansion project, which we used for the program's total costs. Therefore, the Federal Way Expansion is expected to reduce 132 $mtCO_2e$ for every $1 million invested in the project.

ELECTRIC FERRIES — To determine Climate Benefits from the first wave of ferry electrification, we analyzed the cost and emissions figures in the 2040 Long-Range Sustainability plan from Washington State Ferries.[120] Avoided diesel fuel emissions from all ferry conversions and ferry-builds through 2027 are estimated to reach 80,000 tCO_2e per year by 2027 and continue through 2040. Additional electric ferries are planned, but are not assumed in this analysis. Cumulative avoided emissions are estimated to be 1.4 $MtCO_2e$ through 2040.

118 | Washington State Department of Transportation, 2019. t.ly/sXjM

119 | Central Puget Sound Regional Transit Authority, U.S. Department of Transportation, 2016. t.ly/Etwe

120 | WSDOT and WSF, 2019. "2040 Long-Range Sustainability Plan." t.ly/H4Md

Net costs are the combination of capital costs above the capital costs of replacing the ferries with the prior technology rather than new, electric-hybrid technology, plus the fuel cost savings. Program capital costs are $1.5 billion, but avoided capital costs equal to 50% of the cost of each new ferry are assumed. In addition, retrofitting of two ferries is assumed to offset an equivalent expenditure in deferred maintenance costs. Therefore, the new capital costs are estimated to avoid $650 million in capital cost, for a net additional capital cost of $850 million. Avoided fuel costs are estimated to be an additional $150 million in savings through 2040, for a net additional program cost of $700 million.

Combining a net cost of $700 million and a net emissions savings of 1.4 $MtCO_2e$ works out to 2,030 tCO_2e avoided per million dollars of investment. The value of these avoided CO_2 emissions is $105,000 per million dollars invested.

Health Benefits

Electric Ferries is a unique investment program for Washington State, so there was no information about the expected GHG emissions reductions in the CCI project database. Instead, we looked at the reported greenhouse gas and co-pollutant emissions from the 2016 Puget Sound Maritime Air Emissions Inventory.[121] Table 4.4 from the inventory provides tons per year totals from 2016 for CO_2-equivalents and other air pollutants. Applying these ratios to the CACES damage estimates for each pollutant-type results in an estimated $334 of health damages per tCO_2e.

Combined with the above estimate of 2,030 tCO_2e per million dollars invested, the health benefits **work out to $677,500 per million dollars invested**.

WILDFIRE PREVENTION AND PREPAREDNESS — To estimate the avoided greenhouse gas emissions from *wildfire prevention* and preparedness activities, we averaged two methods, each of which shared some overlapping assumptions:

> The costs to treat an acre of forest. Costs per acre of treatment were taken from proposed House Bill 2413, via the revised fiscal note prepared for that bill from February 2020.[122] The cost range used for this analysis, based on the fiscal note, is $500 to $1,000 per acre.[123] We assume a range, since there is some discrepancy in the fiscal note as to whether $500 is the full treatment cost, or is the cost for each treatment (thinning and prescribed burn). This treatment cost range works out to 1,000 to 2,000 acres treated per million dollars.

> The impact of treating an acre on wildfire risks for untreated acreage. A multiplier for the number of acres with reduced fire severity risks per acre treated was used, based on a 2010 study in Oregon.[124] That study found that a 10% area treatment of non-residential forest led to a 20% reduction in average wildfire size across the forested area, indicating two acres of fire-reduction per acre treated. Therefore, there are 2,000 to 4,000 fire-acres equivalent impacted for each million dollars invested.

Method 1: Direct estimate of avoided public health costs per acre of fire burn

Our first method for estimating public health costs uses data from a study of mortality impacts due to major Southern California wildfires.[125] Normalized to the VSL used for our report (see description above), the mortality costs associated with wildfire air pollution are $1,667 per acre of fire burned. When multiplied by 2,000 to 4,000 acres treated, we estimate we estimate **$3.3 million to $6.7 million in avoided health costs for every million dollars spent** on treatment.

121 | Puget Sound Maritime Air Forum, 2018. "Puget Sound Maritime Air Emissions Inventory." t.ly/PRJe

122 | Office of Financial Management, 2020. https://fnspublic.ofm.wa.gov/FNSPublicSearch/GetPDF?packageID=60268

123 | The fiscal not states: DNR estimates per acre cost of terrestrial forest health treatments at two levels - one for small private forest landowners ($800 per acre) and one for all other forest landowners ($450 per acre), and that 8 percent of the treatments funded from this legislation completed each biennia will be on small private forest landowner properties at the higher cost, while the remaining 92% will be done on either (sic) land ownership types."

124 | Ager, A.; Vaillant, N., Finney, M. 2010. https://www.fs.usda.gov/treesearch/pubs/39604

125 | Ikuho Kochi, Patricia Champ, John Loomis, Geoffrey Donovan, 2012. t.ly/3smq

Method 2: GHG - Health multiplier

We include an additional approach for two primary reasons: (1) The forest fire biomass per acre and the proximity of wildfires to population in Southern California used to estimate the per acre avoided public health costs above may not be reliable predictors for eastern Washington, and; (2) Our benefits analysis also accounts for climate benefits, and therefore requires an estimate of avoided GHG emissions from wildfire treatment.

To estimate avoided GHGs per acre treated, we use 2015 wildfire season data from the Forest Service.[126] The GHGs per acre emitted during that wildfire season averaged 22.97 tCO_2e per acre. Each acre treated, therefore, avoids an average of 45.94 tCO_2e. At a social cost of carbon of $52 (see above) and 1,000 to 2,000 acres treated, the climate benefits are **$2.8 to $5.5 million dollars per million dollars invested**.

The avoided climate emissions are multiplied by the health damages ratios determined, as for most other programs, with the GHG-NEI-CACES conversions described in the previous section. However, the unique characteristics of wildfire emissions dictate a special GHG-NEI-CACES bridge. CACES damages were county-weighed using wildfire emissions data from the NEI 2017 dataset. Second, the Harvard 6-Cities (H6C) estimate of mortality per unit of air pollution exposure was omitted from CACES data, as it predominantly pertains to dense urban areas with concentrated air pollution. Lastly, the CACES derived data was set to "elevated stack height", to reflect the dispersal patterns of wildfires. These unique adjustments all served to significantly lower the estimated health impacts of wildfires, compared to an unaltered standard GHG-NEI-CACES procedure. With these adjustments, the total damages from air pollutants was calculated to be $3.3 million associated with 16.8 $MtCO_2e$ of wildfire emissions, or $199/$tCO_2e$.

Combining a $199/$tCO_2e$ with GHG estimates of 45.94 tCO_2e avoided per acre treated and 1,000 to 2,000 acres treated pre million dollars yields an estimated range of **avoided health damages of $9.1 million to $18.3 million per million dollars invested**.

To report one, central estimate for public health damages as a function of program investment, we averaged the two methods to the nearest million dollars. This central estimate is **$9 million dollars** in health benefits for each million dollars invested in *wildfire prevention and preparedness*.

RESILIENT RECOVERY PORTFOLIO WEIGHTING METHODOLOGY

The investment portfolio weighting was developed using a quantitative ranking scale across three dimensions: Jobs (50%), community health benefits (25%) and climate benefits (25%).

All programs and sub-projects were quantified on the jobs metrics. In developing a full ranking on jobs metrics, the rank by FTEs per million dollars was given 65% weighting and the rank by average employee compensation was given 35% weighting to determine an overall 1-18 ranking.[127] On climate benefits, four projects that lacked quantitative estimates of GHG reduction were qualitatively ranked in the bottom third of all projects with reasonable confidence. Therefore, we established 1-18 ranking on jobs and climate benefits.

For community health benefits, fewer projects could be quantified and those remaining did not have sufficient additional detail to qualitatively assign a ranking. Therefore, eight of the 18 programs or sub-projects were given a 0.5% share, and the remaining 10 ranked based on their climate benefits per million dollars invested.

Two formulas were developed, one for assigning portfolio shares by rank for a ranked list of 18 (all programs and sub-projects) and one for assigning portfolio shares to a ranked list of 10 with the other 8 programs and sub-projects receiving a 0.5% share.

126 | Richard Graw, Janice Peterson, James Miller, 2016. t.ly/EJ9R

127 | Employee Compensation per FTE was to determine the jobs ranking for fuller portfolio weighting, and serves as a good but not perfect proxy for wage levels.

For the first formula, a multiplier was determined such that the sum of 18 project shares from a floor of 1.0% for the 18th ranked program sum to 100%. This multiplier worked out to 1.1765, meaning that the 17th slot received a 1.1765 times greater share than the 18th slot (1.1765%) and so on up to the top spot receiving a 15.9% share.

For the second formula, eight unquantified projects were assigned a 0.5% share each with the remaining 96% distributed among 10 projects.A 2.0% share was chosen for the 10th ranked program, and a multiplier determined so that the sum of all 18 programs and sub-projects totaled 100%. To reach 100% the required multiplier was 1.324 and the share for the top ranked program 25%.

TABLE 7.2 Program weighting under different portfolio prioritizations

PROGRAM OR SUB-PROJECT	RESILIENT RECOVERY PORTFOLIO		JOBS PORTFOLIO (50%)		COMMUNITY HEALTH PORTFOLIO (25%)		CLIMATE PORTFOLIO (25%)	
	RANK	SHARE	RANK	SHARE	RANK	SHARE	RANK, CLIMATE	SHARE, CLIMATE
Wildfire Prevention & Preparedness	1	16.9%	2	13.5%	1	25.0%	1	15.9%
Low Carbon Buses & Trucks	2	12.8%	1	15.9%	3	14.3%	8	5.1%
Electric Ferries	3	8.1%	10	3.7%	2	18.9%	7	6.0%
Light Rail — Sound Transit Expansion Federal Way	4	6.7%	3	11.5%	9	2.6%	17	1.2%
Home Energy Efficiency & Renewables	5	6.3%	8	5.1%	5	8.1%	6	7.0%
Urban & Community Forestry	6	6.3%	5	8.3%	Not Ranked	0.5%	5	8.3%
Yakima Basin Ecosystem Restoration	7	6.1%	4	9.7%	Not Ranked	0.50%	9	4.3%
Transit-Oriented Community Development	8	5.2%	7	6.0%	6	6.1%	12	2.7%
Low Carbon Agriculture: Dairy Digesters	9	5.1%	11	3.1%	Not Ranked	0.5%	2	13.5%
Water-Energy Programs	10	4.7%	9	4.3%	Not Ranked	0.5%	4	9.7%
Low Carbon Agriculture: Agricultural Water Efficiency	11	4.3%	12	2.7%	Not Ranked	0.5%	3	11.5%
Clean Vehicle Programs	12	4.3%	15	1.6%	4	10.8%	11	3.1%
Low Carbon Freight Operations: Rail-Bed Replacement	13	4.2%	6	7.0%	Not Ranked	0.5%	13	2.3%
100% Clean Power Readiness: Hydro Expansion & Upgrades	14	2.5%	13	2.3%	10	2.0%	10	3.7%
High-Speed Rail	15	2.3%	14	1.9%	8	3.5%	14	1.9%

Low Carbon Freight Operations: Multi-Source Facility Projects	16	1.9%	18	1.0%	7	4.6%	18	1.0%
100% Clean Power Readiness: Grid Resiliency & Optimization	17	1.2%	16	1.4%	Not Ranked	0.5%	16	1.4%
Low Carbon Freight Operations: Sustainable Industrial Manufacturing Zones	18	1.1%	17	1.2%	Not Ranked	0.5%	15	1.6%

DEEP DECARBONIZATION SYSTEM ANALYSIS METHODOLOGY

While the main methodological steps were summarized in Section 5 of the report, we provide additional detail on each here.

BUSINESS-AS-USUAL EMISSIONS TRAJECTORY

For a business-as-usual emissions trajectory we use the Washington State Department of Commerce's Carbon Tax Assessment Model (CTAM) version 4.0 "Adjusted Emissions" scenario, but do not apply any carbon price.[128] The Adjusted Emissions scenario includes several key pieces of state legislation enacted in 2019, most notably the Clean Energy Transformation Act concerning power utilities shift to zero-carbon by 2045. The CTAM scenarios provide projections of all energy-sector emissions from 2020 through 2050, making them compatible with the E3 Pathways study as a point of comparison.

TABLE 7.3 CTAM Adjusted Business-as-Usual Emissions Scenario

POLLUTION SOURCES	BAU, ANNUAL GHGS ($MMTCO_2E$) - WASHINGTON STATE CTAM V4.0 ADJUSTED EMISSIONS SCENARIO						
	2020	2025	2030	2035	2040	2045	2050
TOTAL	**73.8**	**67.1**	**63.7**	**61.8**	**61.1**	**61.1**	**62.5**
ELECTRICITY	**12.5**	**5**	**3.6**	**2.5**	**1.4**	**0.1**	**0.1**
Electric - Coal	10.01	1.6	0	0	0	0	0
Electric - Nat Gas	2.38	3.29	3.55	2.47	1.28	0	0
Electric - Oil	0.05	0.05	0.04	0.03	0.01	0	0
Electric - Biomass	0.02	0.03	0.03	0.05	0.06	0.08	0.08
RCI	**19.4**	**19.9**	**19.7**	**20**	**20.4**	**21.2**	**21.9**
RCI - Coal	0.16	0.17	0.17	0.16	0.16	0.16	0.17
RCI - Nat Gas	11.9	12.71	12.66	12.6	12.85	13.31	13.58
RCI - Oil	7.01	6.77	6.61	7.01	7.19	7.55	7.94
TRANSPORTATION	**42.2**	**42.4**	**40.7**	**39.5**	**39.5**	**40**	**40.7**
On-road gasoline	21.57	19.78	18.11	16.91	16.44	16.41	16.49
On-road diesel	10.42	9.97	9.87	9.8	9.94	10.13	10.37
Marine vessels	2.77	4.8	4.47	4.11	3.96	3.87	3.76
Jet fuel & aviation	7.43	7.75	8.2	8.65	9.11	9.56	9.99
Rail	0.05	0.05	0.05	0.05	0.05	0.05	0.05

128 | Version 4.0 was released in November 2019. t.ly/EpEA

DEEP DECARBONIZATION EMISSIONS TRAJECTORY

The Deep Decarbonization trajectory, hitting state targets of a 45% reduction versus 1990 levels by 2030 and 95% versus 1990 levels by 2050, was based on sector-specific modelling of Energy and Environmental Economics (E3) through their Pacific Northwest Pathways to 2050 ("Pathways") study. Results from the "Pathways" study were adjusted under two addtional assumptions, namely that the State complies with the 2019 legislation for a coal-free power system by 2025 and a carbon-free power system by 2045, and that all energy-sectors collectively attain the 2020 legislated limits for emissions reduction in 2030 and 2050. Under the Deep Decarbonization trajectory, emissions from power, buildings (residential, commercial and industrial), and transportation drop from 73 million metric tons of CO_2e in 2020 to 2 million metric tons in 2050. With the exception of wildfires, we do not consider non-energy emissions such as agricultural soil and manure, waste or industrial processes in our cost-benefit analysis.

Emissions for the power sector were assumed to track those in the BAU case due to inclusion of the Clean Energy Transformation Act of 2019 into the BAU. In other sectors, emissions were assigned pathways from 2020 to 2050 in line with data extracted from the Pathways study. The building and transportation sectors were scaled accordingly to meet the 2050 limit across all sectors. Emissions between each decade were assumed to connect linearly.

Due to limitation in the BAU and net cost scenarios, only energy-sector emissions were used to determine the net benefits. Building biomass was excluded from the benefits and net cost analysis as well, due to insufficient data on both the health damages and the net costs from different building biomass scenarios.

TABLE 7.4 2050 Deep Decarbonization Trajectory

POLLUTION SOURCES	DEEP DECARBONIZATION, ANNUAL GHG EMISSIONS ($MMTCO_2E$)						
	2020	2025	2030	2035	2040	2045	2050
TOTAL GROSS EMISSIONS	**72.8**	**54.7**	**39.8**	**28.8**	**17.7**	**9.8**	**2.0**
ELECTRICITY, NET CONSUMPTION-BASED	**12.4**	**4.9**	**3.6**	**2.5**	**1.4**	**0.7**	**0**
Coal	10	1.6	0	0	0	0	0
Natural gas	2.4	3.3	3.6	2.5	1.4	0.7	0
Petroleum	0.1	0.1	0	0	0	0	0
Biomass & waste (CH_4 & N_2O)	0	0	0	0	0	0	0
RESIDENTIAL/COMMERCIAL/INDUSTRIAL	**21.4**	**17.1**	**12.8**	**11.2**	**9.5**	**5.7**	**1.9**
Coal	0.2	0.1	0.1	0.1	0	0	0
Natural gas	11.6	9.2	6.9	7.4	7.9	4.9	1.9
Oil	9.3	7.5	5.6	3.6	1.6	0.8	0
TRANSPORTATION	**39.3**	**33**	**23.6**	**15.2**	**6.8**	**3.4**	**0.1**
On-road gasoline	20.8	17.5	12.5	8	3.5	1.7	0
On-road diesel	7.9	6.6	4.7	3	1.3	0.7	0
Marine vessels	2.3	1.9	1.4	0.9	0.4	0.2	0
Jet fuel & aviation gasoline	7.5	6.3	4.5	3	1.5	0.8	0.1
Rail	0.8	0.7	0.5	0.3	0.1	0.1	0

BENEFIT MULTIPLIERS OF ACHIEVING DEEP DECARBONIZATION VERSUS BAU

To determine the benefits from avoided air pollution and climate damages, we apply the previously established GHG-NEI-CACES methodology to the difference in emission between the Deep Decarbonization and BAU scenarios.

A 3% social rate of NPV discounting was applied to the benefits, shown in Table 7.5. Net community health benefits across the energy sectors are projected to be $13.1 billion through 2030 and $49.9 billion through 2050. Climate benefits from the energy sectors are projected to be $8.9B through 2030 and $56B through 2050.

NET COSTS OF ACHIEVING DEEP DECARBONIZATION

The net costs of achieving deep decarbonization are derived from the Clean Energy Transition Institute's (CETI) Meeting the Challenge of Our Time report.[129] Net costs for each fifth year and Washington's share of 2020 emission across the four-state region (ID, MT, OR, and WA) are shown in TABLE 7.6.[130] Costs and emissions reductions were assumed to scale based on Washington's share of projected 2020 emissions, roughly consistent with Figure 3 of Meeting the Challenge, and interpolated linearly between every fifth year. Net costs in Meeting the Challenge are limited to energy system costs, including annualized equipment capital costs, fixed and variable operations and maintenance costs, and fuel costs. Finally, a 3% discounting was applied to determine the NPV net costs.

TABLE 7.5 Cumulative 2030 and 2050 Health and Climate Benefits by Fuel Source

POLLUTION SOURCES	NET BENEFITS 2021-2030 ($M)		NET BENEFITS 2021-2050 ($M)	
	HEALTH	CLIMATE	HEALTH	CLIMATE
TOTAL	**$13,100**	**$8,900**	**$49,900**	**$56,000**
Electric — Coal	$0	$0	$0	$0
Electric — Nat Gas	$0	$0	$0	-$200
Electric — Oil	$0	$0	$0	$0
Electric — Biomass	$600	$0	$2,600	$100
RCI — Coal	$100	$0	$400	$100
RCI — Nat Gas	$800	$1,800	$2,700	$9,100
RCI — Oil	-$100	-$300	$400	$5,100
On-road gasoline	$2,800	$1,800	$15,500	$14,400
On-road diesel	$2,600	$2,000	$9,800	$10,600
Marine vessels	$4,100	$1,400	$11,100	$5,100
Jet fuel & aviation	$200	$1,000	$1,200	$8,700
Rail	-$1,700	-$300	-$2,200	-$400
Wildfire	**$3,700**	**$1,500**	**$8,400**	**$3,400**

129 | Clean Energy Transition Institute (CETI), 2019. Pathways to a Low-Carbon Future for the Northwest." t.ly/o8T0

130 | Net costs across the four-state region for every fifth year of the report projections were checked with the Meeting the Challenge report and modelling team for consistency.

TABLE 7.6 Net Costs of Long-term Energy-system Decarbonization

YEAR	2020	2025	2030	2035	2040	2045	2050
Annual Net Cost (all states, $M)	$565	$1,940	$5,660	$8,740	$9,900	$7,610	$6,060
Cumulative Net cost (all states, $M)		$6,950	$27,800	$65,350	$112,500	$155,200	$188,600
WA cumulative Net cost ($M)		$3,200	$12,700	$29,700	$51,200	$70,600	$85,800
WA cumulative Net cost, NPV ($M)		$2,900	$10,600	$22,300	$35,100	$45,100	$51,800
WA cumulative net cost, NPV ($M), scaled for comparison			$24,800				$58,700

The Meeting the Challenge net costs through 2035 were used to compare the benefits of emissions reductions from the Deep Decarbonization scenario through 2030, when projected emissions decreased to approximately 45% below 1990 levels. Discounting these net costs was limited to through 2030 rather than through 2035, however, hence the NPV estimate for 2030 is larger than the NPV estimate for 2035 ($24.8B versus $22.3B). In addition, cumulative NPV costs through 2050 were scaled according to the increased ambition of the deep decarbonization scenario for the energy sectors (97.5%) compared to the Meeting the Challenge scenario (86%). Net costs on a NPV basis through 2050 are therefore $58.7 billion (equal to $51.8 billion multiplied by 97.5% / 86%).

NPV benefits and costs of wildfire prevention

The long-term benefits and costs of *wildfire prevention* were determined separately from the energy-sector benefits and costs, based on the methodology outlined above scaled to a decadal budget of $554 million dollars based on the proposed budget for Washington 2020 House Bill 2413. Each decadal budget was assumed to be spent, on average, in the middle year of the decade while the average avoided emissions were assumed to accrue by the end of the decade - or five years after the average spend.

Undiscounted, the $9M in health and $3.6M in climate benefits for a $554M, 10-year expenditure total $7B. After discounting of 3% on costs and benefits for each 10-year cycle the net health benefits for each 10-year period to 2050 (2021-2030, 2031-2040, 2041-2050) are projected to be $3.7B, $2.7B, and $2.0B for a total 30-year benefit of $8.4B. The climate benefits are projected to be $1.5B, $1.1B, and $0.8B for a 30-year benefit of $3.4B.

Discounted net costs for each decade are forecast to be $480M, $350M, and $260M for a total, 30-year cost of $1.1B.

VIII. APPENDICES

IMPLAN INPUT ASSEMBLY

Below are the source documents and data inputs assembled for each *Resilient Recovery* program. Notably, data input tables include a solar pv, smart grid, and/or household "basket." Baskets constitute a recurring custom expenditure that IMPLAN can save and re-run. The data assembly of each basket is provided at the end of this section.

CLEAN TRANSPORTATION

HIGH-SPEED RAIL — Project-specific data from the Washington State Department of Transportation's (WSDOT) 2019 Business Case Analysis for UHSGT was used to formulate inputs into the IMPLAN model and health benefits model.[131]

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Construction of new highways & streets	84.1%	Default
Construction of other new nonresidential structures	3.3%	Default
Railroad rolling stock manufacturing	1.9%	Default
Architectural, engineering, & related services	5.0%	Default
Environmental & other technical consulting services	5.0%	Default
State government employee payroll, non-education	0.7%	Default

LIGHT RAIL — SOUND TRANSIT EXPANSION FEDERAL WAY — Project-specific data from Sound Transit's 2020 Financial Plan & Adopted budget was used to formulate inputs into the IMPLAN model.[132] The remaining total 2021-2025 budget, including South King County light rail vehicle fleet allocations, was used to derive IMPLAN inputs. Total expenditures through 2025 equal $1.7 billion, of which 83% is directed towards the construction of new nonresidential and new power and communication structures.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Construction of other new nonresidential structures	71.3%	Default
Construction of new power & communication structure	11.5%	Default
Management consulting services	6.7%	Default
Railroad rolling stock manufacturing	4.9%	0%
Local government passenger transit	3.7%	100%
Transit & ground passenger transportation	1.4%	100%
Architectural, engineering, & related services	0.3%	Default
Environmental & other technical consulting services	0.1%	Default
Other real estate	0.1%	Default

LOW CARBON BUSES AND TRUCKS — Project-specific data for the *Low Carbon Buses and Trucks* Program was derived and modified from the Luskin Center, specifically from data on California's Low-Carbon Transit Operations Program (LCTOP), Hybrid and Zero-Emission Truck and Bus Voucher, Zero-Emission Truck and Bus Pilot, and Zero-Emission Drayage Truck Demonstration.[133]

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Heavy-duty truck manufacturing	44.4%	Default
Local government passenger transit	39.6%	Default
Transit & ground passenger transportation	1.5%	Default
Construction of new nonresidential structures	6.9%	Default
Semiconductor & related device manufacturing	2.9%	Default
Motor vehicle parts manufacturing	1.0%	Default
Construction of new power & communication structures	0.8%	Default
Management consulting services	0.8%	Default
Other commercial service industry machine manufacturing	0.4%	Default
HOUSEHOLD INCOME	**0.3%**	**DEFAULT (100%)**
Employment & payroll only (local government, non-education)	0.3%	100%
Motorcycle, bicycle & parts manufacturing	0.3%	Default
Electric power generation - solar	0.2%	Default
Maintenance/repair construction of nonresidential structures	0.2%	Default
Light truck & utility vehicle manufacturing	0.2%	Default
SOLAR PV BASKET	**0.1%**	**DEFAULT**
Employment & payroll only (state govt, non-education)	0.1%	100%
Showcase, partition, shelving & locker manufacturing	0.1%	Default
SMART GRID BASKET	**0.1%**	**DEFAULT**
Sign manufacturing	0.1%	Default
Broadcast & wireless communication equipment manufacturing	0.01%	Default
Water, sewage, & other treatment & delivery systems	0.0001%	Default

CLEAN VEHICLE PROGRAM — Project-specific data for the *Clean Vehicle Program* was derived and modified from the Luskin Center, specifically from data on California's Financing Assistance Pilot Project, Enhanced Fleet Modernization Plus-Up Program, and Car Sharing and Mobility Options Pilot.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Retail stores - Motor vehicle & parts	39.9%	100%
Individual & family services	14.2%	100%
Automobile Manufacturing	12.1%	0%
Automotive equipment rental & leasing	10.2%	Default
Employment & payroll of local govt, other services	7.3%	100%
Advertising & related services	6.5%	Default
All other miscellaneous electrical equipment & component manufacturing	2.9%	Default
Management consulting services	3.3%	100%
Monetary authorities & depository credit intermediation activities	1.6%	Default
Maintenance & repair construction of highways, streets, bridges, & tunnels	1.6%	Default
Retail stores — Electronics & appliances	0.1%	Default
Broadcast & wireless communications equipment manufacturing	0.1%	Default
Printing	0.05%	Default
Retail stores - Miscellaneous	0.04%	Default
Wired telecommunications carriers	0.02%	Default
Postal service	0.02%	Default
Real estate establishments	0.02%	Default
Business support services	0.01%	Default

TRANSIT-ORIENTED COMMUNITY DEVELOPMENT — Project-specific data for the *Transit-Oriented Community Development* Program was derived and modified from the Luskin Center, specifically from data on California's Affordable Housing and Sustainable Communities Program.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Construction of new multifamily structures	65.8%	Default
Construction of new highways & streets	31.1%	Default
Architectural, engineering, & related services	1.4%	Default
Light truck & utility vehicle manufacturing	0.6%	Default
Transit & ground passenger transportation	0.5%	100%
Heavy duty truck manufacturing	0.3%	Default
Civic, social, professional, & similar organizations	0.1%	100%
Employment & payroll only (local gov, noneducation)	0.1%	100%
Advertising, public relations, & related services	0.02%	Default
Landscape & horticultural services	0.02%	Default
Community food, housing, & other relief services	0.01%	100%
Management consulting services	0.002%	Default
Motorcycle, bicycle, & parts manufacturing	0.001%	Default
Construction of new power & communication structures	0.001%	Default
Printing	0.001%	Default

131 | Washington State Department of Transportation, 2019. t.ly/sXjM
132 | Sound Transit, 2019. "2020 Financial Plan & Adopted Budget." t.ly/TnqI
133 | wUCLA Luskin Center for Innovation, 2018.

WATER, POWER, AND ENERGY EFFICIENCY INVESTMENTS

HOME ENERGY EFFICIENCY AND RENEWABLES — Project-specific data for the *Home Energy Efficiency and Renewables* Program was derived and modified from the Luskin Center, specifically from data on California's Single-Family/Small Multi-Family Energy Efficiency and Solar Water Heating Program, Single-Family Solar Photovoltaics Program, and Large Multi-Family Energy Efficiency and Renewables Program.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Maintenance & repair construction of residential structures	47.8%	100%
Solar PV Basket	32.7%	Default
Individual & family services	10.8%	100%
Management consulting services	8.8%	100%

100% CLEAN POWER READINESS

GRID RESILIENCY AND OPTIMIZATION — Project-specific data for the Grid Resiliency and Optimization Project was derived from the National Renewable Energy Laboratory (NREL) Jobs and Economic Development Impact (JEDI) Transmission Line Model, as well as the Luskin Center.[134]

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Construction of new power & communication structures	34.1%	Default
Power, distribution, & specialty transformer manufacturing	24.1%	Default
Storage battery manufacturing	10.0%	Default
Other communication & energy wire manufacturing	9.8%	Default
Other electronic component manufacturing	8.0%	Default
Architectural, engineering, & related services	4.5%	90%
Electric power transmission & distribution	4.0%	Default
Environmental & other technical consulting services	3.6%	90%
Iron, steel pipe & tube manufacturing from purchased steel	1.5%	Default
Asphalt paving mixture	0.1%	Default
Ready-mix concrete manufacturing	0.1%	Default
Management consulting services	0.1%	90%

HYDRO EXPANSION AND UPGRADES — Project-specific data for the Hydro Expansion and Upgrades Project is derived from the National Renewable Energy Laboratory (NREL) Jobs and Economic Development Impact (JEDI) Conventional Hydropower Model.[135]

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Construction of new power & communication structures	33.0%	Default
Turbine & turbine generator set units manufacturing	39.1%	Default
Architectural, engineering, & related services	24.4%	Default
Power, distribution, & specialty transformer manufacturing	3.0%	Default
Other communication & energy wire manufacturing	0.4%	Default

WATER-ENERGY PROGRAM —

Project-specific data for the Hydro Expansion and Upgrades Project is derived and modified from the Luskin Center report, particularly California's Water-Energy Grant Program.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Maintenance & repair construction of residential structures	19.6%	90%
Totalizing fluid meter & counting device manufacturing	12.2%	Default
Architectural, engineering, & related services	11.0%	100%
Household laundry equipment manufacturing	9.5%	Default
Landscape & horticultural services	9.2%	100%
Plumbing fixture fitting & trim manufacturing	8.7%	Default
Pottery, ceramics, & plumbing fixture manufacturing	7.7%	Default
Other commercial service industry machinery manufacturing	4.3%	Default
Management consulting services	6.5%	86%
Individual & family services	2.9%	100%
Maintenance & repair construction of nonresidential structures	2.4%	92%
Employment & payroll only (local government, non-education)	2.3%	100%
Other electronic component manufacturing	1.1%	Default
Printing	0.5%	Default
Other major household appliance manufacturing	0.4%	Default
Hardware manufacturing	0.3%	Default
Wireless telecommunications carriers	0.3%	Default
Securities & commodity contracts intermediation & brokerage	0.2%	Default
Software publishers	0.2%	Default
Environmental & other technical consulting services	0.2%	100%
Water, sewage, & treatment delivery systems	0.1%	100%
MILEAGE BASKET	**0.07%**	**DEFAULT**
Labor & civic organizations	0.07%	100%
Waste management & remediation services	0.05%	Default
Electronic computer manufacturing	0.03%	Default
Postal service	0.03%	Default
Broadcast & wireless communications equipment manufacturing	0.02%	Default
Radio & television broadcasting	0.02%	100%
Wired telecommunications carriers	0.01%	Default
Other plastics product manufacturing	0.01%	Default
Retail stores - Building material & garden supply	0.01%	Default

FOREST CONSERVATION & ECOSYSTEM RESTORATION

WILDFIRE PREVENTION AND PREPAREDNESS — The *Wildfire Prevention and Preparedness* Program provides funding towards the Department of Natural Resources' 20-year strategic plan for wildfire preparedness and prevention. This is based upon House Bill 2413 and the corresponding fiscal note breakdown of funding allocation by activity.[136]

The plan includes the following major program buckets: Local Fire Service Capacity and Fire Prevention (18%), Staffing and Aircraft for Fire Preparedness (39%), Landscape Risk Assessment (3%), Resilient Communities and Landscapes (16%), Post-wildfire recovery (2%) and Treating Unhealthy Forests (22%). The budget for two bienniums (FY 21-23 and FY 23-25) was used to develop the allocation of funding within this program. The total proposed budget for those bienniums is $106 and $107 million, respectively.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Employment & payroll of state govt, other services	30.3%	100%
Support activities for agriculture & forestry	21.1%	Default
Airplane Manufacturing	7.7%	Default
Wholesale - Professional & commercial equipment & supplies	6.1%	Default
Forestry, forest products, & timber tract production	5.5%	Default
Maintenance & repair construction of residential structures	5.0%	Default
Other aircraft parts & auxiliary equipment manufacturing	3.8%	100%
Maintenance & Repair construction of nonresidential structures	3.5%	Default
Search, detection, & navigation instruments manufacturing	3.2%	Default
Heavy Duty Truck Manufacturing	3.0%	Default
Management consulting services	2.0%	Default
Other Support Services	1.9%	Default
Industrial truck, trailer, & stacker manufacturing	1.7%	Default
Facilities Support Services	1.3%	Default
Other local government enterprises	1.2%	Default
Grantmaking, Giving, & social advocacy organizations	1.1%	Default
Environmental & other technical consulting services	1.1%	Default
Air Transportation	0.5%	Default

134 | National Renewable Energy Laboratory. "JEDI Transmission Line Model." t.ly/UROS

135 | National Renewable Energy Laboratory. "JEDI Conventional Hydropower Model." t.ly/YdZs

136 | Washington State Legislature, 2020. "HB 2413." t.ly/OvCG

URBAN AND COMMUNITY FORESTRY — Project-specific data for the *Urban and Community Forestry* Program is derived and modified from the Luskin Center report, particularly California's *Urban and Community Forestry* Program.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Civic, social, professional, & similar organizations	34.4%	100%
Landscape & horticultural services	23.2%	100%
Forestry, forest products, & timber tract production	10.4%	96.5%
Maintenance & repair construction of highways, streets, bridges, & tunnels	8.4%	100%
Retail stores - building material & garden supply	5.8%	95.1%
Employment & payroll only (local government, non-education)	4.6%	100%
Architectural, engineering, & related services	4.0%	100%
Management & consulting services	2.4%	90.1%
Environmental & other technical consulting services	2.1%	Default
Printing	1.4%	Default
Scientific research & development services	0.6%	Default
MILEAGE BASKET	**0.5%**	**DEFAULT**
Automotive equipment rental & leasing	0.4%	Default
Other educational services	0.3%	Default
All other miscellaneous professional, scientific, & technical services	0.3%	Default
Retail stores - Electronics & appliances	0.2%	Default
Retail stores - Food & beverage	0.2%	Default
Retail stores - Miscellaneous	0.2%	Default
Employment & payroll only (local government, non-education)	0.2%	100%
Software publishers	0.1%	Default
Water, sewage, & other treatment & delivery systems	0.1%	100%
Retail stores - Clothing & clothing accessories	0.1%	Default
Advertising & related services	0.04%	Default
Insurance agencies, brokerages, & related activities	0.04%	Default
Truck trailer manufacturing	0.02%	Default
Specialized design services	0.02%	100%
Retail stores - Gasoline stations	0.01%	Default
Transport by air	0.01%	Default

YAKIMA BASIN ECOSYSTEM RESTORATION — This report focuses on the nearly $400 million in remaining budget for 2020-2023, based on the Department of Ecology's 2018 Cost Estimate and Financing Plan.[137] It does not include water conservation, which is modeled by a separate program in this report. Over 80% of spending is projected to fall in 3 IMPLAN categories: *Construction of new nonresidential structures*, *maintenance and repair construction of nonresidential structures*, and *support activities for agriculture and forestry*. Notably, this report does not consider the Keechelus to Kachess Conveyance Project, an $83M dollar expenditure that recent Environmental Impact Statement documents indicate is no longer being considered.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Construction of other new nonresidential structures	61.4%	Default
Maintenance & repair construction of nonresidential structures	12.4%	Default
Support activities for agriculture & forestry	10.4%	100%
Environmental & other technical consulting services	5.0%	Default
Architectural, engineering, & related services	3.6%	Default
Management consulting services	3.1%	Default
Landscape & horticultural services	1.9%	100%
Water, Sewage, & Other Systems	1.3%	100%
Fruit Farming	0.4%	100%
Dairy Cattle & Milk Production	0.4%	100%
Watch, clock, & other measuring & controlling device manufacturing	0.1%	Default
Totalizing fluid meter & counting device manufacturing	0.1%	Default

137 | Washington State Department of Ecology, 2018. t.ly/M9hc

LOW CARBON AGRICULTURE

AGRICULTURE WATER EFFICIENCY — Project-specific data for the Agriculture Water Efficiency Program was derived and modified from the Luskin Center report, specifically from California's State Water Efficiency and Enhancement Program (SWEEP).

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Other electronic component manufacturing	43.2%	Default
Maintenance & repair construction of nonresidential structures	23.1%	Default
Plastics pipe & pipe fitting manufacturing	15.9%	Default
Pump & pumping equipment manufacturing	12.0%	Default
Hardware manufacture	1.9%	Default
All other miscellaneous electrical equipment manufacturing	1.9%	Default
Construction of new power & communication structures	1.9%	Default
Metal tank (heavy gauge) manufacturing	0.1%	Default

DAIRY DIGESTERS — Project-specific data for the Dairy Digester Program was derived and modified from the Luskin Center report, specifically from California's Dairy Digester Research and Development Program.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Textile bag & canvas mills	28.7%	Default
Power, distribution, & specialty transformer manufacturing	27.9%	Default
Construction of new power & communication structures	23.0%	Default
Architectural, engineering, & related services	10.4%	Default
Heating equipment (except warm air furnaces) manufacturing	5.8%	Default
Pump & pumping equipment manufacturing	3.6%	Default
Scientific research & development services	0.6%	Default

SUSTAINABLE INDUSTRY

ELECTRIC FERRIES — Documentation for project scope and budget was taken from WSDOT's 2040 Long Range Plan.[138] The *Electric Ferries* Program accelerates the first wave of ferry retirements and replacements with hybrid-electric ferries and ferry terminal electrification. The ferries are contracted to be built locally by Vigor Shipyards. This report considers six new ferry builds and two conversions along with ferry terminal electrification projects currently scheduled through 2027, with the hope of accelerating those builds to be completed earlier. The financial scope of the project is $1.5 billion through 2027, which is almost entirely from shipbuilding, retrofitting, and terminal construction. The budget is rounded out with allocations for design, environmental review, and program support.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Ship building & repairing	73.2%	100%
Ship building & repairing	6.7%	Default
Construction of new power & communication structures	19.9%	100%
State Government Passenger Transit	0.2%	100%
Architectural, engineering, & related services	0.02%	100%
Environmental & other technical consulting services	0.01%	100%

LOW CARBON FREIGHT OPERATIONS

MULTI-SOURCE FACILITIES — Project-specific data for the Multi-Source Facilities Project is derived and modified from the Luskin Center report, specifically from California's Multi-Source Facility Demonstration Project.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Heavy-duty truck manufacturing	37.9%	Default
Transport by truck	15.9%	100%
Support activities for transportation	11.0%	100%
Solar PV basket	8.2%	Default
Other industrial machinery manufacturing	7.7%	Default

138 | Washington State Department of Transportation, 2019. "Washington Ferries 2040 Long Range Plan." t.ly/eauq

Other electrical equipment & component manufacturing	6.6%	Default
Architectural, engineering, & related services	3.2%	Default
Construction of new power & communication structures	2.9%	Default
Management consulting services	2.2%	Default
Electric power generation, transmission & distribution	1.2%	Default
Power, distribution, & specialty transformer manufacturing	0.8%	Default
Environmental & other technical consulting services	0.8%	Default
Switchgear & switchboard apparatus manufacturing	0.4%	Default
Employment & payroll only (local govt, non-education)	0.3%	100%
Scientific research & development services	0.3%	100%
Wiring device manufacturing	0.3%	Default
Other electronic component manufacturing	0.3%	Default
Hardware manufacturing	0.1%	Default
Transport by rail	0.05%	100%

SUSTAINABLE INDUSTRIAL MANUFACTURING ZONES— Project-specific data for the SIMZ Project was derived from budgetary data provided by Western Rail Construction and Dr. Cathy Carruthers.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Prefabricated wood building manufacturing	88.5%	Default
Construction of new highways & streets	5.5%	Default
Construction of new manufacturing structures	2.0%	Default
Solar PV Basket	1.8%	Default
Iron & steel mills & ferroalloy manufacturing	0.7%	Default
Wholesale - Other durable goods merchant wholesalers	0.5%	Default
Mark Up .18	0.3%	Default
Total Labor	0.2%	Default
Stone Mining & quarrying	0.2%	Default
Commercial & industrial machinery & equipment rental & leasing	0.1%	Default
Architectural, engineering, & related services	0.1%	Default
Environmental & other technical consulting services	0.1%	Default
Steel wire drawing	0.03%	Default
Wholesale - Machinery, equipment, & supplies	0.03%	Default
Turned product & screw, nut, & bolt manufacturing	0.02%	Default
Wholesale - Other durable goods merchant wholesalers	0.004%	Default

RAIL-BED REPLACEMENT — Project-specific data for the Rail-Bed Replacement Project is derived from Western Rail Construction.

IMPLAN SECTOR	SHARE OF FUNDS	LOCAL PURCHASE RATE
Iron & steel mills & ferroalloy manufacturing	57.9%	Default
Construction of other non residential	11.6%	Default
Architectural, engineering, & related services	8.5%	Default
State Government Employee Payroll	6.9%	Default
Stone Mining & Quarrying	5.9%	Default
Sawmills	5.5%	Default
Sand & Gravel	3.7%	Default

IMPLAN BASKETS AND HOUSEHOLD INCOME

SOLAR PV BASKET — The Solar PV basket represents a mix of industries in the solar sector outlined in *The Economic Benefits of Investing in Clean Energy* from the Center for American Progress.[139] The Solar PV basket is derived from the Luskin Center report.

IMPLAN SECTOR	PERCENTAGE	LOCAL PURCHASE RATE
Construction of new power & communication structures	30%	Default
Hardware manufacturing	17.5%	Default
Miscellaneous electrical equipment & component manufacturing	17.5%	Default
Other electronic component manufacturing	17.5%	Default
Environmental & other technical consulting services	17.5%	Default

SMART GRID BASKET — The Smart Grid Basket represents a mix of industries in the smart grid sector outlined in the Center for American Progress' *The Economic Benefits of Investing in Clean Energy*. The basket is derived from the Luskin Center report.

IMPLAN SECTOR	PERCENTAGE	LOCAL PURCHASE RATE
Construction of new power & communication structures	25%	Default
Mechanical power transmission equipment manufacturing	25%	Default
Other electronic component manufacturing	25%	Default
Miscellaneous electrical equipment & component manufacturing	12.5%	Default
Storage battery manufacturing	12.5%	Default

MILEAGE BASKET — The Mileage Basket represents a mix of industries, based on the average breakdown of annual vehicle costs reported in the American Automobile Association's 2019 *Your Driving Costs* study.[140] Household income is a unique industry in the basket because it does not directly correspond to a vehicle cost and instead represents reimbursement dollars that go toward vehicle depreciation, which vehicle owners may spend in a variety of ways.

IMPLAN SECTOR	PERCENTAGE	LOCAL PURCHASE RATE
Household income	35.9%	
Retail - Gasoline stores	18.7%	Default
Insurance carriers	12.9%	Default
Automotive repair & maintenance, except car washes	12.7%	Default
Monetary authorities & depositor credit intermediation activities	9.9%	Default
Employment & payroll only (state & local government, non education)	8.1%	Default
Tire manufacturing	1.7%	Default

HOUSEHOLD INCOME — Household Income is a unique economic activity in IMPLAN that averages together the many ways in which an increase in household income may be spent, including both savings and the purchase of goods and services. Since spending patterns vary by income, IMPLAN allows users to build in assumptions about the income levels of beneficiaries. This distribution was derived and modified from the Luskin Center and is assumed to be representative of regular transit riders.

INCOME BREAKDOWN	% BASKET
Under $10,000	17.6%
$10,000 to $15,000	10.9%
$15,000 to $25,000	16.9%
$25,000 to $35,000	9.5%
$35,000 to $50,000	9.9%
$50,000 to $65,000	7.8%
$65,000 to $75,000	4.5%
$75,000 to $100,000	11.5%
$100,000 to $125,000	6.9%
$125,000 to $150,000	3.4%
$150,000+	1.1%

139 | Robert Pollin, James Heintz, Heidi Garrett-Peltier, 2009. t.ly/6oBS
140 | AAA, 2019. "Your Driving Costs." t.ly/PoHD

TABLE 8.1 Program-level Summary

INVESTMENT AREA	INVESTMENT CATEGORY	EMPLOYMENT & PAY				BROADER ECONOMY						
		EMPLOYMENT	FULL-TIME EQUIVALENTS (FTE)	WAGES & SALARY PER FTE	WAGES & BENEFITS PER FTE	OUTPUT MULTIPLIER	EMPLOYEE COMPENSATION	WAGES & SALARY	WAGES & BENEFITS	PROPRIETOR INCOME	VALUE ADDED, TOTAL	LEAKAGE (DIRECT INVESTMENT FLOWS OUT OF STATE)
CLEAN TRANSPORTATION	High-Speed Rail	8.2	7	$57,297	$59,087	1.77	$478,103	$403,105	$415,697	$134,579	$1,018,505	$0
	Light Rail - Sound Transit Expansion Federal Way	14.7	13.8	$50,085	$54,955	2.06	$826,889	$691,171	$758,381	$247,188	$1,118,789	$48,713
	Low Carbon Buses & Trucks	12.3	11.6	$58,023	$67,516	1.88	$902,848	$671,307	$781,130	$63,595	$527,978	$446,860
	Clean Vehicle Programs	8.3	7.4	$43,684	$46,328	1.04	$395,755	$323,056	$342,613	$54,823	$682,765	$422,284
	Transit-Oriented Community Development	9.8	9	$50,159	$51,439	1.7	$536,641	$453,387	$464,956	$176,885	$1,145,398	$2
WATER, POWER, & ENERGY EFFICIENCY	Home Energy Efficiency & Renewables	11.1	10.1	$46,871	$48,776	1.85	$567,001	$475,708	$495,037	$136,441	$1,030,031	$0
	100% Clean Power Readiness:Grid Resiliency & Optimization	6.5	5.9	$57,552	$60,968	1.52	$416,065	$340,115	$360,302	$73,026	$786,344	$97,753
	100% Clean Power Readiness: Hydro Expansion & Upgrades	7.2	6.6	$61,531	$63,416	1.71	$483,980	$406,809	$419,271	$86,251	$892,452	$4,348
	Water-Energy Programs	9.3	8.6	$49,867	$51,746	1.76	$513,304	$428,263	$444,403	$88,240	$926,404	$401
FOREST CONSERVATION & ECOSYSTEM RESTORATION	Wildfire Prevention & Preparedness	13.1	12.2	$49,893	$55,437	1.67	$781,114	$608,197	$675,778	$82,431	$1,143,026	$45,132
	Urban & Community Forestry	13	11.8	$42,038	$43,812	1.8	$597,259	$496,128	$517,070	$138,806	$1,108,189	$40,369
	Yakima Basin Ecosystem Restoration	15.9	15	$46,763	$48,197	2.07	$835,034	$701,743	$723,265	$241,335	$1,194,006	$0
LOW CARBON AGRICULTURE	Low Carbon Agriculture: Agricultural Water Efficiency	7	6.6	$60,152	$62,126	1.73	$475,707	$397,964	$411,024	$53,766	$809,894	$0
	Low Carbon Agriculture: Dairy Digesters	7.8	7	$57,227	$60,386	1.68	$491,657	$403,413	$425,680	$63,422	$843,028	$0
SUSTAINABLE INDUSTRY	Electric Ferries	7.4	6.9	$60,704	$58,111	1.74	$512,798	$420,194	$402,241	$83,968	$933,678	$2,305
	Low Carbon Freight Operations: Multi-Source Facility Projects	5.7	5.3	$55,592	$58,479	1.18	$357,279	$293,938	$309,204	$93,822	$644,079	$379,054
	Low Carbon Freight Operations: Sustainable Industrial Manufacturing Zones	7.8	7.3	$34,084	$35,333	1.5	$302,080	$249,439	$258,579	$273,539	$743,563	$9,465
	Low Carbon Freight Operations: Rail-Bed Replacement	9	8.4	$53,448	$56,282	1.89	$546,657	$449,473	$473,305	$103,761	$889,268	-$87,113