Investing in Public Infrastructure in Massachusetts

Impacts of Investment in Clean Energy, Water, and Transportation

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List of Acronyms

ASHP	Air-source heat pump
BTM	behind-the-meter
CELT	Capacity, Energy, Loads, and Transmission
CIP	Capital Improvement Plan
EPA	Environmental Protection Agency
EV	electric vehicle
EVSE	electric vehicle supply equipment (charging stations)
FY	fiscal year
MassDOT	Massachusetts Department of Transportation
MA CEP	Massachusetts Comprehensive Energy Plan
MA WIFC	Massachusetts Water Infrastructure Finance Committee
MBTA	Massachusetts Bay Transit Authority
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance
PV	photovoltaics
RTA	Regional Transit Authority
SDWA	Safe Drinking Water Act

EXECUTIVE SUMMARY

Many types of public infrastructure in Massachusetts are underfunded. Clean water treatment and distribution infrastructure is aging, many miles of water pipes are leaking, and stormwater infrastructure is at risk of flooding and contamination. The public transit system serving the Greater Boston area could benefit from funding for better operation and maintenance (O&M) as well as an expansion of bus routes and rail lines to reduce congestion and improve air quality.[1] The state's energy infrastructure requires a path to aggressive decarbonization to meet climate change mitigation targets and improve air quality. These and many other examples illustrate the need to improve the state's infrastructure for the public good over the next decade. Increasing investment above what is currently being spent will not only bring infrastructure to a state of good repair but will also strengthen the state's economy by supporting job creation. Recent research has shown that public sector jobs in Massachusetts, such as those discussed in this report, can support a family, provide access to health insurance, and build long-term wealth.[2]

For this report, Synapse Energy Economics analyzed the impacts of increasing future investment in the energy, water, and transportation sectors on job creation in Massachusetts. For each sector, we calculated the annual "investment gap" for the years 2020 to 2030 and calculated the total jobs created using the economic analysis IMPLAN model.

Overall, the transportation sector has the largest investment gap to reach a state of good repair, and therefore has the highest job creation potential. Between 2020 to 2030, investment in the transportation sector could produce and sustain an average of 44,000 jobs per year (Table 1). The energy sector investment gap is the second largest and could produce an average of nearly 25,000 jobs per year. Finally, the water sector investment gap could produce an average of nearly 21,000 jobs per year. In total, filling all three investment gaps could sustain nearly 90,000 public sector jobs per year on average over the next decade, bring public infrastructure to a state of good repair, and support Massachusetts families with livable wages and healthcare.

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[1] MassDOT. 2019. Congestion in the Commonwealth: Report to the Governor 2019. Available at: https://www.mass.gov/files/documents/2019/08/12/MassDOTCongestAug19Acc.pdf

[2] Austin, A. 2018. *Public-Sector Jobs Increase the Economics Well-Being of Massachusetts Families*. https://www.demos.org/research/public-sector-jobs-increase-economic-well-being-massachusetts-families.

Table 1. Potential job creation from filling investment gaps in energy, water, and transportation sectors

Sector	Gross Annual Jobs			Average Annual Jobs (2020-2030)
	2020	2025	2030	
Energy	23,100	16,900	30,000	**24,700**
Water	20,800	20,800	18,400	**20,600**
Transportation	44,700	31,800	39,500	**44,000**
Total Impacts	**88,600**	**69,500**	**87,900**	**89,300**

1. Introduction

On behalf of the Labor Network for Sustainability, Synapse Energy Economics, Inc. (Synapse) conducted an analysis of the economic benefits of improving public infrastructure in the Commonwealth of Massachusetts through 2030. This report focuses on jobs added to the energy, water, and transportation sectors as a result of increased investment by the state, municipalities, and the public. For each sector, we evaluated future investment in several different subsectors (see Table 2).

Table 2. Sectors and subsectors evaluated in this report

Sector	Subsectors
Energy	Electric generation resources (solar photovoltaics, onshore and offshore wind, and natural gas generators)
	Utility-scale battery storage
	Heat pumps
	Energy efficiency programs
	Natural gas distribution system
Water	Drinking water infrastructure
	Clean water infrastructure
	Stormwater infrastructure
Transportation	Highways and roads (MassDOT)
	MBTA public transit
	Regional transit (RTAs)
	Bicycling
	Electric vehicles
	Airports
	Seaports

The core of the analysis compares current spending in each subsector to a future in which investment is increased for the public good or to reach a "state of good repair." The differences between the current and future spending levels are referred to in this report as the "investment gap." For example, in the water sector, the spending difference is referred to as the "water investment gap."

This report summarizes the public sector job creation associated with meeting the energy, water, and transportation investment gaps from 2020 through 2030. We also highlight the job impacts of planned investment projects for several key regions and cities in the Commonwealth.

2. Approach and Spending Estimates

For each sector (energy, water, transportation), Synapse reviewed the literature for information on investment gaps between 2020 and 2030. Using this literature review, we estimated the annual changes in spending to fill the gap in each sector. The investment gaps for all sectors were calculated relative to levels of infrastructure investment in 2018.

Finally, we utilized IMPLAN, an input/output economic analysis model, to convert annual spending levels into jobs created in each sector.[3] For the water and transportation sectors, the investment gaps were based on infrastructure needs reports or gap analysis studies. For the energy sector, the investment gap was based on aggressive state policy goals, specifically the Aggressive Conservation and Fuel Switching scenario described in the Massachusetts Comprehensive Energy Plan (MA CEP).[4]

Synapse converted annual spending levels into jobs associated with the construction of infrastructure and jobs associated with the O&M of infrastructure. To do so, we classified spending in the investment gaps as either construction or O&M costs. Construction spending will generate jobs only during the years in which infrastructure construction takes place, whereas O&M spending will generate jobs continuously throughout the life of the infrastructure asset. For construction and O&M jobs, we modeled three types of jobs in IMPLAN—direct, indirect, and induced—each described in Appendix A. All results were reported at the aggregate level for each type of infrastructure (that is, inclusive of direct, indirect, and induced jobs) in all three sectors. All job creation impacts were modeled within Massachusetts only.

2.1. Energy Sector

The energy investment gap was defined as the funding needed to achieve the MA CEP's Aggressive Conservation and Fuel Switching scenario—a future in which energy infrastructure is aligned with the Commonwealth's aggressive policy goals.[5] Of the scenarios included in the MA CEP, this scenario produced the most significant reduction in 2030 greenhouse gas emissions by featuring increased renewable energy supply, increased electrification of buildings and vehicles, decreased consumption in

[3] IMPLAN is an industry-standard model that evaluates job creation and re-spending associated with a set of costs. IMPLAN is a commercial model developed by IMPLAN Group LLC. Information on IMPLAN is available at: http://implan.com/.

[4] Massachusetts Department of Energy Resources (DOER). 2018. *Massachusetts Comprehensive Energy Plan*. Available at: https://www.mass.gov/files/documents/2019/01/10/CEP%20Report-%20Final%2001102019.pdf.

[5] Note that this analysis does not include any investments associated with climate resiliency or mitigation.

the thermal sector, and decreased peak demand.[6] The energy sector analysis also considered the jobs lost in some years due to the reduction in investment in the natural gas industry in the Commonwealth, as well as the jobs generated in some years from the increase in natural gas generation due to increased load from electrification.

The energy investment gap included funding for utility-scale solar photovoltaics (PV), onshore wind, offshore wind, utility-scale battery storage, commercial behind-the-meter (BTM) solar, and residential BTM solar. We further relied on the MA CEP for the change in natural gas generation as well as residential and commercial air source heat pump (ASHP) installation projections.[7] We relied on the Metropolitan Area Planning Council's 2016 *Fixing Our Pipes* report for the miles of leak-prone pipe by gas company that should be replaced.[8] Finally, we relied on the Independent System Operator of New England's (ISO New England) 2018 Forecast Report of Capacity, Energy, Loads, and Transmission (CELT) for energy efficiency projections.[9]

Because spending data is not publicly available in the MA CEP report, we used several sources of data to calculate the spending associated with these investments:

- For battery storage, we used the levelized cost of storage ($ per kilowatt-year) from Lazard's *Levelized Cost of Storage Analysis* (Version 4.0).[10] We assumed all storage is utility-scale lithium-ion, and we broke out the levelized cost of storage into capital expenditure and operations and maintenance (O&M) subcomponents. We found the battery storage gap requires a total of approximately $444 million (in 2018 dollars) from 2020 to 2030 with an average annual investment of $40 million.

- For all categories of solar PV and wind, we used capital costs ($ per kilowatt) and fixed O&M ($ per kilowatt-year) expenses from the National Renewable Energy Laboratory's (NREL) 2018 Annual Technology Baseline.[11] We found the solar PV gap requires a total of approximately $5.2

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[6] In this analysis, building electrification refers to the conversion of non-electric sources of heat (e.g., gas or oil furnaces) to air source heat pumps. Vehicle electrification refers to the conversion of traditional gasoline light-duty vehicles to electric vehicles. Though the energy investment gap does not evaluate job creation from vehicle electrification directly, the analysis does consider the increased electric load from electric vehicles when determining the necessary electric generating resources through 2030.

[7] The ASHP projections include installations primarily related to fuel switching (i.e., ASHPs replacing gas and propane heating) and, to a lesser extent, conservation (ASHPs replacing less-efficient electric resistance baseboard heating).

[8] Metropolitan Area Planning Council and Home Energy Efficiency Team. 2016. *Fixing Our Pipes: Coordinating Natural Gas Main Replacement between Local Governments & Gas Companies*. Available at: http://fixourpipes.org/Fixing%20Our%20Pipes_MAPC%20HEET_10-2016-FINAL.pdf.

[9] The CELT report was used to estimate energy efficiency projections, since the MA CEP holds energy efficiency constant in all scenarios it analyzed.

[10] Lazard. 2018. *Lazard's Levelized Cost of Storage Analysis – Version 4.0*. Available at: https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf.

[11] National Renewable Energy Laboratory. 2018. *Annual Technology Baseline*. Available at: https://atb.nrel.gov/electricity/2018/.

billion (in 2018 dollars) from 2020 to 2030 with an average annual investment of $460 million. We found the wind gap requires a total of approximately $16.5 billion (in 2018 dollars) from 2020 to 2030 with an average annual investment of $1.5 billion.

- For energy efficiency, we relied on levelized costs ($ per kilowatt-hour) calculated from the Massachusetts 2019-2021 Three-Year Energy Efficiency Plan, capturing both programmatic costs as well as customer costs. We found the energy efficiency gap requires a total of approximately $847 million (in 2018 dollars) from 2020 to 2030 with an average annual investment of $77 million.

- For heat pumps, we relied on cost data from the Massachusetts 2019-2021 Three-Year Energy Efficiency Plan. We applied the costs from the Three-Year Energy Efficiency Plan to the commercial and multi-family residential building projections from the MA CEP. We note here that the total cost for heat pumps includes both the cost to the consumer as well as the incentive provided by the Commonwealth. We found the gap in heat pumps requires a total of approximately $12.6 billion (in 2018 dollars) from 2020 to 2030 with an average annual investment of $1.1 billion.

- For gas leak repairs, we relied on the miles of leak-prone pipes, as provided in the *Fixing Our Pipes* report. We then multiplied the total miles of leak-prone pipe by the average cost to replace a mile of leak-prone gas main as provided in the same report. We found the gap in gas leak repairs requires a total of approximately $3.4 billion (in 2018 dollars) from 2020 to 2030 with an average annual investment of $308 million.

- Because the energy investment gap analysis assumed aggressive load increases from heat pumps and electric vehicles, the projection includes a slight increase in natural gas generation in the Commonwealth in several years of our study period. For these resources, we relied on fuel and variable operations and maintenance cost projections from the analysis behind the MA CEP. We found the gap in natural gas generation requires a total of approximately $195 million (in 2018 dollars) from 2020 to 2030 with an average annual investment of $18 million.

2.2. Water Sector

Synapse calculated job impacts associated with additional investments in three types of water infrastructure: drinking water, clean water, and stormwater infrastructure. Drinking water infrastructure is defined by the Safe Drinking Water Act (SDWA) as public water systems used for the treatment and delivery of drinking water.[12] The Massachusetts Water Infrastructure Finance Committee (MA WIFC) defines clean water infrastructure as the network of facilities that collect, treat, and dispose of

[12] Title XIV of The Public Health Service Act: Safety of Public Water Systems (Safe Drinking Water Act). Available at: https://legcounsel.house.gov/Comps/Safe%20Drinking%20Water%20Act-(Title%20Xiv%20Of%20Public%20Health%20Service%20Act).pdf

wastewater and stormwater.[13] Stormwater infrastructure is defined similarly but is designed for collecting and disposing of runoff from impervious surfaces that, if not disposed of properly, can carry pollutants into many other clean water and mineral resources.[14]

The investment gaps for each category of water infrastructure (drinking, clean, and storm) were taken from recent reports published by expert organizations in the field of water quality and infrastructure:

- **Drinking Water Gap:** Synapse relied on the 2015 U.S. Environmental Protection Agency's (EPA) *Drinking Water Infrastructure Needs Survey and Assessment*.[15] This report shows the drinking water gap need based on the necessary investment to comply with the SDWA, including the replacement and rehabilitation of leaking water mains. U.S. EPA found the drinking water gap requires a total of approximately $13 billion (in 2018 dollars) over 20 years, equating to an average annual investment of $645 million.[16]

- **Clean Water Gap**: Synapse relied on the 2012 MA WIFC report titled *Massachusetts's Water Infrastructure: Toward Financial Sustainability*.[17] In this report, the clean water investment gap includes the necessary capital, repair and replacement, operations, maintenance, and debt service costs associated with maintaining Massachusetts' aging clean water infrastructure. The clean water infrastructure gap requires a total investment of approximately $12 billion (in 2018 dollars) over 20 years, equating to an average annual investment of $618 million.

- **Stormwater Gap**: Synapse also used the MA WIFC report to determine the stormwater investment gap. The WICF report calculates the stormwater gap as the necessary funding to prevent flooding and the contamination of drinking water supplies and habitats by untreated stormwater. The stormwater infrastructure gap requires a total investment of approximately $20 billion (in 2018 dollars) over 20 years, equating to an average annual investment of $993 million for 20 years.

For this report, water infrastructure construction investment includes new treatment plants and pipe *replacement*, whereas O&M investment includes the *repair* of equipment or pipes.

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[13] Though there is some overlap in the definition of clean water and stormwater infrastructure, the investment gap estimates are not double-counted.

[14] The MA WIFC defines stormwater infrastructure as including the following: drains, cisterns, spillways, swales, catch basins, detention structures, retention structures, sediment chambers, stormwater basins, vegetative buffers, ground covers, roof treatments, low impact development techniques, and piping.

[15] U.S. Environmental Protection Agency. 2015. *Drinking Water Infrastructure Needs Survey and Assessment*. Available at: https://www.epa.gov/sites/production/files/2018-10/documents/corrected_sixth_drinking_water_infrastructure_needs_survey_and_assessment.pdf

[16] We assume that the 20-year investment is spent in equal increments in each year. We convert all spending amounts to 2018 dollar for consistency.

[17] MA WIFC. 2012. *Massachusetts's Water Infrastructure: Toward Financial Sustainability Report.* Available at: https://www.mapc.org/wp-content/uploads/2017/09/WIFC-Report-Final-.pdf

2.3. Transportation Sector

Synapse calculated job impacts associated with additional investments in seven types of transportation infrastructure: highways and roads, public transit servicing the Boston metro region, public transit outside of the Boston metro region, bicycling, electric vehicles (EVs), airports, and seaports. Based on a report by A Better City (ABC), highway and road infrastructure is defined in this analysis as infrastructure under the funding jurisdiction of Massachusetts Department of Transportation Highway Division (MassDOT).[18] Greater Boston's public transit system is provided by the Massachusetts Bay Transit Authority (MBTA) and consists of commuter rail, subway, bus, and ferry. Regional transit refers to public transportation operated by the 15 Regional Transit Authorities (RTAs) outside of the Greater Boston region.[19] Bicycling infrastructure includes protected bike lanes meant for public use. EV infrastructure consists of vehicle purchases (including in-home chargers) and public charging stations, also called electric vehicle supply equipment (EVSE). Airport investments encompass improvements at 37 of the 39 airports with public flight operations in Massachusetts.[20] Finally, seaport investments include maritime projects predominantly located in Boston.[21]

The investment gaps for each category of transportation infrastructure were taken from recent reports published by expert organizations in the field of transportation quality and infrastructure:

- **MassDOT Highway and Road Gap:** ABC released *An Update on Transportation Finance* as a working document in early 2019. ABC reports a 10-year gap of $6.5 billion (2018$) in MassDOT funding. ABC calculated this gap using information provided by the Performance and Asset Management Advisory Council and the MassDOT Capital Programs Committee. We spread this gap of uncommitted spending needs evenly across the study period to assume a constant annual gap of $643 million (2018$). We also include the $1.4 billion (2018$) in committed capital funding that is allocated to MassHighway projects in MassDOT's FY 2020-2024 Capital Investment Plan.[22]

- **MBTA Public Transit Gap**: The MBTA released a state of good repair assessment in Spring 2019 that estimated $8.2 billion (2018$) is needed by 2030 to bring the MBTA to a state of good

[18] A Better City. 2019. *An Update on Transportation Finance*. Available at: https://www.abettercity.org/assets/images/ABC%20-%20An%20Update%20on%20Transportation%20Finance%202019.pdf.

[19] Task Force on Regional Transit Authority Performance and Funding. 2019. *A Vision for the Future of Massachusetts' Regional Transit Authorities*. Available at: https://www.mass.gov/files/documents/2019/04/17/dot-rta_task_force_report_040519.pdf.

[20] MassDOT Aeronautics Division. 2010. *Massachusetts Statewide Airport System Plan*. Available at: https://archives.lib.state.ma.us/bitstream/handle/2452/205609/ocn851096359.pdf?sequence=1&isAllowed=y.

[21] Massport. 2019. *Proposed FY19-23 Capital Program*. Available at: https://www.massport.com/media/3120/board-book-fy19-23-capital-program.pdf.

[22] MassDOT. 2019. *2020-2024 Capital Investment Plan Update*. Available at: http://massdot.maps.arcgis.com/apps/MapJournal/index.html?appid=33a118c32b3f47b3b90a769498aa68bd.

repair.[23] Approximately 33 percent of the investment in 2019 is projected to be funded via rider fares. This investment accounts for spending needs associated with the MBTA's bus and train networks—such as the Green Line extension and bus procurement.[24] This assessment calculates the need using detailed inventory counts and condition ratings. Synapse used 2018 as the baseline year to calculate the "gap" for the MBTA. Though the MBTA is planning to close this gap over the study period, for the purposes of this analysis, we treated this investment need as the total "MBTA Public Transit Gap." The MBTA Public Transit Gap is largest in the first half of the study period due to the MBTA's Green Line Extension project.

- **RTA Gap**: Synapse used a 2019 report from the Task Force on Regional Transit Authority Performance and Funding for the recommended level of funding for RTAs outside of the Greater Boston region. Using the actual fiscal year (FY) 2020 budget for the Commonwealth Transportation Fund Transfer to RTAs as the baseline, we calculated an estimated $4.5 million (2018$) annual gap in state funding for RTAs in the Commonwealth of Massachusetts.[25] We assume the FY 2020 budget of $85 million (2018$) remains a constant source of committed funding for RTA O&M through the study period. Finally, we include the nearly $240 million (2018$) in committed capital funding that is allocated to transit projects in MassDOT's FY 2020-2024 Capital Investment Plan.[26]

- **Bicycling Gap**: The Boston Green Ribbon Commission's 2019 report *Carbon Free Boston* estimates Boston will need 250 new miles of protected bike facilities to reach the city goals of net zero carbon emission by 2050.[27] We then calculated how many of these miles will be needed during our study period from 2020-2030. The cost per mile of paved bike trail was estimated using MassDOT's 2018 expenditure on paved bike trails. [28] We estimated the gap in bicycling infrastructure investment to be $52.2 million (2018$) over the 10-year study period, and we distributed this gap evenly across the study period to assume a constant annual gap of $5.2 million (2018$).

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[23] Massachusetts Bay Transportation Authority. May 2019. *Capital Needs Assessment*. Slide 23. Available at: https://cdn.mbta.com/sites/default/files/fmcb-meeting-docs/2019/05-may/2019-05-13/originals/2019-05-13-fmcb-H-capital-needs-assessment.pdf

[24] Note that the MBTA Capital Needs Assessment does not include capital expansion upgrades such as electrifying the commuter rail.

[25] Governor's Budget FY 2020. Available at: https://budget.digital.mass.gov/bb/h1/fy20h1/brec_20/hsummary.htm.

[26] MassDOT. 2019. *2020-2024 Capital Investment Plan Update*. Available at: http://massdot.maps.arcgis.com/apps/MapJournal/index.html?appid=33a118c32b3f47b3b90a769498aa68bd.

[27] Boston Green Ribbon Commission and Boston University. 2019. *Carbon Free Boston*. Available at: https://www.greenribboncommission.org/wp-content/uploads/2019/01/FINAL_CFB_SummaryRpt_FEB19.pdf.

[28] MassDOT. 2019. *Massachusetts Pedestrian Transportation Plan*. Available at: https://massdot.maps.arcgis.com/apps/MapJournal/index.html?appid=96339eb442f94ac7a5a7396a337e60c0.

- **EV Gap**: For the purposes of this report, this gap only considers EVs replacing privately owned light-duty gasoline-fueled vehicles, as part of an aggressive vehicle electrification future.[29] Synapse used the gap in the EV trajectories from the MA CEP Aggressive Conservation and Fuel Switching scenario and baseline scenario to calculate the jobs associated with increased purchases of EVs along with investment in EV charging infrastructure. We used vehicle price projections from the Annual Energy Outlook 2019 and the 2016 Draft Technical Assessment Report—issued as part of EPA's mid-term review of federal GHG standards—and applied those price projections to the EV trajectories to calculate the spending gap on EVs.[30, 31, 32] We used the Electric Vehicle Infrastructure Projection Tool Lite—developed through a collaboration between the National Renewable Energy Laboratory and the California Energy Commission—in tandem with EVSE equipment and installation costs from New West Technologies, LLC to calculate the spending gap in EVSE.[33, 34] We estimated the gap on EVs to be $26.5 billion and the gap on EVSE to be $99 million over the 10-year study period. This gap is largest in the second half of the study period as more and more EVs are required to meet the goals of the MA CEP's Aggressive Conservation and Fuel Switching scenario.

- **Airports Gap**: We relied on MassDOT's Massachusetts Statewide Airport System Plan, which identifies a need for $25.4 million (2018$) in annual spending to meet the goals documented in the study's recommendations. The report notes that 61 percent of this spending will go towards system preservation, which we categorize as O&M spending.[35] We assumed the remaining 39 percent of the spending will go towards capital projects.

- **Seaports Gap**: Massport's Proposed FY19-23 Capital Program provides ongoing and proposed spending amounts on several programs including maritime projects. We relied on the spending documented for maritime projects categorized as ongoing, proposed, private, contingent on funding source, and unfunded. This amounts to a total of approximately $2 billion (in 2018$) in

[29] Light-duty vehicles include both cars and light trucks.

[30] DOER. 2018. *MA CEP*.

[31] U.S. Energy Information Administration. 2019. *Annual Energy Outlook 2019*. Available at: https://www.eia.gov/outlooks/aeo/tables_ref.php.

[32] U.S. EPA, U.S. National Highway Traffic Safety Administration, and California Air Resources Board. 2016. *Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025.* This data is consolidated in a report published by Indiana University: Carley, S., D. Duncan, J. D. Graham, S. Siddiki, and N. Zirogiannis. 2017. *A Macroeconomic Study of Federal and State Automotive Regulations*. Available at: https://oneill.indiana.edu/doc/research/working-groups/auto-report-032017.pdf.

[33] National Renewable Energy Laboratory and the California Energy Commission. Electric Vehicle Infrastructure Projection Tool Lite. Available at: https://afdc.energy.gov/evi-pro-lite.

[34] New West Technologies, LLC. 2015. *Costs Associated with Non-Residential Electric Vehicle Supply Equipment*. Available at: https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

[35] System preservation is defined in the report as meeting minimum facility and service objectives as they relate to, e.g., weather reporting, runway width and length criteria, and fueling services.

maritime projects. We also relied on the Massachusetts Port Authority's 2018 Comprehensive Annual Financial Report for annual maritime O&M expenses ($64 million in 2018$).[36]

2.4. Spending Summary

Across all three sectors, the total investment gap through 2030 is over $116 billion (see Table 3). This equates to an annual average investment need of approximately $10.5 billion. The sector with the largest investment gap is the transportation sector, with a total investment gap of nearly $53 billion. The subsector with the largest investment gap is EVs, with a total investment gap of about $27 billion.

Table 3. Investment gap summary by sector and subsector (2018$ millions)

Sector	Subsectors	Total Investment Gap	Average Annual Investment (2020-2030)
Energy	Electric generation resources (solar PV, onshore and offshore wind, and natural gas generators)	$21,830	$1,980
	Utility-scale battery storage	$440	$40
	Heat pumps	$12,620	$1,150
	Energy efficiency programs	$850	$80
	Natural gas distribution system	$3,390	$310
	All Energy Subsectors	**$39,120**	**$3,560**
Water	Drinking water infrastructure	$7,090	$650
	Clean water infrastructure	$6,780	$620
	Stormwater infrastructure	$10,920	$990
	All Water Subsectors	**$24,810**	**$2,260**
Transportation	Highways and roads	$14,060	$1,280
	MBTA public transit	$8,260	$750
	Regional transit	$1,220	$110
	Bicycling	$60	$5
	Electric vehicles	$26,570	$2,420
	Airports	$280	$30
	Seaports	$2,290	$210
	All Transportation Subsectors	**$52,740**	**$4,700**
Total	**-**	**$116,660**	**$10,520**

Note: Value rounded to the nearest ten-thousands, therefore totals may not sum.

[36] Massachusetts Port Authority. November 26, 2018. *Comprehensive Annual Financial Report*. Available at: https://www.massport.com/media/3029/mpa-fy18-cafr-final.pdf.

3. JOB CREATION

In this analysis, we estimated job creation in units of "gross job-years." We report job creation in terms of job-years because each number represents a single full-time equivalent job that exists for a single year. Some jobs are temporary, such as construction jobs, which last only until the building of the infrastructure has ended. Others are longer term, since many resources require ongoing staff for O&M. Therefore, defining the term as "job-years" is a way to equally account for both temporary and permanent jobs.

Furthermore, these numbers are "gross" because they represent only an increase in jobs due to increased investment in selected subsectors of the energy, water, and transportation industries. Importantly, we did not calculate job *loss* within other infrastructure subsectors, except some minor job losses related to declining natural gas generation, as it is displaced by clean energy. For example, we did not calculate any job losses associated with the traditional gasoline vehicle industry as a result of an increase in electric vehicle investment. We expect there to be some job losses associated with investment in electric vehicles and heat pumps, as those industries will likely be displacing some jobs in existing industries. Further research is needed to calculate the "net" job impacts as a result of the increased investment in those two industries.

3.1. Energy Sector

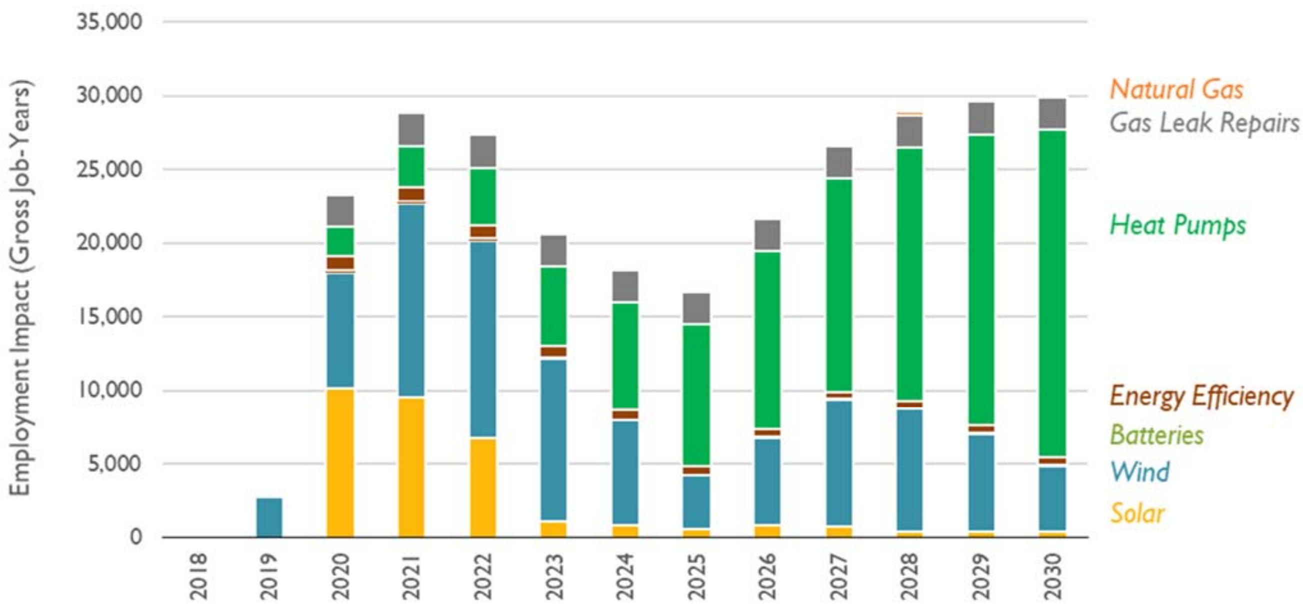
Closing the energy investment gap is expected to create an average of 24,700 job-years in each year from 2020 through 2030 in the energy sector (see Table 4). Heat pumps account for the largest economic impact at an average of 10,600 gross job-years, followed closely by wind at an average of 8,200 gross job-years. Distributed solar PV also has a strong economic impact of 2,700 gross annual job-years. Modeled impacts vary over the study period, as shown in Figure 1. The temporal variation in job impacts is due to annual changes in investment levels and spending needs that we identified throughout the study period, especially those related to the solar and wind industries. One way to mitigate the temporal fluctuations and promote sustained job growth is to continue implementing policies that drive investments in new energy resources. For example, this might include extensions of near-term policies like Massachusetts SMART program for solar or offshore wind procurements.

Table 4. Average annual job impacts from closing the energy investment gap, by year and subsector

Subsector	Gross Annual Job Impacts			Average Annual Job Impacts (2020-2030)
	2020	2025	2030	
Solar	10,200	600	400	**200**
Wind	7,800	3,600	4,500	**8,200**
Battery Storage	100	0	0	**100**
Energy Efficiency	1,000	600	500	**700**
Heat Pumps	2,000	9,600	22,300	**10,600**
Gas Leak Repairs	2,200	2,200	2,200	**2,200**
Natural Gas	-200	200	0	**0**
Total Impacts	**23,100**	**16,900**	**30,000**	**24,700**

Notes: Results are rounded to the nearest hundred job-years. Due to rounding, numbers may not add up to the totals. We combine utility-scale solar with residential and commercial behind-the-meter solar in the "solar" category; we combine onshore and offshore wind in the "wind" category; and we combine residential and commercial heat pumps in the "heat pump" category.

Figure 1. Employment impacts (gross job-years) of closing the energy investment gap



Source: Synapse Energy Economics, Inc. based on IMPLAN results.

In the near term, gross job impacts are dominated by the distributed solar PV and wind industries. The scenario we selected from the MA CEP assumes a large buildout of BTM solar through 2022 and a large deployment of offshore wind between 2022 and 2024. This construction generates jobs in those industries leading up to the official online date. We assumed the construction build time for offshore wind is four years, and we therefore found job creation for offshore wind beginning in late 2019 and early 2020.[37]

In the long term, the main driver of gross job impacts shifts from the wind and solar industries to the heat pump industry. The scenario we selected from the MA CEP assumes an influx of heat pump installations starting in 2025 as aggressive electrification efforts pick up. This results in increased heat pump manufacturing and installation jobs towards the end of the study period. Offshore wind remains a large contributor to job creation throughout the study period because its O&M costs are higher than those for the other resource types.

Overall, energy resources create a larger number of construction jobs than O&M jobs. Table 5 presents the sector-specific employment impacts in terms of gross job-years for construction and O&M separately. All subsectors experience more job growth from the construction of energy resources than from the O&M of those resources.

Table 5. Average annual job impacts of the energy investment gap, by subsector and job type

Subsector	Average Annual Job Impacts (2020-2030)		
	Construction	O&M	Total
Solar	2,500	400	**2,900**
Wind	7,400	800	**8,200**
Battery Storage	0	0	**0**
Energy Efficiency	700	0	**700**
Heat Pump	9,900	700	**10,600**
Gas Leak Repairs	2,200	0	**2,200**
Natural Gas	0	0	**0**
Total Impacts	**22,700**	**1,900**	**24,700**

Note: Results are rounded to the nearest hundred job-years.

Although we did not model job loss within other energy subsectors (except for minor job losses associated with declining natural gas generation in the near-term), we expect that increased adoption of heat pumps could lead to some job loss associated with oil fuel delivery.[38]

While these gross job impacts are relatively modest in the context of Massachusetts' full economy, which currently has total employment of approximately 3.6 million, they are substantial in terms of the energy sector's current size in the Commonwealth.[39] In 2018, Massachusetts employed over 67,000

[37] U.S. Energy Information Administration. 2019. *Cost and Performance Characteristics of New Generating Technologies, January 2019*. Available at: https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf.

[38] For a state-level report that explores this interaction in more depth, see: Meister Consultants Group. 2017. *Rhode Island Renewable Thermal Market Development Strategy*. Available at: https://www.synapse-energy.com/sites/default/files/RI-Renewable-Thermal-15-119.pdf.

[39] See: https://www.bls.gov/oes/current/oes_ma.htm.

"Traditional Energy" workers as well as more than 86,000 workers in energy efficiency.[40] Therefore, these new jobs represent an 11 to 19 percent expansion of the current energy workforce, depending on the year.

Table 6 provides the assumed average annual wages by subsector and job type for construction and O&M jobs. Construction jobs related to offshore wind experience the highest wages, followed by solar PV and onshore wind. Similarly, O&M jobs related to offshore wind experience the highest wages.

Table 6. Average annual wages by energy subsector and job type

Subsector	Average Annual Wage (2018$)	
	Construction	O&M
Utility Solar	$92,400	$75,500
Distributed Solar	$92,400	$75,500
Onshore Wind	$90,600	$83,500
Offshore Wind	$193,900	$139,200
Battery Storage	$67,700	$75,500
Energy Efficiency	$67,700	N/A
Residential Heat Pump	$70,200	$70,200
Commercial Heat Pump	$69,300	$69,300
Gas Leak Repairs	$70,000	$75,500

Source: IMPLAN; U.S. Bureau of Labor Statistics; NREL's JEDI Models; Synapse calculations. Note: Rounded to the nearest hundred dollars. Energy efficiency does not have O&M wages because those measures are considered capital investments.

3.2. Water Sector

If Massachusetts were to comply with the SDWA and invest fully in the water investment gap, the Commonwealth would gain an average annual 20,600 gross job-years from 2020 through 2030 (see Table 7). The stormwater gap accounts for the largest economic impact at an average of 9,200 gross job-years annually, followed by the drinking water gap at an average of 5,800 gross job-years annually and the clean water gap at 5,600 gross annual job-years annually.

[40] Energy Futures Initiative and the National Association of State Energy Officials. 2019. *The 2019 U.S. Energy and Employment Report*. Available at: https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5c7f413824a694af1fd54e04/1551843640724/Massachusetts.pdf.

Table 7. Average annual job impacts from closing the water investment gap, by year and subsector

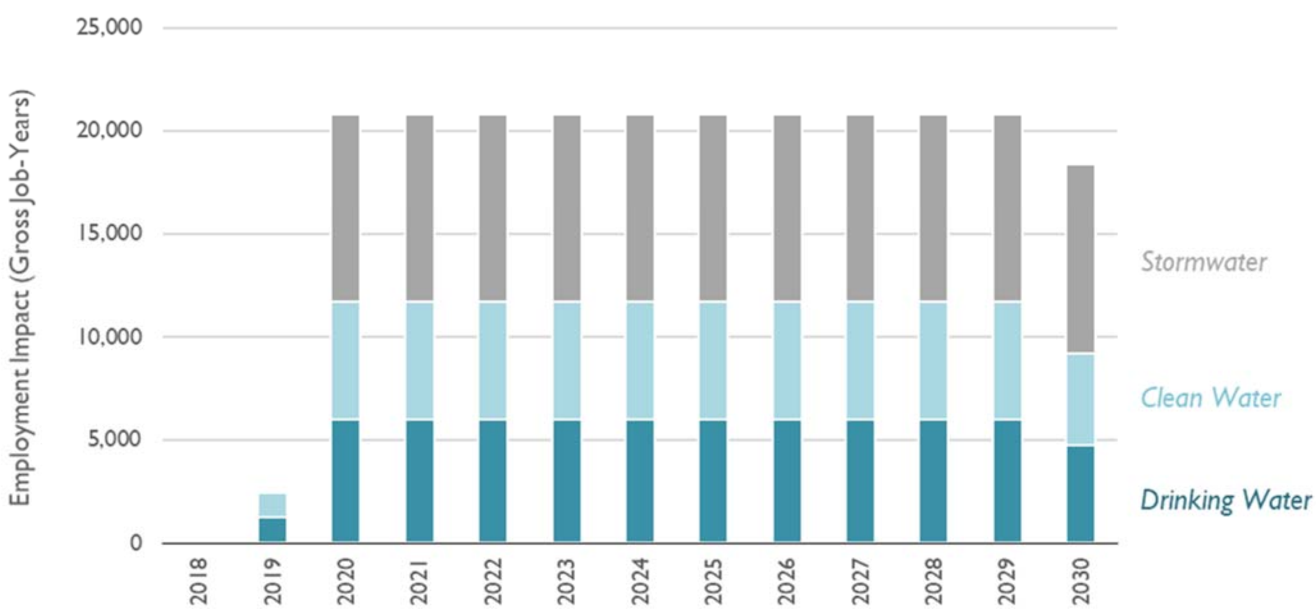
Subsector	Gross Annual Job Impacts			Average Annual Job Impacts (2020-2030)
	2020	2025	2030	
Drinking Water	6,000	6,000	4,700	**5,800**
Clean Water	5,700	5,700	4,500	**5,600**
Stormwater	9,200	9,200	9,200	**9,200**
Total Impacts	**20,800**	**20,800**	**18,400**	**20,600**

Notes: Results are rounded to the nearest hundred job-years.

Our modeled impacts are mostly consistent over the study period until 2030, resulting from our assumption on consistent spending (see Figure 2).

Our analysis projects a sustained increase in jobs (an annual increase of 20,800 gross job-years) from closing the water investment gap over the next 10 years. The consistency of the added job-years can be explained by our assumption that the 20-year investment gap is spent equally over the study period. The primary driver of job creation is the rehabilitation and maintenance of existing infrastructure, which requires an annual average investment need of approximately $1.2 billion. New water infrastructure requires a slightly lesser, but still sizable, amount of investment at just over $1 billion per year. The demand for new infrastructure remains constant until 2030, when job growth from construction decreases slightly.

Figure 2. Employment impact of closing the water investment gap



Source: Synapse Energy Economics, Inc. based on IMPLAN results.

Our water-related job impact results vary by construction and O&M, primarily because investment in water infrastructure is more focused on O&M than it is on construction.[41] Table 8 presents the employment impacts in terms of gross job-years for construction and O&M separately, by subsector.

Table 8. Average annual job impacts of the water investment gap, by subsector and job type

Subsector	Average Annual Job Impacts (2020-2030)		
	Construction	O&M	Total
Drinking Water	2,400	3,400	**5,800**
Clean Water	2,300	3,300	**5,600**
Stormwater	4,600	4,600	**9,200**
Total Impacts	**9,300**	**11,300**	**20,600**

Note: Results are rounded to the nearest hundred job-years.

In 2018, there were only 1,890 water and wastewater treatment plant and system operators in Massachusetts.[42] Though this value does not include water distribution maintenance employees, these impacts still represent a significant increase in employment relative to current levels in the Massachusetts water sector.

Table 9 provides the assumed average annual wages by resource for both construction and O&M jobs. Because we relied on the same IMPLAN industry for each water resource type, the wages are consistent across resource type and across construction and O&M jobs.

Table 9. Average annual construction and O&M wages by water subsector

Subsector	Average Annual Wage (2018$)
	Construction and O&M
Drinking Water	$70,320
Clean Water	$70,320
Stormwater	$70,320

Source: IMPLAN. Rounded to the nearest hundred dollars.

3.3. Transportation Sector

If Massachusetts were to invest in roads and highways, the MBTA, other RTAs, biking infrastructure, EVs and EVSE, airports, and seaports in sufficient amounts to fully close the transportation investment gap, the Commonwealth would gain an average annual 44,000 job-years from 2020 through 2030 (Table 10). In the first half of the study period, MassDOT and the MBTA account for the largest economic impacts,

[41] U.S. Environmental Protection Agency. 2002. *The Clean Water and Drinking Water Infrastructure Gap Analysis*. September 2002, EPA 816-R-02-020. Available at: https://bit.ly/2XBbv7S.

[42] See: https://www.bls.gov/oes/current/oes_ma.htm.

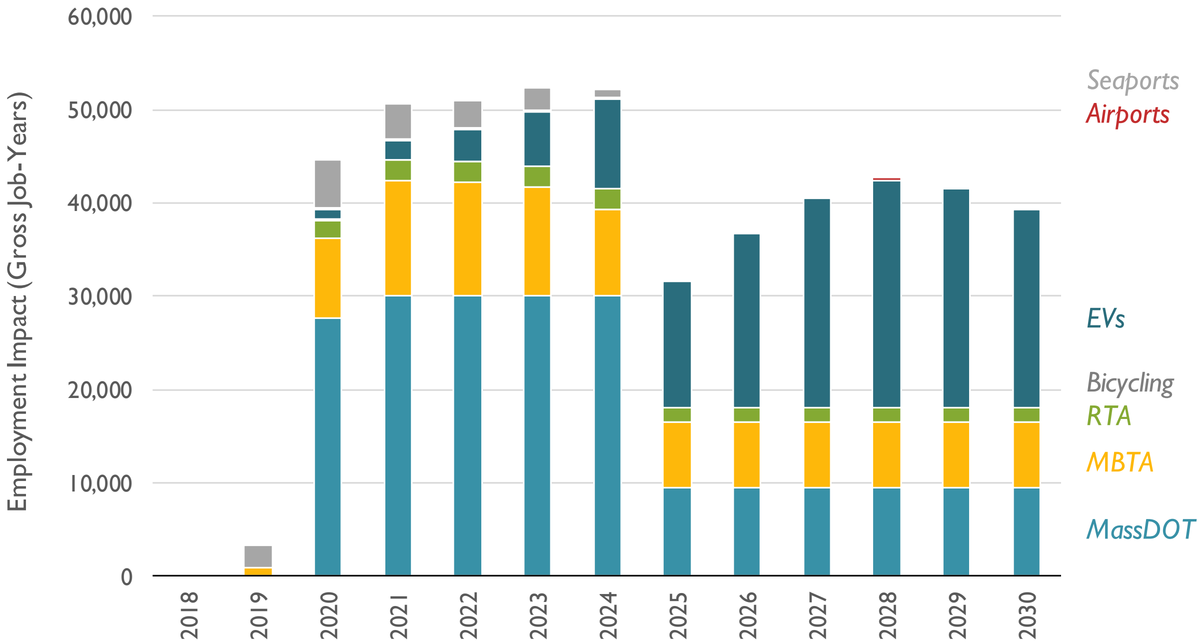
generating 27,700 and 8,600 gross jobs in 2020, respectively. In the second half of the study period, investment in EVs and EVSE provides the largest economic impact and would generate 21,300 gross jobs in 2030. This steep increase in the contribution of jobs from the EV sector is due to the projected exponential growth of EVs through our study period, while the decline in the contribution of jobs from MassDOT after 2024 is due to the unknown capital investment following the implementation of the 2020-2024 Capital Investment Plan. Across the full study period, MassDOT provides the largest economic impact at an average of 18,600 gross job-years annually, followed by EVs and EVSE at 13,200 gross job-years (see Figure 3). To soften the temporal fluctuations in gross job impacts, annual investments in these transportation subsectors could be continued or held constant. As an example, this could include additional MBTA expansion projects like the current Green Line Extension.

Table 10. Average annual job impacts from closing the transportation investment gap, by year and subsector

Subsector	Gross Annual Job Impacts			Average Annual Job Impacts (2020-2030)
	2020	2025	2030	
MassDOT	27,700	9,400	9,400	**18,600**
MBTA	8,600	7,200	7,200	**8,800**
RTA	1,900	1,400	1,400	**1,700**
Bicycling	100	100	100	**100**
EVs	1,100	13,600	21,300	**13,200**
Airports	200	200	100	**200**
Seaports	5,200	0	0	**1,400**
Total Impacts	**44,700**	**31,800**	**39,500**	**44,000**

Notes: Results are rounded to the nearest hundred job-years.

Figure 3. Employment impact of closing the transportation investment gap



Source: Synapse Energy Economics, Inc. based on IMPLAN results.

Our job creation results vary by construction and O&M. The job-years generated from construction-related investments are larger than those from O&M-related investments, primarily because investments in EVs and MassDOT are more focused on capital expenditures than on O&M. In contrast, future investment in the MBTA is projected to focus heavily on O&M. Table 11 presents the employment impacts in terms of gross job-years for construction and O&M separately, by sector.

Table 11. Average annual job impacts of the transportation investment gap, by subsector and job type

Subsector	Average Annual Job Impacts (2020-2030)		
	Construction	O&M	Total
MassDOT	15,600	3,000	**18,600**
MBTA	1,000	7,800	**8,800**
RTA	300	1,400	**1,700**
Bicycling	100	0	**100**
EVs	11,400	1,800	**13,200**
Airports	100	100	**200**
Seaports	1,200	200	**1,400**
Total Impacts	**29,700**	**14,300**	**44,000**

Note: Results are rounded to the nearest hundred job-years.

Although we did not model job loss within other transportation subsectors, we expect that increased investment in electric vehicles would lead to some job losses in the traditional gasoline vehicle industry.[43] However, the petroleum sector is less local to Massachusetts than the electric sector—most jobs are related to petroleum extraction, which takes place out of state—and therefore we expect the regional impacts within that sector to be small. Some of the investments we modeled may encourage mode-shifting from internal combustion engine vehicles to public transportation, a shift that would likely lead to additional job loss in the petroleum sector.

As with the energy and water sector results, these gross job impacts are relatively modest in the context of Massachusetts' full economy, which currently has total employment of approximately 3.6 million. However, they account for between 17 and 28 percent of Massachusetts' current transportation employment of 190,000, depending on the year.[44]

Table 12 provides the average annual wages by transportation subsector and job type (construction and O&M). In general, the MBTA and seaport subsectors have the highest annual wages for both construction and O&M jobs.

Table 12. Average annual construction and O&M wages by transportation subsector

Subsector	Average Annual Wage (2018$)	
	Construction	O&M
MassDOT	$50,000	$50,000
MBTA	$76,400	$72,000
RTA	$59,300	$59,300
Bicycling	$60,300	N/A
EVs – Battery	$40,300	$40,300
EVs – Non-Battery	$45,800	$45,800
EVSE	$40,300	$40,300
Airports	$54,000	$54,000
Seaports	$84,800	$84,800

Source: IMPLAN; U.S. Bureau of Labor Statistics. Rounded to the nearest hundred dollars.
Note: Bicycling does not have O&M wages as those investments are considered construction.

[43] For a state-level report that explores this interaction in more depth, see: Synapse Energy Economics. 2018. *Macroeconomic Analysis of Clean Vehicle Scenarios for Colorado*. Available at: https://www.synapse-energy.com/sites/default/files/CO-Clean-Vehicle-Macroeconomic-Impacts-18-017.pdf.

[44] See: https://data.bls.gov/oes/#/geoOcc/Multiple%20occupations%20for%20one%20geographical%20area.

4. Filling the Investment Gap

The investment gaps calculated in Table 3 represent the amount of total funding needed to bring energy, water, and transportation infrastructure to a state of good repair or to reach the Commonwealth's aggressive energy policy goals. However, Massachusetts has recently committed to meeting a portion of the energy, water, and transportation investment gaps. The level of commitment varies by sector and subsector. Below, we present the number of jobs that are expected to be created from investment that is already committed, as well as the jobs that would be created if the remaining "uncommitted" investment gap is closed. We note that there is still some level of uncertainty in the committed funding, therefore it ought to still be considered part of the "investment gap."

Through state programs and policies, Massachusetts has committed to increasing its renewable energy generation renewables as well as its energy efficiency. Committed jobs represent those that will be created from the investment needed to achieve existing state policy goals.[45] Uncommitted jobs represent those that will be created from additional investment in renewables, necessary to achieve the levels of renewable and electrification in the MA CEP's Aggressive Conservation and Fuel Switching scenario relative to the High Renewables scenario. The total job creation from committed and uncommitted funding in the energy sector is presented in Table 13.

Table 13. Average annual committed and uncommitted job impacts for the energy sector

Subsector	Average Annual Job Impacts (2020-2030)		
	Committed	Uncommitted	Total
Solar	2,800	100	**2,900**
Wind	8,100	100	**8,200**
Battery Storage	100	0	**100**
Energy Efficiency	700	0	**700**
Heat Pump	0	10,600	**10,600**
Gas Leak Repairs	0	2,200	**2,200**
Natural Gas	0	0	**0**
Total Impacts	**11,600**	**13,100**	**24,700**

Notes: Results are rounded to the nearest hundred job-years.

Table 14 presents the average annual committed and uncommitted job impacts for the water sector. We assumed that the funding gaps identified in our literature review reflect uncommitted funding needs, therefore all jobs from our water analysis are currently uncommitted.

[45] Of the scenarios included in the MA CEP, the High Renewables scenario most closely resembles Massachusetts' current legislation and regulations. Therefore, the High Renewables scenario was used to calculate the "committed" investment in the energy sector.

Table 14. Average annual committed and uncommitted job impacts for the water sector

Subsector	Average Annual Job Impacts (2020-2030)		
	Committed	Uncommitted	Total
Drinking Water	0	5,800	**5,800**
Clean Water	0	5,600	**5,600**
Stormwater	0	9,200	**9,200**
Total Impacts	**0**	**20,600**	**20,600**

Notes: Results are rounded to the nearest hundred job-years.

Finally, Table 15 presents the average annual committed and uncommitted job impacts for the transportation sector. Of the resource types we analyzed in our transportation analysis, only the MBTA and the seaport have committed funding to meet the levels of infrastructure investment identified in our literature review. Therefore, about 70 percent of the transportation job impacts are currently uncommitted.

Table 15. Average annual committed and uncommitted job impacts for the transportation sector

Subsector	Average Annual Job Impacts (2020-2030)		
	Committed	Uncommitted	Total
MassDOT	9,200	9,400	**18,600**
MBTA	8,800	0	**8,800**
RTA	1,600	100	**1,700**
Bicycling	0	100	**100**
EVs	0	13,200	**13,200**
Airports	0	200	**200**
Seaports	1,100	300	**1,400**
Total Impacts	**20,700**	**23,300**	**44,000**

Notes: Results are rounded to the nearest hundred job-years.

Across the three sectors (energy, water, and transportation), Massachusetts can expect an average of approximately 32,300 jobs per year from 2020 through 2030 from *committed* funding sources. If the Commonwealth were to close the remaining gap of *uncommitted* funding during that time period, it would likely gain an additional 57,000 jobs per year.

5. INVESTMENT HIGHLIGHTS BY CITY

To illustrate how the statewide investment gaps could translate to individual cities in Massachusetts, Synapse evaluated the job impacts from planned investments in several cities or regions in the Commonwealth. This analysis relied on city and town capital improvement plans (CIP) or capital investment plans, therefore the results are not directly related to the statewide analysis presented above. We describe the specific projects and their impacts in detail below. We note that calculating job impacts on a sub-state level has some level of uncertainty, as commuters often live and work in different cities or regions.

5.1. Metro Boston

First, we estimated the job impacts from planned transportation investment in the Metro Boston region—specifically, MBTA and MassDOT investment.[46] Planned investment for the MBTA in Metro Boston is about $3 billion from 2020 through 2030. This investment is going towards the Green Line Extension Project, new Red and Orange Line vehicles, and new Green Line vehicles and signals. The completion of the updates to the MBTA in Metro Boston alone will contribute a yearly average of 3,400 job-years to the transportation sector from 2020 to 2030. The MassDOT Allston Multi-Modal project, a $1 billion project aiming to reduce congestion in the Greater Boston area, will contribute an estimated 3,600 annual average job years from 2020 to 2030 if the project is seen to completion.

Some capital improvement plans only direct investment within a city's borders. For example, the City of Cambridge intends to invest a total of $33.2 million into street infrastructure. The investment proposed in Cambridge's FY 2021-2024 Operating and Capital Plans will create an estimated average annual 37 job-years for the five-year investment period.[47] The City of Cambridge also outlined a plan to invest $37 million in clean water infrastructure and $52 million in stormwater infrastructure. These investments are estimated to create an annual average of 125 job-years over the five-year investment period. The City of Cambridge intends to invest in city-wide energy efficiency upgrades and solar compacting trash and recycling bins. These small investments are estimated to create a total of 2 job-years in the year 2020.

[46] Using the Metropolitan Area Planning Council's Inner Core region, the Metro Boston Area is defined in this study as including Arlington, Belmont, Boston, Brookline, Cambridge, Chelsea, Everett, Lynn, Malden, Medford, Melrose, Milton, Needham, Newton, Quincy, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

[47] City of Cambridge Annual Budget 2019-2020, 2018. Available at: https://www.cambridgema.gov/~/media/Files/budgetdepartment/FinancePDFs/fy20submittedbudget/fy20submittedbudgetbook.pdf

The Boston Water and Sewer Commission's Capital Improvement Plan could yield over 1,500 total job years if all the planned investments are made.[48] These investments are for $41 million in drinking water infrastructure, $42 million in clean water infrastructure, and $3 million in stormwater infrastructure.

5.2. Worcester

The City of Worcester is planning to invest $14.6 million in upgrades to many roads and bridges from 2020 to 2024.[49] This investment is expected to create an average of 42 job-years annually.

The City of Worcester is also planning to invest $32 million in water infrastructure upgrades for FY2020, including clean water infrastructure, sewers, and storm drain upgrades.[50] This investment is expected to create approximately 116 drinking water and 167 stormwater jobs in 2020. If this investment is spread over the next decade, it would sustain an annual 27 jobs from 2020 to 2030.

5.3. Springfield

The City of Springfield FY2020 budget includes recommended transportation infrastructure investment of $1.8 million in 2020.[51] This investment is allocated primarily for road maintenance, including pothole patching, street sweeping, and snow plowing. This investment is estimated to support a total of 28 jobs in 2020.

Springfield has also allocated over $0.5 million to repair and maintain its stormwater infrastructure in 2020, which will likely support 6 jobs that year.

5.4. Lowell

The FY 2020 Adopted Budget for the City of Lowell includes a $1 million investment for bridge repairs, as well as an investment of nearly $4 million on a city-wide paving and sidewalks program.[52] These investments could generate an estimated 70 jobs in 2020.

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[48] Boston Water and Sewer Commission Capital Improvement Plan 2018-2020. Available at: http://www.bwsc.org/sites/default/files/2019-01/capital_improvement_program_2018-2020_0.pdf.

[49] The City of Worcester Fiscal Year 2020 Capital Budget. Available at: http://www.worcesterma.gov/uploads/19/26/192658c156cbc19cab328e1961b481ce/capital-budget-fY20.pdf.

[50] City of Worcester Capital Budget 2020. Available at: http://www.worcesterma.gov/uploads/19/26/192658c156cbc19cab328e1961b481ce/capital-budget-fY20.pdf.

[51] Springfield, MA Mayor Recommended Budget, 2019. Available at: https://www.springfield-ma.gov/finance/fileadmin/budget/2019/FY20_Mayor_s_Recommended_Budget_-_Compressed.pdf.

[52] City of Lowell FY2020 Approved Budget, 2019. Available at: https://www.lowellma.gov/DocumentCenter/View/8289/City-of-Lowell-FY2020-Approved-Budget.

Though investment towards water infrastructure was not included in Lowell's FY 2020 budget, the city approved $28.5 million in 2019 for water and sewer infrastructure. This investment will likely create about 140 jobs in 2019.

5.5. Fall River

Fall River's CIP for 2020-2024 outlines many potential infrastructure investments the town intends to make.[53] The plan includes nearly $2 million for streets and highways, $11 million for streetscapes, and $450,000 for sidewalks. These investments create an annual average of 14 job-years for the five-year span of the CIP.

The water infrastructure upgrades for 2020-2024 include drinking and clean water system upgrades, totaling $19 million. Additionally, Fall River's planned stormwater upgrades include a two-phase project costing $127 million. These combined water infrastructure improvements are likely to create an estimated 286 annual average job-years from 2020 through 2024.

[53] City of Fall River, MA: Capital Improvement Plan, 2018. Available at: http://www.fallriverma.org/wp-content/uploads/2019/02/City-of-Fall-River-Capital-Imp.-Plan-Updated-1-22-19.pdf.

6. CONCLUSIONS

In July of 2019, 3.7 million people were employed in Massachusetts.[54] Based on this report's analysis, filling the investment gaps in the energy, water, and transportation sectors in Massachusetts could yield an average of nearly 90,000 jobs in each year for the next decade—this represents an annual employment increase of 2.4 percent from 2019 levels. Because the expansion and maintenance of public infrastructure is primarily supported by public-sector jobs, the job creation described in this report is likely to provide Massachusetts families with stable livable wages and healthcare coverage.

This report finds that the transportation sector has the greatest investment gap and could generate an average of 44,000 jobs per year through 2030. Comparatively, the energy and water sectors could generate and sustain an average of 25,000 and 21,000 jobs per year, respectively. Because this analysis examined only three sectors of public infrastructure, we note that our job creation estimates are conservative, as there are several other sectors requiring additional investment not included in this analysis (e.g., telecommunication, health, education, recreation, and climate change resiliency and mitigation).

Massachusetts has recently committed to meeting a portion of the energy, water, and transportation investment gaps (i.e., the funds are already appropriated for spending in the short-term). Across the three sectors, Massachusetts can expect an average of 32,000 jobs per year from 2020 through 2030 from *committed* funding sources. If the Commonwealth were to close the remaining investment gap that does not yet have committed funding sources, it would benefit from an additional 57,000 jobs per year through 2030.

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[54] Bureau of Labor Statistics. 2019. *Economy at a Glance: Massachusetts*. https://www.bls.gov/eag/eag.ma.htm

Appendix A. IMPLAN Modeling Details

Synapse used IMPLAN to convert investments in each sector into jobs. We first identified different types of spending as either construction or operations and maintenance (O&M) costs. We assumed that construction costs generate jobs only during the years in which infrastructure construction takes place, whereas O&M costs generate jobs continuously throughout the life of the infrastructure. We further broke out both construction and O&M spending into the fractions that are focused on labor costs (i.e., spending going to the workers involved in the construction or O&M of these resources) and non-labor costs (i.e., spending going to the materials associated with construction or O&M). We performed this division among construction and O&M, and labor and non-labor spending for each of the three sectors (water, transportation, and energy).

Next, we assigned each subsector of spending (e.g., energy efficiency, wastewater infrastructure, or airport infrastructure) to one of IMPLAN's existing industry categories:

- For the energy sector, we applied the costs associated with electric generating resources (such as new solar PV and wind facilities) to existing IMPLAN industries based on cost allocation data from NREL's JEDI model and supplementary Synapse research. We applied the costs of heat pump construction and O&M to IMPLAN's "Air conditioning, refrigeration, and warm air heating equipment manufacturing" as it most closely resembles the construction and O&M of heat pumps. Finally, we applied the costs associated with energy efficiency to existing IMPLAN industries based on utility energy efficiency spending data.
- For the water sector, we applied the costs associated with all water infrastructure to the existing IMPLAN industry titled "Water, sewage and other streams." This is the only industry that fully encompasses water infrastructure and all its components.
- We applied the costs associated with all transportation infrastructure to various existing IMPLAN industries depending on the transportation category and the sub-costs within that category.

Direct Jobs

Direct jobs are composed of jobs for contractors and construction workers (among others) working on the construction or operation of each type of infrastructure. For example:

- In the energy sector, these jobs may include solar panel and heat pump installers and energy efficiency auditors.
- In the water sector, these jobs may include pipefitters and steamfitters.
- In the transportation sector, these jobs may include highway maintenance workers and rail-track laying equipment operators in the transportation sector.

The creation of direct jobs relies primarily upon three inputs: capital investment, the share of capital investment spent on labor, and state- and industry-specific wages.

Indirect Jobs

Indirect jobs are created at the supplier level, which produces parts, tools, and other inputs to support the construction and O&M of the infrastructure. For instance, an investment in a new water treatment plant not only creates direct jobs at the plant, but also indirect jobs down the supply chain for pipes and other component manufacturers. Importantly, because the suppliers for each subsector are not necessarily located within Massachusetts, we relied on IMPLAN's local purchase percentage for each industry to identify the percentage of spending that goes to Massachusetts firms.

Induced Jobs

Induced impacts result from residents spending more money in the local economy. In this analysis, these impacts were derived only from employees in newly created direct and indirect jobs. We did not calculate changes in customers' energy-, water-, or transportation-related spending. Therefore, we did not model the job impacts associated with customers modifying their spending habits based on changes to energy-, water-, or transportation-related spending.