Economic and Health Impacts Report

A Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study

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1. Executive Summary & Overview

The following technical report describes an analysis of economic and health impacts from decarbonizing the Massachusetts energy system. The work was conducted by a team of researchers at the Cadmus Group, with additional support from Evolved Energy Research (EER), working as part of the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA's) 2050 Decarbonization Roadmap Study. This analysis of energy system spending, health outcomes, and economic impacts extends the analysis of eight alternative decarbonization pathways conducted by EER and is published in the companion *Energy Pathways Report*.

Table 1. Summary of costs for the All Options Pathway (benchmark) and the No Thermal Pathway (highest cost) compared to a Reference case (not GWSA-compliant).

Year	Pathway	Annual Energy System Cost (bn. 2018$)	Energy System Share of 2018 gross state product	Annual increase relative to 2020			Annual increase relative to 2050 Reference		
				Billion 2018$	Per cap.	% change	Billion 2018$	Per cap.	% change
2020	Reference	$19.9	3.3%	N/A	N/A	N/A	N/A	N/A	N/A
2050	Reference	$22.3	3.7%	$2.4	$324	12%	N/A	N/A	N/A
	All Options	$23.8	4.0%	$3.9	$526	20%	$1.6	$202	7%
	No Thermal	$27.5	4.6%	$7.6	$1,026	39%	$5.3	$701	23%

While the *Energy Pathways Report* examined the emissions, cost, and resource impacts of transformations in the energy system consistent with achieving Net Zero by 2050, this supplementary analysis further investigates economic and health impacts associated with those changes. The findings of this supplementary analysis are as follows:

- Decarbonization leads to a shift from imported fossil fuel purchases towards investment in local and regional capital equipment related to both energy demand and energy supply.
- In achieving Net Zero, total energy system costs increase relative to a non-mitigation reference case, but only modestly in comparison to total annual spending on energy and related technologies (Table 1). The total cost increase of a representative mitigation pathway in 2050 ($1.5 billion annual spending) compared to a non-decarbonized reference case in 2050 is less than the expected increase in statewide energy costs from 2020 to 2050 resulting from population and economic growth ($2.4 billion annual spending).
- Several key factors influenced overall costs and economic impacts:
    - Electrification of transportation and building equipment leads to increased demand for electricity transmission and distribution (T&D) infrastructure and for additional renewable generation resources.
    - In-state renewable development generally reduces the cost of decarbonization, while increasing in-state investment. However, substituting thermal electricity generation with a renewable-plus-storage strategy greatly increases overall costs due to the high cost of storage and additional scale of renewables needed to meet capacity needs at all hours.
    - Strategies that rely on higher levels of renewable fuels for decarbonizing end uses or electricity generation require a larger import of higher-cost renewable fuels from out-of-state. This increases overall costs while reducing in-state investment.

- Maximizing in-state spending while minimizing total costs results in stronger economic performance across employment, income, and output indicators. For example, the least-cost pathways (All Options, Regional Coordination, and DER Breakthrough) all experience returns in terms of economic output that are greater than three dollars per dollar spent – levels that are higher than direct investment in impacted industries because such investment reduces the need for, and total cost of, energy imports. Approximately 472,000 job-years[1] are created by investment in the benchmark decarbonization pathway (All Options) over the course of 30 years, translating to an average of 15,000 jobs annually.
- Electrification of end-uses leads to a substantial reduction in harmful air pollutants (e.g., $PM_{2.5}$, NO_x). Annual health impacts for the All Options "benchmark" net-zero pathway in 2050 are:
    - 180-400 lives saved due to improved air quality
    - 24,296 lost workdays avoided
    - Between $2.0 billion (low estimate) and $4.5 billion (high estimate) in health benefits, approximately 98% of which is attributable to a reduction in mortality.
- Air quality improvements resulting from widespread electrification (in all least-cost pathways) dramatically improve health outcomes for residents of Barnstable, Norfolk, and Suffolk counties due to their respective high concentration of elderly, at-risk, and Environmental Justice populations.
- This report does not analyze the expected cost savings due to investments in climate resiliency or adaptation, or the expected economic and public health impacts of climate internal or external to Massachusetts. As a rough benchmark of those potential costs and savings, the federal government in 2016 estimated the likely social cost of carbon in 2050 at about $69 per ton (and as high as $200 per ton in the most severe climate models).[2] A reduction in annual GHG emissions by 60 million tons of CO_2 equivalent in 2050 compared to the reference case would result in avoided social costs of about $4 billion per year by 2050 (with an upper bound of about $10 billion assuming the upper end of damage potential).

The remainder of this document discusses these findings. First, it summarizes the cost impacts of the energy system pathways. Second, it assesses the broader economic impacts including job creation. Finally, it presents the health impacts associated with the pathways. Methods and limitations are presented in each section. The reader is encouraged to review the *Energy Pathways Report* and the *2050 Roadmap Report* for more background on these pathways prior to reading the text below.

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[1] A job year is an industry-specific mix of full-time, part-time, and seasonal employment lasting a year. An annual average that accounts for seasonality and follows the same definition used by the BLS and BEA. IMPLAN Employment is not equal to full time equivalents.

[2] EPA (2016). EPA Fact Sheet Social Cost of Carbon. https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf

2. Impacts on In- and Out-of-State Energy Spending

The analysis underlying the *Energy Pathways Report* uses comprehensive cost data to assess expected costs for, and to track total costs related to, hundreds of individual components of the energy system. Costs are tracked on five-year intervals for relevant sectors and subsectors, and by whether the spending will occur in-state (e.g., local generation, energy efficiency, fuel distribution) or out-of-state (e.g., regional electricity and fuel purchases). Costs are in the form of levelized annual costs which integrate capital and operating expenses. Changes in spending are quantified for each mitigation pathway relative to a no-mitigation *Reference* case, and relative to a benchmark *All Options* mitigation pathway that is used as a comparison point among the net-zero compliant mitigation pathways. Comparisons to the *Reference* case and the benchmark *All Options* pathway are used to highlight key results below.

All net-zero pathways modestly increase net costs to Massachusetts compared to the no-mitigation *Reference* case. Figure 1 shows the total energy system costs associated with the *Reference* case and *All Options* pathway by energy sector. Figure 2 shows the same total energy systems costs broken out into in-state and out-of-state spending. Overall, energy cost increases are driven largely by increases in renewable generation, transmission and distribution (T&D), and demand side costs (e.g., vehicle electrification, building electrification, and building shell improvements). Notably, out-of-state fossil fuel (natural gas and oil product) spending declines dramatically though 2050 in the *All Options* pathway as well as the other mitigation pathways (not shown). These decreases in external spending mostly – but not completely – offset the larger increases in in-state spending.

Figure 1. Total energy system costs associated with the Reference case (not net-zero compliant) and All Options pathway from the Energy Pathways Report

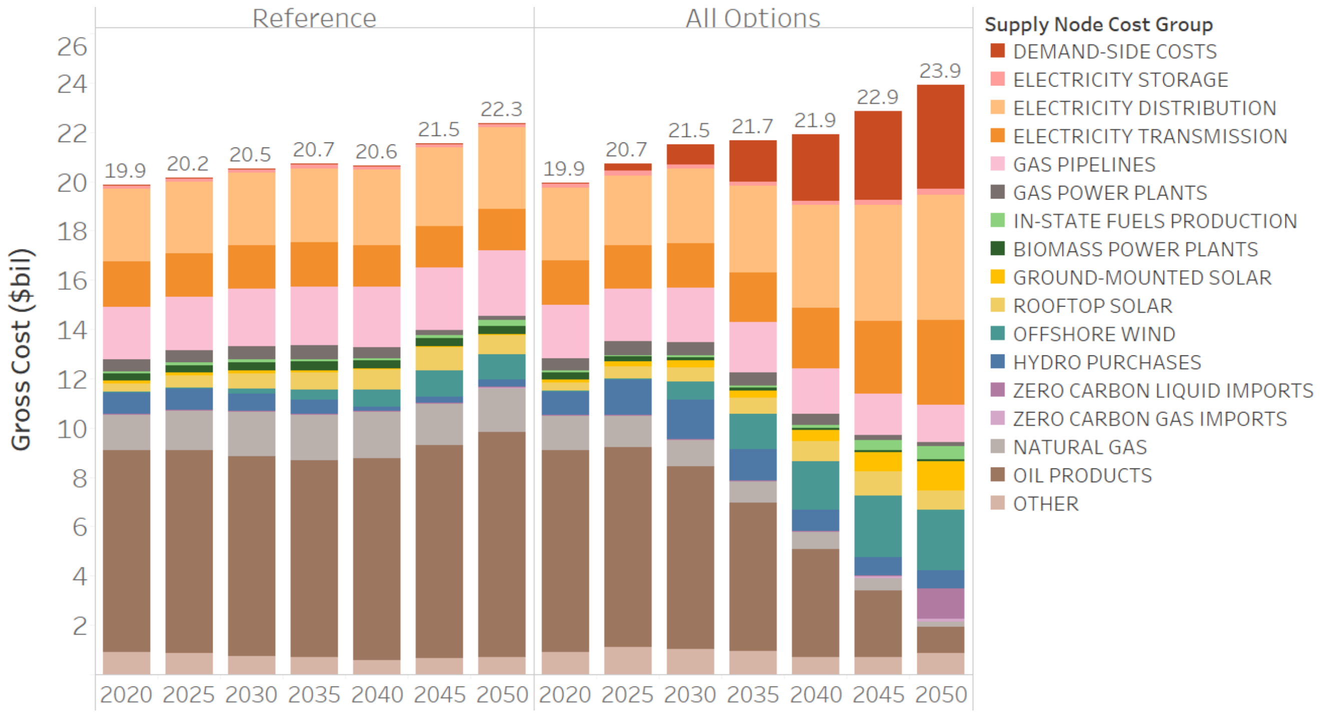
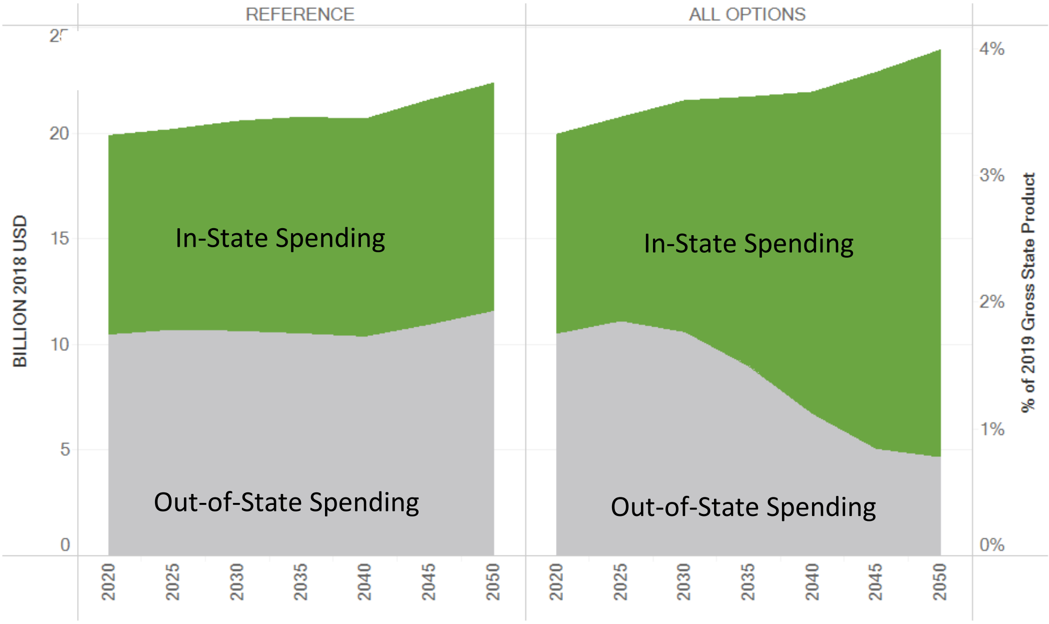


Figure 2. Split of in-state spending and out-of-state energy spending for the Reference case and All Options pathway evaluated in the Energy Pathways report.



The Figure 3 shows the changes to sector spending in each of the alternative pathways relative to the *All Options* pathway evaluated in the *Energy Pathways Report*. Figure 4 shows the changes to internal and external spending resulting from the alternative pathways. Defining elements of each pathway lead to shifts in spending. Several key takeaways can be noted:

- Lower transmission costs assumed in the *Regional Coordination* pathway allows Massachusetts to purchase more low-cost out-of-state clean electricity when available. This lowers both in-state and out-of-state spending.
- The *Offshore Wind Constrained* pathway requires additional in-state solar and more out-of-state hydro purchases. Subsequently, total costs increased modestly; hourly electricity prices increase significantly in the winter when wind generation would coincide with thermal demand.
- The *Limited Efficiency* pathway reduces in-state investment in building shells and higher-performing equipment. The subsequent higher electricity demand requires more out-of-state renewable purchases in the near term, and in the long run requires investment in more in-state renewables along with transmission and distribution. In the *Limited Efficiency* pathway, a spike in decarbonized fuel imports – as well as costs – in 2050 is driven by limited improvement in aviation efficiency that was assumed for this pathway.
- Deferring electrification in the *Pipeline Gas* pathway results in less in-state T&D spending and fewer renewable resources through 2035 as compared to the higher-electrification *All Options* pathway (although this is partly offset by increased gas pipeline and distribution maintenance). Out-of-state spending increases dramatically in later years as scarce imported decarbonized fuels are needed to decarbonize both aviation and delivered gas.
- Requiring *100% Renewable Primary Energy* by 2050 results in a sharp spike in decarbonized fuel demand – as well as costs – from both in-state and out-of-state fuel production.

- Prohibiting thermal generation (*No Thermal*) requires more in-state and in-region solar as well as significant additions of new wholesale-side storage which sharply increases costs in later years.

The *Pipeline Gas*, *Limited Efficiency* and *100% Renewable Primary Energy* pathways all require significant amounts of imported zero-carbon liquid fuels (e.g., bioenergy). Such resources are relatively expensive compared to their fossil counterparts (e.g., \$3/MMBtu vs. \$30/MMBtu for methane) and to the expected future cost of clean electricity. This reliance on expensive out-of-state resources both increases costs overall and shifts spending out-of-state.

Figure 3. Shift in sector spending relative to All Options pathway by alternative scenarios evaluated in the Energy Pathways Report.

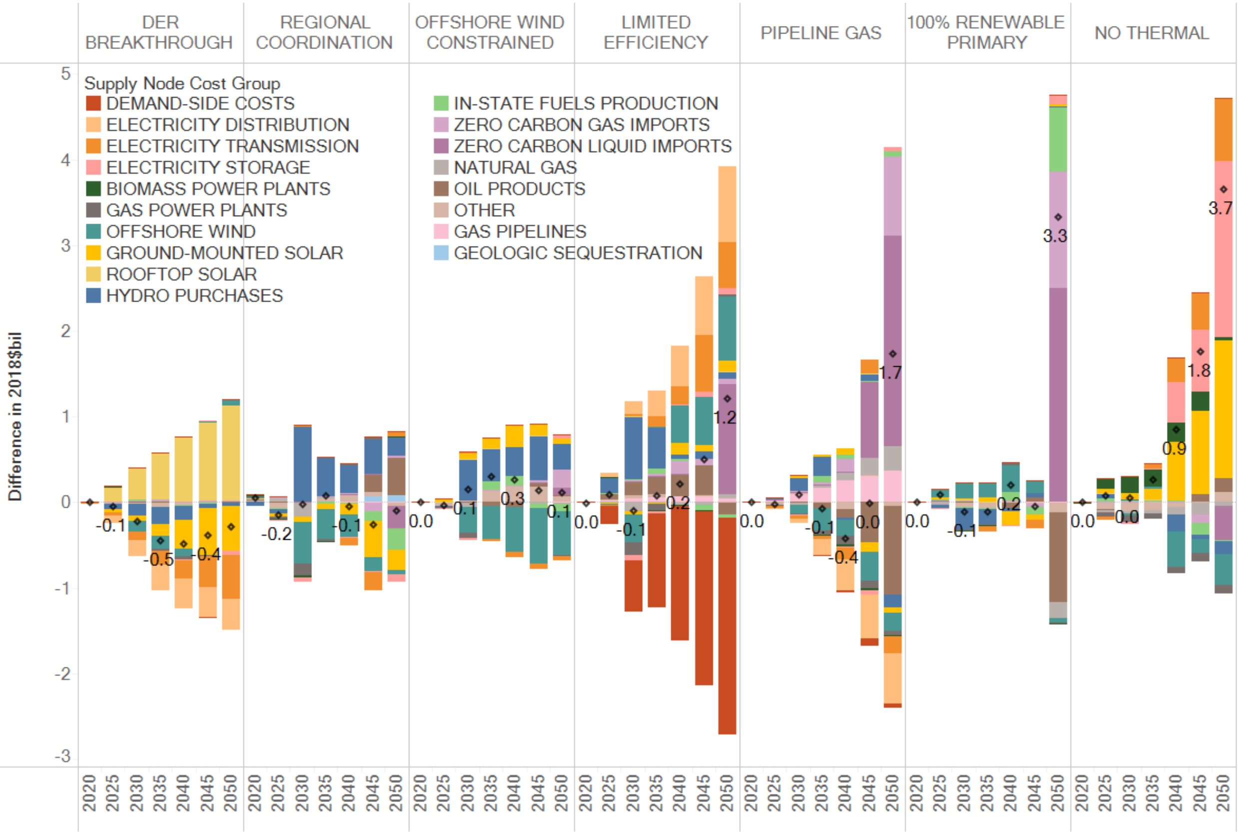
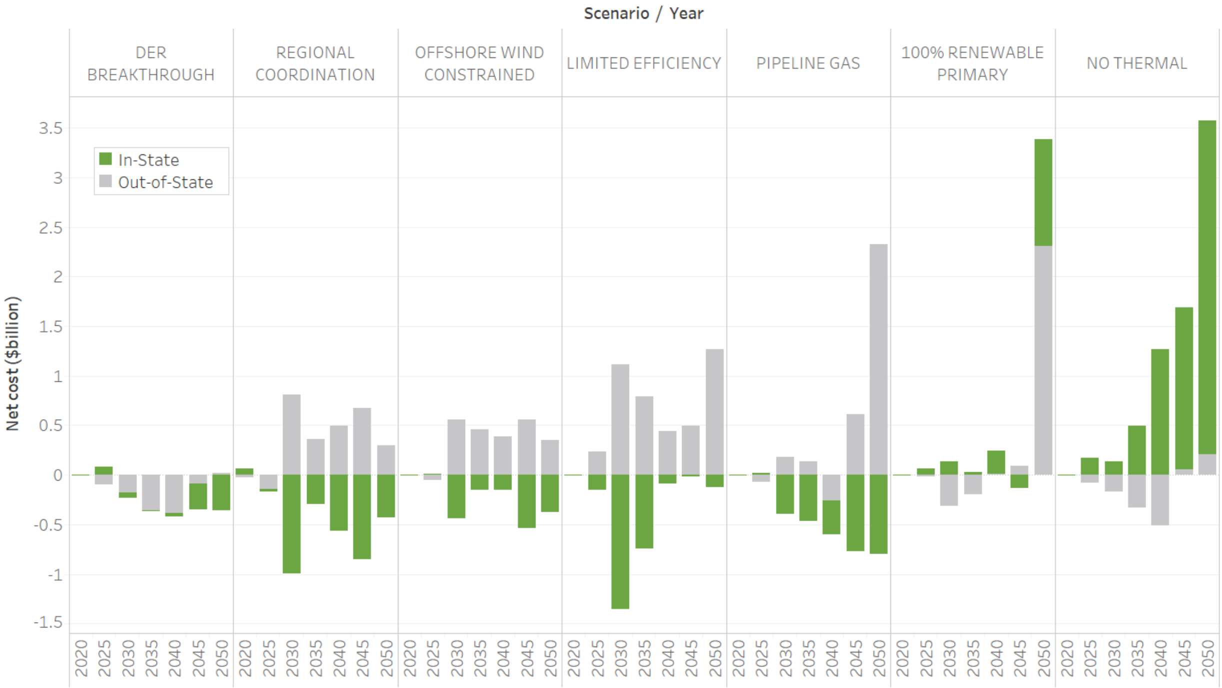


Figure 4. Shift in in-state (green) and out-of-state (grey) spending relative to All Options pathway by alternative scenarios evaluated in the Energy Pathways Report.



All decarbonization pathways studied exhibited higher total energy system cost than the emissions non-compliant *Reference* case, with the lowest-cost pathway (*DER Breakthrough*) representing a cost increase equivalent to about 0.25% of gross state product (GSP) and the highest-cost pathway (*No Thermal*) representing a cost increase equivalent to about 1% of GSP on an annual basis. These costs will likely be incurred by Massachusetts residents, businesses, and institutions across a wide range of mechanisms, including potentially, modestly higher utility rates, increases in fuel costs, and upfront replacement premiums for low carbon technologies. In 2050, in the *All Options* pathway, total household-averaged costs[3] related to decarbonization are approximately $50 a month (Figure 5) above those in the no-mitigation *Reference* case. Costs in 2050 in the *Limited Efficiency* and *Pipeline Gas* pathways double relative to the increase incurred by *All Options*, while mitigations costs triple in the *No Thermal* and *100% Renewable Primary* pathways. This study did not include the avoided costs of climate-related, health impact, or environmental-services damage associated with the no-mitigation *Reference* case.

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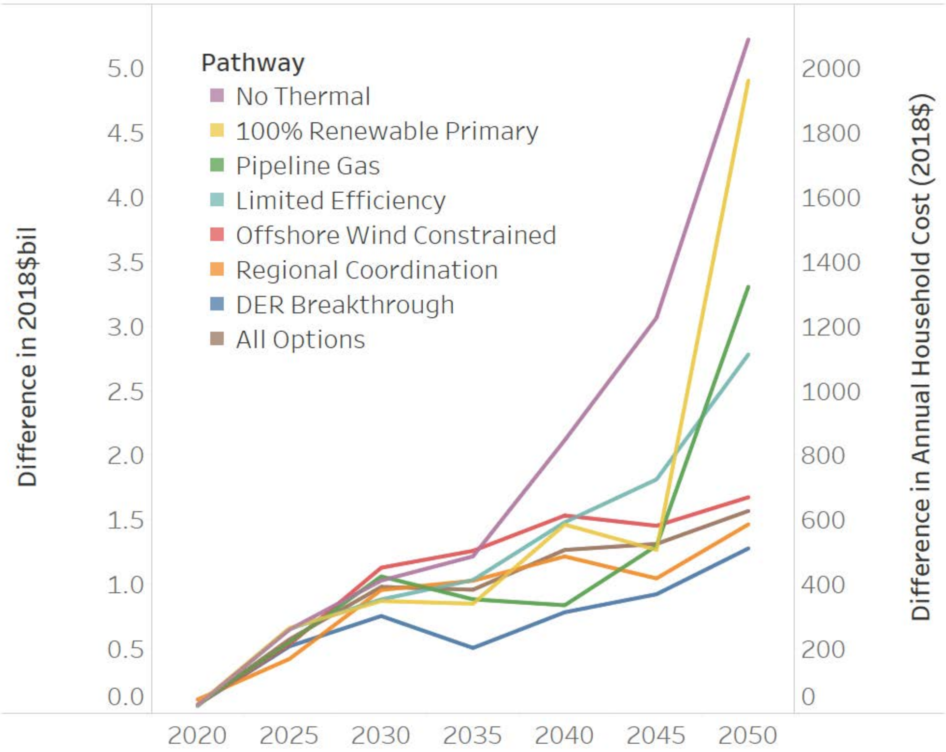
[3] Household average costs assume that all costs incurred by non-residential entities are passed on to households. This is used here for simplicity to illustrate an upper bound for how costs may be realized by households.

Figure 5. Cost differences between the pathways by year relative to the Reference (non-compliant) pathway. Labels indicate 2050 total system costs.



3. Impact on Jobs and Economic Output

Direct spending in a state or region is expected to cascade through the economy, inducing additional rounds of spending. For example, increasing construction activity will also increase demand for construction materials; an increase in new car sales will increase spending across the entire automobile manufacturing and service supply chain. Workers employed as a result of any direct spending and throughout any related supply or service chain receive compensation and then typically "re-spend" a portion of those funds – their earnings – on consumer goods and services. The dollar amount in local circulation typically decreases with each round of spending due to funds being spent out of the region, such as through tourism or for imported goods and services.

The project team utilized IMPLAN[4] to evaluate these standard, expected economic impacts in Massachusetts, across the economy, for each net-zero compliant pathway. IMPLAN is a widely used input-output economic analysis software package. Economic data for 2018 were used to assess changes to impacted industries. Because of the limitations of the model, the results should be interpreted as elucidating order of magnitude impacts rather than establishing specific predictions of future conditions. For example, IMPLAN assumes full employment such that incremental production results in incremental increase to employment and vice versa in cases of reduced production. However, in reality, the marginal behavior of businesses may vary; individual firms may decide to add hours to part-time staff before opening a new position when increasing production. Due to data limitations and reasonable uncertainty about prices and economic indicators thirty-years into the future, the modelling here assumes basic historic economic relationships and performance trends continue.

Opportunity costs are not analyzed in this approach, which may underestimate full impacts of economic activity. Generally, more spending will lead to higher economic activity; however, any modelled spending in theory could have been invested in an alternative action with different economic outcomes. For example, energy system investments modelled here could have alternatively been invested directly in health care, education, or in other areas that variously and at different times may have higher or lower social returns. Indeed, differences in investment and energy costs may alter how much households and businesses spend in other sectors – a complex dynamic which is not analyzed here. Theoretical opportunity costs such as these are difficult to meaningfully bound and compare over a 30-year time horizon and thus were treated as out of scope. Further, large changes in the labor supply regionally or nationwide may result in migration which would have additional economic impacts not assessed here.

Only internal (Massachusetts-based activity) spending is used for this economic impact analysis. Spending categories are mapped to relevant IMPLAN industry/commodity codes using assumptions surrounding capital expenses, operating expenses, and labor contributions for each sector.

All impacts are evaluated in relation to the *Reference* case described in the *Energy Pathways Report*. Reported economic indicators and their definitions are listed in Table 2. The analysis below centers on the *All Options* pathway, referencing differences between the pathways to illustrate findings. While some pathways have larger impacts than others, the variance between them is relatively small, on the order of only six jobs per million dollars spent. The analysis below focuses primarily on *employment* and *output*. Understanding

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[4] IMPLAN (2020). https://implanhelp.zendesk.com/hc/en-us

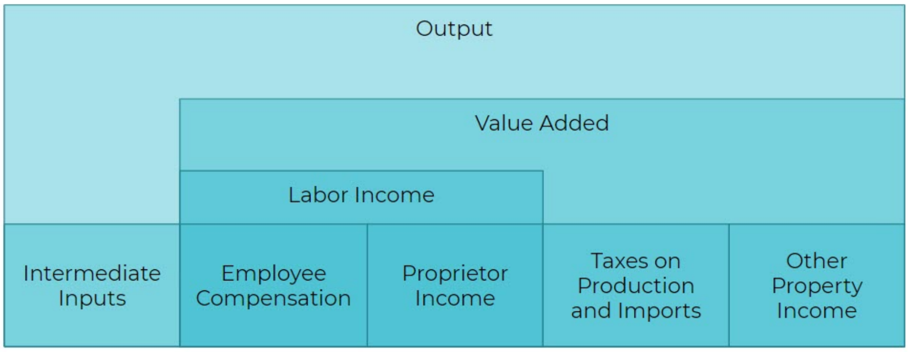
potential employment changes can help inform workforce development needs. Output is the broadest measure of economic activity and is similar to total sales (Figure 6).

IMPLAN calculates three levels of impacts: direct, indirect, and induced. These are also defined in Table 3 and refer to the immediate impacts on the industry, supply chain impacts, and subsequent spending impacts, respectively. When referencing workforce needs, direct employment is reported. When referencing broader economic impacts, the aggregation of direct, indirect, and induced effects is reported. While increased household spending will create an opportunity cost stemming from reduced spending in other areas, the shift from out-of-state energy spending to in-state investment will create indirect and induced impacts that will likely dwarf impacts stemming from any reduced spending in other sectors that is not accounted for here.

Table 2. IMPLAN definitions for economic impacts evaluated in this study.

Employment	An industry-specific mix of full-time, part-time, and seasonal employment lasting a year. An annual average that accounts for seasonality and follows the same definition used by the BLS and BEA. IMPLAN Employment is not equal to full time equivalents.
Labor Income	All forms of employment income, including Employee Compensation (wages and benefits) and Proprietor Income
Value Added	The difference between an industry's or establishment's total output and the cost of its intermediate inputs; it is a measure of the contribution to GDP
Output	The value of industry production; in IMPLAN these are annual production estimates for the year of the dataset in producer prices
Direct Effects	The results of or more production changes or expenditures made by producers/consumers as a result of an activity or policy.
Indirect Effects	Economic Effects stemming from business to business purchases in the supply chain.
Induced Effects	Economic Effects stemming from household spending of Labor Income, after removal of taxes, savings, and commuter income.

Figure 6. Breakdown and components of economic indicators evaluated here.[5]



The *All Options* pathway created in net: 271,000 direct jobs-years, 73,000 indirect jobs-years, and 127,000 induced job-years over the course of the thirty-year period. While total energy system costs over 30 years increase by $29 billion, in-state energy spending increases by $85 billion as a result of reducing out-of-state

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[5] IMPLAN (2020). https://implanhelp.zendesk.com/hc/en-us

energy expenditures (mainly for imported fossil fuels) by $55 billion relative to the *Reference* case. This results in a disproportionately high increase in in-state economic activity relative to the total increase in costs related to decarbonization: $34 billion in additional labor income, $58 billion in additional value added, and $98 billion in output over the next 30 years.

Generally, lower cost pathways with higher relative in-state spending result in higher returns in terms of jobs created, and economic output (Table 3). Economic impacts measured by IMPLAN are normalized here to total net cost to enable consistent comparison of the per dollar impacts of each pathway. Spending on in-state renewable energy resources (solar, wind, energy efficiency) creates economic value for the Commonwealth. Alternatively, relying on out-of-state resources such as imported zero carbon fuels (as in the *Pipeline Gas, 100% Renewable Primary* and *Limited Efficiency*) or higher levels of out-of-state electricity supply due to in-state resource constraints (*Offshore Wind Constrained*) decreases in-state spending and investment.

Table 3. Economic indicators by pathway normalized to total spending relative to the Reference case. Total net MA spending is higher than total costs due to the large shift from imported fossil fuel to local investment.[6] Analysis includes direct, indirect and induced impacts.

Pathway	***Total Net Cost above Ref. Case***	**Change in Out-of-State Spending**	**Change in In-State Spending**	**Employment**	**Return on Investment**		
				jobs per million $ spent	**Labor Income**	**Value-Added**	**Output**
	30-year total (billions $2018)				*$ per $ spent*	*$ per $ spent*	*$ per $ spent*
All Options	$29.2	-$55.4	$84.7	16.2	1.16	1.99	3.35
DER Breakthrough	$21.4	-$61.1	$82.5	18.8	1.32	2.32	3.97
Regional Coordination	$28.1	-$43.4	$71.6	15.1	1.06	1.83	3.02
Pipeline Gas	$33.2	-$45.3	$78.6	15.4	1.10	1.69	2.87
Offshore Wind Constrained	$34.7	-$45.0	$79.7	13.5	0.96	1.63	2.72
Limited Efficiency	$37.8	-$47.7	$85.5	12.8	0.98	1.71	2.84
100% Renewable Energy Primary	$40.5	-$50.6	$91.1	12.6	0.90	1.53	2.60
No Thermal	$56.2	-$54.2	$110.4	12.8	0.93	1.51	2.56

The shift from energy imports to local spending on capital assets is reflected in the output metric which follows these trends noted above. Output multipliers for the industries impacted generally range from under $2 to under $3 of output per $1 spent. Here, the most cost-effective pathways (*All Options, Regional Coordination,* and *DER Breakthrough*) all have returns greater than $3 for each $1 spent. Again, this primarily reflects the shift in spending from imported energy resources to local energy resources and industries in Massachusetts.

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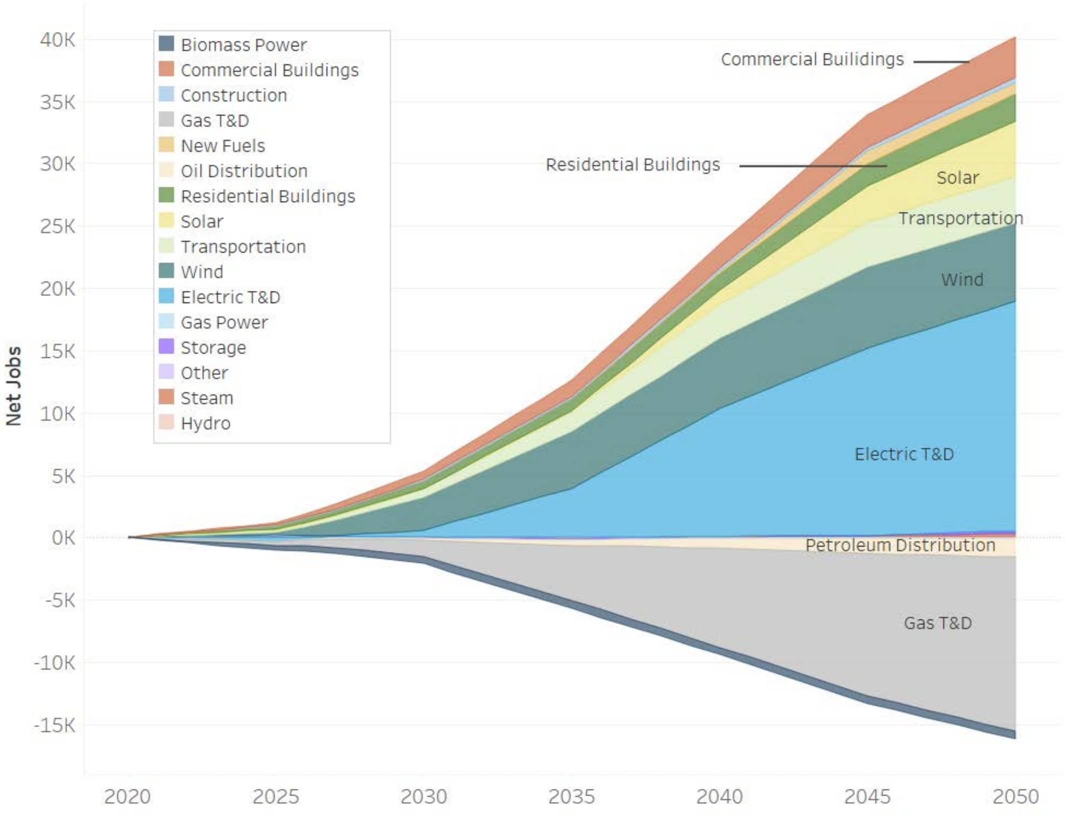
[6] Monetized health impacts are not included in the data below as most savings are realized in terms of value of a statistical life which can be used to assess tradeoffs but does not incur a cash transfer that can be represented in an input-output model such as IMPLAN.

Job impacts in all pathways are relatively low through in the 2020s, the first decade of our analysis (as shown using *All Options* in Figure 7). Out-of-state spending increases modestly, primarily due to additional out-of-state clean energy purchases which, during the 2020s, is the largest single source of emissions reductions, although there is some growth in local demand-side jobs (e.g., energy efficiency and electrification). Around 2030, as decarbonization activity grows outside the electricity sector driven by heating and vehicle electrification, there is a growing need for new electricity system T&D investments. At the same time, similar jobs related to the gas distribution system, and to a lesser degree jobs related to oil and gasoline distribution, start to decline in the 2030s as investment in those systems subsides. Additional drivers of job creation are steady additions of solar, wind, and electric vehicles and related infrastructure.

Figure 7. Net Change in directly created jobs by year for the All Options pathway.



In addition to impacting overall employment levels, the differences underlying each pathway can influence the distribution of jobs. The Limited Efficiency pathway defers building efficiency investment and thus requires investment in additional renewable resources and electricity system T&D infrastructure to meet the demands of higher electric thermal loads. This has impacts on the types of jobs needed. Construction of renewable resources and T&D infrastructure tends to involve higher skill levels and command higher wages than building energy efficiency jobs.[7] This leads to a significant shift in the type of jobs and wage ranges (Table 4, Figure 8). While the Limited Efficiency pathway generates more jobs, it also has a higher level of out-of-state spending on

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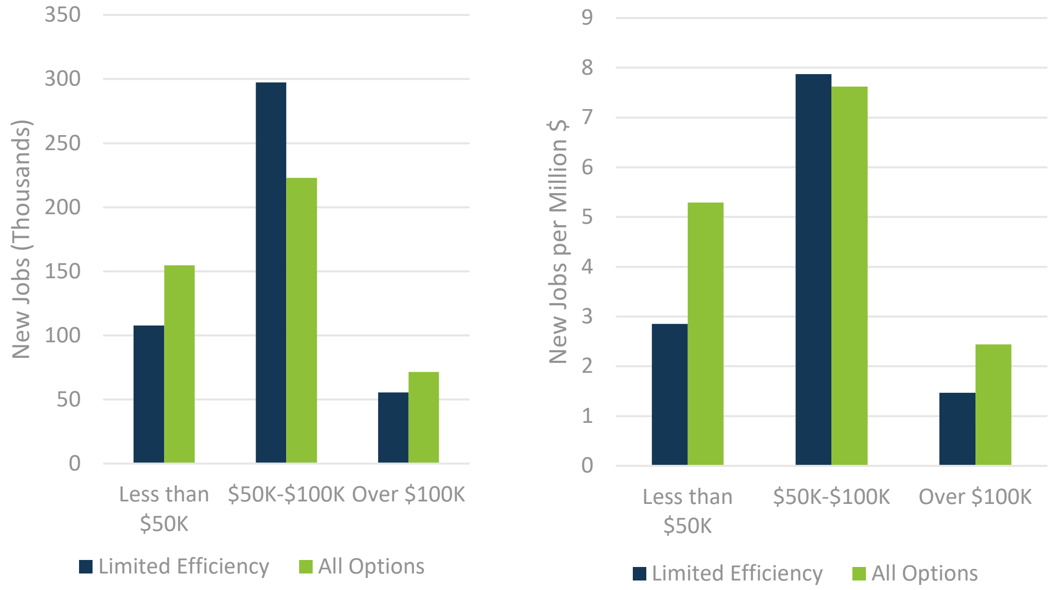
[7] DOE (2015). QER Report: Energy Transmission, Storage, and Distribution Infrastructure. Chapter VIII Employment and Workforce.https://www.energy.gov/sites/prod/files/2015/08/f25/QER%20Chapter%20VIII%20Employment%20and%20Workforce%20April%202015.pdf

zero-carbon imports to decarbonize a less-efficient aviation system. This leads to a lower overall number of jobs-created-per-dollar-spent compared to the All Options pathway.

Table 4. Total jobs created in the All Options and Limited Efficiency pathways highlighting the top 5 industries. The difference in construction jobs are driven primarily by additional T&D infrastructure required by the Limited Efficiency pathway, while the difference in the retail trades is driven by less household and commercial building renovation activity. The top three categories are almost all direct job creation activities, while the fourth, fifth and "other" job categories are a result of indirect and induced impacts.

	All Options	**Limited Efficiency**
Construction	154,590	227,401
Retail trade (e.g., building maintenance)	143,634	77,393
Wholesale Trade	42,175	43,549
Health Care and Social Assistance	40,653	24,981
Professional scientific & technology services	21,519	23,528
Other	69,589	85,639
Total	**472,161**	**482,491**

Figure 8. Jobs created on an absolute basis (left) and per million (right) by wage category (2020-2030)



Forecasted jobs for the clean energy sector over the next 30 years are inherently uncertain, and are sensitive to assumptions regarding the allocation of spending to IMPLAN sectors. For example, this study's estimate of jobs created from wind are approximately one-third lower on a per GW-installed basis than those estimated by the Massachusetts Clean Energy Center's 2018 Massachusetts Offshore Wind Workforce Assessment[8] which conducted a more detailed industry-specific analysis. Still, aggregate total job creation associated with the increase and shift in spending are at expected levels, align with historical economic dynamics, and such uncertainties do not impact overall job and economic output findings.

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[8] MassCEC (2018). 2018 Massachusetts Offshore Wind Workforce Assessment. https://files.masscec.com/2018%20MassCEC%20Workforce%20Study.pdf

4. Health Impacts

Health impacts of the *All Options* pathway in 2050 are assessed using EPA's CO–Benefits Risk Assessment (COBRA) screening model, with county-level resolution. Key COBRA health metrics are shown in Table 5. Total annual state-wide health benefits ranged from $2 billion to $4.5 billion relative to today. Even when comparing the lower estimate of health benefits with the highest estimates of costs, these benefits exceeded the average annual costs increases across all decarbonized pathways compared to the non-mitigation *Reference* case (Table 4). Monetary impacts are driven predominantly by reductions in mortality, represented using the value of a statistical life (VSL) economic metric.[9] Two key items stand out regarding the COBRA analysis, particularly regarding COBRA's county-level representation of demographics:

- Highest per capita monetized benefits are realized in Barnstable county. This is mostly driven by Barnstable county's relatively older population that is more at risk of adverse health outcomes caused by pollution. As a result, it is expected that similar areas with high populations of seniors will likely see similarly high health benefits (that is, a share of benefits that is higher than the area's share of statewide population).
- Norfolk and Suffolk county realize the second and third highest per capita levels of monetized benefits, reduction in mortality, and reduction in hospitalization. Further, Suffolk county experiences the highest level of reduction in infant mortality and work loss days. Suffolk county is significantly younger than Barnstable, but has a disproportionately higher number of environmental justice (EJ) populations including vulnerable health populations.[10][11] As a result, this analysis indicates that similar areas with a higher than average percentage of environmental justice populations, and/or with a higher than average number of vulnerable health EJ populations may similarly see disproportionately high health benefits from the deep decarbonization transition required to achieve Net Zero in 2050.

The reduction of harmful air pollutants thus stands to benefit populations that currently bear a disproportionate share of the burden of these pollutants.

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[9] VSL is not necessarily a cost savings but instead represents wiliness to pay to avoid the risk of dying. It thus follows that if total social mortality VSL exceed the costs of abatement than society should be willing to incur cost of abatement. For more information on VSL see https://www.epa.gov/environmental-economics/mortality-risk-valuation

[10] These findings are corroborated by a Boston-focused, and more granular study of Suffolk and surrounding counties. The authors zeroed out emissions for the non-GHG pollutants within Boston, and used more refined atmospheric and health impacts modeling than what is available with COBRA. Benefits in Suffolk county are lower than our study due to limited emissions-reduction action in the rest of Massachusetts. Still the study found that benefits were disproportionally realized by people of color that are currently at higher risk of being impacted by harmful air pollution. Matthew Raifman *et al* 2020 *Environ. Res. Lett.* **15** 094017 https://doi.org/10.1088/1748-9326/ab842b

[11] As defined in the 2017 EEA Environmental Justice Policy https://www.mass.gov/files/documents/2017/11/29/2017-environmental-justice-policy_0.pdf

Table 5. Selected population-normalized COBRA output showing reductions in heath costs, mortality, work loss days, and hospital admits for a single future year (e.g. 2050) with harmful air pollutant emissions reductions reflecting the changes from the All Options pathway.

	Total Monetized Benefits		**Fewer Deaths (Mortality)**		**Fewer Infant Deaths (Mortality)**	**Fewer Days of Work Lost**	**Fewer Hospital Admits**	**% of State-wide EJ Pop.**
	(low)	**(high)**	**(low)**	**(high)**				
County	*per person*	*per person*	*per million*	*per million*	*per million*	*per million*	*per million*	
Barnstable	$554	$1,250	50.1	113.0	0.061	2,870	18.5	1%
Berkshire	$85	$192	7.7	17.4	0.022	591	1.4	2%
Bristol	$344	$775	31.0	70.0	0.101	3,327	6.0	7%
Dukes	$211	$476	19.1	42.9	0.025	1,769	7.9	0%
Essex	$312	$704	28.1	63.6	0.097	3,350	7.1	10%
Franklin	$118	$267	10.7	24.1	0.022	949	3.2	0%
Hampden	$152	$342	13.7	31.0	0.053	1,470	2.7	10%
Hampshire	$141	$318	12.7	28.7	0.023	1,616	3.7	1%
Middlesex	$224	$503	20.1	45.3	0.065	3,156	5.1	22%
Nantucket	$124	$278	11.1	25.0	0.028	1,852	3.4	0%
Norfolk	$469	$1,055	42.2	95.3	0.120	5,271	6.0	8%
Plymouth	$343	$774	30.9	70.0	0.065	3,150	7.3	5%
Suffolk	$404	$906	36.0	81.3	0.231	7,635	12.1	24%
Worcester	$161	$363	14.5	32.8	0.068	1,779	4.5	11%
Statewide	**$291**	**$655**	**26.1**	**59.1**	**0.094**	**3,530**	**6.6**	**100**

This study did not assess any potential health benefits associated with increasing the use of active transit such as walking and cycling. The multi-university Transportation, Equity, Climate, and Health (TRECH) project has assessed benefits from active transit, as well as air quality associated with the Transportation and Climate Initiative (TCI). The study used comprehensive region-wide transportation and atmospheric modeling to assess TCI program impacts though 2032.[12]

The *Buildings Sector Technical Report* contains an analysis of the heat stress impacts in residential buildings and the impact of mitigation measures such as installation of heat pump cooling equipment. These impacts are not separately monetized here or in the buildings technical report but merit additional research.

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[12] Harvard T.H. Chan School of Public Health (2020). *TRECH Project***.** https://www.hsph.harvard.edu/c-change/news/trechstudy/