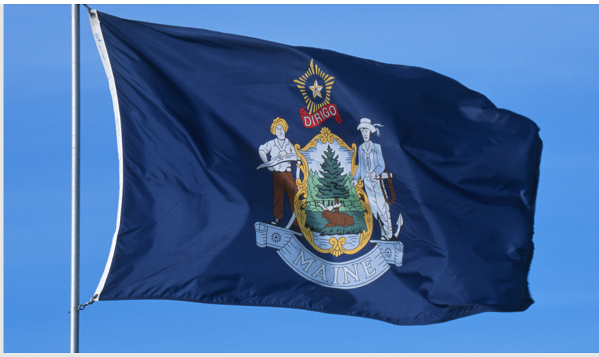
A PROGRAM FOR ECONOMIC RECOVERY AND CLEAN ENERGY TRANSITION IN MAINE

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AUGUST 2020

Acknowledgments

This project was commissioned by the Working Families Party. We greatly appreciate their financial support as well as the fact that they respected our terms of engagement. Those terms included full autonomy in drafting the study and reaching the conclusions presented here.

The study benefitted substantially from discussions with Dan Cantor and Matt Ryan of the Working Families Party and Rachel Ackoff of the Maine People's Alliance. We also benefitted from the outstanding research assistance from Caitlin Kline, Camilo Gallego, and Emily Diaz-Loar.

Kim Weinstein produced this wonderfully readable document out of our multiple cyber-piles of text and tables. PERI's Administrative Director Nicole Dunham provides a bedrock of support for all of our research work.

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SUMMARY OF STUDY

The COVID-19 pandemic has generated severe public health and economic impacts in Maine, as with most everywhere else in the United States. This study proposes a recovery program for Maine that is capable of exerting an effective counterforce against the state's economic collapse in the short run while also building a durable foundation for an economically viable and ecologically sustainable longer-term recovery. Even under current pandemic conditions, we cannot forget that we have truly limited time to take decisive action around climate change. As we show, a robust climate stabilization project for Maine will also serve as a major engine of economic recovery and expanding opportunities throughout the state.

The study is divided into three parts:

1. Economic Stimulus through Restoring Public Health
2. Clean Energy Investments, Public Infrastructure Investments, and Jobs
3. Financing a Fair and Sustainable Recovery Program

The most detailed discussions are in Part 2. We develop here a clean energy investment project through which Maine can achieve its own climate stabilization goals, which are in alignment with those set out by the Intergovernmental Panel on Climate Change (IPCC) in 2018—that is, to reduce CO_2 emissions by 45 percent as of 2030 and to achieve net zero emissions by 2050. We show how these two goals can be accomplished in Maine through large-scale investments to dramatically raise energy efficiency standards in the state and to equally dramatically expand the supply of clean renewable energy, primarily wind and solar power. We also show how this climate stabilization for Maine can serve as a major new engine of job creation and economic well-being throughout the state, both in the short- and longer run. We estimate that in the first year of the program, scaled at $2 billion, overall clean energy investments will generate nearly 15,000 jobs in Maine.

We further present in Part 2 a public infrastructure investment program that will significantly upgrade Maine's transportation system, school buildings, and broadband accessibility, while enhancing the quality of the state's parks, ports, and fisheries, among other critical areas. These public infrastructure investments can also provide a major boost to job creation throughout the state, both in the short- and long run. We estimate that these infrastructure investments will generate about 7,300 jobs per year, with spending averaging about $500 million per year.

This summary first provides a brief overview of the entire study. It then presents a more detailed set of highlights of the main findings of Part 2.

Establishing effective public health interventions. This will generate tens of thousands of jobs through allowing the state to recover safely. The state's hospitality and tourism industries have been hardest hit by the pandemic, accounting for nearly 40 percent of all job losses in the state resulting from the pandemic. These industries will therefore also benefit disproportionately from a safe and sustainable recovery. The health care industry has also experienced severe job losses since March, despite the pandemic. It will therefore benefit greatly from a safe and sustainable reopening. Workers in all industries need to be provided with adequate Personal Protection Equipment so they can perform their jobs safely. They also need their rights at work to be fully protected, including the right to paid sick leave.

Clean Energy Investments and Job Creation. We estimate that public and private investments in Maine to achieve emission reduction targets consistent with the IPCC's goals are capable of producing nearly 15,000 jobs in 2022 through $2 billion in public and private investments. New job creation can also begin on a significant scale sooner, in 2021, though the state's clean energy investment project is not likely to be operating at full scale until 2022. Clean energy investments should then increase along with the state's overall economic growth trajectory, generating an increasing number of jobs each year to 2030. These investments will entail both: 1) greatly enhancing the state's level of energy efficiency, including through deep energy retrofits to public buildings; and 2) massively expanding the state's supply of clean renewable energy sources, starting with wind power and solar power. New job opportunities will open for, among other occupations, carpenters, machinists, environmental scientists, secretaries, accountants, truck drivers, roofers and agricultural laborers.

Just Transition for Displaced Workers in Fossil Fuel-Based and Biomass Electricity Industries. Maine does not produce any fossil fuels within the state's borders. But nearly 60 percent of all the energy it consumes comes from oil and gas, and another 27 percent comes from biomass—i.e. burning wood to create electricity. Workers in the state's fossil fuel-based and biomass electricity industries will therefore experience job losses as the state dramatically reduces consumption of these CO_2-generating energy sources. We estimate that 158 workers per year will be displaced in these industries between 2021 – 2030, while another roughly 200 will voluntarily retire each year.

The most heavily impacted workers will be those employed directly in the state's fossil fuel-based and biomass electricity industries. Displacements for these directly impacted workers total to about 32 per year. It is critical that all of these workers receive pension guarantees, health care coverage, re-employment guarantees, wage insurance, and retraining support, as needed. The remaining 126 workers will face displacement through indirect and induced job loss effects. These workers should be supported through generous unemployment insurance, retraining, and re-employment programs that should also be available to all unemployed workers in Maine.

Upgrading Maine's Public Infrastructure. Maine's economy would receive an additional major boost, in terms of both short-run stimulus and longer-term productivity, by undertaking a large-scale public infrastructure investment program now. We estimate that $500 million in annual infrastructure investments in Maine between 2021 – 2030 will generate about 7,300 jobs per year within the state. Roughly half of these jobs will be in the construction industry, including new opportunities for carpenters, electricians, glaziers, plumbers, pipefitters, and construction laborers. Most of the rest of the jobs will be in manufacturing and a range of services.

Financing a Sustainable Recovery. The Maine state budget, like all state and municipal-level budgets, face, at the least, great uncertainty with their budgetary prospects over the coming year. They also face the real possibility that they could experience massive revenue shortfalls as a result of the ongoing recession. Given this uncertainty, it is not possible to know what funding amounts from sources other than tax revenues within the state will be sufficient to move Maine onto a viable recovery path.

Starting last March with the CARES Act, the federal government has injected $6.4 billion into the state's economy, equal to nearly 10 percent of state GDP, to support state and local government budgets, private businesses and individual residents. We estimate that the state will need an additional $3.4 billion over the 2021 fiscal year (about 5 percent of 2019 GDP) to finance the initiatives we describe in this study—i.e. in the areas of cash assistance, unemployment insurance, Medicare support for unemployed workers, expanded public health and safety interventions, clean energy and public infrastructure investments and support for municipal governments.

As of this writing in August, it is not clear how much additional support the federal government will provide to meet these needs in Maine. As such, we recommend that the state and local governments in Maine develop contingency plans to support a strong recovery. It is critical to recognize that, by statute, the state does have the legal authority as well as the capacity to issue bonds to support capital projects. This capacity has been enhanced through the U.S. Federal Reserve Board's recently created "Municipal Liquidity Facility" which enables the Fed to purchase bonds from state and municipal governments. To date, the state government and municipalities in Maine are able to sell up to $1.1 billion in bonds to the Fed. Maine is also able to borrow at extremely low rates on the open market, with yields on Maine's state and municipal long-term bonds ranging between 1.0 and 1.6 percent as of 8/14/20. With Maine's state and municipal governments being able to borrow at such low rates, the prospects are favorable for these public entities to support large-scale programs to counteract the crisis and move Maine onto a sustainable long-term recovery path.

Part 2 Highlights: Clean Energy Investments, Public Infrastructure Investments, and Jobs

This section of the study examines the prospects for a transformative clean energy investment program for Maine. The centerpiece of the program is clean energy investments, undertaken in combination by the public and private sectors throughout the state. The program will advance two fundamental goals:

- Promoting global climate stabilization by reducing carbon dioxide (CO_2) emissions in Maine without increasing emissions outside of the state.
- Creating roughly 15,000 new jobs in the state per year between 2022 – 2030.

A complementary program of large-scale public infrastructure investments will raise productivity and enhance well-being in the state, while also generating over 7,000 jobs per year.

Reducing CO_2 Emissions

- The first goal for clean energy investments will be to achieve, by 2030, a 50 percent reduction in CO_2 emissions in Maine relative to the 2017 emissions level.

- Emissions in Maine in 2017 were at 24.9 million metric tons after including emissions produced by burning wood to produce electricity. The emissions level as of 2030 will therefore need to be no more than 12.5 million tons.[1]

Major Areas of Clean Energy Investments

- ***Energy Efficiency.*** Dramatically improving energy efficiency standards in Maine's stock of buildings, automobiles and public transportation systems, and industrial production processes.
- ***Clean Renewable Energy.*** Dramatically expanding the supply of clean renewable energy sources—primarily wind and solar power—available at competitive prices to all sectors of Maine's economy.
- ***Total Investment Expenditures.*** The level of investment needed to achieve Maine's energy goals will average roughly $2.2 billion per year between 2021 – 2030.
  - This estimate assumes that Maine's economic growth proceeds at an average rate of 1.5 percent per year.
  - Clean energy investments will need to equal about 3.2 percent of Maine's annual GDP.
  - The average annual clean energy investment level of 3.2 percent of GDP means that nearly 97 percent of Maine's economic activity will be directly engaged in activities *other than* clean energy investments.

Clean Energy Investments Will Deliver Lower Energy Costs

- Raising efficiency standards enable consumers to spend less for a given amount of energy services.
- The costs of wind, solar, geothermal, and hydro power are all presently roughly equal to or lower than those for fossil fuels and nuclear energy.
- The average Maine household should be able to save nearly 40 percent on their overall annual energy bill. This would be after they have paid off their initial up-front efficiency investments, to purchase, for example an electric vehicle, over five years.

Job Creation through Clean Energy Investments

- Investing an average $2.2 billion per year in clean energy projects in Maine over 2022 – 2030 will generate nearly 15,000 jobs per year in the state.
- New job opportunities will be created in a wide range of areas, including construction, sales, management, production, engineering, and office support.
- Current average total compensation in these occupations ranges widely, between about $30,000 and $60,000.
- Employment growth in these areas should create increased opportunities for women and non-white workers to be employed and to raise unionization rates.
- Higher unionization rates should promote gains in compensation and better working conditions in the affected industries.

- Good-quality worker training programs will be needed to ensure that a wide range of workers will have access to the jobs created by clean energy investments and that the newly-employed workers can perform their jobs at high productivity levels.

Just Transition for Fossil Fuel Industry Dependent Workers and Communities

- About 85 percent of all energy consumption in Maine comes from burning oil, biomass and natural gas. Consumption of oil, gas and biomass will all need to fall by 50 percent as of 2050. The state's already negligible coal industry will need to be eliminated altogether.
- About 1,800 workers in Maine are presently employed in the state's fossil fuel-based and biomass electricity industries.
- We estimate that total job displacements will average 32 per year.
    - This is after allowing that an average of 64 workers per year will voluntarily retire.
- A Just Transition program for these 32 workers per year presently employed in Maine's fossil fuel-based and biomass electricity industries should include five components:
    - Pension guarantees for retired workers who are covered by employer-financed pensions;
    - Retraining to assist displaced workers to obtain the skills needed for a new job and 100 percent wage replacement while training;
    - Re-employment for displaced workers through an employment guarantee, with 100 percent wage insurance.
    - Relocation support for all workers who require this support; and
    - Full Just Transition support for older workers who choose to continue past the traditional retirement age of 65.
- The average costs of supporting these workers will amount to about $113,000 per worker. Overall costs will amount to about $3.6 million per year over the duration of the Just Transition program.
- About 126 workers per year will also face displacement through indirect and induced job loss effects.
    - These workers should receive generous unemployment insurance, retraining and re-employment support through programs that apply to all unemployed workers in Maine.

Achieving Net Zero Emissions by 2050

- Maine can reduce its CO_2 emissions by 90 percent relative to its 2005 level, to 2.5 million tons, by 2050 through continuing its clean energy investment program.
- Maine will therefore become a net zero emissions economy, since the growth of Maine's forests absorb about 10 million tons of CO_2 per year.
- Average clean energy investments would need to equal about 1.4 percent of state GDP per year over 2031 – 2050.

- Average job creation through these clean energy investments will range between 7,500 – 8,300 jobs per year.
- Just Transition support for displaced workers over 2031 – 2050 will amount to about $2.6 million per year.

Upgrading Maine's Public Infrastructure

- The American Society of Civil Engineers (ASCE) gave an overall grade of C- to Maine's public infrastructure.
- Based on the ASCE's findings, raising Maine's infrastructure to an overall B grade. will require investments at $500 million per year for 10 years.
- Major spending areas would include surface transportation, school buildings, broadband, repairing existing gas distribution pipelines, parks, fisheries, and public housing.
- Investing $500 million in these areas would generate about 7,300 jobs per year within Maine.

Overall Net Job Creation through Clean Energy and Public Infrastructure Investments

- Our job creation estimates as of 2022 include:
  - 14,582 jobs through $2 billion in spending on energy efficiency and clean renewable energy.
  - 7,294 jobs through $500 million in public infrastructure.
- The total job creation through clean energy and public infrastructure jobs will total to 21,876.
- We estimate that job displacements in Maine's fossil fuel-based and biomass electricity industries will average 158 per year between 2021 – 2030.
  - This includes
    - 32 job displacements per year for workers directly employed in these industries.
    - 126 job displacements per year for workers through indirect and induced job channels within Maine.
- Net job creation as of 2022 is 21,718, or nearly 22,000 jobs.
  - This total equals about 3.1 percent of Maine's 2019 workforce.
  - Job creation will increase annually through 2030.

PART 1:

RESTORING PUBLIC HEALTH AND ECONOMIC WELL-BEING

1.1 The Pandemic in Maine

The State of Maine, like the rest of the United States, has been experiencing an historically unprecedented public health and economic crisis since the COVID-19 pandemic emerged full force in mid-March.

Table 1.1 provides some basic statistics on infection and death rates from COVID in Maine, and for comparison, other New England states, the U.S. overall as well as selected other high-income countries. As we see, as of 8/20/20, there have been 4,235 reported cases of infections in Maine, and 127 deaths attributed to COVID. Of course, these figures are tragically high. But it is notable that the infection and death rates in Maine are much more modest than in the U.S. overall. As Table 1.1 shows, in terms of infections per million, Maine's figure at 3,151, is roughly 81 percent lower than the U.S. figure of 16,846 infections per million. Maine's death rate, at 95 deaths per million, is roughly 82 percent lower than the U.S. overall figure of 528 deaths per million. Maine's infection and death rates are also low in comparison with the other New England states. Infections and fatalities in Maine are, respectively, 39 percent and 70 percent lower than those in New Hampshire, and 83 and 93 percent lower than in Massachusetts. Maine's infection rate is 28 percent higher than that in Vermont, but its death rate is roughly the same.

In comparison with high-income countries other than the U.S., Maine's experience is more mixed. Thus, as we see in Table 1.1, Maine's infection rate is about 6 percent lower than that for Canada, and its death rate is fully 61 percent lower. At the same time, the figures for Maine compare quite poorly relative to those for Japan, Australia and South Korea,

TABLE 1.1
Maine COVID-19 Infection and Death Rates in Comparison with USA, Other New England States, and Other Countries
Figures as of 8/20/20

	Confirmed infections		Confirmed deaths	
	# of Infections	Infections per million	# of Deaths	Deaths per million
Maine	4,235	3,151	127	95
U.S.	5,529,672	16,846	173,174	528
New Hampshire	7,036	5,175	427	314
Vermont	1,533	2,457	58	93
Massachusetts	124,415	18,051	8876	1288
Canada	125,395	3,336	9,094	242
Japan	58,728	465	1,148	9
Australia	24,236	956	463	18
South Korea	16,346	316	307	6

Sources: Johns Hopkins University COVID Database on Github: https://github.com/CSSEGISandData/COVID-19.

three countries that have managed the pandemic effectively. As we see, Maine's infection rate per million is 7 times higher than that in Japan (3,151 vs. 465), 10 times higher than that for South Korea, and 3 times higher than Australia's figure. The Maine death rate per million is 5 times higher than the figure for Australia (95 deaths in Maine vs. 18 in Australia), 16 times higher than South Korea and 10 times higher than Japan. In short, despite the relatively favorable results in Maine within the U.S. and North American context, the comparative evidence from South Korea and Australia make clear that Maine's public health interventions during the pandemic could be substantially improved.

The ways in which Maine can significantly improve its COVID-related public health interventions becomes clear through considering specific sectors underlying the statewide average figures.

- ***Nursing homes*** are a tragic focal point in the state with the USA's oldest demographic profile. As of 6/18/20, 30 residents and 1 staff in nursing homes have died from COVID-19, summing to 30 percent of all deaths in the state as of mid-June.[2]
- ***Health care workers*** have become infected by COVID to a greatly disproportionate extent. As of 4/10/2020, 97 health care workers in Maine had contracted the virus, equal to 17 percent of all infections in the state at that time.[3] More recent figures are not available at the time of this writing, even though Maine was one of the first states to start tracking infected health care workers.
- ***The Black community*** is experiencing far higher rates of infections than whites. For instance, while 1.4 percent of Maine's population identifies as black or African American, 24 percent of all infections in the state are reported by black or African Americans.
- ***People in lower-paying jobs*** face a higher likelihood of being exposed to COVID-19. While no systematic data for Maine have been published as yet, evidence from other U.S states is also likely to reflect conditions in Maine. Thus, in Los Angeles County, in areas where more than 30 percent of residents live in poverty, 303 people per 100,000 residents were infected, compared with 156 people per 100,000 in areas where less than 10 percent live in poverty. Residents of those low-income communities also are more likely to die of the virus, at a rate of 15 deaths per 100,0000 residents, twice the rate of people in the wealthier areas.[4] Similarly, a study for Western Massachusetts found that workers earning less than $20 per hour were 2 – 3 times more likely than those earning more than $40 an hour to lack access to protective measures.[5] This finding is especially significant since lower income workers are much less likely to be able to work from home. According to the Bureau of Labor Statistics, only 6.6 percent of full-time workers in the lowest 25 percent of all U.S. wage-earners have been able to work remotely in their main job. By contrast, 55 percent of those in the highest 25 percent of wage-earners have been able to work from home.[6] Since the intersection between low income workers and black, indigenous, and people of color (BIPOC) communities are high, this puts these communities at higher risk.[7]

Generally then, while Maine's COVID-related public health interventions have been relatively successful in comparison to most other U.S. states, these interventions still need to raise their performance standards significantly, in particular in supporting: 1) nursing home residents and workers; 2) public health workers; 3) lower-paid workers; and 4) the state's BIPOC communities.

1.2 Maine's Economic Collapse

Current Conditions

As with the U.S. economy overall, the Maine economy has experienced an unprecedented collapse resulting from the COVID pandemic. As one clear measure of this, we show in Table 1.2 figures on job losses in Maine since the onset of the pandemic in mid-March. Specifically, we report on initial unemployment insurance claims by workers in Maine from March 9 until June 15. As Table 1.2 shows, this figure for numbers of people in the state who lost their jobs over this period totals to 160,303, equal to 23.3 percent of Maine's workforce as of February 2020. That is, over this three-month period beginning with the onset of the pandemic, nearly one-quarter of all workers in Maine lost their jobs and filed for unemployment insurance.

For comparison, we show in the second column of Table 1.2 the figures over the same time period in 2019. As we see, in the same time period a year ago, total initial unemployment claims over this three-month period totaled to 7,444, equal to 1.1 percent of Maine's workforce then. In other words, job losses over March – June 2020 jumped *21-fold* over the same time period last year.

We also report the comparable figures for the U.S. overall in rows 3 and 4. As we see, the figures for Maine match closely with those for the overall U.S. economy. With the overall U.S. economy, job losses between March and June, 2020 were at 25.4 percent of the labor force then, while over the same time period a year ago, that figure was at 1.6 percent.

TABLE 1.2
Job Losses in Maine and U.S. During COVID-19 Pandemic and One Year Prior

Initial Unemployment Insurance Claims:
Weekly Figures Covering March 15 – June 13, 2020 and March 17 – June 15, 2019

	3/15/20 – 6/13/20 Figures	3/17/19 – 6/15/19 Figures
Figures for Maine		
1. Number of people filing initial unemployment insurance claims	160,303	7,444
2. Number of claims as share of February workforce	23.3%	1.1%
Figures for U.S.		
3. Number of people filing initial unemployment insurance claims	41.9 million	2.6 million
4. Number of claims as share of February workforce	25.4%	1.6%

Sources: U.S. Department of Labor, Employment & Training Administration (https://oui.doleta.gov/unemploy/).

Prospects for 2021

Writing in July 2020, it is impossible to provide a confident forecast as to how rapidly or fully the Maine economy is likely to recover from its collapse over March – June. The Federal Reserve Bank of Boston recently provided one dramatic illustration of the extent of uncertainty surrounding the trajectory of Maine's economy over the next year or two. That is, in an article published on June 22, Boston Fed economist Bo Zhou presented two alternative forecasts for the Maine economy for fiscal year 2021 (July 2020 – June 2021), a "low" and a "high" unemployment scenario. We present the main findings of these two scenarios in Table 1.3.

As we see in this table, under the "low-unemployment scenario," the Boston Fed forecasts that Maine's unemployment for fiscal year 2021 will be 7.8 percent. It also forecasts that tax revenues to fund the state's public sector operations will fall by 3.0 percent over this period. By contrast, under its "high-unemployment scenario," the Boston Fed forecasts Maine's unemployment will be 18.4 percent for fiscal year 2021, nearly 2.5 times greater than the rate under its low-unemployment scenario. The Boston Fed also forecasts that, under its high-unemployment scenario, the fall in Maine's state tax revenue per capita will be 30.6 percent over fiscal year 2021, i.e. a decline in state revenue more than 10 times greater in percentage terms than under its low-unemployment scenario.

Two critical observations follow from this Boston Fed forecast. The first is that even under its "low-unemployment scenario," the unemployment rate in Maine would be sustained at nearly 8 percent through fiscal year 2021. This "low" unemployment rate is nearly equal to the peak unemployment rate in the state of 8.1 percent over 2009-2010, the worst phase of the Great Recession as experienced in Maine. But in addition, we need to give careful consideration to the fact that the Boston Fed considers as plausible that, over fiscal year 2021, Maine could experience an unemployment rate of 18.4 percent, along with a 30 percent collapse in state tax revenues. Coming from a credible source, the suggestion that such a devastating trajectory for the state's economy is even plausible underscores the imperative of enacting public policies to prevent any such outcome from actually occurring. The policy measures advanced in this study can be understood as addressing this critical challenge.

TABLE 1.3
Federal Reserve Bank of Boston's Economic Forecast for Maine for Fiscal Year 2021

	Low-unemployment scenario	High-unemployment scenario
Unemployment rate	7.8%	18.4%
Percentage change in state revenue per capita	-3.0%	-30.6%

Sources: Federal Reserve Bank of Boston: New England Public Policy Center (https://www.maine.gov/dafs/economist/sites/maine.gov.dafs.economist/files/inline-files/NEPPC.pdf).

Industry-Specific Contractions and Job Losses

We can obtain a more detailed perspective on Maine's current economic crisis by examining data on changes in employment level by industry, combining figures for April and May 2020 with comparable figures for April/May 2019. We report these figures in Tables 1.4 and 1.5.

The first set of figures in Table 1.4 presents job loss *within* each industry, both for Maine and the U.S. overall. The second set of figures in Table 1.5 shows the contributions, industry-by-industry, to Maine's *overall* decline in employment relative to 2019. In the second set of figures, we incorporate the size of each industry in terms of employment prior to the crisis. This allows us to measure the relative contribution of each industry to overall job losses based on both 1) the size of the industry; and 2) the industry's job loss rate. Here again, we compare the figures for Maine with those for the U.S. overall.[8]

As we see first, in Table 1.4, the employment level declines for all 11 economic sectors listed. Maine's economic crisis is clearly widespread. At the same time, the extent of decline varies greatly by industry. The most heavily impacted industry is leisure and hospitality. This encompasses the state's major tourism industry. Here the employment decline was nearly 55 percent between April/May 2020 relative to the 2019 level. Six other industries experienced employment declines of 10 percent or greater. This includes, critically, education and health services, where the decline was nearly 14 percent. The industry-by-industry pattern for the U.S. is also basically consistent with that for Maine. Again, for the U.S. overall, the most severely hit industry is leisure and hospitality, with a 44 percent decline. All 11 industries listed, again, experienced employment losses relative to 2019.

TABLE 1.4
Job Losses within Industries, Maine and U.S. Percentages
Figures are based on employment figures, not seasonally adjusted, from April/May 2019 to April/May 2020

Maine: *Decline in state employment = 14.9%*		**United States:** *Decline in national employment = 12.5%*	
Leisure and hospitality	-54.7%	Leisure and hospitality	-44.3%
Information	-21.7%	Other services	-19.9%
Other services	-14.9%	Mining and logging	-13.5%
Education and health services	-13.6%	Trade, transportation, and utilities	-10.7%
Trade, transportation, and utilities	-11.2%	Manufacturing	-9.7%
Manufacturing	-10.9%	Professional and business services	-9.0%
Professional and business services	-10.5%	Construction	-8.9%
Mining and logging	-8.6%	Information	-8.7%
Government	-6.9%	Education and health services	-8.4%
Construction	-3.6%	Government	-4.8%
Financial Activities	-2.0%	Financial Activities	-1.7%

Sources: U.S. Labor Department.

TABLE 1.5
Share of Total Job Losses by Industry, Maine and U.S. Percentages
Figures are based on employment figures, not seasonally adjusted, from April/May 2019 to April/May 2020

Maine: *Decline in state employment = 14.9%*			**United States:** *Decline in national employment = 12.5%*		
	% of state employment	Industry job loss as % of total state employment loss		% of U.S. employment	Industry job loss as % of total U.S. employment loss
Leisure and hospitality	10.5%	-5.7%	Leisure and hospitality	11.0%	-4.9%
Education and health services	20.5%	-2.8%	Trade, transportation, and utilities	18.2%	-2.0%
Trade, transportation, and utilities	18.5%	-2.1%	Education and health services	16.0%	-1.3%
Professional and business services	11.0%	-1.2%	Professional and business services	14.1%	-1.3%
Government	16.4%	-1.1%	Other services	3.9%	-0.8%
Manufacturing	8.4%	-0.9%	Manufacturing	8.5%	-0.8%
Other services	3.5%	-0.5%	Government	15.2%	-0.7%
Information	1.1%	-0.2%	Construction	4.9%	-0.4%
Construction	4.7%	-0.2%	Information	1.9%	-0.2%
Financial activities	5.2%	-0.1%	Financial activities	5.8%	-0.1%
Mining and logging	0.3%	0.0%	Mining and logging	0.5%	-0.1%

Sources: U.S. Labor Department.

In Table 1.5, we see that, after taking account of the relative size of each of the industries in Maine's economy, there are three industries in Maine which, in combination, are responsible for over 70 percent of the state's overall 14.9 percent employment loss in April/May 2020 relative to 2019. These are Leisure and Hospitality, which alone is responsible for 5.7 percent of the 14.9 percent statewide employment decline; Education and Health Services, which accounts for 2.8 percent of the 14.9 percent decline; and Trade, Transportation and Utilities, which accounts for 2.1 percent of the overall decline. The industry-by-industry figures for the U.S. overall are comparable, again for the three industries experiencing the most impactful employment declines—i.e. Leisure/hospitality; Trade/Transportation/Utilities; and Education/Health Services.

Clearly, the state's tourism industry will not return to its 2019 level of activity until the public health issues around COVID-19 have been successfully brought under control. This implies that, in the interim, the state's public sectors will need to promote economic activity and job creation through channels other than tourism alone. This is the most viable channel through which the state's economic recovery can proceed at a rate closer to the Boston Fed's "low-unemployment scenario," if not still better than this scenario, as opposed to its disastrous "high-unemployment scenario." This underscores the priority of the state undertaking large-scale investments in clean energy and public infrastructure in conjunction with increasing its budgets in the areas of health care and public education.

1.3 Establishing Effective Public Health Interventions

Maine's economic crisis is a result of the COVID-19 pandemic. As such, any viable economic recovery program for the state must begin with measures that establish and sustain the highest possible standards for protecting public health.

Thus far, Maine has avoided the magnitude of outbreak seen in nearby epicenter states such as Massachusetts. In general, the state has instituted an effective testing regime and social-distancing precautions that have allowed it to keep both infections and public health costs relatively low. As we have seen, Maine's infections and deaths per million have outperformed other high-income countries, such as Canada.

Maine's health department has pointed to South Korea as its model, aiming to emulate its cumulative positive test-rate of 2 percent as a signal of robustness.[9] However, as noted above, Maine's COVID death rate remains about 16 times higher than that in South Korea. South Korea has been successful in containing COVID-19 through, first of all, maintaining significantly larger testing and tracing programs, and higher public health staffing levels. In turn, this has enabled the Korean public health systems to identify infected people much more effectively, through a combination of rigorous levels of testing, as well as quarantining those identified as infected and tracing the contacts of the infected.

Conditions for Safe Reopening

Maine began a targeted and phased reopening of its economy on May 1, enabling hair salons, barbers, doctors' offices and car dealerships to resume operations within an ongoing set of guidelines to protect public safety, in the areas of distancing and wearing masks. Most retail stores and restaurants were allowed limited re-openings between May 18th and June 1st, followed by outdoor bars on June 12th. A June 9th Executive Order mandated that all those travelling to Maine from other states, other than New Hampshire and Vermont, must either have a negative COVID-19 test or quarantine for 14-days upon arrival. Compliance and enforcement of travel restrictions has been uneven in Maine as well as the other New England states.[10] Beginning July 1, tourists to Maine will have to sign a certificate of compliance when they check into a hotel, motel or other lodging confirming that they have had a COVID-19 test within the previous 72-hours and that they tested negative.[11] Gatherings of over 50 people, the remainder of retail and personal services, and unrestricted tourism will come in later phases.[12]

Maine has indicated that its further reopening plans will proceed according to three metrics, as tracked by the state's CDC:

- a downward trajectory of influenza-like illnesses and COVID-like syndromic cases;
- a downward trajectory of documented cases and newly hospitalized patients; and
- the capacity of Maine's hospital systems to treat all patients without crisis care and the ability of the state to engage in a robust testing program.

These metrics are largely in line with the Reopening Guidelines set out by the White House program, directed by Dr. Deborah Birx. However, Maine proceeded with its reopening plans despite non-compliance with these metrics at the start and throughout the month of May.[13] The state's cases of infected people rose in the weeks after reopening commenced, exacerbated by an outbreak at a nursing home facility beginning on May 20th that resulted in Maine's peak of 78 new cases on that day. Between late May and June 21st, the 7-day average of people per day testing positive for COVID fell by half, from 50 to 25.[14] Maine has never exceeded 5 deaths on any single day. Even with its presently low level of infections, Maine's hospitals remain poorly equipped to manage an influx, with persistently low excess inpatient and intensive care capacity as it relaxes restrictions and opens to tourism from states with large ongoing epidemics.[15]

Despite its premature reopening and early noncompliance, Maine's Governor, Janet Mills, has generally resisted calls to speed or expand the state's reopening. But she has held out the option of suspending forward progress with reopening or even reinstituting restrictions.[16] In late May, Mills postponed the reopening of indoor dining at restaurants in three populous southern Maine counties, and similarly delayed indoor fitness activities statewide due to concerns over infection trends.[17]

At a minimum, Maine's health care and pandemic response system must be adequate to consistently meet the basic requirements of the Birx reopening guidelines. As of late June, the state is meeting or equipped to meet several of these, but lagging in others.

Documented COVID Cases

- Maine's documented COVID cases have been declining since May 20th.[18]

Newly Hospitalized Patients

- Maine continues to see low single-digit numbers of newly hospitalized COVID patients since having hit a peak of 11 new patients on May 31st.[19]

Hospitals

- Maine has limited excess capacity to accommodate a spike in cases, though, as yet, it has not experienced a surge that has jeopardized its capacity to treat COVID. As of late June, 33 percent of Maine's hospital beds were available, while 43 percent of its Critical Care beds remained open.[20]

Testing and Contact Tracing

- Testing in Maine has exceeded the target levels per population set under the Birx guidelines. Maine has also recently announced additional capacity is forthcoming.[21]
- Maine has begun scaling up its contact tracing operations from 30 to 175 individuals on staff, including 50 volunteers. However, when this scale-up is complete, Maine's total will still below the recommended number of 200-400 for Maine's population.[22]

Plans

- Protection of those living and working in high-risk facilities, including nursing homes and prisons.
- Monitor conditions and immediately take steps to limit and mitigate any rebounds or outbreaks by restarting a phase or returning to an earlier phase, depending on severity.

- Maine has communicated a willingness to slow reopening or reinstitute lockdowns conditions if necessary.[23]

In short, the first priority for Maine advancing a sustainable economic recovery program is to raise the state's public health standards to be in full compliance with its basic state and federal guidelines. Towards that end, the state needs to expand its hospital capacity, testing facilities, and contact tracing operations. The state therefore needs to commit significant financial resources to addressing all of the areas in which it is presently deficient. We return to these issues in Section 3 below, focused on budgetary matters.

Expanding Medicare Coverage

The sharp increase in job losses in Maine, as with the U.S. overall, has meant that millions of unemployed workers have lost the health care coverage they had been receiving through their employer. These workers need to be guaranteed health insurance coverage at least over the full course of the pandemic.

U.S. Representatives Pramila Jayapal and Joe Kennedy recently proposed the Medicare Crisis Program, as a measure that would be critical in providing support to families over the course of the pandemic and severe economic downturn.[24] Senator Bernie Sanders introduced a similar measure in the U.S. Senate, the Health Care Emergency Guarantee Act.[25]

The Medicare Crisis program would enable anyone who has filed for unemployment insurance due to the COVID-19 crisis to receive traditional Medicare support for themselves and their families. This will include any testing or treatments related to COVID-19 itself. In addition, under Medicare Crisis, the federal government also absorbs all cost-sharing for unemployed workers and their families, including deductibles, co-payments and any additional out-of-pocket expenses. These costs are normally paid by Medicare enrollees themselves.

Further, under the Medicare Crisis program, all ongoing Medicare enrollees—whether or not they have become unemployed due to the pandemic and economic downturn—will receive additional health insurance benefits. This will include COVID-19 testing and treatment at no costs, as well as a cap on cost sharing for all other treatments at 5 percent of income.

To date, neither this Jayapal-Kennedy proposal in the House of Representatives, or the equivalent Sanders bill in the Senate, have been included in any version of the HEROES Act or any other overall federal stimulus proposals. Nevertheless, this proposal needs to be integral to any recovery project, for Maine and the U.S. more generally. The reasons include the following:

1. It provides critical income support for workers and their families, especially workers who are already unemployed.
2. It will provide an overall boost to the economic recovery. Otherwise, families of unemployed workers are likely to face major new financial burdens due to their loss of health insurance.
3. Without guaranteed health coverage, people will be reluctant to get tested and treated for COVID. This will therefore prolong the ongoing spread of the virus. As such, it will also inhibit the prospects for a sustainable recovery.

Because this kind of initiative is so critical to a successful reopening and economic recovery, it is a measure that Maine should enact on its own at the state level if it is not incorporated in any upcoming rounds of federal stimulus legislation. To date, Maine's Department of Health and Human Services has ruled that MaineCare covers testing.[26] This is, of course, a welcome step in the right direction, but nowhere close to the level of expanded health care provision needed during these crisis circumstances. In Section 3, we provide a rough cost estimate of a full-scale statewide proposal in line with the Jayapal-Kennedy program.

Workers' Rights Protections

The public health provisions described in this section must be matched by a corresponding level of rights and protections extended to all workers in Maine during the pandemic and economic crisis. As a minimum, all workers in the state must have the right to guaranteed paid sick leave. Such an initiative should be understood as a measure that protects the health and well-being of the workers themselves but equally, the health and well-being of the overall community. Of course, when workers who feel compelled to come to a public workplace even if they are experiencing COVID-like symptoms, they are endangering the health of the entire community.

In 2019, Maine became the first state to pass statewide guaranteed paid-time-off legislation.[27] When implemented, the law will allow employees who work for businesses with more than 10 employees to accrue paid time off, covering approximately 85 percent of Maine's workforce. However, the law does not go into effect until January 2021. Governor Mills has maintained that the implementation date will not be moved up in response to the pandemic.[28] This form of protection should be implemented immediately and extended to workers at all business firms, regardless of size.

Some large employers have offered additional protections and benefits to employees.[29] The federal Families First Coronavirus Response Act, enacted on April 1st, requires some employers in Maine to provide their employees with paid sick leave and expanded medical leave for reasons related to COVID-19. The new federal requirements apply to employers with fewer than 500 employees and almost all public employers, and allows for these businesses to be reimbursed for expenses they incur to provide required paid leave through a payroll tax credit. Employees may be eligible for up to two weeks of emergency paid sick leave at full pay and in some cases up to an additional ten weeks of emergency paid family medical leave at partial pay.[30] Of course, all such worker protection measures need to be scrupulously enforced.

In short, a viable recovery program for Maine must include an enhanced commitment to protecting workers' rights at all levels of the state economy, starting with the most vulnerable workers, such as those in Maine's crucial small-business hospitality and service workers.

PART 2:

CLEAN ENERGY INVESTMENTS, PUBLIC INFRASTRUCTURE INVESTMENTS, AND JOBS

2.1 Clean Energy Investments and Climate Stabilization

Maine's Existing Clean Energy Policies

Even under current pandemic conditions, we cannot forget that we have truly limited time to take decisive action around climate change. The Intergovernmental Panel on Climate Change (IPCC) concluded in October 2018 that the world must reduce carbon dioxide emissions by 45 percent as of 2030—10 years from now—and reach net zero emissions by 2050, in order to retain a reasonable chance of moving onto a viable global climate stabilization path.[31] This means that, within the next 30 years, we must totally supplant our current fossil-fuel dominant energy system with one based on the combination of high efficiency and clean renewable energy sources, especially solar and wind power that gets converted into electricity. We also need to take maximum advantage of the natural sources of CO_2 absorption and storage—i.e. "carbon sinks." For the State of Maine specifically, this means protecting its existing abundant forest lands.

For nearly two decades, the State of Maine has supported a series of policy initiatives as well as an overall framework for bringing down CO_2 emissions and advancing climate stabilization in the state. Thus, in 2003, the Maine legislature charged the state's Department of Environmental Protection with developing a statewide emissions reduction plan. This led to the development of the Maine Climate Action Plan in 2004. This plan established an initial target of reducing emissions to 10 percent below 1990 levels as of 2020. The state did achieve this initial goal. The 2004 plan also proposed to reduce emissions over a longer (unspecified) period by 80 percent relative to the 2003 level.

In June 2019, the state adopted a new set of climate policies, with more ambitious emissions reduction goals as well as a series of policy measures designed to accomplish these goals. The main features of the 2019 plan include the following:

Emissions Reduction

- Reduce all greenhouse gas emissions by 45 percent from 1990 levels by 2030.
- Reduce emissions by 80 percent as of 2050.

Regulations to Promote Emissions Reductions

- *Renewable Portfolio Standards.* As of 2030, 80 percent of electricity sales in the state from renewables, and 100 percent electricity generation from renewables as of 2045.
- *Energy Efficiency Standards.* The Efficiency Maine program sets mandatory efficiency targets for the state, most recently a 2.4 percent savings level for electricity between 2020 – 2022.
- *Vehicle Efficiency Standards.* Maine adopted California's Zero-Emission Vehicle (ZEV) program, which requires increasing market share of plug-in hybrid, battery electric, and fuel-cell vehicles from 2018 to 2025, along with a 100 percent zero emissions new car fleet by 2045.

- *Carbon Pricing.* Maine is a participant in the Regional Greenhouse Gas Initiative (RGGI), a regional cap-and-trade program, requiring fossil fuel-fired power plants with a capacity of 25 MW or higher to comply with a regional emissions cap.

Maine has also enacted a broad range of financial incentive and subsidy programs to support clean energy investments. These include:

- ***Net Metering*** in setting electricity prices;
- ***A Public Benefit Fund*** that distributes revenue generated through the carbon pricing program; and
- ***Revenue Decoupling*** for electric utilities, whereby electricity prices are relative to utilities' costs, after allowing for consumption levels to fall through raising efficiency standards.

Current Proposals for Advancing Maine's Energy Transition

We provide fuller details on Maine's existing clean energy policy framework in Appendix 1. Appendix 1 also summarizes two recent valuable studies focused on how Maine can reach the goal of becoming a zero-emissions economy. These two studies are the January 2019 report by the Vermont Energy Investment Corporation, *Advancing Clean Energy Investment in Northern New England* and the November 2019 work by Richard Silkman, *A New Energy Policy Direction for Maine: A Pathway to a Zero-Carbon Economy by 2050*. Later in this section, we consider the critical question of how this existing policy framework can be strengthened to incentivize private clean energy investments in Maine. The aim will be to establish private investments as the primary source of overall funding that will underwrite clean energy investments in Maine at the scale necessary to reach the state's emission reduction targets.

In addition to these detailed studies by the Vermont Energy Investment Corporation and Richard Stillman, two additional reports have been published recently that also give serious attention to the project of achieving a clean energy transformation in Maine. These are the Maine Climate Council—Energy Working Group's report of 6/8/20 and Renew New England's *Regional Policy Framework*, also issued in June 2020. Both of these reports set out broad parameters for achieving dramatic CO_2 reductions in Maine, along with describing how such an emissions reduction project can concurrently serve to expand economic opportunities and greater social equality in the state.[32]

The recommendations of the Maine Climate Council's Energy Working Group focus on include the following[33]:

1. Ensure adequate affordable clean energy supply to meet Maine's 100 percent Renewable Portfolio Standard goal and any increased load through the development of centralized generating resources, distributed energy resources and other measures.
2. Initiate a Power Sector Transformation Stakeholder Process managed by the Governor's Energy Office (GEO) in coordination with the Maine Public Utilities Commission (MPUC) to examine and provide recommendations regarding transformation and plan-

ning of Maine's electric sector to address and facilitate the recommendations of the Maine Climate Council (MCC) and achieve Maine's greenhouse gas reduction requirements.

3. Encourage the utilization of MPUC's long-term contracting authority to include highly efficient combined heat and power (CHP) production facilities.
4. Institute a Renewable Fuel Standard for all heating fuels, with incentives sufficient to drive rapid reductions in emissions from heating and process fuels (i.e. for industrial processes) used in Maine.
5. Develop and implement new financing options necessary to meet Maine's clean energy and emissions reduction targets.

Renew New England's *Regional Policy Framework* sets out a more broadly focused set of goals, organized around a commitment of a Jobs Guarantee throughout New England—i.e. that everyone in the region who wants a job will have one. The report describes how New England will:

> Implement the Jobs Guarantee by supporting local, small businesses and creating new public employment initiatives designed to modernize our region's infrastructure and ensure that everyone's basic needs are met in the areas of 1) housing, 2) healthcare, 3) food, 4) energy, 5) transportation, and 6) clean air and water (p. 1).

The Policy Framework discusses each of these target areas with more detailed descriptions. Some of the most pertinent proposals relative to the clean energy program we develop in this study are in the areas of energy, transportation, and housing. These include:

Energy (pp. 5–6):

- Install solar panels, wind turbines and energy storage devices in order to ensure 100 percent zero-carbon electricity consumption for the entire region by 2030.
- Phase out fossil fuel infrastructure.
- Rapidly increase the proportion of zero-carbon electricity that utilities must supply.
- Expand energy efficiency standards to ensure that all buildings use entirely zero-carbon energy by 2040.

Transportation (p. 6):

- Build a large-scale public-transit system and install electric vehicle charging stations to achieve regionwide zero-carbon transportation by 2040.
- Improve active transportation facilities around mass transit hubs.
- Support electric vehicle purchases.

Housing (p. 2):

- Build new, carbon-neutral, climate-resilient affordable housing units, and repair existing units and install green retrofits.

The *Regional Policy Framework*'s proposals in the area of expanding access to good-quality health care and supporting sustainable farming practices also are closely aligned with policy measures discussed here.

Both of these reports also discuss approaches to financing the proposals they are advocating. In both cases, the financing proposals discussed are similar in their outlines to the specific measures we set out in Part 3 of this study, "Financing a Fair and Sustainable Recovery Program for Maine."

Economic Framework for Building Maine's Net Zero Emissions Economy

Before proceeding with this policy and financing-focused discussion we first examine the following:

1. Maine's existing energy system and sources of CO_2 emissions;
2. A pathway through which Maine can achieve its emissions reduction target within a framework of economic growth;
3. The prospects for expanding job opportunities through clean energy investments in Maine; and
4. Establishing robust Just Transition policies for workers in the state's existing fossil fuel-based and biomass electricity sectors. Workers in these sectors will face job losses due to the state's clean energy transition.

2.2 Energy Sources and CO_2 Emissions for Maine

In this section, we review the sources of energy supply and demand in Maine, as well as the factors generating CO_2 emissions in the state. This discussion will provide necessary background for advancing a viable framework for reaching the state's emission reduction goals for 2030 and 2050.

Table 2.1 shows Maine's energy consumption profile both in terms of sources and uses of energy. In this table and throughout the study, we measure all energy sources uniformly in terms of British Thermal Units (BTUs). A BTU represents the amount of thermal energy necessary to raise the temperature of one pound of pure liquid water by one degree Fahrenheit from the temperature at which water has its greatest density (39 degrees Fahrenheit). Burning a wood match to its end generates about 1 BTU of energy. We will present figures on energy production and consumption, as appropriate, in terms of both trillion and quadrillion BTUs, referring to the acronyms T-BTUs and Q-BTUs respectively.

As one measure of how much energy is provided by 1 Q-BTU of energy, as we see in Table 2.1, total energy consumption in Maine in 2017 was 392 trillion BTUs, or approximately

TABLE 2.1
Maine State Energy Consumption by Sector and Energy Source, 2017
Figures are T-BTUs

	Buildings						
	Residential	Commercial	All buildings	Industrial	Transportation	TOTAL	% of TOTAL
1. Total	**99.3**	**65.6**	**164.9**	**103.7**	**123.2**	**391.8**	**100.0%**
2. % of TOTAL	**25.3%**	**16.7%**	**42.1%**	**26.5%**	**31.4%**	**100.0%**	**---**
3. Petroleum[1]	40.0	17.5	57.6	10.1	115.9	183.6	46.9%
4. Biomass	28.7	15.6	44.3	55.8	6.6	106.7	27.2%
5. Natural gas[2]	8.6	14.1	22.7	21.6	0.7	45.0	11.5%
6. Hydro	11.5	9.7	21.2	10.0	0.0	31.2	8.0%
7. Wind	8.9	7.5	16.4	5.1	0.0	21.5	5.5%
8. Coal	0.7	0.6	1.3	0.9	0.0	2.2	0.6%
9. Solar	0.4	0.1	0.6	0.0	0.0	0.6	0.2%
10. Geothermal	0.1	0.0	0.1	0.0	0.0	0.1	0.0%
11. Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
12. Net interstate flow of electricity[3]	--	--	--	--	--	-14.2	-3.6
13. Net electricity imports from Canada	--	--	--	--	--	15.0	3.8

Notes:
1. Petroleum includes motor gasoline (excluding biodiesel and ethanol), distillate fuel oil, jet fuel, HGL, residual fuel and other petroleum.
2. Includes supplemental gaseous fuels that are commingled with natural gas.
3. The difference between the sum of electricity sales and losses within a state and the total amount of electricity generated within that state.
Source: U.S. Energy Information Agency (U.S. EIA) (https://www.eia.gov/state/?sid=ME).

0.4 Q-BTUs. This means that, roughly, 1 Q-BTU would be able to provide for Maine, at its 2017 consumption level, all the energy consumed for all purposes over 2 ¼ years.

Moving into the specifics of Table 2.1, we see in rows 1 and 2 how total energy consumption is divided between the sectors of Maine's economy. As we see, about 42 percent of all consumption is used to operate buildings (164.9 T-BTUs), both residential and commercial structures. Of the remaining 58 percent, 31 percent is used in transportation (123.2 T-BTUs) and the remaining 26 percent for industrial activity (103.7 T-BTUs). About 4 percent of all energy consumed in Maine is imported from Canada as electricity.

In rows 3 – 12 of Table 2.1, we see how the state's energy supply is broken down by energy source. These figures include energy consumed as electricity, with electricity use distributed within each sector and source. The figures for electricity consumption include energy losses resulting from generating electricity, as we discuss further below.

As we see in row 3, petroleum is, by far, the most heavily utilized energy source in Maine, providing about 47 percent of the state's energy supply. About 63 percent of petroleum is used for transportation in Maine, with another 31 percent for buildings. Biomass is the next largest energy source in Maine, supplying nearly 27 percent of total supply. In fact, Maine relies on biomass to a much greater extent than any other U.S. state.[34] Biomass is used mostly to provide electricity for buildings. Relative to the U.S. overall, natural gas is a relatively modest contributor to Maine's total energy supply at 11.5 percent. The contribution of coal is negligible and nuclear energy does not supply any energy in Maine.

Two clean energy sources, hydro and wind, are providing significant shares to Maine's total energy supply as of 2017, with hydro at 8.0 percent and wind at 5.5 percent. The situation with wind is especially significant. As recently as 2006, wind energy's contribution to Maine's overall energy supply was zero. As of 2010, wind energy still contributed only 1.2 percent to Maine's overall energy supply. But between 2010 and 2017 wind energy consumed in Maine increased more than four-fold. Solar and geothermal are presently negligible energy sources in Maine.

It is clear that expanding overall energy supply in the state from clean renewable sources will be a formidable challenge. Significant initial progress has already been achieved with respect to wind energy, as we have seen. This progress with expanding wind energy supply should therefore serve as a framework for also dramatically advancing clean renewable sources across-the-board in Maine.

Electricity Supply and Demand

To further clarify the profile of energy consumption in Maine, we show data in Tables 2.2 and 2.3 on the uses and sources of electricity in the state.

Electricity, of course, is unique in that it is an intermediate energy source, relying on several primary sources—including hydro, biomass, and wind as its primary sources in Maine—for its generation. It is also unique in that, as Table 2.2 shows, approximately two-thirds of all energy consumed is lost in the conversion process from the primary energy sources to electricity supply, while only one-third is channeled into energy that is consumed. That is why, as we see in Table 2.2, electricity production requires 110.3 T-BTUs of Maine's total energy consumption, amounting to 28 percent of all energy consumed in the state, while, as an energy source to final consumers in the state's building, transportation and industrial sectors, electricity provides only about 38 T-BTUs, or 10 percent of the total energy supplied.

TABLE 2.2
Maine Total Electricity Consumption and Energy Losses in Electricity Generation, 2017

Total energy consumed in generating electricity	110.3 T-BTUs (28.1% of state energy consumption)
Electricity consumption as share of overall energy consumption	38.3 T-BTUs (9.8% of state energy consumption)
Energy losses as share of energy consumed in generating electricity	65.3%

Source: U.S. EIA State Energy Data System.

TABLE 2.3
Maine Electricity Consumption, 2017
Figures are T-BTUs

	Buildings					
	Residential	Commercial	All buildings	Industrial	Transportation	TOTAL
Hydro	4.8	4.0	8.8	2.7	0.0	11.5 *30.1% of total*
Bioenergy	3.8	3.2	7.0	2.2	0.0	9.2 *24% of total*
Wind	3.3	2.8	6.0	1.9	0.0	7.9 *20.7% of total*
Natural gas	3.1	2.7	5.8	1.8	0.0	7.6 *19.9% of total*
Petroleum	0.2	0.2	0.3	0.1	0.0	0.5 *1.18% of total*
Coal	0.1	0.1	0.2	0.1	0.0	0.2 *0.6% of total*
Solar	0.0	0.0	0.0	0.0	0.0	0.0 *0% of total*
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0 *0% of total*
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0 *0% of total*
Total	15.8	13.4	29.2	9.1	0	38.3
Share of total (in %)	41%	35%	76%	24%	0%	100%

Notes: Bioenergy (Wood + Other biomass). Not shown in table: other gas and others (3.4% of the total electricity consumption).
Source: U.S. EIA State Energy Data System.

One evident way to raise energy efficiency, in Maine and elsewhere, would therefore entail reducing the percentage of energy losses through electricity use.[35]

In terms of electricity demand, we see in Table 2.3 that the most prevalent use is for the operation of buildings, accounting for about 76 percent of all electricity demand. Industrial processes utilize the remaining 24 percent of all electricity. At present, electricity is not used to a measurable extent in transportation. But the share of electricity demand for transportation would rise sharply if the use of electricity-powered vehicles were to grow significantly.

Table 2.3 also shows the primary energy sources used in Maine to generate electricity. As we see, the dominant sources are all renewables—hydro at 30 percent, bioenergy at 24 percent and wind at 21 percent. However, as we will discuss below, biomass is not a clean energy source, but rather produces emissions within a 30-year timeframe at a level equal to or greater than coal. Hydro is a clean energy source, but its capacity to expand as an energy source is probably limited in Maine, and elsewhere, due to environmental impacts. It therefore follows, again, that the primary source of expanded energy supply for Maine, assuming the state aims to achieve its stated emissions reduction goals, will have to be wind and solar power, operating within a high energy efficiency economy.

2.3 What Is Clean Energy?

Bioenergy

As we saw in Table 2.1, biomass is the second largest source of energy in Maine, supplying more than 25 percent of Maine's total energy supply, mostly for the purpose of generating electricity. As such, it is critical to recognize that for a given amount of energy supplied, the emissions that result through burning wood are significantly greater than those produced by burning coal, and are far in excess of those produced through either oil or natural gas combustion. Despite this, in the official methodology for measuring CO_2 emissions used in the U.S. (and elsewhere), biomass is treated as a carbon-neutral energy source. This approach is based on the fact that when new crops of trees are planted and grown, they absorb CO_2 by the same amount as the CO_2 that is emitted when trees are burned.

However, this approach to accounting for biomass emissions has been widely refuted in the recent research literature.[36] The main consideration here is that trees require decades to regrow and thereby to absorb CO_2. By contrast, emissions generated by burning wood enter into the atmosphere immediately on combustion. Allowing that we are operating within the emissions-reduction timeframe set out by the IPCC, this means that we have only 10 years to reduce CO_2 emissions by 45 percent and 30 years to reach net zero emissions. As such, the decades-long process through which newly planted trees absorb CO_2 will not deliver carbon neutrality within a 30-year time frame, much less a 45 percent emissions reduction within 10 years.

This point was emphasized in a May 2020 letter to the Members of Congress by 200 leading environmental scientists. The letter states that:

> The scientific evidence does not support the burning of wood in place of fossil fuels as a climate solution. Current science finds that burning trees for energy produces even more CO_2 than burning coal, for equal electricity produced…and the considerable accumulated carbon debt from the delay in growing a replacement forest is not made up by planting trees or woods substitution.[37]

It is therefore critical for our discussion that we incorporate emissions from burning wood into our estimate of overall CO_2 emissions in Maine, especially given that biomass contributes such a high share of overall energy supply in Maine. In fact, emissions from biomass vary widely, depending on the specific qualities of the wood pellets being consumed, including the moisture content of the wood. As an average figure per unit of energy generated, biomass emissions are roughly about 50 percent greater than those from burning coal.[38] Nevertheless, to work with a conservative figure, we will assume that emissions from biomass combustion are approximately equal to those from burning coal.

More generally, a critical feature of a viable climate emissions program for Maine must include the phasing out of wood-burning as an energy source, along with oil, coal, and natural gas.

Natural Gas

There are large differences in the emissions levels resulting through burning oil, coal, and natural gas respectively, with natural gas generating about 40 percent fewer emissions for a given amount of energy produced than coal and 15 percent less than oil. It is therefore widely argued that natural gas can be a "bridge fuel" to a clean energy future.[39] Such claims do not withstand scrutiny. To begin with, emissions from burning natural gas are still substantial, even if they are lower than coal and petroleum. As a straightforward matter, it is not possible to get to a net zero economy through increasing reliance on CO_2-emitting natural gas energy. But it is also imperative, in calculating the full emissions impact of natural gas, that we take account of the leakage of methane gas into the atmosphere that results through extracting natural gas through fracking. Recent research finds that when more than about 5 percent of the gas extracted leaks into the atmosphere through fracking, the impact eliminates any environmental benefit from burning natural gas relative to coal. Various studies have reported a wide range of estimates as to what leakage rates have actually been in the United States, as fracking operations have grown rapidly. A recent survey paper puts that range as between 0.18 and 11.7 percent for different specific sites in North Dakota, Utah, Colorado, Louisiana, Texas, Arkansas, and Pennsylvania.

It would be reasonable to assume that if fracking expands on a large scale in the U.S., or elsewhere, it is likely that leakage rates will fall closer to the higher-end figures of 12 percent, at least until serious controls could be established. This then would greatly diminish, if not eliminate altogether, any emission-reduction benefits from a coal-to-natural gas fuel switch.[40]

Nuclear Energy

Nuclear energy is not part of the energy mix in Maine. An argument for considering it as a possible future source is that nuclear power provides the important benefit that it does not generate CO_2 emissions or air pollution of any kind while operating. At the same time, the processes for mining and refining uranium ore, making reactor fuel, and building nuclear power plants all require large amounts of energy.

But even if we put aside the emissions that result from building and operating nuclear power plants, we still need to recognize the longstanding environment and public safety issues associated with nuclear energy. These include:

- ***Radioactive wastes.*** These wastes include uranium mill tailings, spent reactor fuel, and other wastes, which according to the U.S. Energy Information Agency (EIA) "can remain radioactive and dangerous to human health for thousands of years" (EIA 2012, p. 1).
- ***Storage of spent reactor fuel and power plant decommissioning.*** Spent reactor fuel assemblies are highly radioactive and must be stored in specially designed pools or specially designed storage containers. When a nuclear power plant stops operating, the decommissioning process involves safely removing the plant from service and reducing radioactivity to a level that permits other uses of the property.
- ***Political security.*** Nuclear energy can obviously be used to produce deadly weapons as well as electricity. Thus, the proliferation of nuclear energy production capacity creates

dangers of this capacity being acquired by organizations - governments or otherwise - which would use that energy as instruments of war or terror.

- ***Nuclear reactor meltdowns.*** An uncontrolled nuclear reaction at a nuclear plant can result in widespread contamination of air and water with radioactivity for hundreds of miles around a reactor.

Even while recognizing these problems with nuclear energy, it is still the case that nuclear power presently supplies over five percent of global energy supply. For decades, the prevalent view throughout the world was that these risks associated with nuclear power were relatively small and manageable, when balanced against its benefits. However, this view was upended in the aftermath of the March 2011 nuclear meltdown at the Fukushima Daiichi power plant in Japan, which resulted from the massive 9.0 Tohuku earthquake and tsunami. The full effects of the Fukushima meltdown cannot possibly be known for some time.[41] Still, these safety considerations with nuclear energy must be accorded significant weight. This is especially the case, given the high probability that the necessary tight standards for regulating nuclear power plants will become compromised if the number of such plants were to expand significantly on a global scale. As such, the most appropriate course for Maine is to build its clean energy foundation through safer energy sources.

Geoengineering

This includes a broad category of measures whose purpose is either to remove existing CO_2 or to inject cooling forces into the atmosphere to counteract the warming effects of CO_2 and other greenhouse gases. One broad category of removal technologies is carbon capture and sequestration (CCS). A category of cooling technologies is stratospheric aerosol injections (SAI).

CCS technologies aim to capture emitted carbon and transport it, usually through pipelines, to subsurface geological formations, where it would be stored permanently. One straightforward and natural variation on CCS is afforestation. This involves increasing forest cover or density in previously non-forested or deforested areas, with "reforestation"—the more commonly used term—as one component.

The general class of CCS technologies have not been proven at a commercial scale, despite decades of efforts to accomplish this. A major problem with most CCS technologies is the prospect for carbon leakages that would result under flawed transportation and storage systems. These dangers will only increase to the extent that CCS technologies are commercialized and operating under an incentive structure in which maintaining safety standards will reduce profits.

By contrast, afforestation is, of course, a natural and proven carbon removal technology. Maine's situation on this matter is unique in the United States, in that about 89 percent of the total land area of Maine consists of forests, the most of any U.S. state. A study by the Forest Climate Change Initiative at the University of Maine estimates that annual forest growth in Maine absorbs about 10 million tons of CO_2.[42] This is equal to about 40 percent of the 24.9 million total CO_2 emissions generated in the state as of 2017. Thus, forest growth in Maine provides a major offset to the emissions generated through combusting fossil fuels and biomass to produce energy. Because Maine's forest growth provides a major source of carbon absorption—offsetting the state's annual emissions—Maine can reach a net zero CO_2 emissions threshold by 2050 even while energy consumers in the state continue to rely on fossil fuels to a modest extent. We return to this point in Section 2.10, which focuses on the path for Maine to become a net zero emissions economy.

At the same time, because forests already consume nearly 90 percent of the state's total land area, it is not realistic to expect Maine's forested areas to expand significantly, enabling the state's forests to become an even larger source of CO_2 offsets. Still, it will be necessary to prevent encroachments on the state's existing forested areas and to preserve these forests in their existing natural states. To support these aims, as we discuss below, we suggest a budget starting at around $40 million in 2022 and rising thereafter, in support of such preservation efforts. We incorporate these investments in forest preservation within the framework of renewable energy investments.

The idea of stratospheric aerosol injections builds from the results that followed from the volcanic eruption of Mount Pinatobo in the Phillipines in 1991. The eruption led to a massive injection of ash and gas, which produced sulfate particles, or aerosols, which then rose into the stratosphere. The impact was to cool the earth's average temperature by about 0.6^0C for 15 months.[43] The technologies being researched now aim to artificially replicate the impact of the Mount Pinatubo eruption through deliberately injecting sulfate particles into the stratosphere. Some researchers contend that to do so would be a cost-effective method of counteracting the warming effects of greenhouse gases.

Lawrence et al. (2018) published an extensive review on the range of climate geoengineering technologies, including 201 literature references. Their overall conclusion from this review is that none of these technologies are presently at a point at which they can make a significant difference in reversing global warming. They conclude:

> Proposed climate geoengineering techniques cannot be relied on to be able to make significant contributions…towards counteracting climate change in the context of the Paris Agreement. Even if climate geoengineering techniques were actively pursued, and eventually worked as envisioned on global scales, they would very unlikely be implementable prior to the second half of the century….This would very likely be too late to sufficiently counteract the warming due to increasing levels of CO_2 and other climate forces to stay within the 1.5^0C temperature limit—and probably even the 2^0C limit—especially if mitigation efforts after 2030 do not substantially exceed the planned efforts of the next decade, (pp. 13-14).

Energy Efficiency and Clean Renewable Energy

Given these major problems with biomass, natural gas, nuclear energy and geoengineering, it follows, in advancing a program to cut emissions by 50 percent as of 2030 and to net zero emissions by 2050, that Maine should focus instead on the most cautious clean energy transition program, i.e. investing in technologies that are well understood, already operating at large-scale, and, without question, safe. In short, we focus here on investments that can dramatically raise energy efficiency standards and equally dramatically expand the supply of clean renewable energy sources.

2.4 Prospects for Energy Efficiency

Energy efficiency entails using less energy to achieve the same, or even higher, levels of energy services from the adoption of improved technologies and practices. Examples include insulating buildings much more effectively to stabilize indoor temperatures; driving more fuel-efficient cars or expanding well-functioning public transportation systems; and reducing the amount of energy that is wasted both through generating and transmitting electricity and through operating industrial machinery.

Expanding energy efficiency investments supports rising living standards because raising energy efficiency standards, by definition, saves money for energy consumers. A major 2010 study by the National Academy of Sciences (NAS) found, for the U.S. economy, that "energy efficient technologies…exist today, or are expected to be developed in the normal course of business, that could potentially save 30 percent of the energy used in the U.S. economy while also saving money." Similarly, a 2010 McKinsey and Company study focused on developing countries found that, using existing technologies only, energy efficiency investments could generate savings in energy costs in the range of 10 percent of total GDP, for all low- and middle-income countries.

In her 2015 book, *Energy Revolution*: *The Physics and Promise of Efficient Technology*, the Harvard University physicist Mara Prentiss argues, further, that such estimates understate the realistic savings potential of energy efficiency investments. This is because, in generating energy by burning fossil fuels, about two-thirds of the total energy available is wasted while only one-third is available for powering machines. By switching to renewable energy sources, the share of wasted energy falls by 50 percent. This is what Prentiss terms the "burning bonus."

After taking account of the burning bonus as well as the efficiency gains available in the operations of buildings, transportation systems and industrial equipment, Prentiss concludes, with respect to the U.S. economy specifically, that economic growth could proceed at a normal rate while total energy consumption could remain constant or even decline in absolute terms. Prentiss's conclusions regarding the U.S. economy are consistent with the most recent projections for U.S. energy demand—as well as global energy demand—by the International Energy Agency (IEA 2019). The IEA assumes that the U.S. economy will grow at a 2.0 percent average annual rate between 2018 – 2040. Nevertheless, under its "Current Policies Scenario," which reflects existing policy commitments within the U.S. but nothing beyond these, the IEA assumes that U.S. energy consumption will decline by an average of -0.2 percent per year. But under its more ambitious "Sustainable Development Scenario," the IEA estimates that U.S. energy demand will fall by -1.3 percent per year, even while economic growth still proceeds at a 2.0 percent average rate.[44]

Estimating Costs of Efficiency Gains

How much will it cost to achieve major gains in energy efficiency, in general and with respect to Maine specifically? In fact, estimates as to the investment costs of achieving energy efficiency gains vary widely. For example, the 2010 study by the National Academy of Sciences estimated average costs for building, transportation and industrial efficiency improvements in the United States at $29 billion per Q-BTU of energy savings. More recent studies, focused on the U.S. building sector alone, report similar cost estimates.[45] However, a 2008 World Bank study by Taylor et al. puts average costs at $1.9 billion per Q-BTU of energy savings, based on a study of 455 projects in both industrial and developing economies, a figure that is only 7 percent of the National Academy of Sciences estimate. A 2010 study by the McKinsey consulting firm estimates costs for a wide range of non-OECD economies at $11 billion per Q-BTU of energy savings.

It is not surprising that average costs to raise energy efficiency standards should be significantly higher in industrialized economies. A high proportion of overall energy efficiency investments are labor costs, especially projects to retrofit buildings and industrial equipment. However, these wide differences in cost estimates between the various studies do not simply result from variations in labor and other input costs by regions and levels of development. Thus, the World Bank estimate of $1.9 billion per Q-BTU includes efficiency investment projects in both industrialized and developing countries.

These alternative studies do not provide sufficiently detailed methodological discussions that would enable us to identify the main factors generating these major differences in cost estimates. But it is at least reasonable to conclude from these figures that, with on the ground real-world projects, there are likely to be large variations in costs down to the project-by-project level. Thus, the costs for energy efficiency investments that will apply in any given situation will necessarily be specific to that situation, and must always be analyzed on a case-by-case basis. At the same time, for our present purposes, we need to proceed with some general rules-of-thumb for estimating the level of savings that are attainable through a typical set of efficiency investments in Maine.

A conservative approach is to use the National Academy of Sciences estimate as a baseline figure, at $29 billion per Q-BTU of energy savings through efficiency investments. In addition, it would be prudent to assume that the average costs per Q-BTU of savings will have increased, given that some significant energy efficiency investments have been undertaken in Maine over the past decade. We discuss this further below. For now, the point is that these efficiency gains were likely to have been concentrated among projects that offered relatively lower-cost energy savings opportunities. As such, we will assume here that the average costs will be $35 billion to achieve one Q-BTU of energy savings in Maine, or $35 million per T-BTU.

Rebound Effects

Raising energy efficiency levels will generate "rebound effects"—i.e. energy consumption increases resulting from lower energy costs. But such rebound effects are likely to be modest in Maine, within the current context of a statewide project focused on reducing CO_2 emissions and stabilizing the climate. Among other factors, energy consumption levels in Maine are close to saturation points in the use of home appliances and lighting—i.e. we are not likely to clean dishes much more frequently because we have a more efficient dishwasher. The evidence shows that, in general, consumers in advanced economies are likely to heat and cool their homes as well as drive their cars more when they have access to more efficient equipment. But these increased consumption levels are usually modest. Average rebound effects are likely to be significantly larger in developing economies.[46]

2.5 Prospects for Clean Renewable Energy

A critical factor for building a net zero economy in Maine, and throughout the world, by 2050 is the fact that, on average, the costs of generating electricity with clean renewable energy sources are now at parity or lower than those for fossil fuel-based electricity. Table 2.4 shows the most recent figures reported by the International Renewable Energy Agency (IRENA), for 2010 and 2017, on the "levelized costs" of supplying electricity through alternative energy sources. Levelized costs take account of *all costs* of producing and delivering a kilowatt of electricity to a final consumer. The cost calculations begin with the upfront capital expenditures needed to build the generating capacity, continue through to the transmission and delivery of electricity, and include the cost of energy that is lost during the electricity-generation process.

As we see in Table 2.4, the levelized costs for fossil-fuel generated electricity range between 4.5 and 14 cents per kilowatt hour as of 2017. The average figures for the four clean renewable sources are all within this range for fossil fuels as of 2017, with hydro at 5 cents, onshore wind at 6 cents, geothermal at 7 cents and solar PV at 10 cents. The costs of geothermal and hydro did not fall, and actually rose modestly, between 2010 and 2017. However, the costs of onshore wind fell by 25 percent, from 8 to 6 cents. The most impressive result though is with solar PV, in which levelized costs fell by 72 percent from 2010 to 2017, from 36 cents to 10 cents per kilowatt hour. These average cost figures for solar and wind should continue to decline by significant amounts as advances in technology and economies of scale proceed along with the rapid global expansion of these sectors.[47]

We emphasize that these cost figures from the IRENA are simple averages. They do not show differences in costs due to regional or seasonally-specific factors.[48] In particular, solar and wind energy costs will vary significantly by region and season. Moreover, both wind and solar energy are intermittent sources—i.e. they only generate energy, respectively, when the sun is shining or the wind is blowing. These issues of energy storage will become significant as Maine, the U.S., and global economies approach the net zero emissions goal by 2050.

TABLE 2.4

Average Global Levelized Costs of Electricity from Utility-Scale Renewable Energy Sources vs. Fossil Fuel Sources, 2010 – 2017

Average levelized costs for fossil-fuel generated electricity:
4.5 – 14 cents per kilowatt hour

	2010	2017
Solar PV	36 cents	10 cents
Onshore wind	8 cents	6 cents
Geothermal	5 cents	7 cents
Hydro	4 cents	5 cents

Source: International Renewable Energy Agency (IRENA) (https://www.irena.org/Statistics/View-Data-by-Topic/Costs/LCOE-2010-2017).

Over the decade 2021 – 2030, these issues will not be pressing. This is because petroleum, biomass and natural gas will be supplying roughly 85 percent of Maine's total energy supply as of 2021, with that figure still maintained at over 40 percent as of 2030. Thus, the economy's baseload energy source will continue to be fossil fuels and biomass through 2030 and several years beyond.

Keeping all such considerations in mind, we can still roughly conclude from these figures that, for the most part, clean renewable energy sources are rapidly emerging into a position at which they can produce electricity at comparable or lower costs than non-renewable sources and biomass. As such, assuming that wind, solar and geothermal energy production can be scaled up and combined with Maine's existing hydro resources to meet virtually all the state's energy demand by 2050, then the costs to consumers of purchasing this energy should not be significantly different from what these consumers would have paid for non-renewable energy. Indeed, overall, the costs to consumers of purchasing electricity from clean renewable sources, are likely to be *lower* than what they would be from fossil fuel sources. It is critical to also emphasize that this is *without* factoring in the environmental costs of burning oil, coal and natural gas.

Costs of Expanding Renewable Capacity

By a substantial amount, the largest share of overall costs in generating electricity from renewable sources is capital costs—i.e. the costs of producing new productive equipment, as opposed to the costs of operating and maintaining that productive equipment once it has been built and is generating energy. These capital costs are at about 65 percent of total costs for geothermal, 73 percent for onshore wind, and 81 percent for solar PV.[49] From these figures on levelized costs, we can also estimate the capital costs of installing renewable energy capacity as a lump sum—i.e. how much investors need to spend *upfront* to put this capital equipment into place and in running order.

We produce estimates of these lump sum capital costs in Table 2.5. Specifically, these figures represent the present values of total lump-sum capital expenditures needed to produce one Q-BTU of electricity from onshore wind, solar PV, and geothermal energy.[50] As we see, the average lump-sum costs range from $112 billion per Q-BTU for geothermal, $160 billion for onshore wind, and $190 billion for solar.

If we assume that, roughly speaking, the global expansion of clean renewable energy capacity will consist of 45 percent respectively from wind and solar PV technologies, and

TABLE 2.5
Capital Expenditure Costs for Building Renewable Electricity Productive Equipment:
Present values of total lump-sum capital costs per Q-BTU of electricity

Wind	$160 billion
Solar PV	$190 billion
Geothermal	$112 billion
Average costs *assuming investments are 45% wind, 45% solar, and 10% geothermal*	**$169 billion**

Sources: U.S. EIA (https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf). See Pollin et al. (2014) pp. 136 – 37 for methodology in converting levelized costs per Q-BTU into lump-sum capital costs.

10 percent from geothermal energy, this would place the average costs of producing one Q-BTU of overall renewable energy equipment at about $169 billion, which we can round up to $170 billion per Q-BTU of clean renewable capacity. This $170 billion figure can therefore serve as a benchmark for estimating the average costs of expanding the supply of clean renewable energy within Maine. At the same time, as with our cost estimate for investments in energy efficiency, we will want to err, if anything, on the side of overestimating, rather than underestimating, the costs of expanding clean renewable energy. One consideration is that, with the build-out of the clean energy supply proceeding rapidly throughout the U.S, and globally, over the next decade and beyond, the average costs are likely to rise as production bottlenecks emerge.

In addition, with respect to Maine specifically, offshore wind will be one major focus of new investment activity over time. At present, both the capital costs specifically and the overall costs of generating electricity from offshore wind are 3.5 times those for onshore wind.[51] This is why no commercial offshore wind projects operate now in Maine. But to take account of the prospects of incorporating offshore wind projects into Maine's overall clean energy mix gradually over 2021 – 2030, we will assume that the average costs of expanding the state's clean energy supply will be $225 billion per Q-BTU, i.e. about 30 percent higher than the $170 billion average figure we have derived from the current levelized costs data.

We can now work with our two rough high-end estimates of the overall costs of both raising energy efficiency standards and building new clean renewable energy capacity--$35 billion per Q-BTU ($35 million per T-BTU) for efficiency gains and $225 billion per Q-BTU ($225 million per T-BTU) for expanding renewable capacity—to generate an estimate of the total costs of achieving a 50 percent CO_2 emissions reduction in Maine by 2030 and to reach net zero emissions by 2050.

2.6 Determinants of Maine's CO_2 Emission Levels

Table 2.6 shows how, in 2017, Maine generated 15.5 million tons of CO_2 from burning oil, natural gas and a small amount of coal, along with another 9.4 million tons from burning biomass. This brings total emissions in 2017, from both fossil fuels and biomass, to 24.9 million tons. In column 1, we see again that oil is, by far, the largest source of fossil fuel energy supply in the state, at 185.7 T-BTUs. Column 2 shows that burning oil in Maine produces 12.9 million tons of CO_2 emissions, which amounts to a rate of 69.5 million tons of CO_2 per Q-BTU of energy, as shown in column 3. Natural gas consumption in Maine is much less substantial than with oil, at 45.1 T-BTUs. Since natural gas burns modestly cleaner than oil, at 53.2 million tons per Q-BTU, overall then, emissions in Maine from natural gas are also low, at 2.4 million tons as of 2017. Since there is almost no coal consumption throughout the Maine economy, at 2.2 T-BTUs, it also follows that emissions from coal in Maine are almost non-existent, at 0.2 million tons as of 2017. This is how Maine gets to a total of 15.5 million tons of CO_2 emissions from burning all fossil fuels.

But as is also clear from Table 2.6, biomass is a major source of additional emissions, to a uniquely high level relative to other U.S. states.[52] Thus, total energy consumption from biomass is, as we saw in Table 2.6, at 104.9 T-BTUs, accounting for 27 percent of Maine's total energy supply as of 2017. In terms of CO_2 emissions, if we work with the conservative assumption that emissions from biomass are roughly equal, on average, to those from burning coal, at

TABLE 2.6
Sources of CO_2 Emissions for Maine: *2017 Actuals and 2030 Projections*

	2017 Actuals			2030 Projections	
	1) 2017 Energy consumption *(in T-BTUs)*	**2) 2017 CO_2 emissions** *(in million metric tons)*	**3) CO_2 emissions per Q-BTU** *(= column 2/ column 1)*	**2030 Energy consumption** *(in T-BTUs)*	**2030 CO_2 emissions** *(in millions of tons; = column 3 x column 4)*
Fossil fuels					
Petroleum	185.7	12.9	69.5	92.9	6.5
Natural Gas	45.1	2.4	53.2	22.6	1.2
Coal	2.2	0.2	90.9	0	0
Fossil Fuel Totals	233.0	15.5	---		7.7
Biomass	104.9	9.4 *rough approximation*	90— *rough approximation*	52	4.7
Totals, including Biomass estimate	**337.9**	**24.9**	---	**167.5**	**12.4**

Notes: There are some minor differences in the energy consumption figures that are reported in this table relative to the figures reported in Table 2.1. These small differences are embedded in the source material presented by the EIA. They appear to result from differences in the way they calculate and report figures for overall energy consumption versus their figures on CO2 emissions. The assumption made for the 2030 projected scenario is that oil and natural gas are reduced by 50 percent and coal is reduced by 100 percent.

Source: U.S. EIA (https://www.eia.gov/environment/emissions/state/).

90 million tons per Q-BTU of energy, it then follows that emissions in Maine from biomass amounted to 9.4 million tons. This makes biomass, by far, the second leading source of CO_2 emissions in the state, accounting for nearly 40 percent of all statewide emissions.

It is clear from these figures that driving down overall emissions in Maine from about 25 to 12.5 million tons overall will require across-the-board cuts of 50 percent in burning oil, biomass, and natural gas, as well as the elimination of coal altogether as a statewide energy source. Working within this framework, let us assume that oil, biomass and natural gas will continue to be consumed in Maine at roughly their current proportions as of 2030. Natural gas and biomass will also continue to be consumed primarily to generate electricity while petroleum will continue to be used primarily as a liquid fuel for transportation. Under this assumption, oil consumption will fall to 92.9 T-BTUs, natural gas will fall to 22.6 T-BTUs, and biomass will fall to 52 T-BTUs. Through following this scenario, total CO_2 emissions in Maine will fall by half, to 12.4 million tons. Columns 4 and 5 of Table 2.6 present the calculations through which we derive this result.

GDP, Energy Intensity, and Emissions Intensity as Emissions Drivers

In order to develop an effective strategy for achieving Maine's emissions reduction goals, it will be useful to present a more detailed breakdown of the factors generating the state's current levels of emissions. More specifically, it will be valuable to decompose the emissions per capita ratio for Maine, as well as other states and the U.S. overall, into three component parts. This yields three ratios, each of which provides a simple measure of one major aspect of the climate change challenge, for Maine, the rest of the U.S. states and elsewhere. That is, CO_2 emissions per capita can be expressed as follows:

Emissions/population = (GDP/population) x (Q-BTUs/GDP) x (emissions/Q-BTU).

These three ratios provide measures of the following in each state, regional, or country setting:

1. *Level of development*: Measured by GDP per capita (i.e. GDP/population);
2. *Energy intensity*: Measured by Q-BTUs/GDP;
3. *Emissions intensity*: Measured by emissions/Q-BTU.

In Table 2.7, we show these ratios for Maine, as well as, for comparison purposes, some other U.S. states. Some significant observations emerge through considering these ratios. The first, most generally, is that there are three distinct ways in which any country, state or region can achieve a low figure for per capita emissions. The first is for the relevant economic area—the state, country or region—to operate at a low level of economic activity—i.e. at a low GDP level. For example, the Indian economy operates with a very low figure for emissions per capita of 1.6. But this is entirely due to the fact that per capita income in India is also still extremely low, at about $1,600.

By contrast, per capita income in Maine as of 2017 was about $47,000. This is about 22 percent below the average figure for the U.S. overall, at $60,062. Maine's ranking in 2017 was 42nd in per capita income among the 50 U.S. states.

TABLE 2.7

Determinants of Per Capita CO_2 Emissions Levels in Various States, 2017

Level of development, energy intensity and emissions intensity

CO_2 Emissions/population = (GDP/population) x (Q-BTUs/GDP trillion dollars) x (Emissions/Q-BTU)

	Per capita CO_2 emissions *(in metric tons)*	**Per capita GDP** *(in current US$)*	**Energy intensity ratio:** *Q-BTUs/trillion dollars GDP*	**Emissions intensity ratio:** *CO_2 emissions/Q-BTU*
Maine	18.7	$46,585	6.5	63.5
United States	17.2	$60,062	5.0	57.2
New York	8.7	$81,887	2.3	46.5
California	9.8	$71,626	2.8	48.8
Texas	25.8	$58,866	8.1	54.4
Colorado	16.2	$62,368	4.2	62.1
West Virginia	50.9	$40,266	10.3	122.8
Wyoming	106.1	$64,694	14.3	114.3

Note: Figures are inclusive of biomass emissions.

Sources: U.S. EIA for emissions figures, U.S. Census for population figures, and Bureau of Economic Analysis for state-level GDP figures.

With respect to this average income level, Maine could, hypothetically, reduce its per capita emissions figure by half as of 2030 by also cutting per capita GDP in half, to around $24,000, while maintaining its existing energy infrastructure fully intact. But this is obviously not a program for expanding well-being while also reducing emissions. To the contrary, the aim of a statewide clean energy project, again, is to achieve the 2030 emissions reduction level to no more than 12.5 million tons of CO_2 while the state's economy grows at a reasonable rate and job opportunities expand.

We therefore need to focus on the two other factors that, as a matter of straightforward accounting, are responsible for Maine's current level of per capita emissions at present. These are:

1. *Energy efficiency*: The state operates at an energy efficiency level that is about 30 percent worse than the national average, with an energy intensity ratio of 6.5 Q-BTUs per $1 trillion in GDP versus the U.S. national average of 5.0. But Maine also utilizes energy far less efficiently than either New York, whose energy intensity ratio is 2.3, or California, with a 2.8 energy intensity ratio, or Colorado, with a 4.2 ratio. New York's high efficiency level is due primarily to the intensive use in the state of both rail transit and apartment-based residential dwellings. This is not possible for Maine to replicate. But California has achieved its high efficiency level largely through relatively high automobile efficiency standards. Colorado is not as efficient as California, but is still utilizing energy 33 percent more efficiently than Maine. One of the main policy initiatives in Maine should therefore be to raise energy efficiency so that it reaches a standard somewhere within the range of California and Colorado.

2. *Clean-burning energy*: After factoring in biomass emissions, Maine's emissions intensity ratio of 63.5 million tons per Q-BTU of energy is about 11 percent above the U.S. average of 57.2. There are two main drivers here: heavy use of oil as a liquid fuel, and intensive use of biomass to generate electricity. Natural gas consumption is also a problem, if to a lesser extent. As such, the program to substitute clean renewable energy for biomass for generating electricity and to greatly expand the fleet of electric vehicles in Maine is capable of delivering major CO_2 emissions reductions in the state.

In addition to these factors explaining Maine's level of per capita emissions at present, it is also important to recognize that the state has achieved some gains over time in what is termed "absolute decoupling"—i.e. achieving absolute reductions in emissions per capita levels over the recent past even while both average incomes and population in the state have grown. We can see the factors driving the absolute decoupling trend in Table 2.8. As the table shows, per capita emissions fell between 1998 and 2017 from 30.2 to 24.9 tons, while per capita GDP rose from $37,680 to $44,700. This amounts to an average reduction in emissions per capita of about 1 percent per year while average per capita incomes rose by 0.9 percent per year. This absolute decoupling resulted through gains in both energy efficiency and in the share of renewable energy supplied within the state.

Thus, in terms of energy efficiency, we see in Table 2.8 that the state's energy intensity ratio fell from 9.6 to 6.5, a 34 percent improvement. This is equal to a 2.1 percent average improvement in the state's overall efficiency every year from 1998 – 2017. These gains in overall energy efficiency in Maine from 1998 – 2017 are a major achievement. They resulted mainly from the Efficiency Maine program, which has been operating in the state since 2004. The Natural Resources Council of Maine summarizes the accomplishments of the Efficiency Maine program since its inception as follows:

> Efficiency Maine is the state's initiative to save energy and money through energy efficiency improvements —and it has a proven track record of success in delivering cost-effective savings from efficiency. Since it began in 2004, Efficiency Maine has saved Maine people and businesses nearly $490 million on their energy bills. Efficiency Maine had **saved** as much total electricity in

TABLE 2.8
Determinants of Maine Per Capita CO2 Emissions, 1998 and 2017
Level of growth, energy intensity and energy mix

Maine	Total CO_2 emissions from fossil fuel and biomass consumption *(in million metric tons)*	Population	Per capita emissions *(in metric tons)*	GDP *(in 2017 dollars)*	Per capita GDP *(in 2017 dollars)*	Energy consumption *(in T-BTUs)*	Energy intensity ratio *(Q-BTUs per trillion of 2017 dollars GDP)*	Emissions intensity ratio *(CO_2 emissions/ Q-BTU)*
1998	30.2	1.25 million	24.2 tons/capita	$47.0 billion	$37,680	453	9.6	66.6
2017	24.9	1.34 million	18.7 tons/capita	$59.9 billion	$44,700	392	6.5	63.5

Source: See Table 2.7.

> its first five years of operation as all Maine households use in one year…Efficiency helps reduce peak demand, which also provides savings to all ratepayers, about $500 million for Maine ratepayers in its first five years of operation.[53]

Despite Maine's significant gains in efficiency over the past 20 years, it is still the case, as we saw in Table 2.7, that the state's current level of efficiency remains 20 percent less efficient than the U.S. overall, with the overall U.S. energy intensity ratio at 5.0, as well as 33 percent less efficient than Colorado and 55 percent less efficient than California, as two better-performing states (though not the best-performing, which is New York).

Maine's emissions intensity also fell over this period, though much more modestly, from 66.6 to 63.5 in CO_2 emissions per Q-BTU of energy consumed in the state, a 0.2 percent average annual improvement. This reduction in the state's emissions intensity ratio was driven mainly by the strong expansion in the supply of wind energy as a source of electricity.

Maine's absolute decoupling trajectory is certainly a favorable development. At the same time, for the state to reduce emissions by 50 percent by 2030 will require a much more aggressive, absolute, decoupling trajectory. Specifically, emissions will need to fall by an average of 6.7 percent per year. We assume that this nearly 7 percent per year decline in emissions will occur while average incomes in the state will be rising, at a rate at least equal to the 0.9 percent rate that prevailed from 1998 – 2017.

To accomplish these two ends will therefore require an intensive project to both raise energy efficiency standards and to expand the state's clean renewable energy generating capacity. These are the issues to which we now turn.

2.7 Achieving a 50 Percent Emissions Reduction by 2030

The 10-year clean energy investment initiative being proposed in this study is designed to achieve, again, two interrelated fundamental goals. The first is to bring total CO_2 emissions in Maine down by 50 percent, to 12.5 million tons by 2030, from its 2017 level of 25 million tons. The second is to advance this climate stabilization program while the Maine economy grows at an adequate rate between now and 2030, so that existing jobs are protected, job opportunities expand, and average well-being rises throughout the state. In this section of the study, we describe the clean energy investment levels that will be needed to bring together these two goals.

To explore the prospects for achieving the 2030 emissions reduction goal within the context of a growing Maine economy, we must, unavoidably, work with some assumptions as to the state's real economic growth trajectory between 2021 - 2030. Thus, we assume that the Maine economy will grow in real (i.e. inflation-adjusted) terms between now and 2030 at an average rate of 1.5 percent per year. This is close to the 1.2 percent average annual growth rate that Maine experienced over the recent 20-year period, i.e. 1998 – 2017. If we assume that the Maine economy, and the U.S. economy more generally, emerge in 2021 out of its current severe slump tied to the COVID pandemic, it is reasonable to assume that the economy's growth trajectory will be at least modestly stronger than over 1998 – 2017. For one thing, the 20-year period of 1998 – 2017 includes the 2007 – 2009 Great Recession, the most severe U.S. economic downturn other than the 1930s Great Depression and the current COVID-based crisis. In addition, the aim of the full program we are proposing for Maine in this study will be to support a healthy growth rate through the clean energy investment program, along with public infrastructure investments and a significantly improved public health system.

In Table 2.9, we first report on Maine's real GDP as of 2017 (expressed in 2017 dollars) and the projected level in 2030, assuming the economy's average real growth rate is maintained at 1.5 percent through 2030. We see that, under this growth assumption, Maine's real GDP will be approximately $72.7 billion in 2030, growing from the 2017 figure of $59.9 billion. Within this full time period, we are most interested in the years 2021 – 2030, over which Maine will be achieving its 50 percent emissions reduction relative to the 2017 level. Assuming again a 1.5 percent average annual growth rate, the 2021 GDP will be $63.6 billion. The midpoint over the 2021 – 2030 decade will be effectively January 1, 2026. Maine's real GDP will be at $68.7 billion at that midpoint.

Within this framework, we can then project an energy and CO_2 emissions profile for Maine for 2030. We consider two distinct scenarios. For the first 2030 scenario, we assume that the state's energy infrastructure as of 2017 remains basically intact through 2030. We see the results of this scenario in Table 2.10. Specifically, in column 1 of Table 2.10, we show the actual breakdown of energy consumption and emissions as of 2017. In column 2, we then present projected figures, assuming Maine's economy grows at an average annual rate of 1.5 percent through 2030 and the state's energy infrastructure remains basically intact. We term this the "steady state" energy infrastructure trajectory for Maine. In this

TABLE 2.9
Maine State GDP Levels, 2017 Actual and Projections for 2021, 2026, and 2030
Figures are in 2017 dollars

2017 GDP	\$59.9 billion
Projected average growth rate through 2030	1.5%
Projected 2021 GDP	\$63.6 billion
Projected 2030 GDP	\$72.7 billion
Projected midpoint GDP between 2021 – 2030 (2026)	\$68.7 billion

Source: BEA and authors' calculations.

scenario, all energy sources with the exception of hydro grow at exactly the state's overall 1.5 percent annual GDP growth rate. We are assuming hydro remains at a fixed level of production, and that the increase in overall energy supply commensurate with a 1.5 percent average annual growth rate is provided through increases in wind energy supply.

Thus, we see in row 2, columns 1 and 2, that Maine's energy intensity ratio remains constant between 2017 and 2030, at 6.5 Q-BTUs per \$1 trillion in GDP. The state's emissions intensity ratio also remains basically unchanged, as shown in row 13, columns 1 and 2, increasing slightly from 63.5 to 63.9 million tons in CO_2 emissions per Q-BTU of energy. We see the impact of this 1.5 percent average economic growth pattern on statewide CO_2 emissions in row 12 of Table 2.10. That is, total CO_2 emissions increase from 24.9 to 30.2 million tons, an increase of 21.3 percent.

In column 3 of Table 2.10, we then show the impact on the energy mix and emissions levels of a clean energy program focused on bringing down CO_2 emissions to around 12.5 million tons by 2030. The first component of this program is energy efficiency investments. As noted in section 2.4, we assume energy efficiency investments will span across the building, transportation and industrial sectors of the Maine economy. Following from that prior discussion, we assume that, by 2030, Maine is capable of reducing the economy's energy intensity ratio from the 2017 level of 6.5 to 4.0 Q-BTUs per \$1 trillion of GDP. This would be a 38 percent gain in overall energy efficiency in the state. It would bring Maine to an efficiency level approximately midway between the levels at which California and Colorado operated in 2017. Correspondingly, total energy consumption at the 2030 GDP level, would fall from 392 to 291 T-BTUs, or a change of 101 T-BTUs.

We then need to consider the energy mix that will be necessary to allow for 291 T-BTUs of consumption while still maintaining emissions at no more than 12.5 million tons. As we have seen in Table 2.6, in order to bring overall CO_2 emissions in Maine down to 12.5 million tons by 2030, one viable path would be for the consumption of oil, biomass, and natural gas to all fall by half, while the small amount of coal consumption as of 2017 would be eliminated entirely. As we see in column 3 of Table 2.10, this implies that oil is at 92.8 T-BTUs as of 2030, biomass is at 52.5 T-BTUs and natural gas is at 22.6 T-BTUs. Maine also continues to operate without any reliance on nuclear energy in this scenario. In combination then, the non-renewable energy sources along with high-emissions bioenergy would provide Maine with a total of 167.9 T-BTUs of energy in 2030.

This then entails that 123.1 T-BTUs of energy will need to be provided by clean renewable sources in order for Maine's overall energy consumption to reach 291 T-BTUs in 2030.

TABLE 2.10
Maine State Energy Consumption and Emissions:
2017 Actuals and 2030 Alternative Projections

	1) 2017 actuals	2) 2030 with approximate Steady State Energy Infrastructure *(= categories grow at 1.5% average annual rate)*	3) 2030 through Clean Energy Investment Program
1) Real GDP	$59.9 billion	72.7	72.7
2) Energy intensity ratio *(Q-BTUs / $1 trillion of GDP)*	6.5	6.5	4.0
3) Total energy consumption *(T-BTU)*	392	472	291
Energy mix			
Non-renewables and bioenergy *(T-BTUs—rows 4 - 8)*	337.9	410.1	167.9
4) Petroleum	185.7	225.4	92.8
5) Bioenergy	104.9	127.3	52.5
6) Natural gas	45.1	54.7	22.6
7) Coal	2.2	2.7	0
8) Nuclear	0	0	0
Clean renewables *(T-BTUs—rows 9 - 11)*	53.3	61.9	123.1
9) Hydro	31.2	31.2	31.2
10) Wind	21.5	30.0	70.0
11) Solar and geothermal	0.6	0.7	21.9
Emissions			
12) Total CO_2 emissions *(million metric tons)*	24.9	30.2	12.4
13) Emissions Intensity Ratio *(CO_2 emissions per Q-BTUs)*	63.5	63.9	42.6
14) CO_2 emissions per capita *(with 2017 actual population = 1.33 million and projected 2030 population = 1.34 million)*	18.7	22.5	9.5

Source: Tables 2.1, 2.6, and 2.7; authors' calculations.

As noted above, we assume that the supply of hydro power remains constant through 2030, at 31.2 T-BTUs.

As of 2017, wind, solar, hydro and geothermal energy combined to supply 53.3 T-BTUs to Maine. Effectively then, 69.8 T-BTUs of *new supply* needs to be provided by wind, solar, and geothermal in order to bring Maine's total energy supply to 291 T-BTUs in 2030, with emissions falling by 50 percent, from 24.9 to 12.5 million tons as of 2030.

As discussed in section 2.5, we assume, as a high-end estimate, that the average lump-sum capital expenditures needed to expand clean renewable energy supply by 1 Q-BTU will be $225 billion. This then means that, to expand the clean renewable supply in Maine by 69.8 T-BTUs, will require $15.7 billion in new capital expenditures. Working, again, with the assumption that this is a 10-year investment program, this implies that the average level of expenditures per year to increase the supply of clean renewable energy by 69.8 T-BTUs in 2030 will be about $1.6 billion per year.

In Table 2.11, panels A – C, we summarize the main features of the 2030 clean energy investment program. These include the following:

TABLE 2.11
Maine Clean Energy Investment Program for 2021- 2030

A) Energy Efficiency Investments

1. 2030 Energy Intensity Ratio	4.0 Q-BTUs per $1 trillion GDP *(38% improvement over 6.5 Q-BTU per $1 trillion GDP steady state figure)*
2. Total energy consumption	291 T-BTUs *(= 38% reduction relative to 472 T-BTU steady state figure)*
3. Energy saving relative to steady state	181 T-BTUs *(= 472 – 291 T-BTUs)*
4. Average investment costs per Q-BTU in efficiency gains	$35 billion per Q-BTU
5. Costs of energy savings	$6.3 billion *(= $35 billion x 181 T-BTUs in savings)*
6. Average annual costs over 2021 – 2030	$630 million *(= $6.3 billion/10)*
7. Average annual costs of efficiency gains as % of mid-point GDP	0.9% *(= $630 million/$68.7 billion*

B) Clean Renewable Energy Investments

1. Total renewable supply necessary	123.1 T-BTUs *(= 291 T-BTUs – 167.9 T-BTUs supplied by non-renewables/ biomass)*
2. Expansion of renewable supply relative to 2017 level	69.8 T-BTUs *(= 120.1 – 53.3 T-BTUs)*
3. Average investment costs per Q-BTU for expanding renewable supply	$225 billion per Q-BTU
4. Costs of expanding renewable supply	$15.7 billion *(= 69.8 T-BTUs x $225 billion)*
5. Average annual costs over 2021 – 2030	$1.6 billion *(= $15.7 billion/10)*
6. Average annual costs of renewable supply expansion as % of midpoint GDP	2.3% *(= $1.6 billion/$68.7 billion)*

C) Overall Clean Energy Investments: Efficiency + Clean Renewables

1. Total clean energy investments	$22.0 billion *(= $6.3 billion for energy efficiency + $15.7 billion for renewables)*
2. Average annual investments	$2.2 billion *(= $22.0 billion/10)*
3. Average annual investments as share of midpoint GDP	3.2% *(= $2.1 billion/$68.7 billion)*
4. Total energy savings or clean renewable capacity expansion	250 T-BTUs *(= 181 T-BTUs in energy saving + 69.8 T-BTUs in clean renewable supply expansion)*

Sources: Tables 2.5, 2.9, 2.10.

- ***Efficiency.*** $ 630 million per year in energy efficiency investments between 2021 – 2030, amounting to about 0.9 percent of Maine's projected midpoint GDP between 2021 – 2030. These efficiency investments will generate 181 T-BTUs of energy savings relative to the steady state growth path for Maine through 2030.
- ***Clean renewables.*** $1.6 billion per year for investments in onshore and offshore wind, solar, and geothermal energy production. This will amount to about 2.3 percent of Maine's projected midpoint GDP between 2021 – 2030. It will generate an increase of 69.8 T-BTUs of clean renewable supply by 2030.
- ***Overall program and emissions reduction.*** Combining the efficiency and clean renewable investments, the program will therefore cost about $2.2 billion per year, or 3.2 percent of Maine's projected midpoint GDP between 2021 – 2030. Overall, this program will generate 251 T-BTUs in either energy savings relative to the steady state scenario or expanding the clean renewable energy supply. The end result of this program will be that overall CO_2 emissions in Maine in 2030 will be 12.4 million tons, 50 percent less than its level for 2017. Maine will have achieved this 50 percent emissions reduction while the state's economy also will have grown at an average rate of 1.5 percent per year through 2030.

Is $2.2 Billion per Year in Clean Energy Investments Realistic for Maine?

The short answer is "yes." To understand why, it is important to consider our estimate of Maine's annual clean energy investment needs within the broader context of the state's overall economic trajectory. As we have already noted above, this $2.2 billion annual investment figure represents about 3.2 percent of Maine's average GDP over 2021 – 2030, assuming that the state grows, on average, at about 1.5 percent per year over that 10-year period. In other words, our estimate of Maine's annual clean energy investment needs for bringing CO_2 emissions down in the state by 50 percent as of 2030 implies that roughly 97 percent of all economic activity in Maine can continue to be directly engaged in activities *other than* clean energy investments.

It is also critical to recognize that Maine's clean energy transition will deliver lower energy costs for all state consumers. This results because raising energy efficiency standards means that, by definition, consumers will spend less for a given amount of energy services, such as being able to travel 100 miles on a gallon of gasoline with a high-efficiency plug-in hybrid vehicle as opposed to 30 miles a gallon with a standard gasoline-powered car. Moreover, as we have seen, the costs of supplying energy through wind, solar, geothermal and hydro power are now, on average, roughly equal to or lower than those for fossil fuels and nuclear energy.

As an additional valuable metric, we roughly estimate that, for 2019, the level of clean energy investments in Maine was already in the range of $350 million or higher.[54] From this figure, we conclude that clean energy investments in the state between 2021 – 2030 will need to increase about 6-fold relative to current investment levels. This will certainly be a substantial challenge. But, as we have discussed above, Maine does already have a policy infrastructure in place to support clean energy investments, mainly through incentivizing private investors. Increasing the level of clean energy investments will therefore primarily entail strengthening this existing policy framework.

Leveraging Public Funds for Expanding Total Clean Energy Investments

What level of public funding will be needed to generate a total of $2.2 billion a year in total new clean energy investments in Maine? To help answer that question, it will be useful to briefly review the experience with the federal Department of Energy Loan Guarantee Program, which was one part of the 2009 American Recovery and Reinvestment Act—i.e. the Obama stimulus program. This program helped underwrite about $14 billion in new clean energy investments between 2009 – 2013. Even after taking full account of the large-scale and widely publicized failure of the Northern California solar company Solyndra, the default rate and corresponding financial obligations stemming from this program were modest. According to our estimates discussed in Pollin et al. (2014), total losses from the government covered by the government's loan guarantees amounted to about $300 million, i.e. equal to about 2.1 percent of the $14 billion in new loans for clean energy investments that the government guaranteed. This means that the leverage rate for the loan guarantee program was about $47 in additional clean energy investments underwritten by $1 of federal support.

If Maine were able utilize its full set of policy tools, including the set of financial subsidies, tax incentives, and regulations described above to leverage at the same 47/1 rate as the 2009 federal Energy Loan Guarantee program, that would imply that the state would need to spend about $44 million per year to deliver $2.2 billion in total clean energy investments in Maine. Such public spending could take the form of direct public investments, loan guarantees and other forms of credit subsidies, or tax benefits. The remaining roughly $2 billion would be coming from private investors. The $44 million in public funding would amount to about 1 percent of the state's total budget of roughly $4 billion for fiscal year 2020.

However, for various reasons, this leverage ratio is almost certainly too high. One factor is that Maine is a small state, with limited administrative capacity to operate a loan guarantee program at the scale of the 2009 federal program. On the other hand, Maine's clean policy framework does include features that would support a high leverage ratio. One is that energy efficiency investments pay for themselves over time. As such, loans to finance energy efficiency investments can be structured so the repayment funds are provided directly through energy savings.

In fact, such lending arrangements are already operating in New York and other states, through what is termed "on-bill financing." With on-bill financing, a loan that pays for an energy efficiency or renewable energy investment is repaid through a utility bill and secured by a strong contract with the utility. Additional collateral must be obtained by the lender since non-payment can lead to borrowers having their electricity delivery suspended. New York's on-bill financing program is available for both households and businesses, and for investments in both energy efficiency and solar photovoltaic and other renewable energy projects.

Considering these and related factors, it is certainly difficult to establish firmly what we would expect the average leveraging ratio to be for public funds to finance the state's overall public plus private clean energy investment project. This would include funding from the federal government as well as Maine's state and municipal budgets. A reasonable low-end assumption would be that Maine is capable of leveraging $9 in private clean energy investments for every $1 provided in public funds, assuming the state's clean energy incentive and regulatory policies are operating effectively.

For 2021 – 2022, the first years of the investment program, overall investment spending would be around $2 billion (with $2.2 billion/year being the midpoint amount over 2021 – 2030). For 2021, this would imply that the state would need to contribute about $200 million on clean energy projects, an amount that would then be matched by $1.8 billion in private sector investments. The $200 million in public investments would amount to about 4 percent of Maine's current annual state budget. Note that this 9/1 leveraging ratio is about one-fifth the ratio that was achieved with the federal clean energy loan guarantee program over 2009 – 2013.

2.8 Clean Energy Investments and Job Creation

In Tables 2.12 and 2.13, we present our estimates as to the job creation effects of investing in energy efficiency in Maine. Tables 2.14 and 2.15 then present comparable estimates for investments in clean renewable energy in the state. In both cases, we report two sets of figures—first, job creation per $1 million in expenditure, then, job creation given the annual level of investment spending we have proposed for 2022, i.e. $600 million in energy efficiency and $1.4 billion in clean renewable energy.[55]

Direct, Indirect and Induced Job Creation

Before reviewing the actual data on job creation in Tables 2.12 – 2.15, we need to briefly describe the three channels through which jobs will be generated through clean energy investments. In fact, these three sources of job creation will be associated with any expansion of spending in any area of the economy, including clean energy investments. They are: direct, indirect, and induced employment effects. For purposes of illustration, consider these categories in terms of investments in home retrofitting or building wind turbines:

1. *Direct effects*—the jobs created, for example, by retrofitting buildings to make them more energy efficient or building wind turbines;
2. *Indirect effects*—the jobs associated with industries that supply intermediate goods for the building retrofits or wind turbines, such as lumber, steel, and transportation. In other words, indirect effects measure job creation along the clean energy investment supply chain;
3. *Induced effects*—the expansion of employment that results when people who are paid in the construction or steel industries spend the money they have earned on other products in the economy. These are the multiplier effects within a standard macroeconomic model.

In Tables 2.12 – 2.15, we first report figures for direct and indirect jobs, along with the totals for these main job categories. We then include the figures on induced jobs, and show total job creation when induced jobs are added to that total.

Job Creation through Energy Efficiency Investments

In Table 2.12, we show the job creation figures per $1 million in spending for our four categories of efficiency investments: building retrofits; industrial efficiency; electrical grid upgrades; and public transportation expansion and upgrades. As Table 2.12 shows, direct plus indirect job creation per $1 million in spending ranges between 5.0 jobs for electrical grid upgrades to 14.7 jobs for public transportation expansion and upgrades.

Spending to bring high efficiency automobiles into operation rapidly will be an important component of the overall efficiency investment initiative. However, our assumption, as shown in Table 2.12, is that this will not be a source of new job creation. This is because

TABLE 2.12
Job Creation in Maine through Energy Efficiency Investments
Job creation per $1 million in efficiency investments

	Direct jobs	Indirect jobs	Direct + indirect jobs total	Induced jobs	Direct, indirect + induced jobs total
Building retrofits	5.7	3.3	9.0	2.8	11.8
Industrial efficiency	4.5	1.4	5.9	2.2	8.1
Electrical grid upgrades	4.0	1.0	5.0	1.9	6.9
Public transport expansion/upgrades	13.0	1.7	14.7	3.2	17.9
Expanding high efficiency automobile fleet	0	0	0	0	0

Sources: Authors' calculations using IMPLAN 3.0. See Appendix 3.

producing high efficiency automobiles will basically substitute for producing lower-efficiency models. Roughly the same level of employment will be needed either way.

In Table 2.13, we show the level of job creation through spending $600 million on these efficiency projects in Maine in 2022. We have assumed that 60 percent of the $600 million is channeled into building retrofits, and the remaining 40 percent supports the other efficiency investment areas equally, at 10 percent of the total each. The result of efficiency investment spending at this level, as we see, will be the creation of 3,342 direct jobs and 1,434 indirect jobs, for a total of 4,776 direct plus indirect jobs created through this energy efficiency investment program. Including induced jobs adds another 1,446 jobs to the total figure. This brings the total job creation figure for efficiency investments, including induced jobs to 6,222 jobs.

Job Creation through Clean Renewable Energy Investments

In Table 2.14, we show the job creation figures for our four clean renewable energy categories—onshore and offshore wind, solar, and geothermal power, along with investments in land restoration and agriculture. As we see, the extent of direct plus indirect jobs ranges from 3.5 direct plus indirect jobs per $1 million in expenditure for onshore wind projects to 15.7 jobs for investing $1 million in land restoration and agriculture. Adding induced jobs brings the range to 4.7 jobs for onshore wind, 6.2 for solar, 6.1 for offshore wind, 16.1 for geothermal and 19.0 for land restoration and agriculture.

Based on these proportions, we see in Table 2.15 the levels of job creation in Maine generated by $1.4 billion in spending in 2022 in these areas of clean renewable energy and land restoration/agriculture. As we see in Table 2.15, we have divided spending levels as follows: 60 percent for onshore wind, 30 percent for solar PV and 3.3 percent each for offshore wind, geothermal and land restoration. We have assigned these budgetary priorities to reflect the priority for wind energy expansion in Maine but also the reality that offshore wind is still in its early stages of commercial development. We also assume that of this total level of new investments in clean renewables needed to deliver an additional 66.8 T-BTUs of energy in Maine by 2030, only 10 percent of the total *manufacturing activity* will take place

TABLE 2.13
Job Creation in Maine through Energy Efficiency Investments:
Job creation through spending $600 million in 2022 in efficiency investments

ASSUMPTIONS FOR ENERGY EFFICIENCY INVESTMENTS
- 60% on building retrofits
- 10% on industrial efficiency measures
- 10% on electrical grid upgrades
- 10% on public transportation expansion/upgrades
- 10% on expanding high-efficiency auto fleet
    - No job creation through auto purchase subsidies

	Spending amounts	Direct jobs	Indirect jobs	Direct + indirect jobs Total	Induced jobs	Direct, indirect + induced jobs total
Building retrofits	$360 million	2,052	1,188	3,240	1,008	4,248
Industrial efficiency	$60 million	270	84	354	132	486
Electrical grid upgrades	$60 million	240	60	300	114	414
Public transportation expansion/upgrades	$60 million	780	102	882	192	1074
Expanding high efficiency automobile fleet	$60 million	0	0	0	0	0
TOTALS	**$600 million**	**3,342**	**1,434**	**4,776**	**1,446**	**6,222**

Sources: Authors' calculations using IMPLAN 3.0. See Appendix 3.

TABLE 2.14
Job Creation in Maine through Clean Renewable Energy Investments:
Job creation per $1 million in clean renewable investments

ASSUMPTIONS:
- 10 percent of new manufacturing activity retained in Maine

	Direct jobs	Indirect jobs	Direct + indirect jobs Total	Induced jobs	Direct, indirect + induced jobs
Onshore wind	2.5	1.0	3.5	1.2	4.7
Solar	3.2	1.4	4.6	1.6	6.2
Offshore wind	3.3	1.2	4.5	1.6	6.1
Geothermal	8.9	3.1	12.0	4.1	16.1
Land restoration/ agriculture	14.7	1.0	15.7	3.3	19.0

Sources: Authors' calculations using IMPLAN 3.0. See Appendix 3.

within Maine. In other words, we assume that 90 percent of the manufacturing goods needed to produce 66.8 T-BTUs of additional clean renewable energy in Maine as of 2030 will be imported from outside the state.

Following from these assumptions, we see in Table 2.15 that total direct plus indirect job creation generated in Maine by this large-scale expansion in the state's clean renewable energy supply will be 6,282 jobs. If we include induced jobs, then the total rises to 8,360 jobs.

TABLE 2.15
Job Creation in Maine through Clean Renewable Energy Investments:
Job creation through spending $1.4 billion billion in 2022 in clean renewable investments

ASSUMPTIONS FOR CLEAN RENEWABLE INVESTMENTS

• 60% on onshore wind energy
• 30% on solar PV energy
• 3.3% on offshore wind
• 3.3% on geothermal energy
• 3.3 on land restoration/agriculture
  - 10% of new manufacturing activity in Maine

	Spending amounts	Direct jobs	Indirect jobs	Direct + indirect jobs total	Induced jobs	Direct, indirect + induced jobs total
Onshore wind	$850 million	2,125	850	2,975	1,020	3,995
Solar	$425 million	1,360	595	1,955	680	2,635
Offshore wind	$42 million	139	50	189	67	256
Geothermal	$42million	374	130	504	172	676
Land restoration/ agriculture	$42 million	617	42	659	139	798
TOTALS	**$1.4 billion**	**4,615**	**1,667**	**6,282**	**2,078**	**8,360**

Sources: Authors' calculations using IMPLAN 3.0. See Appendix 3.

Table 2.16 brings together our job estimates for both energy efficiency and clean renewable energy through spending about $2 billion per year on this project in Maine as of 2022. We show total figures for direct plus indirect jobs only, then we also show the total when induced jobs are included.

We see in row 12 of Table 2.16 that total direct and indirect job creation as of 2021 is 11,058 jobs and 14,582 jobs when we add induced jobs to the total. As we see in row 13, this level of job creation amounts to between 1.6 and 2.2 percent of total employment in Maine as of 2019, the range depending on whether we include induced jobs in the total.

Indicators of Job Quality

In Table 2.17, we provide some basic measures of job quality for the jobs that will be generated through clean energy investments in Maine. These basic indicators include: 1) average total compensation (including wages plus benefits); 2) the percentage of workers receiving health insurance coverage; 3) the percentage having retirement plans through their employers; and 4) the percentage that are union members.

We focus here on the *direct* jobs that will be created through clean energy investments in Maine. By definition, the direct jobs are the ones that are fully integrated within the state's clean energy investment activities. As such, the characteristics associated with these directly created jobs will most fully reflect the specific range of opportunities that will result through building a clean energy economy in Maine. The jobs created through the indirect and induced channels will be more diffuse in their characteristics. Indeed, the characteristics of

TABLE 2.16

Annual Job Creation in Maine through Combined Clean Energy Investment Program

Estimates are for 2022

Industry	Number of direct and indirect jobs created	Number of direct, indirect and induced jobs created
$600 million in energy efficiency		
1) Building retrofits	3,240	4,248
2) Industrial efficiency	354	486
3) Electrical grid upgrades	300	414
4) Public transportation expansion/upgrades	882	1,074
5) Total energy efficiency job creation	4,776	6,222
$1.4 billion in clean renewables and land restoration/agriculture		
6) Onshore wind	2,975	3,995
7) Solar	1,955	2,635
8) Offshore wind	189	256
9) Geothermal	504	676
10) Land restoration/agriculture	659	798
11) Total job creation from clean renewables and land restoration/agriculture	6,282	8,360
12) TOTALS *(= rows 5+11)*	**11,058**	**14,582**
13) TOTAL AS SHARE OF 2019 MAINE EMPLOYMENT	**1.6%**	**2.2%**

Sources: See Tables 2.12 – 2.15. Maine's 2019 employment is 672,000.

TABLE 2.17

Indicators of Job Quality in Maine Clean Energy Industries: Direct Jobs Only

	Energy Efficiency Investments				Clean Renewable Energy Investments				
	1. Building retrofits *(2,052 workers)*	2. Industrial efficiency *(270 workers)*	3. Grid upgrades *(240 workers)*	4. Mass transit *(780 workers)*	5.Onshore wind *(2,125 workers)*	6. Offshore wind *(139 workers)*	7. Solar *(1,360 workers)*	7. Geo-thermal *(374 workers)*	7. Land restoration/agriculture *(617 workers)*
Average total compensation	$50,400	$61,300	$60,600	$32,300	$55,400	$56,200	$56,200	$52,800	$32,200
Health Insurance coverage, percentage*	36.9%	48.7%	43.1%	35.6%	42.5%	43.2%	45.3%	43.7%	35.4%
Retirement plans, percentage*	25.5%	34.2%	32.5%	28.2%	31.6%	31.1%	34.5%	33.1%	12.6%
Union membership, percentage	4.4%	2.7%	5.1%	12.9%	4.6%	5.0%	2.6%	2.9%	0.2%

Notes: *These figures are based on regional data, as opposed to Maine alone, due to small sample sizes.

Sources: See Appendix 4.

the induced jobs created will simply reflect the overall characteristics of Maine's present-day workforce.

Starting with compensation figures, we see that the averages range between about $32,000 for workers in the mass transit sector to about $56,000 in the wind, solar, and geothermal sectors, to around $60,000 for industrial efficiency and grid upgrades.

The range for workers carrying employer-based health insurance coverage is narrower, from 35 percent of workers in the land restoration/agricultural sectors to nearly 50 percent in industrial efficiency. Thus, in none of these clean energy sectors is more than half of the workforce provided with employer-sponsored health insurance.

The range of coverage with respect to private retirement plans is still lower than that for health insurance. The low-end figure is with land restoration/agriculture, in which only about 13 percent of workers have retirement plans. Beyond this, between 26 – 35 percent of workers in the other clean energy sectors presently have private retirement plans—i.e. in all cases, well below 50 percent of the workforce. The figures on union coverage are also quite low. The highest extent of coverage is in mass transit, in which 13 percent of workers are union members. Otherwise, union coverage rates are never more than 5 percent of the workforce in the various clean energy sectors.

These indicators of job quality will be valuable for purposes of comparison when we consider the jobs that will be lost in Maine as a result of the contraction of fossil fuel production and consumption in the state through 2030. What is especially important to highlight now—in anticipating our discussion in section 2.9 on workers in Maine's fossil fuel related industries—is that, for the most part, the compensation figures in clean energy industries are lower than those for fossil fuel industry-based workers. As such, one of the aims of a clean energy investment agenda for Maine should be to raise wages, benefits and working conditions in the newly-created clean energy investment industries.

Raising unionization rates in these industries will provide an important foundation in support of these goals. As one feature of the overall clean energy transition project for Maine, the state should therefore require neutrality with respect to union organizing campaigns in any clean energy investment projects that are either state-owned or partially financed by the state. We return to this issue below when we discuss policy proposals.

Educational Credentials and Race/Gender Composition for Clean Energy Jobs

In Table 2.18, we present data on the educational credentials for workers in jobs that are directly tied to clean energy investment activities in Maine as well as the race and gender composition of these workers.

Educational Credentials

With respect to educational credentials, we categorize all workers who would be employed directly by clean energy investments in Maine according to three educational credential groupings: 1) shares with high school degrees or less; 2) shares with some college or Associate degrees; and 3) shares with Bachelor's degree or higher.

As Table 2.18 shows, the distribution of educational credentials varies widely depending on the specific clean energy industry. Thus, the percentages of workers in each sector with high school degrees or less range from a low of 22 percent in industrial efficiency to

TABLE 2.18
Educational Credentials and Race/Gender Composition of Workers in Maine Clean Energy Industries: Direct Jobs Only

	Energy Efficiency Investments				Clean Renewable Energy Investments				
	1. Building retrofits *(2,052 workers)*	2. Industrial efficiency *(270 workers)*	3. Grid upgrades *(240 workers)*	4. Mass transit *(780 workers)*	5.Onshore wind *(2,125 workers)*	6. Offshore wind *(139 workers)*	7. Solar *(1,360 workers)*	7. Geo-thermal *(374 workers)*	7. Land restoration/agriculture *(617 workers)*
Share with high school degree or less	52.7%	21.5%	62.3%	51.6%	45.9%	36.1%	41.3%	44.3%	37.2%
Share with some college or Associate degree	32.1%	16.1%	26.1%	32.1%	28.4%	23.9%	26.6%	27.5%	30.4%
Share with Bachelor's degree or higher	15.3%	62.3%	11.6%	16.3%	25.7%	39.9%	32.0%	28.2%	32.3%
Racial and gender composition of workforce									
Pct. non-white	3.9%	1.4%	3.4%	4.5%	4.5%	2.7%	3.4%	3.5%	0.3%
Pct. female	7.6%	31.2%	7.3%	30.5%	13.8%	19.0%	19.2%	14.7%	16.2%

Sources: See Appendix 4.

62 percent in grid upgrades. The percentages with Bachelor's degrees or higher is then a rough mirror image of the pattern with high school or less, with a low of 15 percent having Bachelor's degrees or more in building retrofits up to 62 percent in industrial efficiency. The percentages with some college or Associate degree is mostly clustered between 24 and 32 percent. Industrial efficiency is the one exception here, at a low 16 percent figure.

If we consider this range of clean energy investment areas as a whole, it is clear that there will be new jobs generated at roughly comparable proportions for workers at all educational credential levels. This means that there will be a substantial expansion of job opportunities for workers at all credential levels through large-scale clean energy investments in Maine.

Race and Gender Composition

It is clear from the figures in Table 2.18 that, at present, the jobs created by clean energy investments are held predominantly by white male workers. The percentages of non-white workers within the various clean energy sectors ranges between 0.3 – 4.5 percent. These figures are broadly consistent, though lower, than the percentages for Maine's population, in which whites account for 93 percent, while African Americans, Hispanics and Asians, separately, range between 1.3 and 1.8 percent. With respect to gender composition, women are also under-represented across all sectors. The share of female employment is between 8 – 32 percent, even while women make up 48 percent of Maine's workforce.

Despite these disparities in the current composition of the workforce associated with clean energy investments in Maine, especially with regard to women, the large-scale expansion of these investments will provide a major opportunity to increase opportunities for both non-white and female workers. An initiative focused on equal opportunity in the growing clean energy investment areas could be readily integrated into the broader investment project.

Prevalent Job Types with Clean Energy Investments

To provide a more concrete picture of the jobs that will be created in Maine through investments in energy efficiency and clean renewable energy, in Tables 2.19 – 2.22 we report on the prevalent job types associated with the various efficiency and renewable energy activities. Table 2.19 provides data for investments in building retrofits, our largest category of energy efficiency investments. Table 2.20 combines data for the other efficiency investment areas, i.e. industrial efficiency, electric grid upgrades, and public transportation expansion and upgrades. Table 2.21 then reports these same figures for the largest category of clean renewable energy investments, onshore wind. Table 2.22 shows the employment profile for the other three areas of clean renewable energy investments, i.e. offshore wind, solar, and geothermal power as well for the land restoration/agriculture sector. In all cases, we report on the job categories in which we estimate that 5 percent or more of the new jobs will be created through clean energy investments.

It is difficult to summarize the detailed data on job categories presented in these tables. But it will be useful to underscore a few key patterns. First, a high proportion of jobs will be created in the construction industry through all of the clean energy investment activities. Of course, this is true with the 60 percent of jobs created through building retrofit investments. But we also find that 49 percent of jobs in the onshore wind sector will be in construction, along with 34 percent of jobs in other areas of renewable energy investments and 22 percent in other areas of energy efficiency investments. The specific types of construction industry jobs will vary widely, given the different types of construction projects that will be pursued. Thus, investments in building retrofits as well as the other areas of efficiency investments will create large numbers of jobs for laborers, carpenters, and electricians. This pattern of job creation holds as well with renewable-energy based construction work.

Jobs in management also constitute a large share of overall job creation across all categories, accounting for between 12 – 22 percent of total jobs created in the various specific clean energy investment categories. Beyond this, what emerges generally from Tables 2.19-2.22 is that clean energy investments will generate a wide range of new employment opportunities. This broad range of new opportunities will be available for workers in Maine that will have been displaced by the contraction of the state's fossil fuel industry activities, as well as more broadly throughout the state's labor force.

TABLE 2.19
Building Retrofits: Prevalent Job Types in Maine Industry
(Job categories with 5 percent or more employment)

Job category	Percentage of total industry employment	Representative occupations
Construction	60.0%	Electricians, construction equipment engineers; first-line supervisors
Management	23.1%	Property managers; financial managers; construction managers
Installation and maintenance	6.8%	Telecommunications line installers; truck mechanics; heating, air conditioning, refrigeration mechanics and installers

Sources: See Appendix 4.

TABLE 2.20
Industrial Efficiency, Electric Grid Upgrades, Public Transportation Expansion/ Upgrades: Prevalent Job Types in Maine Industry
(Job categories with 5 percent or more employment)

Job category	Percentage of total industry employment	Representative occupations
Transportation and material moving	36.0%	Loading machine operators; bus drivers; vehicle cleaners
Construction	21.7%	First-line supervisors; construction laborers; carpenters
Management	12.1%	Marketing managers; computer and information systems managers; chief executives
Financial specialists	6.5%	Compliance officers; cost estimators; purchasing agents
Production	6.1%	Inspectors; machine tool setters; welding workers

Sources: See Appendix 4.

TABLE 2.21
Onshore Wind: Prevalent Job Types in Maine Industry
(Job categories with 5 percent or more employment)

Job category	Percentage of total industry employment	Representative occupations
Construction	48.9%	Electricians, construction equipment engineers; first-line supervisors
Management	21.8%	General managers; industrial production managers; construction managers
Installation and maintenance	5.6%	Telecommunications line installers, security and fire alarm installers; heavy vehicle technicians
Office and administrative support	5.6%	Office clerks; first-line supervisors; secretaries
Life, physical, and social science	5.3%	Science technicians; physical scientists; biological scientists

Sources: See Appendix 4.

Requirements for Generating Good-Quality Jobs

What is clear from the evidence we have reviewed is that: 1) large-scale job creation will certainly result in Maine through clean energy investments in the range of $2 billion per year, or 3 percent of average state GDP over 2021 – 2030; but that 2) these jobs will not necessarily be good jobs. As we have seen, average compensation varies widely in the various clean energy sectors, from roughly $30,000 to $60,000, depending on the sector. These figures are also low, in general, in comparison with standards elsewhere in New England. Meanwhile, union membership levels in the various sectors are mostly at 5 percent or less of total employment levels. These low unionization rates mean that there is not an entity in place that

TABLE 2.22
Solar/Offshore Wind/ Geothermal/ Land Restoration/Agriculture: Prevalent Job Types in Maine Industry
(Job categories with 5 percent or more employment)

Job category	Percentage of total industry employment	Representative occupations
Construction	34.0%	First-line supervisors; construction laborers; carpenters
Management	20.4%	Marketing managers; farmers; construction managers
Life, physical, and social science	10.6%	Physical scientists; biological scientists; conservation scientists and foresters
Farming, Fishing, and Forestry Occupations	7.8%	Logging workers; forest and conservation workers; agricultural workers
Office and administrative support	5.2%	First-line supervisors; bookkeeping clerks; data entry keyers

Sources: See Appendix 4.

will advocate strongly for high job-quality standards as clean energy employment levels in the state expand.

This is an important consideration, since an effective union presence and strong labor standards will be critical in determining whether the jobs created through clean energy investments in Maine will be good jobs. This becomes clear in comparing the respective experiences in the solar installation sectors in California and Arizona. The California sector operates within a framework of relatively strong unions and labor laws while these are both relatively weak in Arizona. A 2014 study by University of Utah economist Peter Phillips describes how these distinct institutional settings play out within the respective state-level solar installation labor markets. Phillips writes:

> Jobs building utility-scale solar electricity generating facilities are not inevitably good jobs paying decent wages and benefits and providing career training within construction. Under some labor market conditions, many solar farm jobs can be bad jobs paying low wages, with limited benefits or none at all, working for temporary labor agencies with no prospect for training, job rotation, or career development.
>
> In California, this low-road approach to utility-scale solar construction is uncommon for several reasons. First, when any federal funds are involved, the project is governed by federal prevailing wage regulations mandating that, for each occupation on the project, the wage in the local area that prevails for that occupation, based on Davis-Bacon surveys, must be paid.
>
> All states are covered by the federal Davis-Bacon Act, but in some states, such as Arizona, for some construction crafts, nonunion rates prevail in many counties, meaning that prevailing wage jobs can be paid low wages with limited benefits. In California, union strength has meant that in most cases on prevailing wage solar projects, workers will get paid good wages with good benefits. State right-to-work laws play a role in determining union strength. By undercutting union strength, Arizona's right-to-work law plays a role in determining the low-road practices found on

> some solar farm construction in that state. In contrast, California's resistance to right-to-work regulations reinforces federal Davis-Bacon wage mandates, thereby helping lead California's solar farm work along a high-road approach to construction.

In addition to the support for good clean energy industry jobs provided by unions and labor standards, it will also be critical that workers have access to high-quality training programs that will enable them to enter their new jobs with the skills they need to succeed. Without high-quality and accessible training opportunities, the likelihood increases that labor force quality standards will become compromised. Sam Appel of the Blue/Green Alliance of California has documented this problem in California's energy efficiency sector, writing as follows:

> Poor installation of energy efficiency (EE) measures is a pervasive problem in California, and nationally. Industry, government, and academic studies show that poor installation of EE measures often results in energy savings losses of up to 50 percent compared to projected savings goals. The California Energy Commission, for instance, reports that up to 85 percent of replacement HVAC systems are installed or designed incorrectly, resulting in substantial unrealized energy savings. Ratepayer-funded studies also find that lighting control systems installed by workers without lighting-control specific certification result in high rates of installations errors leading to lost savings.
>
> Poor workforce standards and insufficient training pipelines are the root cause of pervasive installation errors. California's Investor Owned Utilities (IOUs) confirm that workers installing ratepayer-subsidized HVAC systems rarely have the technical knowledge, skills, or abilities necessary to implement industry standards for HVAC quality installation and, as a result, there are "high failure rates for job performance on routine tasks." To paint a picture, less than half of HVAC technicians in California are even aware of basic national standards for work quality, according to studies conducted by California agencies.
>
> Without explicit workforce standard policies on the books … California EE program administrators have relied on code compliance, contractor licensing requirements, and safety and building permit requirements to ensure proper installation. These minimal, insufficient requirements lead to the proliferation of a low skill, low pay workforce.

The problems described by Appel with poor workforce standards and insufficient training pipelines in the California energy efficiency sector are also being reported by employers in the sector from their distinct perspectives. In Tables 2.23 and 2.24 below, we report on the results of a 2018 survey conducted by the U.S. Labor Department, in which, among other questions, employers in clean energy sectors were asked whether they faced difficulties in hiring new workers. We show the survey results in the three largest areas of clean energy employment to date in the U.S.—i.e. energy efficiency, in which 2018 employment was at 2.3 million; solar electricity, with 242,343 people employed; and wind electricity, with 111,166 people employed. We show the results for each clean energy sector broken out according to sub-sectors, including construction; professional/business services; manufacturing; wholesale trade, distribution and transport; utilities; and other services.

TABLE 2.23
Firms that Reported Hiring Difficulties in Solar, Wind, and Energy Efficiency Sectors

A) Energy Efficiency; 2018 Employment = 2.3 million

	2018 Employment level	Firms reporting hiring difficulties		
		Somewhat difficult	Very difficult	All firms reporting difficulties
Construction	1.30 million	32%	52%	84%
Professional/business services	484,481	21%	61%	82%
Manufacturing	321,581	14%	58%	72%
Wholesale trade, distribution, transport	180,339	24%	48%	72%
Other services	42,881	40%	36%	76%

B) Solar Electric Power; 2018 Employment 242,343

	2018 Employment level	Firms reporting hiring difficulties		
		Somewhat difficult	Very difficult	All firms reporting difficulties
Construction	177,320	54%	31%	85%
Professional/business services	48,142	57%	16%	73%
Manufacturing	46,539	60%	18%	78%
Other services	32,937	54%	23%	77%
Wholesale trade, distribution, transport	26,759	73%	6%	79%
Utilities	3,295	31%	31%	62%

C) Wind Electric Power; 2018 Employment 111,166

	2018 Employment level	Firms reporting hiring difficulties		
		Somewhat difficult	Very difficult	All firms reporting difficulties
Construction	36,706	58%	28%	86%
Professional/business services	27,058	66%	15%	81%
Manufacturing	26,490	53%	26%	79%
Wholesale trade, distribution, transport	11,783	77%	8%	85%
Utilities	6,231	50%	33%	83%
Other services	2,898	40%	33%	73%

Source: *The 2019 U.S. Energy & Employment Report* (https://www.usenergyjobs.org/).

TABLE 2.24
Summary Figures: All Firms Reporting Hiring Difficulties in Energy Efficiency, Solar Electricity, and Wind Electricity Sectors

	Energy efficiency	Solar electricity	Wind electricity
Construction	84%	85%	86%
Professional/business services	82%	73%	81%
Manufacturing	72%	78%	79%
Wholesale trade, distribution, transport	72%	77%	85%
Utilities	---	79%	83%
Other services	76%	62%	73%

Source: The 2019 U.S. Energy & Employment Report, (https://www.usenergyjobs.org/).

In the energy efficiency sector, the largest source of employment by far is in construction, with 1.3 million out of the total employment of 2.3 million—i.e. 56 percent of total energy efficiency investment. We see in Table 2.23 that fully 84 percent of employers reported difficulties in hiring workers, with 52 percent finding it "very difficult" to hire qualified workers.

The results are only moderately lower in the other sub-sectors within energy efficiency. Thus, manufacturing firms reported the lowest level of hiring difficulties, at 72 percent. As we see in Tables 2.23 B and C, as well as in the summary Table 2.24, these patterns are similar in the solar and wind electricity sectors and sub-sectors as well.

The survey further found that "lack of experience, training or technical skills" was the most important reason that employers were facing difficulties in hiring workers. The other, less significant factors were location and a relatively small applicant pool.

The study's conclusion from these survey results is that "The need for technical training and certifications was also frequently cited, implying the need for expanded investments in workforce training and closer coordination between employers and the workforce training system," (2019, p. 6).

It is clear therefore that high-quality and accessible workforce training programs need to be included as an important component of Maine's overall clean energy transition project. In Section 2.9, the policy section of the study, we discuss both the existing relevant training programs in Maine as well as initiatives elsewhere in the U.S. These discussions will provide a basis for considering approaches to expanding high-quality programs throughout the state as its clean energy investment projects grow.

Which Clean Energy Projects are "Shovel-Ready?"

Given the current recession conditions, it will be a challenge to move the full $2 billion into the state's investment spending stream within the first months of this program. Some activities will inevitably face delays. It is therefore important to take seriously issues around how best to time the launch of various components of the overall project. The point is to ensure that we maximize both their short-term stimulus benefits in addition to their longer-term impacts.

This means that we need to identify the subgroup of green investment projects that can realistically roll into action at scale within a matter of months. One good example would be to undertake energy efficiency retrofits of all public and commercial buildings. This would entail improving insulation, sealing window frames and doors, switching over all lightbulbs to LEDs, and replacing aging heating and air conditioning systems with efficient ones, preferably, where possible, with heat pumps. It is also critical that Maine's construction industry has been permitted to operate since early May within a framework of COVID-focused public health and safety guidelines.[56]

As we see in Table 2.12, the energy efficiency investment program will generate about 12 jobs per $1 million in expenditures within Maine. Thus, $360 million in energy efficiency investments included in the Table 2.13 calculations will generate about 4,000 jobs quickly within the state, for secretaries, truck drivers, and accountants as well as for construction workers. It is also capable of delivering immediate energy savings of about 30 percent and comparable levels of reduced emissions. Front-loading these projects with larger budgetary outlays will also increase job creation proportionally.

Building off this initial set of truly shovel-ready projects, a full clean energy investment project, at a spending level of about 3.2 percent of the state's GDP every year until 2030, can then be phased in as quickly as possible. The ramping up of the rest of the clean energy investment program will provide a strong overall boost to the economy in moving out of recession and into recovery.

2.9 Just Transition for Fossil Fuel and Biomass Industry Workers

As we have shown above, in order for Maine to bring total CO_2 emissions down from its 2017 level of 24.9 million tons to no more than 12.5 million tons by 2030, we have developed a 10-year program for reducing the consumption of oil, natural gas and biomass all by 50 percent as of 2030, and to eliminate coal consumption altogether from its current minimum consumption level in Maine. As we have seen, oil consumption in 2017 was at 185.7 T-BTUs in 2017, 47.4 percent of total statewide energy consumption, biomass was at 104.9 T-BTUs, 26.8 percent of total state consumption, natural gas was at 45.1 T-BTUs, 11.5 percent of total consumption, and coal was at 2.2 T-BTUs, 0.6 percent of statewide consumption.

The issue on which we focus in this section is what the impact will be on workers in industries in Maine that are dependent on statewide consumers continuing to purchase fossil fuel and biomass energy. We assume that production activity and employment in these industries will also decline by approximately 50 percent as of 2030.[57] In particular, we develop here a Just Transition program for the workers in these fossil fuel and biomass-related sectors who will face displacement as a result of the statewide contraction in the consumption of CO_2-producing energy sources.

All oil and gas consumed in Maine is imported. But of course, there are still a range of sectors that are active in the state that are engaged in delivering the state's supply of oil, natural gas and small amount of coal energy. The primary sectors include: wholesale marketing of petroleum and petroleum products; natural gas distribution; petroleum refining; fossil fuel electricity generation; as well as pipeline transportation and construction. There are also small oil and gas drilling and extraction operations in the state. These are in addition to the sector that generates electricity through burning biomass.

Our primary focus in this section is on the *direct* jobs that will be lost in Maine through the 50 percent contraction of the state's oil and gas-based and biomass electricity sectors, along with the full shut-down of its currently negligible coal-based activities. Our reasoning for focusing on the contraction of direct jobs is the same as we discussed above with respect to the job quality issues regarding clean energy investments in the state. That is, the direct jobs that will be lost in Maine through the 50 percent consumption cut in CO_2-generating energy sources are the jobs that are, at present, most closely associated with the state's fossil fuel-based and biomass electricity sector activities. The workers currently employed in these jobs will therefore be the ones that will be most in need of Just Transition support as Maine phases out these CO_2-generating activities. The jobs that will be lost through the indirect and induced channels will be more diffuse in their characteristics. A high proportion of the jobs lost through the indirect channels are likely to match up reasonably well with those in the clean energy economy, including in areas such as administration, clerical, professional services, and transportation services. The characteristics of the induced jobs created will simply reflect the overall characteristics of Maine's present-day workforce. The job losses that will result through the indirect and induced channels can therefore be appropriately managed through the same set of policies that are available to all workers in Maine who experience unemployment. We return to this issue below, after we first review here job figures and Just Transition policies as they apply to the direct jobs that will be lost.

Measuring Direct Employment Levels

In Table 2.25, we show employment levels for the 10 fossil fuel and ancillary industries in Maine as of 2018, along with the figures on electricity generation from biomass. As we see, there are, as of 2018, 1,420 people employed in the fossil fuel and ancillary industries in Maine. There are also 364 people employed in the biomass electricity generation sector. As we see, within the fossil fuel energy industry, two sectors are most significant, accounting between them for 56 percent of fossil fuel-based employment in Maine. These are wholesale marketing of petroleum and petroleum products (500 jobs--35 percent of all industry employment) and natural gas distribution (293 jobs—21 percent of all industry employment).

Biomass electricity production then accounts for another 364 jobs. If we therefore add all the fossil fuel-based and biomass electricity jobs, the total level of employment for CO_2-producing energy sources is 1,784, with fossil fuel-based jobs accounting for about 80 percent of the total and biomass electricity generation for the remaining 20 percent. As Table 2.25 shows, these 1,784 jobs in the fossil fuel and ancillary industry as well as biomass electricity generation were equal to 0.3 percent of the total employment in Maine as of 2018, at 673,150.

TABLE 2.25
Number of Workers in Maine Employed in Fossil Fuel-Based and Biomass Electricity Generation Industries, 2018

Industry	2018 Employment levels
Wholesale -petroleum and petroleum products	500
Natural gas distribution	293
Oil and gas extraction	167
Petroleum refining	162
Fossil fuel electric power generation	131
Pipeline transport	87
Drilling oil and gas wells	28
Pipeline construction	25
Support activities for oil/gas	18
Support activities for coal	9
Fossil fuel industry total	***1,420***
Biomass electricity generation	***364***
TOTAL: FOSSIL FUEL AND BIOMASS ELECTRICITY GENERATION	**1,784**
TOTAL FOSSIL FUEL AND BIOMASS EMPLOYMENT AS SHARE OF MAINE EMPLOYMENT *(Maine 2018 employment = 673,150)*	**0.3%**

Sources: IMPLAN, 3.0, U.S. Department of Labor. See Appendix 4.

Characteristics of Fossil Fuel-Based and Biomass Industry Jobs

Table 2.26 provides basic figures on the characteristics of the direct jobs in Maine for workers in fossil fuel-based sectors, and biomass electricity sectors. Focusing first on the fossil fuel-based jobs, we see that, on average, these are relatively high-paying jobs. The average overall compensation is $83,200, 50 percent higher than the $50,400 average compensation currently paid to workers in Maine's clean energy sectors.[58] As we also see, pay is much lower in the biomass sector, where the average pay is $44,600, roughly half the pay level for the fossil fuel industry-based jobs in Maine.

In terms of private health insurance coverage, both the fossil fuel industries as well as the biomass electricity generation are, for the most part, providing coverage for their workers. In the fossil fuel industry, 78 percent of workers have employer-based health insurance. The figure for the biomass sector is 84 percent. Overall, health insurance coverage is consistently much higher than is generally the case with the industries that would expand as a result of clean energy investments. As we saw in Table 2.17, the extent of health insurance coverage in the clean energy industries ranges between 35 – 49 percent.

Union membership is quite low, at only 6.2 percent for fossil fuel sector jobs. However, the figure is relatively high, at 20.8 percent, for workers in the biomass electricity sector.

Table 2.26 also reports figures on educational credential levels for workers in each of the industries, as well the percentages of non-white and female workers. With respect to educational credentials, the overall level of attainment is relatively high. With the fossil fuel-based sectors, roughly 40 percent of workers have Bachelor's degree or higher, and another 20 percent have some college or Associate degree. The remaining roughly 40 percent have high school degrees only or less. With the biomass sector, over half have Bachelor's degrees,

TABLE 2.26
Characteristics of Workers Employed in Fossil Fuel-Based Sectors and Biomass Electricity Generation in Maine
Figures are for 2018

	Fossil fuel-based industries	Biomass electricity generation
Average total compensation	$83,200	$44,600
Health insurance coverage	77.9%	84.0%
Retirement benefits	74.5%	65.6%
Union membership coverage	6.2%	20.8%
Educational credentials		
Share with high school degree or less	39.5%	24.5%
Share with some college or Associate degree	19.1%	21.6%
Share with Bachelor's degree or higher	41.4%	53.9%
Racial and gender composition of workforce		
Pct. non-white workers	0.3%	1.6%
Pct. female workers	36.1%	27.7%

Source: See Appendix 4.

with the remaining half divided fairly evenly between those with some college or Associate's degree, and those with high school degrees or less. Women account for a minority of the workforce in both the fossil fuel-based and biomass sectors, at 36 percent for fossil fuels and 28 percent for biomass. In terms of racial composition, basically the entire workforce for both fossil fuels and biomass is white.

In Table 2.27, we gain further detailed information on workforce and employment conditions for workers in Maine's fossil fuel-based and biomass electricity generation sectors.

TABLES 2.27
Prevalent Job Types in Maine's Fossil Fuel-Based and Biomass Electricity Sectors

A) Fossil Fuel-Based Sectors

Job category	Percentage of direct jobs lost	Representative occupations
Office and administrative support	19.5%	Billing clerks; shipping clerks; secretaries
Transportation	17.2%	Hoist operators; dredge machine operators; marine oilers
Architecture and engineering	14.9%	Electronic engineers, mechanical engineers, petroleum engineers
Computer and math specialists	14.0%	Computer network architects; software developers; computer system analysts
Production	12.8%	First-line supervisors; inspectors; plant and system operators; welding workers
Installation and maintenance	9.6%	First-line supervisors; control and valve installers; electrical power line repairers

B) Biomass Electricity Generation

Job category	Percentage of direct jobs lost	Representative occupations
Production	22.6%	Plant operators and dispatchers; inspectors; first-line supervisors
Office and administrative support	17.1%	Bookkeeping clerks; weighers; first-line supervisors; production clerks
Architecture and engineering	13.2%	Electronic engineers; surveyors; mechanical engineers
Management	12.9%	Chief executives; marketing managers; sales managers
Computer and math specialists	12.7%	Software developers; mathematical scientists; computer system analysts
Installation and maintenance	7.2%	Truck mechanics; electric power line installers and repairers
Financial specialists	5.4%	Budget analysts

Source: See Appendix 4.

For both the fossil fuel-based and biomass sectors, we show the most prevalent job categories and the representative occupations in each job category.

The key finding that emerges from these tables is that the fossil fuel and biomass-related industries in Maine provide a wide range of employment opportunities for the nearly 1,800 workers currently employed in these sectors. Thus, with fossil fuel-based sectors, as shown in panel A of Table 2.27, the largest share of jobs is in the area of office and administrative support, at 19.5 percent of all employment. But other job categories—including transportation, architecture/engineering, computer and math specialists, production workers, and installation/maintenance/repair workers each account for between 10 – 17 percent of total employment. In the biomass sector, shown in panel B of Table 2.27, about 23 percent of the workforce is in production, including plant operators and dispatchers, inspectors, and first-line supervisors. Beyond this, between 5 – 17 percent of the work force is spread out between office support, engineering, management, and computer technicians, installation/maintenance/repair and financial workers.

Overall, from the data presented in Table 2.27 for both the fossil fuel and biomass-based sectors, we see that there are a large number of jobs, probably a majority, that match up well with new types of employment that will be generated through clean energy investments in Maine, as well as expanded investments in public infrastructure. But that will not be the case with *all occupations* in which workers are now employed in Maine's fossil fuel-based and biomass electricity activities. As such, any Just Transition program to support displaced workers in Maine's fossil fuel and biomass-related industries will need to be focused on the specific background and skills of each of the impacted workers. We now turn to estimating the magnitude of this problem as Maine transitions out of CO_2-generating energy sources.

Features of a Just Transition Program

We present here a Just Transition program for workers who face job losses through direct channels from the 50 percent contraction of the state's fossil fuel-based and biomass electricity sectors. The program has three major elements. These are:

1. Guaranteeing the pensions for the workers in affected industries who will retire up until the year 2030;
2. Guaranteeing re-employment for workers facing displacement;
3. Providing income, retraining, and relocation support for workers facing displacement.

We describe each feature of this program in what follows, as well as provide estimates of the costs of effectively operating each measure within the overall program.

To translate these general principles of a Just Transition into specific policies, and to estimate the costs of providing these policies, we now examine a basic policy package. We present the provisions of this policy package in Table 2.28.

As we see in Table 2.28, the detailed policy package includes five components. These are:

1. Pension guarantees for retired workers who are covered by employer-financed pensions, starting at age 65;

TABLE 2.28
Policy Package for Displaced Workers in Maine's Fossil Fuel-Based and Biomass Electricity Sectors

Pension guarantees for workers (65+) voluntarily retiring	-Legal pension guarantees
Employment guarantee	--Jobs provided through clean energy and public infrastructure investment expansions
Wage insurance	--Displaced workers guaranteed 3 years of total compensation at levels in fossil fuel-based or biomass electricity jobs
Retraining support	--2 years of retraining, as needed
Relocation support	--$75,000 for one-half of displaced workers

2. Re-employment for displaced workers through an employment guarantee, with 100 percent wage insurance. With wage insurance, workers are guaranteed that their total compensation in their new job will be supplemented to reduce any losses relative to the compensation they received working in the fossil fuel or biomass-based industry;[59]
3. Retraining, as needed, to assist displaced workers to obtain the skills required for a new job, with 100 percent wage replacement while training;
4. Relocation support for 50 percent of displaced workers, assuming only 50 percent will need to relocate; and
5. Full Just Transition support for workers 65 and over who choose not to retire.

Steady versus Episodic Industry Contraction

We will provide further details and cost estimates for each of these measures within the overall policy package. But before moving into the discussion of these cost estimates, it is first necessary to understand how any such policy measures will be affected by the conditions under which the fossil fuel and biomass electricity industries contraction occurs in Maine. Specifically, the scope and cost of any set of Just Transition policies will depend substantially on whether the contraction is steady or episodic.

Under a pattern of steady contraction, there will be uniform annual employment losses between 2021 – 2030 in the affected industries. But it is not realistic to assume that the pattern of industry contraction will necessarily proceed at a steady rate. An alternative pattern would entail relatively large episodes of employment contraction, followed by periods in which no further employment losses are experienced. This type of pattern would occur if, for example, one or more relatively large firms were to undergo large-scale cutbacks at one point in time as the industry overall contracts, or even for such firms to shut down altogether.

The costs of a 10-year Just Transition will be much lower if the transition is able to proceed smoothly rather than through a series of episodes. One reason is that, under a smooth transition, the proportion of workers who will retire voluntarily in any given year will be substantially greater than if several large businesses were to shut down abruptly and lay off their full work force at a given point in time. Another factor is that it will be easier to find new jobs for displaced workers if the pool of displaced workers at any given time is smaller.

We proceed here by assuming that Maine will successfully implement a relatively smooth contraction of its fossil fuel and biomass energy sectors. As we will see, a smooth transition should be realistic as long as the state's policymakers remain focused on that goal.

Estimating Attrition by Retirement and Job Displacement Rates

In Table 2.29, we show figures on annual employment reductions in Maine's fossil fuel-based and biomass electricity sectors over 2021 – 30 that would result from a smooth 50 percent contraction in state-wide energy from these sources.[60]

We also then show the proportion of workers who will move into voluntary retirement at age 65 by 2030. Once we know the share of workers who will move into voluntary retirement at age 65, we can then estimate the number of workers who will be displaced through the 50 percent contraction in each of the relevant sectors. As described above, the Just Transition program will provide support for all displaced workers through a re-employment guarantee along with wage replacement, retraining, and relocation support.

All forms of Just Transition support will also be fully available to those workers 65 and over who choose to continue working. We therefore need to estimate how many workers 65 and older are likely to choose to remain employed. For the fossil fuel sector taken as a whole, we approximate that about 20 percent of workers who are 65 and over choose to continue

TABLE 2.29
Attrition by Retirement and Job Displacement for Fossil Fuel and Biomass Electricity Sector Workers in Maine

	1. Fossil fuel workers	2. Biomass electricity workers	TOTALS *(= columns 1 + 2)*
1) Total workforce as of 2018	1,420	364	1,784
2) Job losses over 10-year transition, 2021-2030	779	182	961
3) Average annual job loss over 10-year production decline *(= row 2/10)*	78	18	96
4) Number of workers reaching 65 over 2021-2030 *(=row 1 x % of workers 54 and over in 2019)*	667 *(47% of all workers)*	142 *(39% of all workers)*	809
5) Number of workers per year reaching 65 during 10-year transition period *(=row 4/10)*	67	14	81
6) Number of workers per year retiring voluntarily	53 *(80% of 65+ workers)*	11 *(80% of 65+ workers)*	64
7) Number of workers requiring re-employment *(= row 3 – row 6)*	25	7	32

Source: The 80 percent retirement rate for workers over 65 is derived from U.S. Bureau of Labor Statistics (BLS) (https://www.bls.gov/cps/cpsaat03.htm). According to these BLS data, 20 percent of 65+ year-olds remain in the workforce.

on their jobs.[61] We therefore assume that this same 20 percent of older workers will choose to continue working while the fossil fuel-based and biomass electricity sectors undergo their contractions between 2021 – 2030. Specifically, we incorporate into our calculations in Table 2.29 an estimate that, of the total number of workers reaching age 65 in any given year, 80 percent will retire voluntarily while 20 percent will choose to continue working.

We can see, step-by-step, how these various considerations come into play through the figures we show in Table 2.29. As we see in column 3 of Table 2.29, there were, as of the most recent 2018 figures, 1,784 workers in Maine employed in all fossil fuel-based and biomass electricity sectors. We assume these sectors will all contract by 50 percent between 2021 and 2030 on a steady basis, with the exception of coal. We assume all coal-related activities will contract by 100 percent between 2021 and 2030 on a steady basis. As we see in row 2 of the table, this means that total employment in these sectors will fall by 961 as of 2030, which means that there will be another 823 jobs retained. If we then assume that the contraction in the industry proceeds at a steady rate between 2021 – 2030, this means that 96 jobs in the industry will be lost each year, as we see in row 3 (i.e. 961 job losses in total/10 years of industry contraction = 96 job losses per year).

We see in row 4 that, of the workers presently employed in these sectors in Maine, 809, or 45 percent, will be between 55 – 65 over 2021 – 2030. If all these workers were to voluntarily retire at a steady rate over 2021 – 2030, this would mean that 81 workers will move into retirement every year over the 10-year period. However, we are assuming that only 80 percent of these workers will retire once they reach 65. That is, as we see in row 6, we estimate that 64 workers employed in these sectors will retire voluntarily every year between 2021 – 2030.

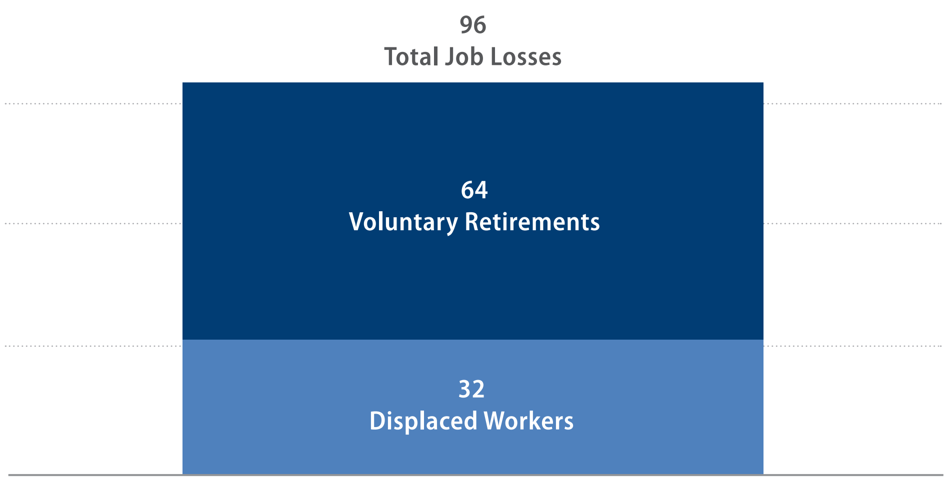
Given that total job losses each year will average 96 over the 2021 – 2030 period, that in turn means that the total number of workers currently employed in Maine's fossil fuel-based and biomass electricity sectors that will require re-employment will be 32 per year. We show this figure in row 7 of Table 2.29.

This is a critical result. The immediate point it establishes is that the Just Transition program will need to focus in two areas: 1) Guaranteeing the pensions for the 64 workers per year moving into voluntary retirement; and 2) Providing all the forms of re-employment support, including the re-employment guarantee, for the 32 workers per year facing displacement. Of course, these figures are not meant to be understood as precise estimates, but rather to provide broadly accurate magnitudes. Among other factors beyond what these figures themselves show, we again have to recognize that the pattern of contraction is not likely to be as smooth as is being assumed in our calculations.

Nevertheless, precise details aside, it is the overall finding that these results firmly establish that is most central: that the number of workers in Maine who are likely to experience job displacement through the state's transitioning away from CO_2-generating energy sources will be small—indeed, the number of workers facing displacement should be well below 100 people total per year, even allowing that our estimate of 32 workers per year may not be precisely accurate. Given that there are nearly 1,800 people employed presently in Maine's fossil fuel-based and biomass electricity sectors, we acknowledge that it may appear implausible that there should be only about 32 workers per year who would be displaced through a program to cut consumption from CO_2-generating energy sources by 50 percent as of 2030. But as we saw in Table 2.29, this finding is not due to any kind of unreasonable assumptions or incomprehensible mathematical manipulations.

In Figure 1, we illustrate the main results of our calculations in Table 2.29.

FIGURE 1: Estimated Annual Job Losses, Voluntary Retirements, and Workers Displaced in Maine's Fossil Fuel and Biomass Related Industries, 2021–2030



Source: See Table 2.29.

Cost Estimates for a Just Transition Program

Pension Guarantees for Retiring Workers

What becomes clear from the evidence on the steady rate of contraction for Maine's fossil fuel related industries is that guaranteeing workers' pension funds must be a centerpiece of the state's overall Just Transition program. This is especially important, given that the fossil fuel-based and biomass electricity business enterprises will likely face financial challenges as a result of the 50 percent contraction of the industry between 2021 – 2030. Under these circumstances, these firms may not consider their pension fund commitments to be a top financial priority. Despite this, guaranteeing workers' pensions as a first-tier financial obligation for employers can be established through regulatory policies. For example, the State of Maine could work in coordination with federal regulators, at the Pension Benefit Guarantee Corporation (PBGC) to place liens on company assets when pension funds are underfunded. Through such measures, the pension funds for most of the affected workers can be protected through regulatory intervention alone, without the government having to provide financial infusions to sustain the funds.[62]

Guaranteed re-employment

New employment opportunities will certainly open up in the expanding clean energy sectors, with approximately 11,000 new direct plus indirect jobs created per year in Maine through clean energy investments at the level of $2 billion per year (see Table 2.16).[63] The new state clean energy projects are likely to be financed at least partially through public-sector funding.

Given such public sector funding, the state could require job preference provisions for the displaced workers. Again, our estimate of the number of displaced workers that will need re-employment is 32 workers total. It will not be difficult for the state to set aside 32 guaranteed jobs for these displaced workers, or, for that matter, even, say, 320 jobs, as needed for this purpose. As we will discuss in the next section of this study, an additional 7,300 new jobs per year will likely be created through $500 million annual spending on public infrastructure projects in Maine. Here again, the state could easily set aside 32 jobs per year on average for displaced workers from the state's fossil fuel-based and biomass energy sectors.

Income Support through Wage Insurance

Though it will not be difficult to find new employment opportunities for the 32 fossil fuel-based and biomass electricity workers that will be displaced annually on average, there is a high likelihood that, for workers currently employed in the fossil fuel-based industries and re-employed in clean energy activities, their new jobs will be at lower pay levels than their previous jobs. As we have seen, the average compensation for fossil fuel-based workers in Maine at present is $83,600. This compares with the average compensation in the clean energy areas, ranging, as we saw in Table 2.17, between about $30,000 – $60,000 per year in the various specific sectors. It will therefore be necessary for the fossil fuel-based sector workers to be provided with wage insurance so that they experience no income losses in their transition from fossil fuel industry jobs into new positions. As an average, this will not be an issue for displaced workers coming from the biomass electricity sector, with the average compensation level there being about $45,000, i.e. lower than most of the sectors in the clean energy economy.

To provide some initial specifics on the costs of providing wage insurance for displaced workers who move into jobs at lower pay levels, we propose that all displaced workers facing pay cuts receive 100 percent compensation insurance for three years. That is, they will be paid the full difference between any disparities in the compensation they receive in their new jobs relative to what they received in their previous jobs in the fossil fuel or ancillary industries.

The data in Table 2.30 presents a framework for calculating a rough estimate as to what the costs would be for such a compensation insurance program. In row 1, the table shows the figures we have seen in Table 2.29 on the number of displaced workers in the fossil fuel-based sectors—i.e. 25 workers per year. Row 2 then shows their average compensation level of $83,200. In row 3, we show the mean compensation level for Maine's clean energy sectors, as reported in Table 2.17, which is $50,400. From this difference in average compensation levels, we then calculate that the annual cost of compensation insurance for 25 workers will be about $820,000.

Retraining Support

As we have seen above (Tables 2.18-2.22), the range of new jobs that are being generated through clean energy investments vary widely in terms of their formal educational credentials as well as special skill requirements. Some of the jobs will require skills closely aligned with those that the displaced workers used in their former fossil fuel and biomass electricity sector jobs. These include a high percentage of construction-related jobs for efficiency investments as well as most management, administrative and transportation-related positions

TABLE 2.30
Estimating Costs of 100 Percent Compensation Insurance for Displaced Workers in Maine's Fossil Fuel-Based Sectors

1. Number of fossil fuel-based displaced workers per year requiring re-employment	25
2. Average compensation for displaced workers	$83,200
3. Average compensation for clean energy sector jobs	$50,400
4. Average compensation difference between fossil fuel-based and clean energy jobs *(= row 2 – row 3)*	$32,800
5. Annual cost of compensation insurance for 25 workers *(= row 4 x row 1)*	$820,000
6. Total cost of compensation insurance for 3 years *(= row 5 x 3)*	$2.5 million

Source: See Tables 2.17, 2.26, and 2.29.

throughout the clean energy industries. In other cases, new skills will have to be acquired to be effective at the clean energy industry jobs. For example, installing solar panels is quite distinct from laying oil and gas pipelines. This is why a Just Transition program must include a provision for retraining for the displaced fossil fuel and biomass electricity sector workers. The Just Transition program will also need to serve as a job placement clearinghouse for all displaced workers.

There will be two components of this job retraining program for displaced workers. The first will be to finance the actual training programs themselves. We can estimate this with reference to the overall costs of providing community college education. An upper-end figure for annual non-housing costs for community college in Maine is around $4,000.[64] We then also allow an additional $2,000 per year per worker to cover other expenses during their training program, such as purchases of textbooks and equipment. We assume that workers would require the equivalent of two full years of training, which they would most likely spread out on a part-time basis, as they move into their guaranteed jobs. By this measure, the average annual costs of the training program for 32 workers would be about $192,000.

Relocation Support

Some of the displaced workers will need to be relocated to begin their new jobs. For the purposes of our discussion, we assume that one-half of the 32 displaced workers per year will need relocation allowances, at an average of $75,000 per displaced worker.[65] That would bring the annual relocation budget to about $1,200,000, for 16 workers each year.

Overall Costs for Supporting Displaced Workers

In Table 2.31, we show estimates of the full costs of providing this set of wage insurance, retraining and relocation support for 32 workers per year. As Table 2.31 shows, the total

TABLE 2.31

Total and Annual Average Costs for Just Transition Support for Displaced Fossil Fuel-Based and Biomass Electricity Workers in Maine, 2021 – 2030

Year	Income support *(3 years of support for 25 workers)*	Retraining support *(2 years of support for 32 workers)*	Relocation support *(1 year of support for 16 workers)*	Total *(cols. 1+2+3)*
2021	$820,000 (1 cohort)	$192,000 (1 cohort)	$1.2 million	$2.21 million
2022	$1.64 million (2 cohorts)	$384,000 (2 cohorts)	$1.2 million	$3.22 million
2023	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2024	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2025	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2026	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2027	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2028	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2029	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2030	$2.46 million (3 cohorts)	$384,000 (2 cohorts)	$1.2 million	$4.04 million
2031	$1.64 million (2 cohorts)	$192,000 (1 cohort)		$1.83 million
2032	$820,000 (1 cohort)			$820,000
Total	**$24.6 million**	**$3.8 million**	**$12.0 million**	**$40.4 million**
Average annual costs	**$2.1 million** *(12 years of support)*	**$349,000** *(11 years of support)*	**$1.2 million** *(10 years of support)*	**$3.6 million**

Source: Tables 2.28 – 2.30.

level of annual spending will vary, depending largely on the number of cohorts of displaced workers that are receiving Just Transition benefits.

For example, in 2021, the first cohort of 32 displaced workers will receive support through the Just Transition program, including wage insurance, retraining and relocation support, as needed. As we can see in column 4, these full costs will amount to $2.2 million in 2021. Costs increase in 2022, since we now have two cohorts of displaced workers receiving income and retraining support, as well as one cohort receiving relocation support. Thus, total costs in 2022 rise to $3.22 million. In 2023, there are now three cohorts of displaced workers receiving income support, along with 2 cohorts receiving retraining support and, again, one cohort receiving relocation support. This totals to $4.04 million, the figure that then prevails through 2030. In 2031 and 2032, with smaller cohorts eligible for income and retraining support, and no further cohorts receiving relocation support, the costs of the program fall correspondingly, to $1.8 million, then to $820,000.

In total, Just Transition benefits provided to 32 displaced workers per year in Maine will total to $40.4 million, or an average of $3.4 million per year over 12 years, in total costs and about $126,000 per worker.

Transitional Support for Workers Facing Indirect and Induced Job Losses

In Table 2.32, we present figures on the indirect and induced job losses that would result in Maine through the 50 percent contraction of the state's CO_2-generating energy industries. We used the same method for estimating these figures as we had with the direct job losses, as presented in Table 2.29. As we see in Table 2.32, we estimate that, over 2021 – 2030, about 2,500 indirect and induced jobs will be lost in the state through the 50 percent contraction in CO_2-generating energy activities. This amounts to about 250 job losses per year over the decade. But since, from demographic data, we also estimate that voluntary retirements in these employment categories will average about 125 jobs per year, that means that average annual job displacements will amount to 126 per year. As Table 2.32 shows, this figure is equal to about 0.01 percent of the 14,582 clean energy jobs that will be created in 2021 in Maine between the clean energy investment program we have outlined, with that job creation figure growing each year through 2030 if we assume that the Maine economy expands at about 1.5 percent per year.

It should not be a challenge, either administratively or financially, to provide transition support for such a small number of workers facing displacement through indirect and induced job channels. This is especially the case because, on balance, there should be no jobs lost in Maine through the induced employment channel after we take account of the Just Transition program for workers who experience displacement through the direct employ-

TABLE 2.32
Indirect and Induced Job Losses through 50 percent Contraction of Maine's Oil, Gas and Biomass Electricity Industries, 2021 – 2030

1. Indirect job losses: contraction in fossil fuel-based and biomass electricity industry supply chains	1,533
2. Induced job losses: job contraction in overall Maine economy	975
3. Total indirect + induced job losses *(= rows 1 + 2)*	2,508
4. Average annual indirect + induced job losses *(= row 3/10)*	251
5. Voluntary retirements per year	125
6. Total job displacements per year *(= row 4 – 5)*	126
7. Total job displacements as share of clean energy job creation	0.01% *(= 126 indirect + induced jobs displaced/14,582 clean energy jobs created)*

Sources: IMPLAN 3.0 database; Table 2.29.

ment channel. This is because, as we have described above, induced employment effects refer to the expansion of employment that results when people in any given industry—such as clean energy or fossil fuels—spend money and buy products. This increases overall demand in the economy, which means more people are hired into jobs to meet this increased demand. It follows that the loss of incomes through a contraction of employment will create a reverse induced employment effect. People will have less money to spend, overall demand for goods and services will contract, and therefore the demand for employees will decline correspondingly. However, our proposed Just Transition program provides that workers facing displacement through the direct jobs channel will be guaranteed re-employment at a compensation level equal to what they were earning before they became displaced. It follows that implementing the Just Transition program will mean that there will also be no reverse induced employment effects in Maine even as the fossil fuel-based and biomass electricity industries themselves contract.

2.10 Achieving Net Zero CO_2 Emissions by 2050

If Maine is able to bring overall CO_2 emissions in the state down to 12.4 million tons by 2030—a 50 percent decline relative to the 2017 level of 24.9 million tons—it should also be able to achieve a 90 percent emissions reduction by 2050. CO_2 emissions in Maine would then be 2.5 million tons as of 2050.

As we have discussed above, Maine's forests absorb about 10 million tons of CO2 per year through their natural growth cycle. This means that the state will have clearly become a net zero economy by 2050 if it brings down its annual statewide emissions level to 2.5 million tons. Moreover, with CO_2 emissions in Maine at 2.5 million tons as of 2050, Maine will then be capable of also absorbing CO_2 generated in other states, becoming a carbon sink for the U.S. economy overall. This will support the achievement in the U.S. overall of a net zero emissions threshold by 2050.

Maine should be able to bring down its emissions level to 2.5 million tons by 2050 basically through continuing the clean energy investment project that would have proceeded from 2021 – 2030. Moreover, on an annual basis, the scale of the investments in energy efficiency and clean renewable energy between 2031 – 2050 that will be needed to reach a 90 percent emissions reduction by 2050 should be significantly more modest than what we have described above for the project through 2030.

As we saw in Table 2.11, our estimate of the clean energy investment costs for bringing emissions down to 12.4 million tons by 2030 was about 3.2 percent of Maine's GDP per year between 2021 – 2030. Over 2031 – 50, as we will see, we estimate that the average annual clean energy investment costs necessary to bring emissions down to 2.5 million tons to be about 1.4 percent of Maine's average GDP. The impact of the investment project on job opportunities throughout the state are therefore likely to also be more modest than during 2021 – 2030, though still strongly in the positive direction.

This study certainly does not attempt to develop a full assessment as to the technical feasibility of achieving a 90 percent emissions reduction in Maine by 2050. However, many researchers, focused on different regions and countries, have concluded that conversion to an economy relying on clean renewable sources to meet 100 percent of energy demand is technically feasible within a few decades or less. One important study reaching this conclusion is by the Harvard University physicist Mara Prentiss. Prentiss concludes in her 2015 book, *Energy Revolution: The Physics and the Promise of Efficient Technology,* that "Electricity generated by renewable energy can easily provide 100 percent of the average energy consumption of the United States during those next 50 years, virtually eliminating the negative environmental consequences associated with fossil fuel consumption," (2015, p. 304).[66]

Within a framework that recognizes the technical feasibility of bringing CO_2 emissions down by 90 percent in Maine by 2050, our focus here is to assess the economic trajectory of how this goal can be accomplished while the state's economy and job opportunities continue to grow. Of course, considering how such a trajectory is likely to proceed entails making a series of assumptions about the economy's long-term growth path. This exercise necessarily becomes increasingly speculative the further out one moves in time. To keep our discussion as realistic as possible, we rely on a small number of assumptions that are credible within the body of knowledge that is available to us at present.

The assumptions on which we will rely are as follows:

1. *Economic growth.* We assume that economic growth in Maine proceeds at basically the same rate as we have assumed for 2021 – 2030, i.e. at 1.5 percent per year.
2. *Energy efficiency.* We have already assumed that Maine will have achieved major gains in energy efficiency between 2021 – 2030, specifically that the state's energy intensity ratio will have fallen from 6.5 to 4.0 Q-BTUs per $1 trillion of GDP—a 38 percent improvement. We assume that further efficiency gains are possible through continued investments, and that the costs of achieving these efficiency gains will remain at $35 billion per Q-BTU, the same cost figure for our 2021 – 2030 scenario. We make this assumption of stable overall costs, based on two ideas: 1) technological improvements will occur in raising efficiency standards; but 2) the "low-hanging fruit" possibilities for efficiency gains will have dissipated. We assume that these two factors will roughly counteract each other.
3. *Clean renewable energy.* Technological advances in generating, storing and transmitting renewable energy will certainly occur between 2031 – 2050, especially given that these industries will have scaled up dramatically over 2021 – 2030. But to proceed cautiously, we assume only a modest rate of average technological improvement for renewables overall—that the average costs of creating 1 Q-BTU of renewable capacity falls at an average rate of 1 percent per year between 2031 – 2050. This means, specifically, that average costs for expanding renewable energy supply will fall from the 2030 level of $225 billion per Q-BTU to $203 billion.
4. *Job creation.* We assume that labor productivity in all clean energy investment activity improves at an average annual rate of 1 percent per year. These gains in productivity will proceed concurrent with the 1.5 percent average annual GDP growth rate. As such, the net increase in employment will be 0.5 percent per year.

Working from these assumptions on 1) economic growth; 2) the costs of achieving energy efficiency gains and an expanded clean renewable energy supply; and 3) labor productivity, we then develop projections as to how Maine's economy would advance toward bringing CO_2 emissions down to 2.5 million tons by 2050. We present these results in Tables 2.33 – 2.38.

In Table 2.33, we show Maine's GDP projection for 2050 based on a 1.5 percent average annual growth rate for 2031 – 2050. This growth path begins at the 2030 GDP baseline of $74 billion. This figure is itself a projection, of course, which we derived through assuming that Maine's GDP would grow at an average annual rate of 1.5 percent between 2017 – 2030, starting from the 2017 actual GDP level of $60 billion. Based on these assumptions, as we see in Table 2.33, Maine's GDP will be $100 billion in 2050. We then calculate the midpoint GDP level between 2031 – 2050 under this scenario. As we see, this midpoint figure is $87 billion.

In Table 2.34, we then estimate the investment costs necessary to bring Maine's energy intensity ratio down from the 2030 figure of 4.0 to 2.5 Q-BTUs of energy/$1 trillion in GDP. We had projected in Table 2.10 that Maine would be at the 4.0 intensity ratio by 2030 under the clean energy investment program we outlined for 2021 – 2030. Table 2.34 shows that to arrive at a 2.5 energy intensity ratio by 2050 will require $5.3 billion in new energy efficiency investments between 2031 – 2050 under the 1.5 percent growth scenario. Con-

TABLE 2.33

Maine Average Economic Growth Projection for 2031 – 2050

Assumption is 1.5% average GDP growth

Projected 2030 GDP level *from Table 2.9*	$74 billion
Projected 2050 GDP level	$100 billion
Midpoint GDP level for investment spending estimates *(= (2030 GDP + 2050 GDP)/2)*	$87 billion

Source: See Table 2.9; authors' calculations

TABLE 2.34

Energy Efficiency Investments Needed to Bring Maine Energy Intensity Ratio to 2.5 by 2050

Energy Intensity Ratio = Q-BTUs of energy/GDP in trillions of dollars1.5% average GDP growth

1) 2050 GDP assumption *from Table 2.33*	$100 billion
2) Total 2050 energy consumption at 4.0 energy intensity ratio *(=4.0 x $100 billion)*	400 T-BTUs
3) Total energy consumption at 2.5 energy intensity ratio *(=2.5 x $100 billion)*	250 T-BTUs
4) Gains in energy efficiency through 2031 – 2050 efficiency investments *(= rows 2 – 3)*	150 T-BTUs
5) Costs of achieving energy efficiency gains *(= row 4 x $35 billion/Q-BTU from Table 2.11)*	$5.3 billion
6) Costs per year over 20-year investment cycle *(row 5/20)*	$265 million/year

Sources: Tables 2.11 and 2.33 and authors' projections.

sidered on an annual basis, these total costs amount to an average of $265 million per year under the 1.5 percent growth scenario.

In Table 2.35, we perform a comparable set of calculations for clean renewable energy investments between 2031 – 2050. We begin these calculations with the assumption of a 2.5 energy intensity ratio for 2050. This then entails that, in 2050, overall energy consumption in Maine will be at 250 T-BTUs. We then see in row 2 of Table 2.35 that petroleum consumption in 2050 will be at 36 T-BTUs, the maximum amount that can be consumed while maintaining overall statewide CO_2 emissions at 2.5 million tons. Petroleum will continue to be used modestly in 2050 to provide liquid fuel. Both biomass and natural gas will have been supplanted entirely by clean renewable sources for generating electricity. Burning 36 T-BTUs of petroleum will then produce 2.5 million tons of CO_2—this then being the sole source of CO_2 emissions in Maine as of 2050.

TABLE 2.35
Clean Renewable Energy Investments Needed to Reach 90 percent Emissions Reduction by 2050
(= CO_2 emissions at 2.5 million tons)

1) 2050 Energy consumption level with 2.5 energy intensity ratio *from Table 2.34*	250 T-BTUs
2) Petroleum consumption	36 T-BTUs
3) CO_2 emissions generated by petroleum consumption *from Table 2.6*	2.5 million tons *(36 T-BTUs x 70 tons/Q-BTUs of emissions)*
4) Total clean renewable energy supply required *(= row 1 – 2)*	214 T-BTUs
5) Clean renewable energy supply as of 2030 *from Table 2.11*	120 T-BTUs
6) Renewable energy expansion needed by 2050 *(= rows 4–5)*	94 T-BTUs
7) Midpoint cost per Q-BTU of expanding clean renewable supply *assumes average costs decline at 1% per year relative to 2030*	$203 billion per Q-BTU
8) Total costs of reaching 94 T-BTUs in renewable supply *(= rows 6 x 7)*	$19.1 billion
9) Average annual costs over 20-year investment cycle *(= row 8/20)*	$954 million

Sources: Tables 2.6, 2.11 and 2.34 and authors' projections..

In Table 2.11, we derived that, as of 2030, total energy supplied by clean renewable sources would be at 123 T-BTUs through the clean energy investment project from 2021 – 2030 (we round down to 120 T-BTUs for these further calculations). From this baseline figure, we can derive that the expansion of clean renewable capacity will need to be at 94 T-BTUs. As we see in rows 6 – 9 of Table 2.35, achieving this higher level of productive capacity in clean renewables will require a level of investment averaging $954 million per year.

In Table 2.36, we then summarize these results for bringing Maine's total CO_2 emissions to 2.5 million tons as of 2050. As we see, we estimate these overall costs to be $24.4 billion, which averages to $1.2 billion per year over 2031 – 2050. As a share of Maine's projected midpoint GDP over 2031 – 2050, these annual cost figures would amount to 1.4 percent of GDP. As mentioned above, these figures are significantly below the cost level we have estimated for the initial 2021 – 2030 investment period that would be necessary to bring Maine's CO_2 emissions down to 12.4 million tons by 2030. We estimate these costs to amount to about 3.1 percent of the state's average GDP.

Employment Creation through 2031 – 2050 Investment Project

In Table 2.37, we provide rough estimates as to the level of employment creation that would be generated by the clean energy investment levels necessary to bring Maine's CO_2 emissions down to 2.5 million tons by 2050. We have estimated these employment figures based on two assumptions: 1) the overall clean energy investment spending levels for 2031 – 50 as a

TABLE 2.36
Overall Estimated Costs of Achieving 90 Percent Emissions Reduction in Maine by 2050

1) Total energy efficiency investment costs *from Table 2.34*	$5.3 billion
2) Total renewable energy investment costs *from Table 2.35*	$19.1 billion
3) Total clean energy investment costs *(= rows 1 + 2)*	$24.4 billion
4) Average annual costs per year for 20-year investment cycle *(= row 3/20)*	$1.2 billion
5) Average annual costs per year as percentage of midpoint GDP *(= row 4/Table 2.33 figure)*	1.4 percent

Sources: See Tables 2.33, 2.34 and 2.35.

TABLE 2.37
Average Annual Maine Employment Creation through Clean Energy Investments, 2031 – 2050

1) Estimated job creation through 2030 clean energy investments (rounded) *from Table 2.16*	15,000
2) Approximate average annual investment spending as pct. of 2030 spending *from Tables 2.11 and 2.36*	50% *(= 1.4% of GDP/3.1% of GDP)*
3) 2031 Employment creation	7,500 *(= row 1 x .5)*
4) 2050 Employment creation *(with 1% productivity and 1.5% GDP growth on average annual basis)*	8,300

Sources: Tables 2.11, 2.16 and 2.36.

proportion of the 2021 – 2030 spending level; and 2) our assumption of a 1 percent average annual increase in labor productivity in these clean energy investment projects, while clean energy investments increase at the same rate as GDP growth, i.e. at 1.5 percent per year.

We saw in Table 2.16 that, for 2030, our estimate of total employment—direct, indirect and induced employment—through clean energy investments at $14.5 billion would be close to 15,000 jobs. This rounded figure of 15,000 jobs is repeated in row 1 of Table 2.37. In row 2, we then calculate average annual clean energy investment spending for 2031 – 2050 as a share of 2030 spending—that is, roughly 50 percent (i.e. 1.4 percent GDP in 2031 - 2050/3.1 percent of GDP for 2021 – 2030). From this figure, as we see in row 3, we estimate total employment through clean energy investments in 2031 as being 7,500. With a 1 percent average rate of labor productivity growth through 2050 combined with a 1.5 percent growth in annual clean energy investments, we then estimate that job creation will be at 8,300 as of 2050.

Just Transition Program

In Table 2.38, we provide estimates for the Just Transition program for 2031 – 2050. The figures we present in Table 2.38 are derived from the material we have developed for the 2021 – 2030 period in section 2.9 of this paper, including in Tables 2.29 and 2.30.

With the 2021 – 2030 analysis, we reported in Table 2.25 that a total of 1,784 workers were employed in Maine as of 2017 at jobs in either fossil fuel-based or biomass electricity sectors. In Table 2.29, we provide the estimate that by 2030, a total of 961 of these jobs, equal to 54 percent of the jobs, will be lost. This results from our assumption that oil, biomass, and natural gas consumption will all decline in Maine by 50 percent as of 2030 and coal will have been phased out entirely. These cuts in consumption will then correspond to equivalent cuts in production activity and employment levels. This result also implies that, as of 2030, 823 jobs will remain in these industries across Maine (=1,784 - 961).

Starting from the goal that Maine is going to achieve a 90 percent emissions reduction between 2017 and 2050, bringing total statewide emissions down from 24.9 to 2.5 million tons over these years, this also implies that emissions will need to fall by 80 percent between 2030 and 2050. This follows from our result that emissions will be at 12.5 million tons as of 2030. The emissions decline from 12.5 million tons in 2030 to 2.5 million tons in 2050 is an 80 percent decline.

TABLE 2.38

Costs of Just Transition Program for Displaced Workersin Fossil Fuel and Biomass Electricity Sectors: *2031 – 2050 Scenario*

	1. Fossil fuel workers	2. Biomass electricity workers	TOTALS *(= columns 1 + 2)*
1) Projected number of workers employed in fossil fuel and biomass electricity industries in 2030	641	182	823
2) Employment contraction, 2031 – 2050 *(80% contraction)*	513	146	659
3) Average employment contraction per year *(= row 2/20)*	26	8	34
4) Projected number of workers reaching retirement between 2031 – 2050 *(workers 45 years and over in 2031)*	224 *(35% of all workers)*	101 *(56% of all workers)*	325
5) Average annual attrition through voluntary retirement *(= row 4 x 80%/20)*	8	4	12
6) Average number of workers displaced annually, 2031 – 2050 *(= row 3 – row 5)*	18	4	22
7) Annual costs of 100% compensation insurance, retraining and relocation support	$2.4 million *[(= row 6 x $148,000x 20 cohorts)/22 years JT program duration]*	$180,000 *[(= row 6 x $50,000x 20 cohorts)/22 years JT program duration]*	$2.6 million

Sources: Projections based on figures from Tables 2.29 and 2.31.

That in turns means that employment in Maine's fossil fuel industries will also fall by 80 percent between 2030 and 2050—from 823 to 164. Of the 823 workers employed in these jobs as of 2030, we assume that roughly 40 percent will reach retirement age at 65 between 2031 – 2050 and that 260 of them—80 percent—will retire. With the average annual rate of job contraction being 34 jobs while the average rate of attrition though retirements at 12 jobs per year, this means that the average number of workers who will face displacement over 2031 – 2050 will be 22. We show this in row 6 of Table 2.38. These 22 workers will all need to receive the full package of Just Transition support that we described in Section 2.9 for the period 2021 – 2030. This includes 100 percent compensation insurance when these displaced workers move into their guaranteed new jobs; as well as both retraining and relocation support. This level of support would then imply an overall cost for Just Transition support for displaced workers in Maine at $2.6 million per year. The average costs will be much higher for fossil fuel workers, at $148,000 per worker versus $50,000 for the biomass electricity workers. The difference in costs is due to the fact that, as we saw above, wages in the biomass electricity sector, at $45,000, are lower than our benchmark wage figure from the clean energy sectors, at $50,400. As such, when the displaced biomass sector workers move into their guaranteed jobs in the clean energy sectors, they will not have to be paid compensation insurance. Indeed, on average, they will receive a substantial raise through moving into the clean energy economy, without the need for any form of wage subsidy.

2.11 Upgrading Maine's Public Infrastructure

Maine's economy would receive a major boost, both in terms of short-run stimulus and longer-term productivity, by undertaking a large-scale public infrastructure investment program now. This becomes clear from considering the findings of the American Society of Civil Engineers (ASCE) in its 2016 assessment on Maine's infrastructure, its most recent such report on Maine. The ASCE gave Maine's infrastructure an overall grade of C- as of 2016. The ASCE's analysis identifies major problems in all areas of Maine's infrastructure. The grades the ASCE has assigned to individual areas of infrastructure range between D and B-. We show the ASCE's individual sectoral assessments in Table 2.39. We also note that Maine has not undertaken public infrastructure investments since 2016 that would likely improve the ASCE's assessment as of 2016.

The ASCE also evaluated the quality of the public infrastructure for the U.S. overall in 2013 and 2017.[67] In both years, the ASCE gave the U.S. an overall grade of D+. Their assessment for Maine is therefore modestly more favorable—or more precisely, modestly less unfavorable—than that for the country overall. The ASCE also estimated that the overall costs of bringing the U.S. infrastructure to a B level of quality would require about $2 trillion in investment spending over a decade, or about $200 billion per year for 10 years.

Maine accounts for about 0.3 percent of U.S. GDP. As such, the state's share of the ASCE's overall U.S. investment program would amount to about $600 million if funding

TABLE 2.39
American Society of Civil Engineers Grades Individual Sector of Maine's Public Infrastructure
Grades are for 2016

Aviation	C+
Bridges	C-
Dams	D+
Drinking water	C+
Education	C
Energy/electricity	B-
Ports	B-
Levees	D
Parks	C+
Rail	C
Roads	D
Solid waste	C-
Public transit	D+
Wastewater	D+

Source: American Society of Civil Engineers (https://www.infrastructurereportcard.org/state-item/maine/).

were allocated on the basis of each state's relative GDP levels. However, because the ASCE assesses Maine's infrastructure quality level as being modestly better than the U.S. overall, we assume that the budget requirements for upgrading to a B level of infrastructure quality in Maine will be $500 million per year between 2021 – 2030 as opposed to $600 million.

In terms of allocating the annual $500 million investment budget into the individual infrastructure sectors, we mainly follow the proportions set out by the BlueGreen Alliance in its 2017 study, *Making the Grade 2.0*. We then make some small adjustments to the BlueGreen Alliance spending proportions to incorporate three additional infrastructure investment areas, these being: 1) expanding broadband access, in support of achieving universal broadband access throughout Maine; 2) fixing leaking gas pipes; and 3) increasing the supply of affordable public housing.[68] We also give additional funding in the area of inland waterways/ports/fisheries, to reflect the importance of both the commercial and recreational fishing industries in Maine.

In Table 2.40, we present estimates as to the level of job creation that would result through $500 million in annual public infrastructure investments between 2021 – 2030 in the areas listed, and at the funding levels presented, in Table 2.40. As with the figures on clean energy investments, we report figures for direct, indirect and induced jobs generated by the infrastructure investments, as well as the total figures for job creation, for each sector as well as for the overall $500 million annual investment project.

TABLE 2.40
Job Creation in Maine through $500 Million/Year Public Infrastructure Investment Program

	Job creation per $1 million in spending				Job creation at $500 million in spending		
	1.Direct jobs	2.Indirect jobs	3.Induced jobs	4. Total job creation *(= columns 1+2+ 3)*	5. Budget per investment area	6. Direct and indirect job creation per year *(= (columns 1 + 2) x 5)*	7) Total job creation per year *(= columns 4 x 5)*
Surface transportation					$225 million	2,858	3,532
Schools	13.9	1.9	4.3	20.2	$75 million	1,185	1,515
Broadband	2.7	2.6	1.6	6.9	$37.5 million	199	259
Gas distribution pipelines—leak repairs only	1.6	2.3	1.7	5.6	$30 million	117	168
Water/wastewater	6.5	2.3	2.8	11.6	$25 million	220	290
Dams and levees	9.5	2.3	4.0	15.8	$25 million	295	395
Parks and recreation	13.0	2.9	3.9	19.8	$25 million	398	495
Public housing	11.0	2.1	4.2	17.3	$20 million	262	346
Inland waterways/ports/fisheries	3.5	2.2	1.8	7.5	$15 million	86	112
Railroads	3.3	1.7	2.0	7.0	$10 million	50	70
Airports	3.5	1.1	1.8	6.4	$10 million	46	64
Hazardous and solid waste	7.7	2.8	3.4	13.9	$3.5 million	37	48
					$500 million	**5,753**	**7,294**

Source: IMPLAN 3.0 database.

As Table 2.40 shows, overall, we estimate that $500 million in annual infrastructure investments in Maine between 2021 and 2030 will generate about 5,800 direct and indirect jobs within the state, and about 7,300 jobs in total if we include the induced job creation channel. As with the clean energy jobs, some of these projects cannot be expected to be undertaken immediately—i.e. they are not "shovel-ready" projects capable of providing a short-term boost to counteract the present slump. At the same time, some of the infrastructure investments are shovel-ready or close to being so. These include road and bridge repairs; maintenance and repair work at airports, schools, water and gas distribution pipelines; much of the spending to upgrade inland waterways, ports and fisheries, as well as overall spending on parks and recreation.

As with the clean energy investment projects, creating hundreds, if not thousands, of new jobs in these areas with shovel-ready projects can serve as the initial phase of a longer-term infrastructure investment program that will help Maine establish a durable economic recovery. Overall, some of the areas in which the full-scale set of infrastructure investments will generate substantial new employment opportunities include the following:

Surface transportation: construction equipment operators, cement masons, paving equipment operators, carpenters, construction laborers.

Water/wastewater: maintenance and repair workers, treatment plant and system operators, meter readers, construction managers.

Electricity: electricians, electric power-line installers and repairers, electrical assemblers, construction laborers.

In addition, as with the clean energy investment projects, the public infrastructure projects will generate major new employment opportunities for, among others, secretaries, office managers, customer service representatives, and accountants.

2.12 Net Job Creation through Clean Energy and Infrastructure Investments

We have now estimated the employment impacts in Maine for the year 2022 of: 1) clean energy investments at $2 billion; 2) a 50 percent contraction of the state's fossil fuel-based and biomass electricity sectors; and 3) a public investment upgrade at $500 million per year. As such, we can now bring these three estimates together to estimate the net employment effects of all three measures for 2022. Our figure for 2022 will then also closely approximate the annual employment effects of continuing each of these programs at comparable scale through to 2030.

We present the full set of employment estimates, and the net employment total, in Table 2.41. To present a consistent set of the broadest employment estimates that we have generated, we report in Table 2.41 the figures for *all employment impacts* through each of the three channels that we have documented—i.e. direct, indirect, plus induced employment effects in all three cases.

TABLE 2.41
Overall Net Job Creation through Clean Energy and Public Infrastructure Investments
Figures are total direct, indirect and induced jobs, based on estimates for 2022

Clean energy investments	
1. Energy efficiency: $600 million *from Table 2.13*	6,222
2. Renewable energy: $1.4 billion *from Table 2.15*	8,360
3. Clean energy total: $2 billion *(= rows 1 + 2)*	14,582
4. Public infrastructure: $500 million	7,294
5. Total for clean energy and infrastructure *(= rows 3 + 4)*	21,876
6. Job displacements in fossil fuel-based and biomass electricity sectors - Figure accounts for voluntary annual retirements *from Tables 2.29 and 2.32*	158
7. Net job creation *(= row 5 – 6)*	21,718
8. Net job creation as share of 2019 Maine labor force *(Maine 2019 labor force = 672,000)*	3.2%

As Table 2.41 shows, we have estimated the clean energy investment project in Maine, budgeted at $2 billion in 2022, as generating a total of 14,582 jobs. This includes 6,222 jobs resulting from $600 million in energy efficiency investments and 8,360 jobs resulting from clean renewable energy investments. We then estimate that public infrastructure projects, budgeted at $500 million for 2022, will generate a total of 7,294 jobs. Thus, we estimate that the two big investment projects for Maine—clean energy and public infrastructure—will produce a total of 21,876 jobs in Maine in 2022.

Against these two sources of employment growth, we also estimate that the 50 percent contraction of Maine's oil, natural gas and biomass electricity sectors, along with the full shutdown of the state's negligible coal sector, will produce 158 *job displacements*—that is, people whose jobs will be lost and will need new jobs. We generate this figure after estimating that there would be 96 direct jobs lost but 64 workers in the direct jobs category that will voluntarily move into retirement at age 65, as well as 250 indirect and induced jobs lost, with 126 workers in these categories choosing retirement at age 65.

Overall then, the net jobs created in Maine in 2022 would be 21,718, or nearly 22,000 new jobs in the state. This amounts to about 3.2 percent of Maine's labor force as of 2019.

On their own, these clean energy and public infrastructure investment projects will not be of sufficient scale to end Maine's current employment crisis on their own, if it is the case that unemployment in Maine were to remain in the range of 10 percent through 2021 and into 2022. Nevertheless, on their own, these investments will be able to bring down the state's unemployment rate from, say, 10 percent to 7 percent, or from 7 percent to 4 percent. This would be a major accomplishment within either employment scenario.

These investment projects will also work in complementary ways with the public health interventions we have discussed in Section 1.3 that will enable Maine's economy to reopen on a sustainable basis, assuming especially that the rest of the U.S. also implemented comparable public health measures to control the spread of COVID-19. A sustainable reopening of Maine's economy will then be the primary driver supporting an expansion of employment opportunities and a sharp fall in the state's unemployment rate. This will especially be true in the areas of tourism—i.e. leisure and hospitality—along with education, health care and transportation. As we saw in Section 1.2, these sectors of Maine's economy accounted for fully two-thirds of the state's 14.9 percent decline in employment in April/May 2020 relative to April/May 2019.

PART 3:

FINANCING A FAIR AND SUSTAINABLE RECOVERY PROGRAM FOR MAINE

The state and municipal-level governments in Maine, along with their equivalents throughout the country, face, at the least, great uncertainty with their budgetary prospects over the coming year, as well as the real possibility that they could experience massive revenue shortfalls.

For the 2020 fiscal year that just ended (July 2019 – June 2020), the state's tax revenue fell by around $150 million, a decline of about 4 percent relative to the state's budget for 2020 of $4 billion. A revenue decline of at least this level is not surprising, given that about 85 percent of the state's revenue comes from income and sales taxes. Once the pandemic and lockdown conditions began in mid-March, it followed that incomes and business sales would fall sharply along with the spike in unemployment that we reported in Section 1.2.

Despite this economic collapse beginning in March, the state government was able to cover its revenue shortfall and balance its 2020 budget by dropping previously drawn up proposals to increase state spending and instead setting aside $192 million for the pandemic.[69] The revised budget, passed mid-March, only maintained spending increases related to the COVID-19 onset by allocating $73 million in funds towards public education, emergency health care, and transport infrastructure. The state also bolstered its budget stabilization fund, known as the Rainy Day Fund.[70] At present, the Rainy Day Fund has a balance of about $250 million, equal to about 6.3 percent of the state's currently allocated spending level.

Overall then, the state government's primary response thus far to the pandemic and economic collapse has been to modestly increase public spending in the vital areas of education and health care. It has been able to achieve this without creating any significant budgetary stresses. But there remains great uncertainty whether this relatively positive fiscal stance can be sustained into the 2021 fiscal year (which just began in July 2020). This was conveyed clearly through our review in Section 1.2 of the Boston Federal Reserve Bank's 2021 revenue projections for the state. As we saw in Section 1.2, the Boston Fed presented two alternative scenarios, a "low" unemployment scenario in which the state's unemployment rate averages 7.8 percent over 2021, and a "high" unemployment scenario in which unemployment averages 18.4 percent for the year. Under the Boston Fed's "low" unemployment scenario, state revenue would fall by 3.0 percent, or roughly $120 million. A revenue decline of this amount would be manageable, given the state's option of drawing on its $250 million Rainy Day Fund. But under the Boston Fed's "high" unemployment scenario, state revenue falls by 30.6 percent, that is by about $1.2 billion. This amount is roughly 5 times larger than the state's Rainy Day Fund.

The situation becomes still more serious when we incorporate the prospects for major revenue shortfalls at the level of Maine's municipal governments as well. As of the 2017 census figures (the most recent publicly available comprehensive data), general local government revenue in Maine was $5.1 billion. Municipal government spending in Maine in total—from all municipal entities in the state—is therefore about 25 percent greater than the $4 billion state-government budget. At the same time, fiscal transfers from the state government to the municipalities account for about 27 percent of all municipal governments' overall budgets.[71] This means that the municipal governments' own tax and other revenue sources, independent of the fiscal transfers they receive from the state, are approximately equal to the $4 billion generated by state-level taxation. A sharp decline in the municipal government's revenues would therefore deepen the fiscal crisis that Maine would experience over 2021.

According to an estimate by the economist Timothy Bartik of the Upjohn Institute, revenue shortfalls for local governments throughout the U.S. will be in the range of $200 billion through June 2021 or about 11 percent of U.S. local government revenue.[72] If we assume that Maine municipalities lose 11 percent of their funding—that is, at the rate of the average U.S. municipality—this would amount to $561 million for Maine over 2021. Even if we reduce this amount by 27%, the share of total local government funding transferred from the state's budget, the municipalities' combined revenue loss would still be about $409 million.

Considering these prospects for Maine, it is imperative that the public entities at all levels undertake serious consideration of some non-conventional financing possibilities, including bond sales to the Federal Reserve as well as additional borrowing on the open market. This would be in addition to obtaining increased economic stimulus and recovery funding from the U.S. Treasury. Recognizing the range of possibilities around all of these options will be the most effective approach towards preventing the Boston Fed's "high unemployment scenario" for Maine ensuing over 2021.

Federal Government Support

In the federal CARES Act, which became law in March 2020, and related measures, the U.S. government did provide large-scale support to state and local governments and other entities through various specific channels.[73] We summarize the total federal funding injection into Maine's economy in Table 3.1.

As we see, the general relief funding authorized or disbursed to the Maine state government was $1.25 billion, equating to about 1.9 percent of the state's 2019 GDP. In addition, $240 million was available for specific state government agencies in Maine, and $420 million was authorized for specific beneficiaries by their function, such as airports, transport authorities or financial aid to students.[74] Total support amounted to $1.9 billion, equal to 2.8 percent of Maine's 2019 GDP.[75] In terms of support for Maine's businesses, the main source of support was provided through the Paycheck Protection Program, which disbursed $2.2 billion through June. Maine received an additional $520 million in Economic Injury Disaster Loans. The total level of business support was therefore $2.7 billion, equal to 4.0 percent of state GDP by end of June. Support for individuals through the CARES Act totaled to $1.8 billion by end of June, through supplemental unemployment insurance and the separate cash assistance fund.

The federal government's level of support beginning in March, via the CARES Act and related measures, thus totals to $6.4 billion, or 9.5% percent of Maine's 2019 GDP. At the same time, these headline figures may overstate the actual level of support they bring so far. This is primarily because the state has so far expended only $309 million, or 25 percent, of its $1.25 billion relief fund.[76]

This is the context in which the U.S. House of Representatives passed the HEROES Act on May 15. This measure would provide additional funding support for Maine and other states. Estimates as to how much Maine is slated to receive range between about $3.5 and $5 billion in support.[77] This amount on top of the figures already received would go a long way towards sufficient funding. However, it is far from certain that the HEROES Act, or anything equivalent, is going to pass the Senate in its present form and be signed by President Trump.

TABLE 3.1
Federal COVID-19 Related Funding to Maine

	Funding level	Funding as share of Maine 2019 GDP
Assistance to public entities		
Coronavirus Relief Fund to state government	$1.3 billion	1.9%
Other funds to state government	$240 million	0.4%
Funding to local government	0	0%
Funding to other public entities*	$420 million	0.6%
Total assistance to public entities	**$1.9 billion**	**2.8%**
Assistance to businesses		
Paycheck Protection Program *(through 6/24)*	$2.2 billion	3.3%
Economic injury disaster loans	$520 million	0.8%
Total assistance to businesses	**$2.7 billion**	**4.0%**
Assistance to individuals		
Pandemic unemployment compensation for all standard employees as of 7/8/20	$610 million	0.9%
Pandemic unemployment assistance for freelancers, self-employed and gig workers *(as of 7/8/20)***	$70 million	0.1%
Cash assistance	$1.1 billion	1.6%
Total assistance to individuals	**$1.8 billion**	**2.6%**
TOTAL ASSISTANCE	**$6.4 billion**	**9.5%**

* Includes certain funds going directly to private entities, e.g. emergency student financial aid.

** Includes Pandemic Emergency Unemployment Compensation and funding of first week of unemployment.

Sources: Bureau of Economic Analysis (2019 GDP), Maine Bureau of the Budget, Government Accountability Office.

State-Level Funding Prospects

Given the uncertain situation, Maine needs to develop its own contingency plans for alternative funding to support a strong recovery. In considering this, it is critical to recognize that, by statute, the state does have the legal authority as well as the capacity to issue bonds to support capital projects.[78] Such capital projects could, for example, be in the areas of traditional infrastructure such as roads or school buildings. Capital projects could also include public sector-led clean energy investments to, for example, raise energy efficiency standards in public buildings through retrofitting projects. Where bond issuance exceeds $2 million, voter approval has to be sought, so for future bond issuance, swift action alongside a robust public discussion on the use of these funds is important for these funds to be available in a timely manner.[79] As one important step in this direction, on July 14, the state's voters overwhelmingly approved new bond issues amounting to about $120 million to support new statewide investments in internet and transportation infrastructure.[80]

In addition, the state can expand the range of investment projects that can be financed through borrowing, by issuing "human capital" bonds, to cover expenditures on health and education. Focusing on state-level funding in the area of educational financing, the University of Massachusetts Amherst economist Gerald Epstein (2020) has developed a proposal in detail as to how "human capital bonds" could be introduced.[81] Epstein writes:

> Most states' balanced budget requirements only apply to the budgets for current spending. These states have separate capital budgets for longer-term investments, such as in new schools, new buildings on college campuses, new roads, etc., that are designed for borrowing. So, one way around the balanced budget problem is to identify this emergency education spending as a type of capital spending and put it under the capital budget. This would entail denoting the borrowing instruments as investments in *human capital*, using parlance long established in the economics profession. The bonds could be called, for example, *human capital bonds* and they could be issued under states' capital budgets (2020, p. 3).

As Epstein (2020) further explains, the Federal Reserve currently operates a program to purchase bonds from state and municipal governments, what the Fed has termed its "Municipal Liquidity Facility." Under its current operating procedures, the Fed has the capacity under this facility to purchase up to a total of $500 billion in state and municipal bonds.[82] Under this program, the state government and municipalities in Maine are able to sell up to $1.1 billion in bonds to the Fed.[83] The state does not anticipate drawing on this funding source at present. But in the current state of extreme economic uncertainty, this Fed program is one major viable funding option that cannot be ruled out. Indeed, if the Fed's bond purchasing capacity were to increase in response to the ongoing severe recession, Maine's ability to increase its borrowing through this program could then rise correspondingly. Such funding support, again, could also be supplemented by municipal bond sales on the open market beyond the $120 million in new state borrowing that Maine voters recently approved.

What Are Maine's Funding Needs?

As we have discussed, there is a great deal of uncertainty regarding the trajectory of the Maine economy over the next year. This is equally true for the U.S. and global economies. It is therefore not possible to know what funding amounts would be sufficient to move Maine onto a viable recovery path. Broadly speaking, we do nevertheless know that large-scale funding will be needed, at the least, to support short-term interventions in the areas of public health, unemployment insurance, and cash assistance, as well as longer-term investment projects in health and education, clean energy, and public infrastructure.

In Table 3.2, we provide some rough estimates of funding requirements over both the very short-term of the next three months as well as within a longer-term framework of the first year of multi-year projects in the areas we have discussed above in this study—public health, unemployment insurance and cash assistance, clean energy and public infrastructure. The budget amounts listed in Table 3.2 are all based on the various financing considerations that we have presented in the earlier sections.

TABLE 3.2
Proposed Budgets for Maine Public Health, Short-Term Stimulus, and Long-Term Investment and Recovery Programs

	Budget level	Time frame for spending
State government support		
Cash assistance	$1 billion	3 months —reassess in October
Supplemental unemployment insurance	$500 million	3 months —reassess in October
Medicare crisis health insurance	$250 million	3 months —reassess in October
Supplemental public health/safety interventions	$500 million	1 year
Clean energy investments—public funds	$200 million	1 year
Public infrastructure investments	$500 million	1 year
Total state-level support	**$3 billion**	**Combined 3 months and 1 year**
Municipal government support	**$400 million**	**1 year**
TOTAL STATE PLUS MUNICIPAL GOVERNMENT SUPPORT	**$3.4 billion**	**Combined 3 months and one year**

Sources: Funding levels described in text.

Our proposal does not consider additional support to businesses through extending the Paycheck Protection Program or any alternative targeted at bolstering small businesses. But such support focused on small businesses will continue to be warranted both as long as the severe recession is ongoing and the support funds can be equitably allocated to their intended recipients—i.e. truly small business operations.[84]

Thus, starting with the 3-month time period, Table 3.2 first lists cash assistance and unemployment insurance support, at $1 billion and $500 million respectively. These figures equal the federal support levels received thus far in Maine through the CARES Act. The budgetary allocations we have provided for these programs would therefore extend the programs at their CARES Act level of support for another three months.

The $250 million allocated for the Medicare Crisis program, as listed in Table 3.2, would also be over a 3-month period. This figure is based on the estimate Pollin, Wicks-Lim and Arno generated of the overall funding level for this proposed program on a national basis, as reported in Section 1.3. Our estimate of the overall funding requirements for this program is $106 billion, assuming that, on average over the next three months, 30 million people would be receiving unemployment benefits throughout the U.S.[85] The corresponding Maine figure for residents receiving unemployment insurance would be about 70,000 people, based on the figures for continued and initial claims as of mid-June.

Moving into the longer-term budgetary allocations listed in Table 3.2, the $500 million for supplemental public health/safety interventions represents a roughly 10 percent increase in the state's Health and Human Services funding level over the $4.9 billion included in the 2021 fiscal year's budget (with the federal government covering $2.9 billion of the total funding). We roughly estimate this as being the amount of additional financial support necessary in Maine over the next year to provide adequate public health interventions to control the COVID pandemic at a level roughly equivalent to countries such as Australia, Japan or South Korea. As we have reviewed in Section 1.1, management of the pandemic in these three countries, as well as others, has been dramatically more effective than those in Maine or the U.S. generally.

These public health investments will also generate major increases in employment for health care workers. As we saw in Table 1.4, employment in Maine's health care and education service sector declined by nearly 14 percent in April/May 2020 relative to 2019. This is at precisely the time at which the state was focused intensively on controlling the spread and mitigate the impact of COVID-19. Jobs in public health need to be restored and expanded in Maine to sustain a safe reopening of the economy.

The $500 million for public infrastructure projects and $200 million in public funding for clean energy investments are the amounts that we derived in the discussions on these respective programs, in Sections 2.7 and 2.11 above. Note, again, from our Section 2.7 discussion, we assume that $200 million in public funds for clean energy investments will be matched by $1.8 billion in private funding.

Finally, Table 3.2 includes $400 million in overall support for municipal entities throughout the state. This is the figure we presented above, based on the projection by Timothy Bartik on municipal government revenue losses over the coming 12 months.

As we see, adding everything up, we estimate the total level of additional public funding needs for Maine in the areas of public health, unemployment insurance, cash assistance, public infrastructure and clean energy as being $3.4 billion. This is equal to about 5 percent of Maine's 2019 GDP. It is obviously a large sum. The figure would of course be higher still if it included assistance to businesses in the state. If businesses in Maine were to receive further support through the Paycheck Protection Program or an alternative at the 4.0 percent of state GDP figure provided through the CARES Act, the total for a new round of funding would rise to about 9 percent of GDP, or $6.1 billion. This level of support, including now for business assistance, would be in line with the overall funding level provided through the CARES Act, which, as we saw in Table 3.1, provided about $6.4 billion to Maine through its various channels, equal to about 9.5 percent of state GDP.

Where to Find the Funds?

The U.S. House version of the HEROES Act which passed the U.S. House of Representatives in May would be funded at $3 trillion, or about 14 percent of U.S. GDP. If Maine were to receive its equal share of funding from the HEROES Act, at 14 percent of state GDP, that would amount to $9.5 billion—i.e. nearly 50 percent more support than we are proposing through the combined programs for public health, unemployment insurance, cash assistance, clean energy and public infrastructure, plus additional funding to small businesses. This $9.5 billion figure is also far more than the $3.5 - $5 billion amounts that the sources we cited above have predicted Maine will receive through a final version of the second round of federal stimulus support, via the HEROES Act or its equivalent.

In addition to the CARES Act and a possible new round of stimulus funding, interventions undertaken by the Federal Reserve during the COVID crisis are projected to reach between $5 and $8 trillion, or up to 40 percent of U.S. GDP.[86] These interventions operate through bond purchases from both private and public entities, including state and municipal governments, as well as direct loans to private businesses and Wall Street firms.

Overall then, more than sufficient support should be available to finance a robust second round of stimulus injections into the Maine economy, assuming that some version of the HEROES Act broadly similar to that which passed the U.S. House in May becomes law. This support from the U.S. Treasury could then be bolstered through the Federal Reserve purchasing of state and municipal bonds from Maine at highly concessionary interest rates. At present, bonds issued by the state and municipalities in Maine are already being marketed at very low rates. As of 8/14/20, , the yield on Maine state and municipal bonds ranged between 1.0 and 1.6 percent.[87] These rates could also fall still further—i.e. to near-zero—and remain at this level to the extent that the Federal Reserve engages in an active program to purchase Maine's public sector bonds. With Maine's state and municipal governments being able to borrow at such low rates, the prospects will remain highly favorable for these public entities to support the large-scale funding programs that will likely be needed to counteract the economic crisis.

Appendix 1

Detailed Description of Existing Clean Energy Policies in Maine and Summaries of Proposed Policies from Silkman and VEIC 2019 Reports

Maine's Existing Clean Energy Policy Framework

GREEN ENERGY STANDARDS

Renewable Portfolio Standards

- In 2019, Maine significantly strengthened its statewide Renewable Portfolio Standard. The new standard requires 80% of the state's electricity sales to come from renewable sources by 2030, including 4% from thermal energy. The target increases to 100% renewable electricity by 2050. Maine's list of eligible renewable sources includes solar, wind, fuel cells, tidal, geothermal, hydroelectric, biomass using wood, landfill gas, anaerobic digestion, and municipal solid waste. Sources eligible to satisfy the thermal energy requirement include heat, steam, hot water, or thermal energy produced from sunlight, biomass, biogas, or liquid biofuels.[88]

Greenhouse Gas Emissions Standards for Power Plants

- Maine participates in the Regional Greenhouse Gas Initiative (RGGI), a regional cap and trade program to reduce carbon dioxide emissions from power plants. As a member of RGGI, all fossil fuel-fired power plants with a capacity exceeding 25 megawatts must comply with the RGGI regional emissions cap, which is set to stepwise reduce emissions 65% between 2009 and 2030.[89]

Energy Efficiency Standards and Targets

- Efficiency Maine produces triennial efficiency plans with yearly energy efficiency and energy reduction targets, including: capturing all cost-effective efficiency measures, reducing total consumption of electricity, natural gas, and heating oil, and widescale home weatherization. The 2020-2022 plan targets annual savings of 2.3% for electricity and 0.1% for natural gas, among targets for other fuels. The triennial plans also incorporate transformational 10- and 20-year targets, established by statute, into the agency's strategy and budgeting.[90]

Public Building Requirements

- Maine requires that construction or renovation of state buildings must incorporate energy efficient and sustainable building standards when cost-effective. Maine also requires energy efficiency considerations in the planning and design of state buildings, including an energy-use target that exceeds commercial and industrial standards by at least 20%, and a 30-year life-cycle cost analysis incorporating the costs and benefits of efficiency improvements.[91]

Building Energy Codes

- Maine has adopted the 2015 versions of the IRC, IBC, IEBC. ECC remains as the 2009 version. ASHRAE standards have been updated to the 2013 version. 89 of Maine's 533 municipalities are required to provide enforcement of energy codes, representing 60% of the state's residential population. Municipalities with less than 4,000 residents are not required to enforce the state codes, but if they adopt a code, it must be consistent with the state adopted code.[92]

Tailpipe Emission Standards

- Maine adopted California's Low-Emission Vehicle Program in 2005, committing to a 30% reduction in average new vehicle greenhouse gas emissions from 2002 levels by 2016. The state has also adopted California's Zero-Emission Vehicle (ZEV) program, which requires increasing market share of plug-in hybrid, battery electric, and fuel-cell vehicles from 2018 to 2025.[93]

GREEN ENERGY FINANCIAL INCENTIVES

Efficiency Maine Incentive Programs

- In 2010, the Efficiency Maine Trust was established to coordinate state efficiency financing and rebate programs. Efficiency Maine is a quasi-state agency managed by a stakeholder board of trustees with oversight from the MPUC, and receives funding from a system benefit charge and the Regional Greenhouse Gas Initiative.[94] Efficiency Maine offers rebates and discounts range from $50-$6,000 for various energy efficiency measures, including heat pumps and boiler systems[95], lightbulbs and appliances[96], weatherization services[97], electric vehicles[98], and energy audits.[99]

PACE Financing

- While there are no active PACE programs reported in Maine, the Efficiency Maine Trust and municipalities can create loan programs for energy-saving improvements and renewable energy installations using PACE program funding sources, including federal Energy Efficiency and Conservation Block Grant funds.[100]

Net Metering

- All of Maine's electric utilities must offer net energy billing for individual customers generating renewable energy up to 660 kilowatts, and limited Shared-Ownership net-metering arrangements are allowed for up to 10 individuals engaged in small community generation. Maine's net-metering covers a range of renewable sources, including electricity generated using biomass, combined heat and power, fuel cells, geothermal electric, hydroelectric, municipal solid waste, solar photovoltaics, solar thermal electric, tidal, and wind.[101]

Commercial and Industrial Custom Program:

- The Efficiency Maine Trust provides an incentive program for large electrical efficiency and distributed generation projects that reduce grid-supplied electricity consumption from Maine businesses, institutions, and governments.[102] The incentive awards range from $10,000 to $1,000,000 per project, or up to 50% of total project costs, and totaled $3.4 million in 2019.[103]

Decoupling Policies

- Maine allows revenue decoupling mechanisms for electric utilities, and Central Maine Power, the state's largest electric utility serving roughly 80% of statewide load, was granted decoupling in its rate case in 2014.[104]

GREEN ENERGY ACCESS POLICIES

Solar Easements

- Since 2009, Maine property owners are legally allowed to protect their access to sunlight, and local ordinances or bylaws cannot interfere with access except under extraordinary circumstances.[105]

Green Pricing programs

- Since 2012, Maine offers green power as an option to residential and small commercial customers through the Maine Green Power Program.[106] The renewable energy purchased by Maine Green Power participants cannot be used by Maine's electricity providers to fulfill their Renewable Portfolio Standard mandate, and thus represents renewable power generation above and beyond the regulatory requirements in the state.[107]

Richard Silkman Policy Proposals

FROM: Silkman (2019) *A New Energy Policy Direction for Maine: A Pathway to a Zero-Carbon Economy by 2050*

Beneficial Electrification

ELECTRIFICATION OF MAINE'S TRANSPORTATION SECTOR

Electric Utility Rate Restructuring

- Delivery Service rates for Maine's electric utilities should be restructured as two-part tariffs consisting of a monthly flat customer charge that recovers the cost of interconnecting the customer to the grid and a usage-based demand charge. This rate structure maintains effective price signaling to electricity consumers and distributed energy resources by taking full advantage of the Advanced Metering capabilities and billing system enhancements paid for by ratepayers.

EV-Charging Mandate in Building Permits

- Building permits for new commercial and industrial construction or retrofits of existing facilities that currently impose mandates with respect to parking facilities as a condition for the issuance of a permit should be further conditioned to require that 5-10% of such parking spaces be equipped with charging stations within the first 10 years of operation.

EV-Charging Mandate for Garages and Public Parking Lots

- Municipal ordinances should be amended to require that all parking garages or other public parking lots have a minimum of 1 charging station for each 20 parking spaces by 2025, and 25% of all parking spaces by 2045.

Investment Incentives for Interstate Charging Stations

- The Maine Department of Transportation should provide competitive grant money to private, non-utility entities to provide EV charging stations along major arteries entering and leaving Maine. The location of those stations should be determined by MDOT with the purpose of encouraging and facilitating the use of passenger and commercial EVs for long-haul trips in and through Maine.

Electrification of School Bus Fleet

- The Maine Department of Education, in coordination with MDOT, should require that a minimum of 150 school buses each year be converted from fossil fuel to electric, beginning in 2030, or earlier depending on the price and availabilities of qualified vehicles.

EV Per-mile Tax

- The MDOT and the Maine Secretary of State should develop a proposal to tax EVs based on miles driven in lieu of gasoline consumed. All monies collected would flow into the state's Highway Fund.

ELECTRIFICATION OF HOME HEATING

Target Heat Pump Installation Incentives to Low Income Housing

- The Efficiency Maine Trust should maintain its programs of education and promotion of heat pumps and its grant programs to support heat pump installation. With respect to the latter, monies should be targeted over the next 10 years to low income housing units that are currently heated with distillate fuels, combined with building envelope improvements.

Public Buildings Heat Pump Conversion

- State, County and Municipal governments should initiate long-term capital plans to convert a minimum of 10% of all government owned heated space from distillate fuels to heat pumps by 2025, expanded to 100% by 2050. Further, all newly constructed or renovated buildings should be required to be heated with ground-source or air-source heat pumps.

Policies to Promote Renewable Energy Generation Development

ON-SHORE RENEWABLE GENERATION

Small-scale Interconnection Incentives

- Allocate the first $5 million of any upstream grid costs required to interconnect a generator to electric loads in Maine. This relieves distributed generation resources of the need to upgrade the immediately upstream substation as well as any feeders, reclosers, switches or other equipment located on the circuit serving the interconnecting generator, since these costs are almost always less than $5 million. Large-scale generators whose interconnection may impose significantly more costs on the utility will bear all costs in excess of the $5 million.

Property Tax Exemptions for Renewable Energy Generation

- The state should exempt real estate and business or personal property that is used directly or indirectly in the generation of electricity from zero-carbon, renewable energy generation resources from municipal property taxes. In lieu of property taxes, renewable energy generation projects should make reasonable contributions to the host communities related to the costs of providing police and fire protection services.

Phase out Net-Metering

- Solar PV, on-shore wind or shallow water off-shore wind generation should not require further subsidies or incentives from the state. All net-metering in any form should be phased out over 10 years as the costs of solar rooftops impose too great a burden on those without such facilities. With the correct rate design for delivery service and the restructuring of key aspects of wholesale energy markets, the layered values that distributed solar PV systems provide to the grid can be monetized and captured by these systems.

DEEP WATER, FLOATING OFF-SHORE WIND DEVELOPMENT

Continued State Support for Projects Under Development

- The state should provide continued support for the University of Maine Aqua Ventus project. This support should include a new negotiated long-term contract to purchase the generation output from the project as well as support for the University's ongoing efforts to secure research and development funding from the Department of Energy.

Offshore Transmission Grid with Interconnection to Regional Grid

- In anticipation of significant development of Maine's deep water off-shore wind resource, Maine should initiate a five-year planning process to interface with the federal government regarding the issuance of long-term leases to generation developers and with the utilities and ISO-NE regarding the development of an off-shore transmission grid to interconnect this generation to the regional transmission grid.

DISTRIBUTED SOLAR PV

Zoning Ordinance Accommodations

- Building set-back requirements for buildings located in nonresidential zones should be relaxed to allow for the placement of HVAC systems and other equipment, that would otherwise have been located on the roof, in the space in those setbacks. This modification should only apply where rooftop solar is installed.

- Property rights to solar irradiance need to be incorporated into zoning ordinances to protect investments in solar PV systems from actions of abutters that would impact generation output.
- Municipal ordinances should not be permitted to prohibit the development of solar PV systems in any manner consistent with the zoning for the property. This includes prohibitions designed to protect open space or related in any way to the visual impacts of installed systems.

Mandatory Rooftop Solar on New Construction

- Municipalities should consider imposing mandatory rooftop solar PV systems on all new construction. This will add costs to new homes and commercial buildings, but much of these costs are offset over time by savings in electricity costs as these costs will fall as the cost of solar falls.

Financing and Investment Proposals

Creation of an Energy Generation Authority

- The state should form a new entity, the Maine Energy Generation Authority (MEGA) to aggregate the demand for the electricity generated by renewable resource generators and provide highly rated and inexpensive investment capital.
    - The state should enact legislation that defines MEGA's purpose, establishes legislative authority for its existence, sets forth its governance structure and outlines the set of activities it can engage in and the actions it can take. The legislation should be structured as enabling; it should impose no mandatory obligations on Maine's municipalities.

Vermont Energy Investment Corporation (VEIC) Policy Proposals

From: VEIC (2019), ***Advancing Clean Energy Investment In Northern New England***

Policy and Regulatory Strategies for Scaling Clean Energy Investment

Implement Regional Carbon Pricing for all Energy Produced from Fossil Fuels

- Carbon pricing must be expanded beyond the electricity-generating sector. The Transportation and Climate Initiative (TCI) and Western Climate Initiative (WCI) provide possible roadmaps for action. Carbon pricing should limit GHG emissions from all major sources of climate change pollutants, not just from electricity generation at power plants, and include emissions associated with electricity imported from outside the region.

Support Activities that Advance Performance-Based Regulation

- Maine should consider performance-based regulation as a way to restructure the cost basis and revenue mechanisms for utilities and make increased clean energy financing available through the utilities. It can provide a new performance-based approach for increasing utility investment in energy efficiency, transportation electrification, and grid modernization. A policy framework that achieves energy efficiency, renewable energy, and carbon reduction goals should engage all key stakeholders and seek opportunities to combine tools such as rate decoupling and a renewable portfolio standard with performance-based regulation.

Address Policy and Regulatory Barriers to Community Solar

- Maine should eliminate any policy or regulatory complexities or barriers that can increase costs and decrease the likelihood that developers will pursue community solar, and expand financing for community solar by advocating for lower interconnection costs and more predicable net-metering credit revenue to attract developer attention and draw new capital, especially from local banks and credit unions.

Engage in Electric Vehicle Policy and Regulatory Development

- Maine should engage with EV industry stakeholders to understand what regulatory issues may be hindering market adoption as well as what actions utilities may consider, such as investing in EV infrastructure, vehicle incentives, consumer outreach, and/or other programs that will further advance transportation electrification. Maine PUC regulators may benefit from additional education and learning from the Vermont Public Utility Commission EV investigation that is currently underway and other states on setting appropriate limits on ratepayer EV investments.

Enable Plug-in Electric Vehicle Market Transformation

- Plug-in electric vehicle market transformation activities should prioritize the most critical barriers of purchase price, consumer knowledge, charging infrastructure, and availability of vehicles suitable for Northern New England conditions. Incentive programs are commonly used in other states and funded by vehicle emission legal settlements, such as the VW diesel settlements, and other programs could explore promotion of used vehicles to lower purchase costs. Ideally these programs would have a minimum 2 to 3-year lifespan.

Support Electric Transit and School Bus Market Transformation

- Electrification of transit and school buses should be piloted, refined, and implemented. VW funding can help jump-start this, with the help of clear policy direction from the administration and/or legislative leaders on effectively leveraging these one-time funds. As electric bus costs decrease, opportunities should develop to work with municipalities and bus manufacturers to develop leasing options or other financing programs to increase uptake. There is a need for outreach to increase recognition of the value of electric buses, such as using their batteries for behind-the-meter energy storage systems that increase resilience and reduce peak electric use and/or feeding back into the distribution grid to benefit renewable energy generation.

Modify and Develop New Clean Energy Finance Tools

Implement a Regional Clean Energy Underwriting Initiative

- Clean energy underwriting involves implementing a regional approach targeted at lenders and the real estate industry in Maine to update underwriting practices to consider utility costs in the debt-to-income ratio, while increasing mortgage loan-to-value ratios for energy efficient properties or for property purchases that include energy efficiency upgrades at the time of purchase.

Implement Commercial Property Assessed Clean Energy (C-PACE)

- C-PACE provides financing for energy efficiency and renewable energy projects for small-to-medium enterprises, commercial and industrial facility owners, and municipalities, universities, schools, and hospitals without adding long-term debt to their balance sheets. There is substantial interest among clean energy thought leaders in Northern New England in advancing C-PACE in each state.
- C-PACE in Maine will entail securing capital from private investors or lenders, bondholders, ratepayers, and/or the public sector. Typically, C-PACE portfolios are aggregated and sold to investors so new dollars become available before the capital pool is depleted. The capital should not be structured as a loan but rather as a tax assessment that is repaid over 10 to 20 years. C-PACE usually requires a senior lien position, such that failure to repay the assessment results in the same outcome as the failure to pay any other portion of a property tax bill.

Expand Municipal Lease-Purchasing

- A municipal or quasi-governmental entity should secure lease-purchase financing to raise capital for financing clean energy investments. An intermediary would be required to originate, underwrite, and service loans for eligible projects. One underwriting approach is for the debt service payments to be covered by the energy and dollar savings resulting from the projects. This function could potentially be provided by an existing entity, making cash available for municipalities to pay the upfront costs of cost-effective energy efficiency, renewable energy, and transportation electrification projects that ultimately would payback and reduce municipal energy bills.

Expand Tariffed On-Bill Financing

- Maine lacks affordable, accessible, easy-to-use clean energy investment options for renters and income eligible households. Current solutions for paying for home energy upgrades are limited to the lending market that underwrites the customer. This poses market barriers to homeowners and multifamily property owners who will not, or cannot, borrow for energy improvements. Tariff financing offers a solution that removes most underwriting barriers and opens up new options for the commercial and residential markets, including renters and low and moderate-income households.

Continue Assessing the Need for a Green Bank

- A green bank specializes in financing energy efficiency, clean energy, and other green infrastructure. Green banks offer financing products (directly or via intermediaries) that underwrite the savings from energy efficiency and value the elimination of fuel costs and fuel price volatility from solar, wind, and biomass projects. Alternatively, Maine may benefit from an initiative to increase green lending by existing banks and credit unions serving the region. Examples include leveraging private capital by deploying public monies for credit enhancements that enable lenders to offer financing for clean energy projects that would otherwise not be approved.

Appendix 2
Deriving an Estimate of 2019 Clean Energy Investment Level in Maine

The relevant data that are available include the following:

Energy Efficiency Investments. $99 million in 2019, including $48 million in Efficiency Maine programs and $51 million in private funds.[108]

Solar Energy. $42 million in 2019, and $218 million overall.[109]

Wind Energy. We are unable to find a reliable figure for this for 2019. The cumulative level of wind energy investment for Maine is $1.9 billion.[110] Without a figure for 2019 per se, we therefore extrapolate a 2019 figure, working from the ratio for the solar energy sector of 2019 investments as a share of cumulative investments. This ratio for solar energy is 19.3%. Because the wind sector in Maine is far more developed than the solar energy sector, it is reasonable to assume that the 2019 investment level for wind will be a significantly smaller proportion of the overall level of investment for the sector than it is for solar. As a rough approximation, we therefore assume that the level of wind energy investment in Maine in 2019 is 10 percent of the cumulative investment level, or about $200 million.

Based on this assumption for the 2019 investment level for wind, we can approximate the overall level of clean energy investment in Maine in 2019 as follows:

Wind energy investments	$200 million
Energy efficiency investments	$99 million
Solar energy investments	$42 million
TOTAL CLEAN ENERGY INVESTMENTS	**$341 million**

Appendix 3
Clean Energy and Energy Efficiency Employment Estimating Methodology

The employment estimates for Maine were developed using an input-output model. Here we used IMPLAN v3, an input-output model which uses data from the U.S. Department of Commerce as well as other public sources. The data set used for the estimates in this report is the 2018 Maine data. An input-output model traces linkages between all industries in the economy as well as institutional sources of final demand (such as households and government). A full discussion of the strengths and weaknesses of input-output (I-O) models and their application to estimating employment in the energy sector can be found in Appendix 4 of Pollin et al. (2014).

One important point to note here is that I-O models to date do not identify renewable energy industries such as wind, solar, or geothermal, or energy efficiency industries such as building retrofits, industrial efficiency, or grid upgrades.[111] However, all of the components that make up each of these industries are contained in existing industries within the models. For example, the hardware, glass production, and installation industries that are all activities within "solar" are each an existing industry in the I-O model. By identifying the relevant industries and assigning weights to each, we can create "synthetic" industries that represent each of the renewable energy and energy efficiency industries within the model. Below we show the industries and weights used in this study. A full discussion of the methodology for creating synthetic industries can be found in Garrett-Peltier (2017).

The energy industries and weight of each component industry are shown in Table A3.1, on page 105.

Scaling Manufacturing Activity

The employment estimates produced in the IMPLAN model are disaggregated into over 500 sectors. The expansion of clean energy that we propose in this report is significant and occurs rather rapidly. While it may be possible for construction and service activities to keep pace with the rapid scaling up of clean energy consumption in Maine, we assume that manufacturing facilities will take longer to develop. While manufacturing activity will indeed expand within the state, in the first ten years of clean energy expansion, some of the clean energy manufacturing will develop out of state. Here we make the conservative assumption that manufacturing will only increase 10% relative to the overall increase in clean energy activity. Thus, the employment multipliers will be lower in this constrained case than if we were to assume that all sectors, including manufacturing, scaled up at the same pace. In the IMPLAN model, to incorporate this change, we reduce manufacturing activities by 90 per cent to generate conservative estimates of jobs.

To err on the side of underestimating rather than overestimating in this study, we use the constrained employment numbers in the right-hand column of Table A3.2 in our estimates.

Modelling the Contraction of Employment in the Fossil Fuel and Biomass Electricity Industries

We divide the phase-out of the fossil fuel and biomass electricity industries into two periods: Phase I (2021-2030) and Phase II (2031-2050). The rate of phase-out, and the corresponding emission reduction targets, are based on the IPCC's October 2018 goals. Table A3.3 describes the rate of the contraction of the fossil fuel and biomass industries.

We use the IMPLAN (v3.0) software to model the contraction and find out the possible impacts on the employment and labor income in the state of Maine. We contract the gross output of the fossil fuel and biomass electricity industries at the same rate as described in Table A3.3.

For some fossil-fuel related industries like "other nonmetallic mineral services" (related to the production and processing of coal and its byproducts) and "construction of other new nonresidential structures" (related to the pipeline transportation of natural gas), we assume that only a portion of these industries will be contracting, as those sectors are not fully associated with the fossil fuel industry. We assume that these sectors contract 50.0% and 0.3%, respectively.

For example, the "other nonmetallic mineral services industry" will experience a contraction of its total gross output level in 2018 by 50% in Phase 1 and 0.0% in Phase 2. The 0.3% figure we use to approximate the activity within "construction of other new nonresidential structures" that is related to oil and gas pipeline construction is based on the ratio of employment in pipeline construction as a share of total construction employment, as reported by the U.S. Labor Department's Quarterly Census of Employment and Wages for Maine's private sector in 2018. Table A3.3 describes, in detail, the reduction in total output for all industries.

TABLE A3.1
Composition and Weights for Modelling Energy Industries within the I-O Model

Energy industries	Composition and weights of industries within the I-O model
Building retrofits	50% maintenance and repair construction of residential structures, 50% maintenance and repair construction of non-residential structures
Industrial efficiency	30% environmental and technical consulting services, 20% repair construction of non-residential structures, 10% air purification and ventilation equipment manufacturing, 10% heating equipment manufacturing, 10% A/C, refrigeration, and warm air heating equipment manufacturing, 10% all other industrial machinery manufacturing, 10% turbine and turbine generator set units manufacturing
Grid upgrades	25% construction of new power and communication structures, 25% mechanical power transmission equipment manufacturing, 25% commercial and industrial machinery and equipment repair and maintenance, 25% other electronic component manufacturing
Public transport/ rail	30% construction of other new non-residential structures, 21% motor vehicle body and parts manufacturing, 6% railroad rolling stock manufacturing, 43% transit and ground passenger transportation
Wind (on-shore)	26% construction of new power and communication structures, 12% plastic and resin manufacturing, 12% fabricated structural metal manufacturing, 37% turbine and turbine generator manufacturing, 3% mechanical power transmission equipment manufacturing, 3% electronic connector manufacturing, 7% miscellaneous professional, scientific, and engineering services
Wind (off-shore)	25% construction of new power and communication structures, 27% turbine and turbine generator, 10% environmental and other technical consulting, 8% cement manufacturing, 6% water transportation, 10% plastic manufacturing, 10% fabricated structural metal manufacturing, 2% electrical equipment, 2% other electronic components
Solar PV	30% construction of new power and communication structures, 17.5% hardware manufacturing, 17.5% mechanical power transmission equipment manufacturing, 17.5% capacitor, resistor, coil, transformer, and other inductor manufacturing, 17.5% miscellaneous professional, scientific, and engineering services
Geothermal	15% drilling wells, 45% construction of new non-residential structures, 10% pump and pumping equipment manufacturing, 30% scientific research and development services
Land restoration/ agriculture	40% support activities for agriculture and forestry, 15% pump manufacturing, 25% farm machinery manufacturing, 10% construction of new commercial structures, 10% scientific research and development

TABLE A3.2
Employment Multipliers per $1 million in Unconstrained and Constrained Cases

	Direct, indirect, and induced jobs per $1 million	
	If all sectors expanded 100 percent	Constrained: manufacturing expands 10% only
Wind (on-shore)	7.6	4.7
Wind (off-shore)	8.9	6.1
Solar PV	8.7	6.2
Geothermal	16.7	16.1
Land restoration/agriculture	21.0	19.0

TABLE A3.3
Contraction of the Fossil Fuel and Biomass Industries

	Oil contraction	Natural gas contraction	Coal contraction	Electricity production-biomass
Phase 1 (2021 – 2030)	50.0%	50.0%	No coal consumption	50.0%
Phase 2 (2031 – 2050)	40.0%	No natural gas consumption	No coal consumption	No biomass consumption

Appendix 4
Estimating Job Characteristics for Clean Energy, Fossil Fuel and Biomass Industry Jobs

Characteristics of Jobs Created by Clean Energy Investments

Our strategy for identifying the types of jobs that would be added to the economy due to an investment in one of the energy efficiency and clean energy sectors involves two steps.

The first step is to calculate, for each specific investment program, the level of employment generated in each of 526 industries through our input-output model (IMPLAN) as explained in Appendix 3.

Next, we apply this information on the industry composition of the new employment created by an investment with data on workers currently employed in the same industrial mix of jobs. We use the characteristics of these workers to create a profile of the types of jobs and the types of workers that will likely hold the jobs created with each investment. These characteristics include types of occupations, gender, race/ethnicity, union status, credential requirements, and job-related benefits. Income data for these workers come directly from IMPLAN and are reported in 2020 dollars.

Our information about the workers currently employed in the industrial mix of jobs created by an investment comes from the Current Population Survey (CPS). The CPS is a household survey administered by the U.S. Census Bureau, on behalf of the Bureau of Labor Statistics of the U.S. Labor Department. The basic monthly survey of the CPS collects information from about 60,000 households every month on a wide range of topics including basic demographic characteristics, educational attainment, and employment status. Among a subset of its monthly sample—referred to as the outgoing rotation group (ORG)—respondents are asked more detailed employment-related questions, including about their wages and union status. The CPS' survey in March includes a supplement, referred to as the Annual Social and Economic survey (ASEC) that asks additional questions, particularly about income, poverty status, and job-related health insurance and retirement benefits. We pool data from 2015-2019 for our analyses.[112]

To create a profile of the types of jobs and the types of workers that will likely hold the jobs created with each investment, we weight the CPS worker data with the industry shares generated by IMPLAN. This creates a sample of workers with an industry composition that matches that of the jobs that we estimate will be added by investing in a clean energy/energy efficiency sector.

Specifically, we use the IMPLAN industry shares to adjust the sampling weights provided by the CPS. The CPS-provided sampling weights weight the survey sample so that it is representative at various geographic levels, including national and state. We adjust the CPS-provided sampling weights by multiplying each individual worker's sampling weight with the following:

$$S \times \frac{\text{IMPLAN's estimate of the share of new jobs in worker i's industry j}}{\sum \text{CPS sampling weights of all workers in industry j}}$$

where S is a scalar equal to the number of direct jobs produced overall by the level of investment being considered. For example, say Maine's investment in solar power of $400 million would generate 1,000 direct jobs, then S is equal to 1,000.

Some of the 546 IMPLAN industries had to be aggregated to match the industry variable in the CPS, which has 242 categories, and vice versa. For example, among IMPLAN's 546 sectors, there are 13 construction sectors while the CPS has only one construction industry. In the end, 194 industry sectors are common to both IMPLAN and the CPS.

We use these adjusted sampling weights to estimate the job-related health insurance and retirement benefits, and union membership among workers in the specific industrial mix of jobs associated with each type of investment. We also estimate demographic characteristics, such as percent female and percent non-white, as well as, workers' educational attainment. Finally, we determine what are the most prevalent occupations held by workers in the industrial mix of jobs associated with each type of investment.

Note that because the CPS ASEC—which asks about job-related retirement and health benefits—is only administered in March, the sample sizes for the variables in the supplement are substantially smaller than for the basic monthly or ORG data files of the CPS. Due to this feature of the ASEC survey, the sample sizes for the health and retirement benefits measures were too small for a Maine-only analysis, despite pooling five years of data (2015-2019). As a result, we estimated these job features using data from the entire New England region, which includes Maine, as well as, Connecticut, Massachusetts, New Hampshire, Rhode Island, and Vermont.

Characteristics of Jobs in Fossil Fuel and Biomass Electricity Related Industries

We use the same basic methodology for identifying fossil fuel and biomass electricity generation related jobs and worker characteristics. The only difference here is that IMPLAN's I-O models have well-defined sectors for the fossil fuel and biomass energy activities, i.e., we do not have to create "synthetic" industries. These sectors are listed in Table 2.25.

We can therefore use IMPLAN to model the industry distribution of the jobs that will be lost as the fossil fuel and biomass related sectors in Maine contract (see Appendix 3). We use IMPLAN's estimates to create an industry profile of the types of jobs that will be lost as this combination of industries contract. As with the clean energy jobs, we weight the CPS worker data with the industry shares generated by IMPLAN. This creates a sample of workers with an industry composition that matches that of the jobs that we estimate will be lost as fossil fuel and biomass electricity generation sectors contract.

Definition of Jobs in IMPLAN

The employment figures in IMPLAN are based on the employment concept used by the Bureau of Economic Analysis. The BEA's concept of employment includes:

- wage and salaried workers
- self-employed workers in incorporated businesses, and
- proprietors employment, which includes self-employed workers in unincorporated businesses.

The BEA's concept of employment is more expansive than what is typically used by the U.S. Labor Department's Bureau of Labor Statistics (BLS). Well-known BLS employer-based data on employment, such as from the Quarterly Census of Employment and Wages (QCEW), for example, do not include the unincorporated self-employed. The BLS' CPS data, on the other hand, does include the unincorporated self-employed. However, the CPS data on employment are based on household surveys and only counts the employment of the unincorporated self-employed if their self-employment is their primary job. Moreover, each person can only represent one job in the CPS. The BEA's concept of proprietor's employment allows for the unincorporated self-employed to represent multiple units of employment. For example, if an individual has various different businesses operating during the year, each business would count as a unit of employment. To ensure that we use a consistent measure of employment effects in terms of both job *creation* from clean energy and energy efficiency investments, and job *losses* from the contraction of fossil fuel and biomass industry contractions, we use IMPLAN's (i.e., the BEA's) concept of employment throughout this report.

Endnotes

1 Our basic measures of CO_2 emissions throughout this study are units of metric tons. However, to simplify, for the most part we refer hereafter to this unit as "tons" of CO_2 emissions.

2 Nursing home deaths are tallied from home by home data downloaded from https://data.cms.gov/Special-Programs-Initiatives-COVID-19-Nursing-Home/COVID-19-Nursing-Home-Dataset/s2uc-8wxp 18 June update, and summing over total COVID-19 deaths of residents and staff respectively. This figure is low relative to a tally from 5/22/20, that reports 38 deaths in nursing homes, or 51% of all deaths then. While the differences may come from varying methods of counting, both figures agree on the preponderance of deaths in nursing homes. Data from 22nd May are at: https://www.kff.org/health-costs/issue-brief/state-data-and-policy-actions-to-address-coronavirus/.

3 https://www.buzzfeednews.com/article/zahrahirji/us-health-care-workers-coronavirus.

4 https://calmatters.org/california-divide/2020/05/poor-los-angeles-are-infected-and-dying-at-twice-the-rate/.

5 https://www.umass.edu/lrrc/sites/default/files/Western%20Mass%20Essential%20Worker%20Survey%20-%20May%202020.pdf.

6 https://www.bls.gov/news.release/flex2.t01.htm.

7 https://www.usatoday.com/story/news/health/2020/04/22/how-coronavirus-impacts-certain-races-income-brackets-neighborhoods/3004136001/

8 Formally, the figures reported in Table 1.5 are derived by multiplying the industry-specific employment loss figures shown in Table 1.4 by the percent of overall employment—in Maine and the U.S. overall—as shown in the "industry job loss as % of total state employment loss" columns in Table 1.5.

9 Maine's positive COVID-19 rate of all tests given has trended lower as testing has expanded, and was down to 4.46 percent [in mid-June] after being between 5 and 6 percent for much of the pandemic. After testing expanded in mid-May, the daily percent positive rate has usually been about 2 to 3 percent, which is slowly reducing the cumulative rate. https://www.pressherald.com/2020/06/17/quick-action-at-cape-memory-care-limited-covid-19-cases-in-community/.

10 https://bangordailynews.com/2020/06/18/news/state/maine-business-owners-frustrated-by-new-englands-patchwork-of-travel-restrictions/.

11 https://www.newscentermaine.com/article/news/health/coronavirus/proof-of-negative-covid-19-test-can-be-ticket-into-maine-mills-announces/97-355371e4-8da1-4bbe-8063-e987d0170a8b.

12 https://www.maine.gov/covid19/restartingmaine.

13 https://www.pressherald.com/2020/05/17/maine-reopening-despite-missed-benchmarks-inadequate-testing-regime/?rel=related.

14 https://www.nytimes.com/interactive/2020/us/maine-coronavirus-cases.html.

15 Covidexitstrategy.org.

16 https://bangordailynews.com/2020/06/16/politics/virus-cases-finally-declined-in-maines-biggest-hotspots-heres-what-it-means-for-reopening/.

17 https://www.pressherald.com/2020/05/27/mills-to-update-re-opening-as-maine-reports-two-more-deaths-28-new-covid-19-cases/?rel=related.

18 https://www.nytimes.com/interactive/2020/us/maine-coronavirus-cases.html.

19 https://bangordailynews.com/2020/06/17/news/state/virus-case-counts-continue-to-drop-hospitalizations-flat-as-maine-accelerates-reopening/.

20 https://www.cdc.gov/nhsn/covid19/report-patient-impact.html.

21 https://www.pressherald.com/2020/06/14/quadrupling-of-state-labs-covid-19-testing-capacity-puts-maine-in-good-position-public-health-experts-say/.

22 https://www.pressherald.com/2020/05/31/contact-tracing-could-be-key-to-stopping-future-outbreaks-but-will-mainers-buy-in/.

23 https://www.boston.com/news/coronavirus/2020/05/28/maine-restaurant-opening-delay.

24 https://jayapal.house.gov/2020/05/01/as-uninsured-rate-skyrockets-jayapal-kennedy-lead-32-colleagues-in-introducing-legislation-to-guarantee-health-coverage-during-covid-19-pandemic/.

25 https://www.sanders.senate.gov/newsroom/press-releases/sanders-jayapal-unveil-emergency-legislation-to-provide-health-care-for-all-during-pandemic-.

26 https://mainebeacon.com/mills-paid-sick-days-law-will-not-be-implemented-more-quickly-to-address-pandemic/

27 https://mainelegislature.org/legis/bills/getPDF.asp?paper=SP0110&item=4&snum=129

28 https://mainebeacon.com/mills-paid-sick-days-law-will-not-be-implemented-more-quickly-to-address-pandemic/

29 https://www.sunjournal.com/2020/04/11/we-asked-maines-largest-employers-whats-your-covid-19-sick-leave-policy/

30 https://www.maine.gov/labor/news_events/article.shtml?id=2320015

31 https://www.ipcc.ch/sr15/chapter/spm/. The Biden for President campaign platform on climate is aligned with the IPCC's goal of achieving net zero emissions by 2050. The first highlighted point in the platform states that the Biden Administration will "ensure that the U.S. achieves a 100 percent clean energy economy and net-zero emissions no later than 2050," https://joebiden.com/climate-plan/#.

32 These two reports can be found, respectively, at: https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/EnergyWG_FinalStrategyRecommendations_June2020.pdf; and https://renewnewengland.org/wp-content/uploads/2020/06/Renew-Regional-long-c4.pdf

33 See pp. 1-2 at: https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/EnergyWG_FinalStrategyRecommendations_June2020.pdf

34 The state with the next largest share of biomass consumption is Vermont, at 19.4 percent. The mid-point state is Indiana, with biomass at only 4.4 percent of total energy supply (US EIA: https://www.eia.gov/state/seds/).

35 Various approaches to reduce energy losses in electricity generation are described in Prentiss (2015).

36 See, for example, https://iopscience.iop.org/article/10.1088/1748-9326/aaac88/meta; https://science.sciencemag.org/content/359/6382/1328.full; https://iopscience.iop.org/article/10.1088/1748-9326/aaa512/meta.

37 https://www.documentcloud.org/documents/6889670-Scientist-Letter-to-Congress-8May20.html. Among the research findings cited in this letter is that by Sterman et al. (2018), who concludes that "Although bioenergy from wood can lower long-run CO_2 concentrations compared to fossil fuels, its first impact is an increase in CO_2, worsening global warming over the critical period through 2100 even if the wood offsets coal, the most carbon-intensive fossil fuel. Declaring that biofuels are carbon neutral as the EU and others have done, erroneously assumes forest regrowth quickly and fully offsets the emissions from biofuel production and combustion. The neutrality assumption is not valid because it ignores the transient, but decades to centuries long, increase in CO_2 caused by biofuels," (2018), p. 8, https://iopscience.iop.org/article/10.1088/1748-9326/aaa512/pdf.

38 https://www.pfpi.net/wp-content/uploads/2011/04/PFPI-biomass-carbon-accounting-overview_April.pdf.

39 https://www.yaleclimateconnections.org/2016/07/pros-and-cons-the-promise-and-pitfalls-of-natural-gas/.

40 See, e.g. Alvarez et al. (2012); Room (2014); Howarth (2015); and Peischl (2015).

41 https://www.who.int/ionizing_radiation/a_e/fukushima/faqs-fukushima/en/.

42 https://crsf.umaine.edu/wp-content/uploads/sites/214/2020/02/FS_FINAL_2.13.20L.pdf. This study reports Maine's emissions levels in terms of carbon, as opposed to CO_2. We convert their figure of 2.8 tons of carbon into 10.3 tons of CO_2, under the formula that one unit of carbon produces 3.67 units of CO_2.

43 https://earthobservatory.nasa.gov/images/1510/global-effects-of-mount-pinatubo.

44 These IEA projections are on pp. 686, 687, and 753 of its 2019 *World Energy Outlook*.

45 These more recent studies include Molina (2014), Ackerman et al. (2016) and Rosenow and Bayer (2016).

46 See the discussion and references in Pollin et al. (2015), pp. 92 – 96.

47 These cost figures are comparable with those reported for the U.S. economy exclusively through the U.S. Energy Information Agency (EIA). See the EIA's annual publication, "Levelized Costs and Levelized Avoided

Cost of New Generation Resources," in the *Annual Energy Outlook*. The 2020 edition is here: https://www.eia.gov/outlooks/aeo/electricity_generation.php.

48 Such detailed figures are also available in IRENA (2019).

49 These figures are from the EIA, "Levelized Costs," https://www.eia.gov/outlooks/aeo/electricity_generation.php.

50 The full methodology for generating these costs is presented in Pollin et al. (2014) pp. 136-37.

51 EIA, "Levelized Costs," https://www.eia.gov/outlooks/aeo/electricity_generation.php.

52 Thus, as we have seen, biomass accounts for more than 27 percent of all primary energy consumption in Maine, the highest in the U.S. by a significant amount. The U.S. state with the next highest percentage of biomass consumption is Vermont, at 19.4 percent. Only four other states rely on biomass for more than 10 percent of their total energy supply (EIA, State Energy Data, 2018).

53 https://www.nrcm.org/programs/climate/energy-efficiency/energy-efficiency-in-maine/. Accessed 6/30/20. Efficiency Maine's own report on its performance to date can be found in its 2019 Annual Report: https://www.efficiencymaine.com/docs/FY19-Annual-Report_final.pdf. A news story from 2019 which summarizes Efficiency Maine's performance less formally is: https://energynews.us/2019/01/14/northeast/maine-energy-efficiency-spending-rebounds-with-rggi-auction-prices/.

54 In Appendix 2, we explain how we derive this rough estimate of $350 million or higher in clean energy investments in Maine for 2019.

55 Note that the number of jobs created through a given amount of spending, such as $1 million, will no longer continue after the $1 million has been expended. Additional funding will be required for the jobs to be continued further.

56 https://www.pressherald.com/2020/03/30/maine-construction-industry-slows-down-but-keeps-working/.

57 We emphasize that this assumption of a 50 percent decline in production and employment in Maine's fossil fuel related and biomass industries by 2030, tied to a 50 percent decline in statewide consumption, also as of 2030, is only a *rough approximation*—though we believe it is the most reasonable such approximation. There are reasons to assume that production and employment in the affected industries will decline by less than the full fall in consumption. It is possible that Maine's fossil fuel and biomass related businesses will find it profitable to maintain a disproportionately large workforce even while overall demand declines because doing so maintains their operations at the most effective level. By contrast, it could also follow with some firms that the decline in demand for their products will encourage them to lay off workers by a more than proportional extent—i.e. to reorganize production with a higher level of capital intensity. Some firms could also shut down altogether due to the steady decline in demand (Pollin and Callaci (2018) discuss this latter prospect more fully). Given this range of possibilities—some of which are counteracting—on balance, we conclude, again, that the most reasonable working assumption for our purposes is that the decline in production and employment in Maine's fossil fuel and biomass related industries will be commensurate with the decline in statewide consumption.

58 The "average" compensation figure here for Maine's clean energy sectors is the weighted mean figure, from the sectoral means reported in Table 2.17.

59 For convenience, we use the terms "wage insurance" and "wage replacement" for the policy tools described in this section. But as the passage in the main text notes, we are in fact referring to both insurance and replacement policies for the full level of compensation that the displaced fossil fuel related industry workers will have been receiving at the time of their displacement.

60 As we discuss below, the exception to this is our assumption that coal-related activities contract fully over 2021-2030 rather than by 50 percent.

61 According to data published by the U.S. Labor Department, 20 percent of 65+ year-olds remain in the workforce. See: https://www.bls.gov/cps/cpsaat03.htm. According to these BLS data.

62 See more detailed discussions on these pension fund policies in, for example, Pollin et al. (2019).

63 An additional 3,000 – 4,000 jobs will also likely be generated through "induced" job creation channels.

64 https://www.mccs.me.edu/admissions-tuition-aid/tuition-aid/tuition-fees/.

65 According to the 2020 article in Moneyzine "Job Relocation Expenses," these expenses for an average family range between $25,000 and $75,000 (https://www.money-zine.com/career-development/finding-a-job/

job-relocation-expenses/). The costs include: selling and buying a home, including closing costs; moving furniture and other personal belongings; and renting a temporary home or apartment while house-hunting for a more permanent residence. For our calculations, we assume the upper-end figure of $75,000.

66 Prentiss does, however, recognize that, beyond providing the average level of energy demanded at any given time is the challenge of meeting the specific energy demand needs, given that wind and solar power both are intermittent energy sources. Thus, she explains that technological advances will also be necessary to achieve an energy infrastructure that relies on renewable energy for 100 percent of supply. She writes that "The question of whether renewable energy could provide all of the actual instantaneous energy needs of the United States is an open question that depends on how fluctuating renewable energy sources can be harnessed to provide power on demand. A revolutionary advance in large-scale energy storage would greatly ease the transition to a 100 percent renewable- energy economy; however, a combination of increases in energy efficiency due to widespread adoption of existing technologies and "smart grid" that pool energy supply and demand over large geographical areas may allow a renewable energy economy to flourish even without large-scale energy storage," (2015, p. 2). Prentiss reiterates that basic conclusion in a more recent 2019 article, "The Technical Path to Zero Carbon," in which she concludes that through a range of approaches, including battery storage and straightforward improvements in energy transmission systems, "science and technology are not preventing us from achieving a 100 percent US renewable energy economy." A broadly similar assessment as to the potential for renewable energy to supply 100 percent of energy needs for India was developed by Prof. S.P. Sukhatme in his 2013 paper, "Can India's Future Needs of Electricity be Met by Renewable Energy Sources?"

67 https://www.infrastructurereportcard.org/.

68 We took the figures for broadband and gas pipes from the May 2020 joint report of PERI and the Sierra Club, https://www.peri.umass.edu/component/k2/item/1297-job-creation-estimates-through-proposed-economic-stimulus-measures. The figures for Maine's public housing needs come from https://nlihc.org/housing-needs-by-state/maine

69 https://www.newscentermaine.com/article/news/politics/lawmakers-told-current-budget-ok-but-next-year-will-have-problems/97-cd91df90-49ba-4b15-9eff-a7147ec6ed9a.

70 https://www.maine.gov/governor/mills/news/governor-mills-legislative-leaders-reach-bipartisan-agreement-revised-supplemental-budget.

71 https://www.census.gov/data/datasets/2017/econ/local/public-use-datasets.html.

72 https://www.upjohn.org/research-highlights/updated-proposal-timely-responsive-federal-aid-state-and-local-governments-during-pandemic-recessionhttps://www.upjohn.org/research-highlights/updated-proposal-timely-responsive-federal-aid-state-and-local-governments-during-pandemic-recession.

73 The sources for Maine's share of federal support through the CARES Act is provided in the following sources. The Maine State Legislature includes detailed estimates of federal awards for government and businesses as of 5/27/2020, which can be supplemented with information about federal unemployment assistance from the Maine Department of Labor and the one-time economic impact payments from the Government Accountability Office. See: https://www.maine.gov/labor/cwri/ui.html and https://www.gao.gov/mobile/products/GAO-20-625

74 Spreadsheet: Federal Grant Awards Available Through COVID-19 Legislation (updated 6/24/2020) linked on Maine Bureau Budget website: https://www.maine.gov/budget/sites/maine.gov.budget/files/inline-files/Federal%20Grant%20Awards%20Available%20Through%20COVID-19%20Legislation_4.xlsx.

75 Local governments in Maine were not eligible to directly receive federal funds under the rules that applied under the CARES Act, which excluded all but the largest metropolitan areas from direct federal support.

76 Spreadsheet: Governor's Commitments for Use of Coronavirus Relief Funds (CRF) (updated 6/8/2020) linked on Maine Bureau Budget website: https://www.maine.gov/budget/sites/maine.gov.budget/files/inline-files/Governor%20Commitments%20for%20Use%20of%20Coronavirus%20Relief%20Funds%20%28CRF%29.xlsx.

77 https://reason.org/commentary/the-estimated-funding-each-state-would-get-from-the-3-trillion-heroes-act/; https://taxfoundation.org/heroes-act-state-local-aid/, https://pingree.house.gov/news/documentsingle.aspx?DocumentID=3371.

78 https://www.ncsl.org/research/fiscal-policy/state-constitutional-and-statutory-requirements-fo.aspx.

79 Article 9, Section 14 Maine Constitution: https://www.maine.gov/legis/const/#a9.

80 https://www.newscentermaine.com/article/news/politics/maine-politics/maine-election-day-july-2020-everything-you-need-to-know-about-today-maine-election-results-will-be-right-here/97-f64512ea-267c-4d64-bf9d-6ca7f0b70028

81 https://www.peri.umass.edu/publication/item/1286-the-federal-reserve-public-education-emergency-financing-facility-peeff-a-proposal.

82 https://www.marketwatch.com/story/fed-expands-municipal-debt-purchase-plan-to-allow-more-counties-and-cities-to-participate-2020-04-27.

83 https://www.maine.gov/budget/sites/maine.gov.budget/files/inline-files/Federal%20Grant%20Awards%20Available%20Through%20COVID-19%20Legislation_4.xlsx.

84 The Paycheck Guarantee Act, introduced into the House of Representatives by Representative Pramila Jayapal is a much more effective measure for supporting small businesses and workers than the Paycheck Protection Program that became law. Under this proposal, the federal government would provide grants to all private and public-sector employers of all sizes to enable them to maintain their operations and keep all of their workers on payroll, despite the fall off in revenues these entities will have experienced resulting from the pandemic and lockdown. Through this program, there would be no further significant increases in unemployment. As such, no further workers would lose their employer-based health care coverage, and those who have already lost this coverage would get it restored. The Paycheck Guarantee Plan would be similar in design and scope to policies that are already operating effectively in several European economies, including Germany, the UK, Denmark, and France. See, e.g.: https://foreignpolicy.com/2020/04/24/united-states-europe-coronavirus-pandemic-shutdown-unemployment/.

85 https://www.peri.umass.edu/publication/item/1287-assessing-the-medicare-crisis-proposal.

86 https://www.ft.com/content/ec10b41a-84af-4e44-ad3f-5bb86b6e1eaa.

87 https://maine.municipalbonds.com/bonds/recent/.

88 http://legislature.maine.gov/bills/getPDF.asp?paper=SP0457&item=3&snum=129.

89 https://www.c2es.org/content/multi-state-initiatives/.

90 https://www.efficiencymaine.com/triennial-plan-iv/.

91 http://www.mainelegislature.org/legis/statutes/5/title5sec1764-A.html.

92 https://www.maine.gov/dps/fmo/building-codes.

93 http://www.cleancarscampaign.org/web-content/stateaction/stateaction.html.

94 https://www.efficiencymaine.com/docs/EMT-FY18-Annual-Report.pdf.

95 https://www.efficiencymaine.com/renewable-energy/about-biomass-boilers-and-furnaces/, https://www.efficiencymaine.com/heating-solutions/, https://www.efficiencymaine.com/at-home/water-heating-solutions/, https://www.efficiencymaine.com/natural-gas-combi-boilers/, https://www.efficiencymaine.com/about-heat-pumps/, https://www.efficiencymaine.com/at-home/ecm-circulator-pump-solutions/, https://www.efficiencymaine.com/renewable-energy/geothermal-heating-cooling-systems/.

96 https://www.efficiencymaine.com/at-home/lighting-solutions/; https://www.efficiencymaine.com/appliance-solutions/.

97 https://www.efficiencymaine.com/at-home/insulation/, https://www.efficiencymaine.com/at-home/home-energy-savings-program/air-sealing/.

98 https://www.efficiencymaine.com/ev/rebate-process/.

99 https://www.efficiencymaine.com/at-home/energy-audit/.

100 https://programs.dsireusa.org/system/program/detail/4062 , https://c2es.carto.com/viz/90d8f7be-180d-4636-a219-4b54e837c9c4/embed_map.

101 http://www.mainelegislature.org/legis/bills/display_ps.asp?snum=129&paper=HP0077&PID=1456.

102 https://www.efficiencymaine.com/custom-distributed-generation-projects/.

103 For specs see: https://www.efficiencymaine.com/docs/FY19-Annual-Report_final.pdf.

104 https://www.ncsl.org/Portals/1/Documents/energy/Utility_Incentives_4_2019_33375.pdf?ver=2019-04-04-154310-703.

105 https://programs.dsireusa.org/system/program/detail/3455.

106 http://www.maine.gov/mpuc/greenpower/faq.shtml#about.

107 http://www.maine.gov/mpuc/legislative/documents/Green power rule.pdf.

108 Efficiency Maine Trust. 2020. *Efficiency Maine FY2019 Annual Report*, p. 1. https://www.efficiencymaine.com/docs/FY19-Annual-Report_final.pdf.

109 Solar Energy Industries Association (SEIA). 2020. *State Solar Spotlight: Maine*. https://www.seia.org/sites/default/files/2020-06/Maine_0.pdf.

110 American Wind Energy Association (AWEA). 2020. *Wind Energy In Maine*. https://www.awea.org/Awea/media/Resources/StateFactSheets/Maine.pdf.

111 In recent data sets, IMPLAN has started reporting electricity generation from some renewable sources — biomass, solar, geothermal, hydro, etc., which primarily captures the operation and maintenance of the industry.

112 We use the CPS data files provided by IPUMS-CPS: "Integrated Public Use Microdata Series, Current Population Survey: Version 7.0, Minneapolis, MN: IPUMS, 2020," published by Sarah Flood, Miriam King, Renae Rodgers, Steven Ruggles and J. Robert Warren. https://doi.org/10.18128/D030.V7.0.

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