Economic Impacts of a Clean Energy Transition in New Jersey

Image Credit: Swiss Re

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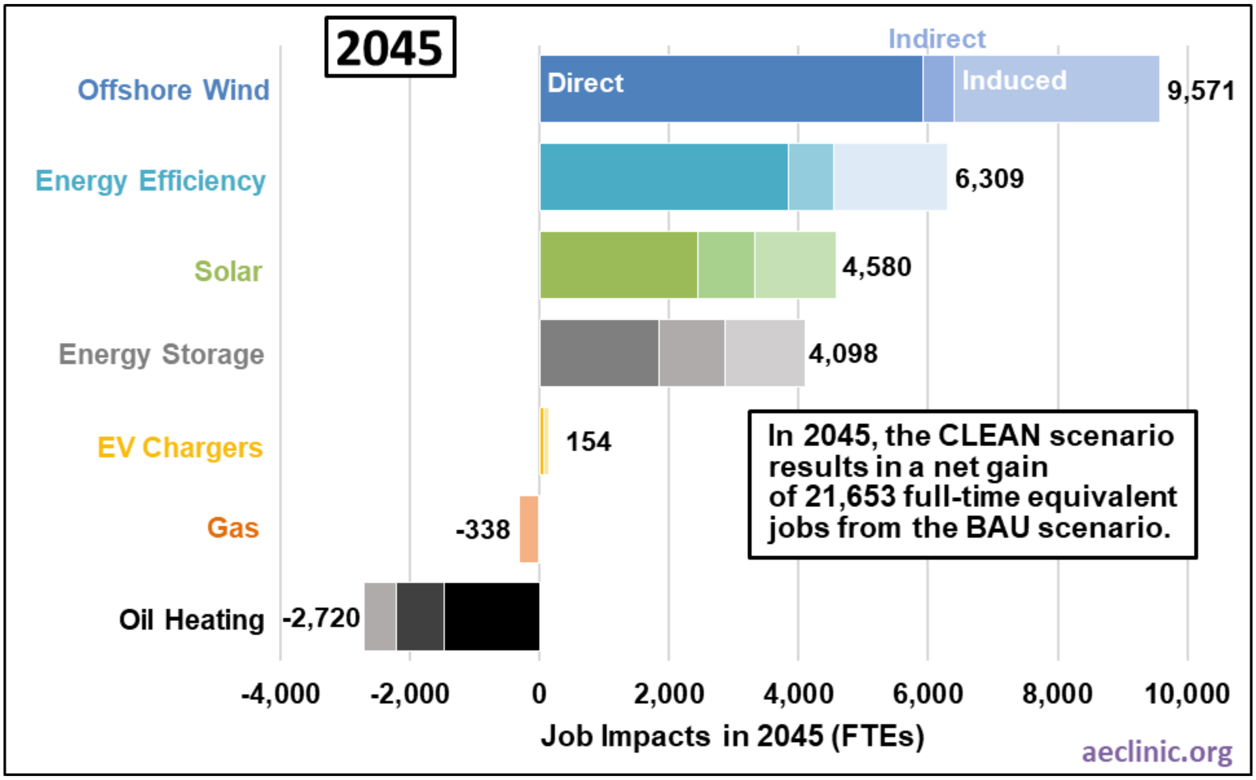
Executive Summary

The State of New Jersey aims to achieve its climate and energy goals of an 80 percent reduction in greenhouse gas emissions (relative to 2006 levels) and 100 percent clean energy supply by 2050. By moving away from fossil fuels and shifting towards zero-emission resources, a clean energy transition will benefit New Jersey's residents and natural environment by adding new, relatively high paying jobs, increasing tax revenues and economic activity, reducing greenhouse gas emissions and local pollution, and creating opportunities to improve equity in energy burdens and the availability of energy services. This Applied Economics Clinic (AEC) report analyzes the jobs and other economic impacts associated with a clean energy transition in New Jersey that aims to achieve the State's climate and energy goals in the coming decades.

From 2025 to 2050, we estimate that New Jersey's clean energy transition will result in almost 300,000 more "job-years" (an average of about 11,000 jobs per year) than would be created without it. In 2045, for example, we estimate a new increase of nearly 22,000 jobs (see Figure ES-1 for additional jobs from the clean energy transition (CLEAN) in 2045 compared to a business-as-usual scenario (BAU)).

A "job-year" is the number of "jobs per year" added up across multiple years (i.e., one job-year is the equivalent of one person working full-time for one year). For example, a worker that has the same full-time job for 5 years has one job but 5 job-years.

Figure ES-1. Annual job impacts in 2045 in the CLEAN scenario less the BAU (existing policy) scenario



In 2045, the CLEAN scenario results in a net gain of 21,653 full-time equivalent jobs from the BAU scenario.

Over the 26 year period modeled, the cumulative job gains from renewable energy (154,461 added job-years), energy storage (60,541 added job-years), energy efficiency (117,348 added job-years), and EV charging (5,774 added job-years) is roughly 6.6 times higher than the job losses experienced from reduced gas-fired power plants (5,210 lost job-years) and oil heating (45,954 lost job-years) (see Table 2).

Table ES-1. Cumulative job impacts between 2025 and 2050 in the CLEAN scenario less the BAU scenario

Cumulative Job Impacts 2025-2050	Full-time equivalents (FTEs) in job-years			
	Direct	Indirect	Induced	TOTAL
Energy Efficiency	71,347	13,309	32,691	**117,348**
Solar	46,556	17,412	24,844	**88,812**
Offshore Wind	41,031	2,596	22,022	**65,649**
Energy Storage	27,224	14,965	18,353	**60,541**
EV Chargers	2,455	181	3,138	**5,774**
Gas	-360	-4,538	-312	**-5,210**
Oil Heating	-24,728	-12,622	-8,604	**-45,954**
TOTAL	**163,526**	**31,302**	**92,132**	**286,960**

Note: A "job-year" is the number of "jobs per year" added up across multiple years (i.e., one job-year is the equivalent of one person working full-time for one year). For example, a worker that has the same full-time job for 5 years has one job but 5 job-years. The underlying data for AEC's analysis is derived from New Jersey's 2019 EMP 5-year snapshot data. Due to the lack of annual data, AEC assumes that job impacts change on a linear (smooth) basis between each of the 5-year snapshots to estimate the cumulative job impacts over the entire analysis period.

Our main findings include:

- The difference in spending between New Jersey's clean energy transition and a business-as-usual case amounts to a net value of $0.8 billion in 2025 growing to nearly $7.4 billion dollars in 2045 at the height of new clean energy investments. Reduced spending in the EMP on gas-fired power plants is small, and added investment in offshore wind, energy storage, energy efficiency measures, and, to a lesser degree, solar and EV chargers, is much larger.

- New Jersey's clean energy transition creates more job opportunities than the business-as-usual scenario—more than a net 21,600 additional full-time jobs in 2045. While annual job losses in the gas-fired generation and oil heating sectors are 460 and 2,800, respectively, the growth in green jobs is far greater.

- In addition to job creation, the CLEAN scenario also results in an estimated $2,739 million more in state GDP (or overall economic activity) in 2045 than the BAU (existing policy) scenario.

- Although new gas-fired power plants are not anticipated in either the BAU (existing policy) or CLEAN scenarios, the operation and maintenance of existing plants is accounted for throughout these plants' lifetimes. Labor costs at gas-fired power plants typically do not vary based on how much electricity is generated. In our modeling, therefore, the direct jobs from gas generation only change when a unit is retired.

In addition, AEC identifies a variety of additional important benefits of a clean energy transition, including several potential benefits that are conditional on the design and implementation of the transition.

A clean energy transition will:

- **Create job opportunities** by generating safe, quality career options,
- **Protect the environment** by curbing contamination of natural ecosystems, and
- **Improve public health and safety** by decreasing the risk of chronic illnesses.

With intentional design, a clean energy transition can:

- Make progress in **redressing historical inequalities** if the needs and input of overburdened communities are prioritized.
- Result in **lower energy bills** if it employs flexible electric resources.
- **Enhance grid resilience** if it uses sustainable community microgrids.
- Repurpose "brownfields" and **optimize land use** if clean energy resources are strategically sited.
- **Create accessible and safe modes of transportation** if it focuses on the needs of all communities.

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About the Applied Economics Clinic

Based in Arlington, Massachusetts, the Applied Economics Clinic (AEC) is a mission-based non-profit consulting group that offers expert services in the areas of energy, environment, consumer protection, and equity from seasoned professionals while providing on-the-job training to the next generation of technical experts.

AEC's non-profit status allows us to provide lower-cost services than most consultancies and when we receive foundation grants, AEC also offers services on a pro bono basis. AEC's clients are primarily public interest organizations—non-profits, government agencies, and green business associations—who work on issues related to AEC's areas of expertise. Our work products include expert testimony, analysis, modeling, policy briefs, and reports, on topics including energy and emissions forecasting, economic assessment of proposed infrastructure plans, and research on cutting-edge, flexible energy system resources.

AEC works proactively to support and promote diversity in our areas of work by providing applied, on-the-job learning experiences to graduate students—and occasionally highly qualified undergraduates—in related fields such as economics, environmental engineering, and political science. Over the past four years, AEC has hosted research assistants from Boston University, Brandeis University, Clark University, Tufts University, and the University of Massachusetts-Amherst. AEC is committed to a just workplace that is diverse, pays a living wage, and is responsive to the needs of its full-time and part-time staff.

Founded by Director and Senior Economist Elizabeth A. Stanton, PhD in 2017, AEC's talented researchers and analysts provide a unique service-minded consulting experience. Dr. Stanton has had two decades of professional experience as a political and environmental economist leading numerous studies on environmental regulation, alternatives to fossil fuel infrastructure, and local and upstream emissions analysis. AEC professional staff includes experts in electric, multi-sector and economic systems modeling, climate and emissions analysis, green technologies, and translating technical information for a general audience. AEC's staff are committed to addressing climate change and environmental injustice in all its forms through diligent, transparent, and comprehensible research and analysis.

I. Introduction

As national, state, and local governments establish ambitious climate and energy goals, the production and consumption of energy must move away from fossil fuels and shift to zero-emission resources. A clean energy transition leads to economy-wide reductions in greenhouse gas emissions that enable governments to meet their climate goals as well as realize a variety of important benefits, including several potential benefits that are conditional on the design and implementation of the transition.

Enacted in 2007, New Jersey's Global Warming Response Act (GWRA) aims to achieve an 80 percent reduction in statewide greenhouse gas emissions (relative to 2006 levels) by 2050.[1] In November 2021, Governor Phil Murphy's Executive Order No. 274 established an interim target of 50 percent statewide emissions reductions by 2030, relative to 2006 levels.[2] In May 2018, Governor Murphy's Executive Order No. 28 increased this commitment to 100 percent clean energy in New Jersey by 2050.[3] In November 2019, Governor Murphy signed Executive Order No. 92 increasing the state's offshore wind commitment from 3.5 GW by 2030 to 7.5 GW by 2035.[4] In addition, the 2018 Clean Energy Act requires: 2,000 MW of energy storage by 2030, 2 percent reductions in utilities' annual electric sales and 0.75 percent reductions in annual gas sales, and accelerating the solar renewable portfolio standard to 5.1 percent in 2021.[5] New Jersey's *2019 Energy Master Plan* (EMP)[6] provides a vision of what actions the state will need to take to achieve its climate and energy goals.

Technological advancements within the clean energy sector drive down costs and create more efficient systems that can influence the planning and implementation of a clean energy transition. Over the past few years, the cost of clean energy technologies has rapidly declined making these zero-carbon solutions increasingly competitive with their fossil fuel counterparts.[7] Newer, more efficient energy technologies are being developed and deployed throughout all sectors of the economy (e.g., longer duration batteries, more efficient solar panels, wind turbines and heat pumps, longer range electric vehicles, etc.). Intentional design that seeks to prioritize equitable outcomes throughout the transition process enables clean energy resources to provide important benefits to overburdened communities that would otherwise not be realized.

A clean energy transition creates job opportunities, protects the natural environment, and improves public health and safety in the state. Depending on how a clean energy transition is implemented, communities can also realize other important benefits including enhanced grid resilience, lower electric bills, optimize land use, expand transportation options, and contribute to redressing historical inequalities.

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[1] New Jersey Public Laws Chapter 112 (GWRA), (2007). *Global Warming Response Act.* Available at: https://www.nj.gov/dep/aqes/docs/gw-responseact-07.pdf

[2] New Jersey Governor Phil Murphy. Executive Order No. 274 (2021). Available at: https://www.nj.gov/infobank/eo/056murphy/pdf/EO-274.pdf

[3] New Jersey Governor Phil Murphy. Executive Order No. 28 (2018). Available at: https://nj.gov/infobank/eo/056murphy/pdf/EO-28.pdf

[4] New Jersey Governor Phil Murphy. Executive Order No. 92 (2019). Available at: https://nj.gov/infobank/eo/056murphy/pdf/EO-92.pdf

[5] The Senate and General Assembly of the State of New Jersey. 2018. "NJ Clean Energy Act" (P.L.2018, c.17). *An Act concerning Clean energy, amending and supplementing P.L.1999, c.23, amending P.L.2010, c.57, and supplementing P.L.2005, c.354 (C.34:1A-85 et seq.)* Available at: https://lpdd.org/wp-content/uploads/2020/12/NJ-Clean-Energy-Act-2018.pdf

[6] New Jersey Board of Public Utilities (NJ BPU). 2020. *2019 New Jersey Energy Master Plan: Pathway to 2050*. Available at: https://www.nj.gov/emp/docs/pdf/2020_NJBPU_EMP.pdf

[7] Taylor, M., et al. 2021. *Renewable Power Generation Costs 2020.* International Renewable Energy Agency (IRENA). Available at: https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020

Beyond these important benefits, the clean energy transition in New Jersey provides an additional benefit: a dramatic reduction in greenhouse gas emissions across the state, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). If New Jersey were its own country, its net emissions of 97.0 million metric tons of CO_2 equivalents in 2018 (roughly 10.9 metric tons per capita)[8] would rank it as the 30th-largest per-capita emissions producer in the world.[9]

Decarbonizing New Jersey is a necessary contribution to the critical national—and global—effort to curb greenhouse gas emissions and limit global warming and the devastating effects of climate change. A statewide decarbonization program in New Jersey could lead the way, spurring similar action in other states in the United States, which could prompt a massive reduction in global emissions.[10] Reducing global emissions contributes to the prevention of more frequent and extreme weather events, sea-level rise, and the resulting damage to health, ecosystems, and infrastructure. If climate change and its ramifications can be kept in check, communities worldwide and New Jersey—a particularly vulnerable U.S. state to climate change due to its large coastline and dense population—will be the beneficiaries.

A clean energy transition in New Jersey would allow the state to achieve its climate and energy goals, while also creating a variety of potential benefits for its residents. This Applied Economics Clinic (AEC) report estimates the economic impact associated with a clean energy transition and finds that adding in-state renewables and storage, and electrifying transportation and buildings creates additional job opportunities, while also bolstering the state's economy. AEC also identifies and describes the impacts of a clean energy transition in New Jersey. Our assessment focuses on how New Jersey's communities—especially those that are disproportionately burdened by existing inequities and/or lack the capacity to withstand new or worsening burdens—will be impacted by an economy-wide shift to zero-emitting energy resources.

The report begins in Section II with an overview of a potential pathway for New Jersey's clean energy transition. Section III reports on the findings of our jobs and economic impact analysis. Section IV reviews the core benefits of a clean energy transition and Section V discusses the conditional benefits that could be realized if the transition is designed and implemented in a thoughtful manner. Appendix A provides some caveats and additional insight into AEC's modeling decisions and data limitations, which are important to understanding the findings of this analysis. Appendices B and C describe our methods used to adjust the 2019 EMP's "Least Cost" scenario and estimate the costs for the electric, buildings, and transportation sectors. Appendix D presents the methodology and assumptions used in AEC's economic impact analysis, and Appendix E presents our detailed modeling results.

In a companion publication to this report—*Barriers and Opportunities for Green Jobs in New Jersey*—AEC discusses equity, diversity and inclusion in New Jersey's clean energy sector along with barriers that impede equitable representation in New Jersey's green jobs.[11]

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[8] New Jersey Department of Environmental Protection (NJ DEP). 2019. *2018 Statewide Greenhouse Gas Emissions Inventory*. NJ DEP. Available at: https://www.nj.gov/dep/aqes/docs/nj-ghg-inventory-report-2018.pdf

[9] Ritchie, H. and Roser, M. 2020. "CO2 and Greenhouse Gas Emissions". *OurWorldInData*. Available at: https://ourworldindata.org/co2-emissions

[10] United Nations Environment Programme. 2019. *Emissions Gap Report 2019*. UNEP. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf?sequence=1&isAllowed=y

[11] Woods, B., J.R. Castigliego, E. Seliga, S. Peddada, T. Stasio, and E.A. Stanton. June 2022. *Barriers and Opportunities for Green Jobs in New Jersey.* Available at: https://aeclinic.org/publicationpages/2022/06/07/barriers-and-opportunities-for-green-jobs-in-new-jersey

II. New Jersey's clean energy transition in numbers

A clean energy transition provides important benefits to New Jersey's communities. AEC's analysis shines a light on the jobs and other economic impacts associated with achieving New Jersey's climate and energy goals through a clean energy transition over the next few decades.

New Jersey's 2019 EMP provides several scenarios depicting actions the state needs to take to achieve its climate and energy goals. Our analysis utilizes the 2019 EMP's "Least Cost" scenario as a basis for assessing the economic impacts associated with achieving a clean energy transition in New Jersey over the next few decades. However, the 2019 EMP is only one potential approach and there may be others that come to light as relevant policies and technologies continue to develop over time. In fact, New Jersey's clean energy policies and commitments have already changed since the development of the 2019 EMP with an updated offshore wind commitment of 7.5 GW by 2035 that is not reflected in our analysis.[12] In addition, technological advancements in solar and battery storage resources over the past few years have made these technologies even more cost competitive compared to their fossil fuel-fired counterparts, a change that is reflected in our calculations and results.

To provide an estimate of the job and economic impacts possible from the EMP's "Least Cost" action plan, our modeling results estimate the economic impacts of a clean energy transition over and above the economic impacts of a business-as-usual, or no new policy, plan:

- **"Business-as-usual" or "BAU" scenario:** The EMP's "Reference 2" scenario represents existing policies and targets, including: renewable energy (50 percent by 2030, including 2 GW of storage and 3.5 GW of offshore wind), electric vehicles (330,000 EVs by 2025), energy efficiency (annual 2 percent savings for electric and 0.75 percent for gas).[13] This scenario (existing state policy) does not meet New Jersey's Global Warming Response Act (GWRA) emission reduction goals.
- **"Clean Energy Transition" or "CLEAN" scenario:** The EMP's "Least Cost" scenario presents a portfolio of clean energy transition measures across the electric, buildings, and transportation sectors to meet New Jersey's energy and climate goals of achieving 100 percent clean electric supply by 2050 and the GWRA goal of an 80 percent reduction in statewide greenhouse gas emissions (relative to 2006 levels) by 2050. For this analysis, AEC has made several important adjustments to the EMP's "Least Cost" scenario to update its assumptions based on more recent price information as well as replace gas- and biogas-fired resources with energy storage, but has not updated the 2019 EMP's assumptions to reflect changes in New Jersey's clean energy commitments (see *Appendix B*: Electric Sector Adjustments and Cost Methodology below for a detailed description of these adjustments).

New Jersey's electric capacity (that is, the resources that are on hand to deliver electricity as needed) differs greatly between the BAU (existing policy) and CLEAN scenarios (see Figure 1). In the CLEAN scenario, all gas-fired power plants in New Jersey are assumed to be retired by 2050. Growing investments in energy storage along with renewable energy resources, like offshore wind and solar, are added to the system to replace the retired gas-fired capacity and make up for the increased electric demand caused by electrification in the buildings and transportation sectors.

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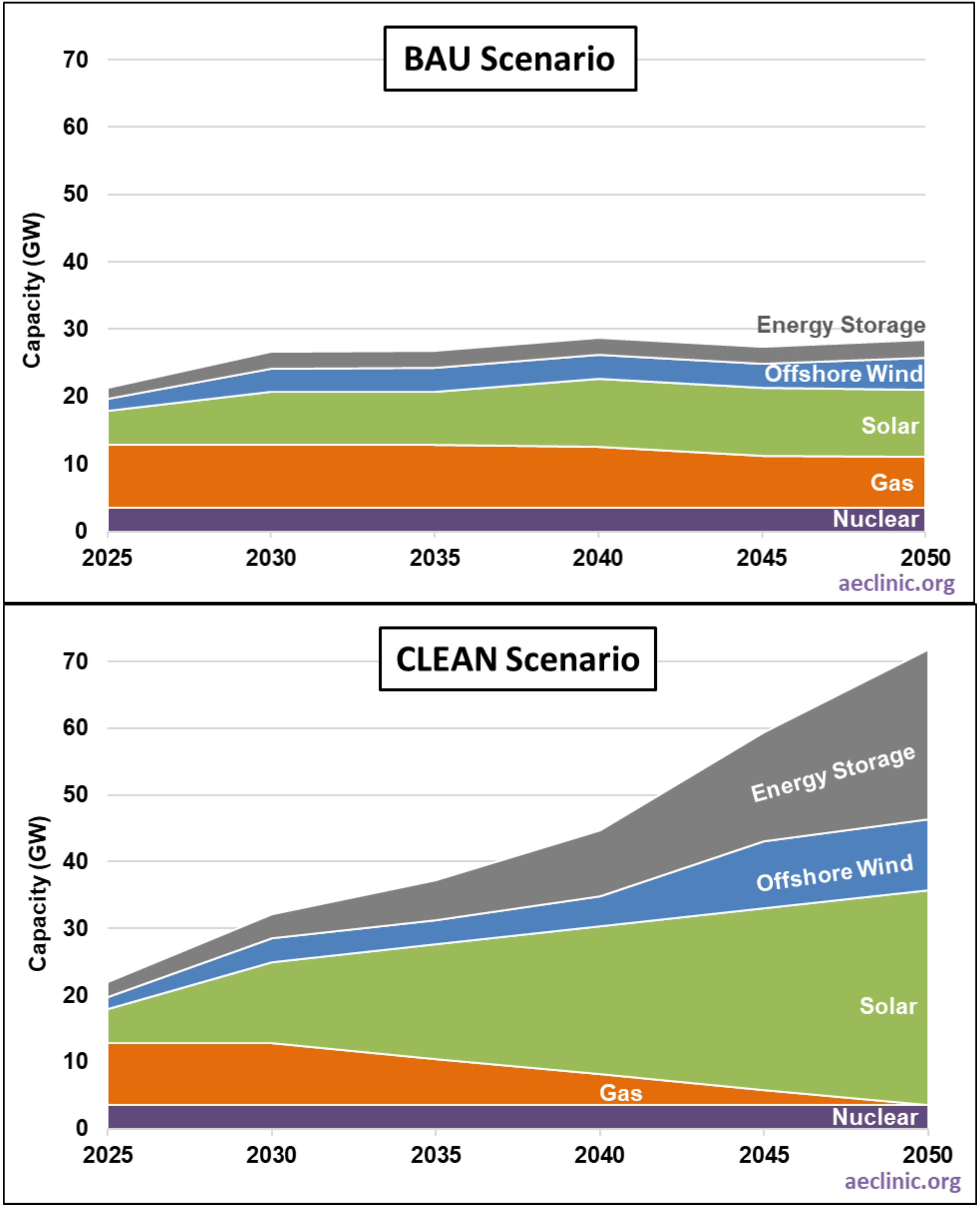
[12] New Jersey Governor Phil Murphy. Executive Order No. 92 (2019). Available at: https://nj.gov/infobank/eo/056murphy/pdf/EO-92.pdf

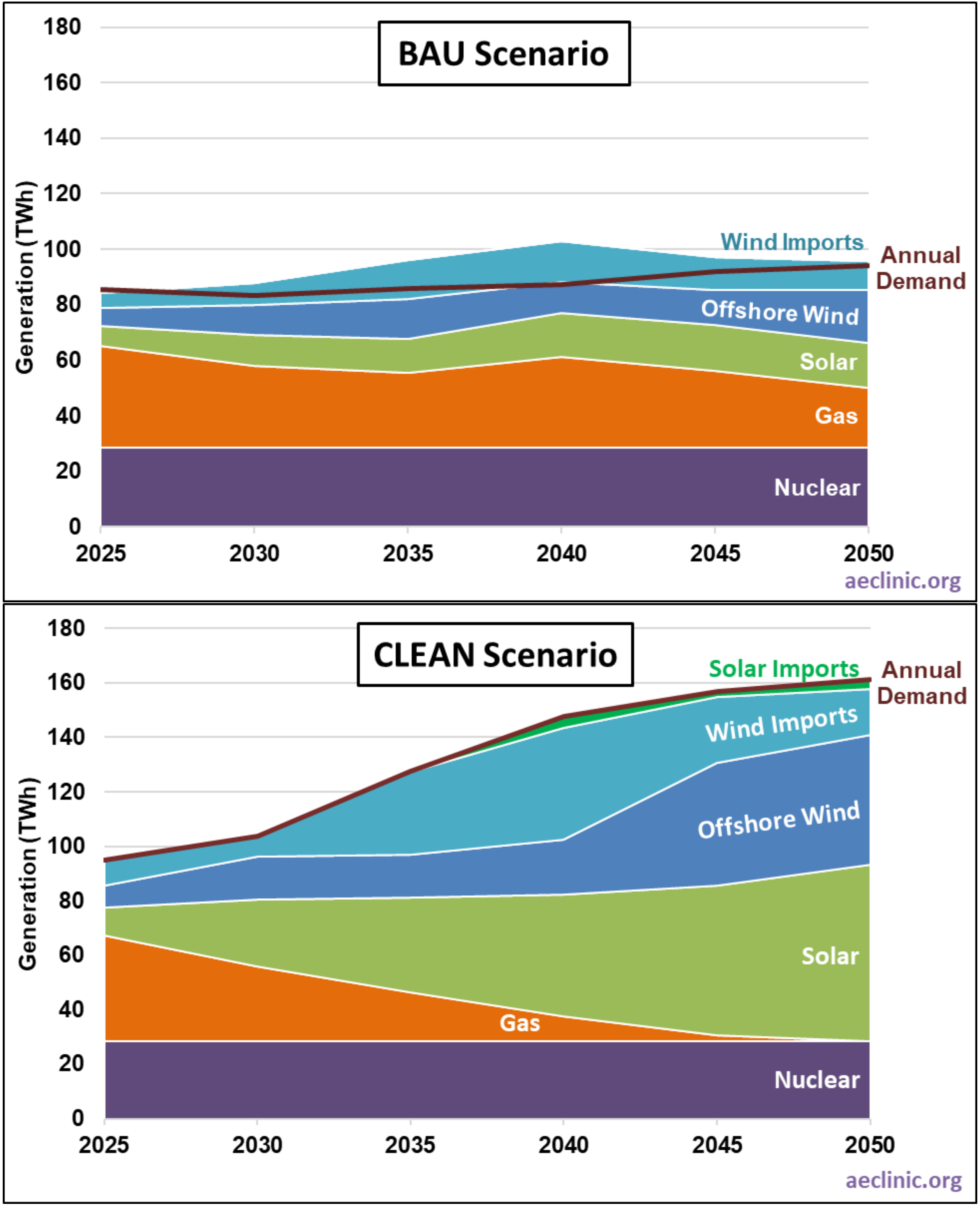
[13] Evolved Energy Research. 2019. *New Jersey 2019 IEP Technical Appendix*. Available at: https://www.nj.gov/emp/pdf/New_Jersey_2019_IEP_Technical_Appendix.pdf p. 8

Figure 1. Electric capacity (GW) in New Jersey under the BAU and CLEAN scenarios



Note: This analysis does not account for New Jersey's revised offshore wind goal of 7.5 GW by 2035, which would accelerate the deployment of offshore wind compared to the 2019 EMP. Both scenarios also have electric capacity from "onshore wind" (7 MW) and "other" (less than 300 MW).

Figure 2. Electric generation (TWh) in New Jersey under the BAU and CLEAN scenarios

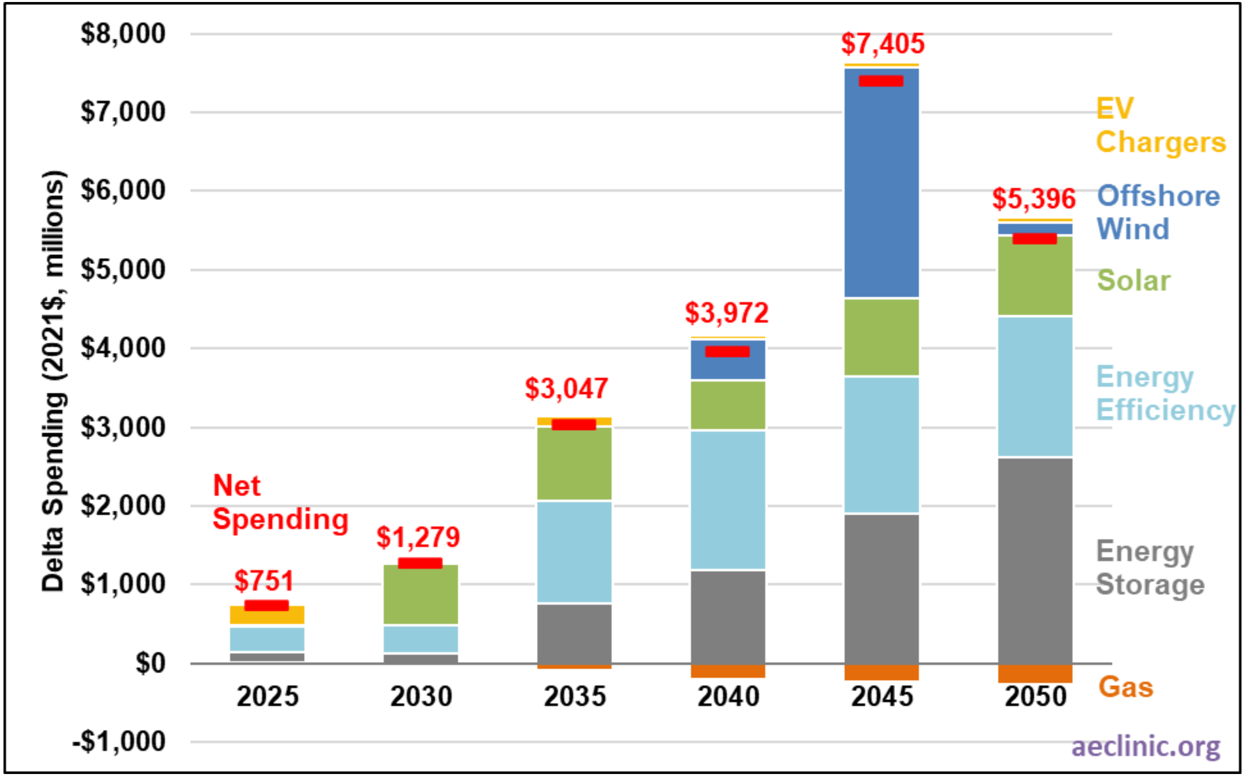


Note: This analysis does not account for New Jersey's revised offshore wind goal of 7.5 GW by 2035, which would accelerate the deployment of offshore wind compared to the 2019 EMP. The BAU (existing policy) scenario includes 1,310 GWh of gas imports in 2025 and solar imports between 85 and 153 GWh between 2030 and 2050. Both scenarios exclude electric generation from "onshore wind" and "other" due to a lack of generation data.

Customers' annual demand for electricity nearly doubles from 2025 to 2050, along with the electric generation needed to support it (see Figure 2 above). In both scenarios, wind and solar generation imported from out of state is needed to supply sufficient generation to meet demand, and nuclear generation is unchanged between the two scenarios. The CLEAN scenario meets the rapid growth of electric demand needed to power new electric heat pumps and electric vehicles (EVs) with added investment in offshore wind and solar panels, paired with a rapid reduction in gas-fired generation.

This report focuses on the difference in spending, jobs, and other economic activity created by the CLEAN scenario in excess of the BAU (existing policy) scenario. This difference in spending amounts to a net value of $0.8 billion in 2025 growing to nearly $7.4 billion dollars in 2045 at the height of new clean energy investments (see Figure 3, the steep drop in offshore wind spending between 2045 and 2050 depicts the loss of wind construction jobs; the remaining wind jobs are in operations and maintenance). The CLEAN scenario results in a net increase in spending: Reduced spending on gas-fired power plants is small, and added investment in offshore wind, energy storage, energy efficiency measures, and, to a lesser degree, solar and EV chargers, is much larger.

Figure 3. Spending by resource type in the CLEAN scenario less the BAU (existing policy) scenario



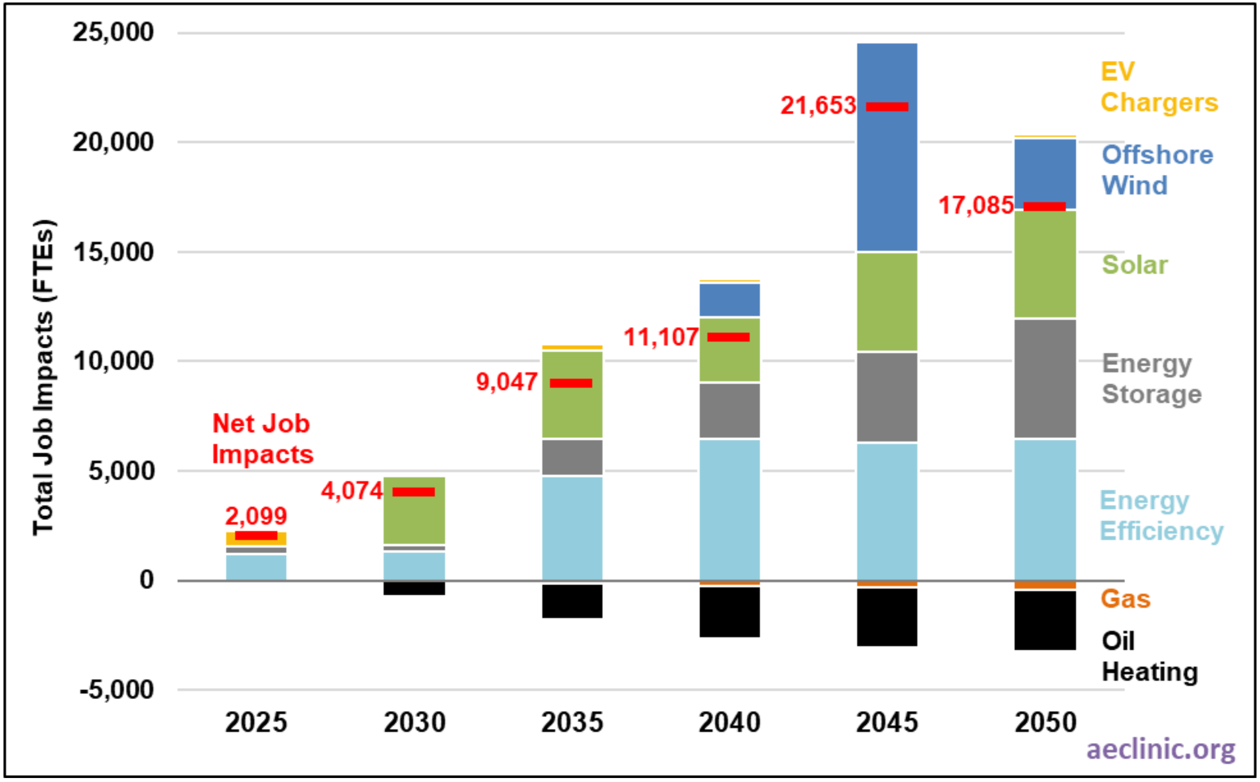
Note: This analysis does not account for New Jersey's revised offshore wind goal of 7.5 GW by 2035, which would accelerate the deployment of offshore wind compared to the 2019 EMP. See Appendices B and C for a detailed description of these spending estimates.

Using these spending differences, AEC estimates gains and losses in three kinds of economic impacts: jobs, state income (or state "gross domestic product", GDP), and labor income from salaries and wages. In the following section, these impacts are presented as differences between the two scenarios (and not as the total jobs or economic activity in either scenario). These results are presented in five year "snapshots": a view of the annual results in each snapshot year (and not as the cumulative impact of those five years added together).

III. Economic impact results

The CLEAN scenario creates more New Jersey job opportunities than the BAU (existing policy) scenario—more than a net 21,600 additional full-time jobs in 2045 (see Figure 4). While job losses in the gas-fired generation and oil heating sectors grow to over 3,000, the growth in green jobs is far greater. Energy efficiency, energy storage, solar panels, and EV chargers are consistently growing sources of jobs throughout the modeling period. In contrast, offshore wind jobs are primarily in manufacture and installation; fewer jobs remain once these resources are operational. Note that this study follows the 2019 EMP's assumption of reaching 3.5 GW of offshore wind by 2030 and does not take into account New Jersey's revised goal of 7.5 GW of offshore wind by 2035. For comparison, the 2019 EMP does not reach 7.5 GW of offshore wind until 2043.[14] (See *Appendix E: Detailed Economic Impact Results* for a more detailed breakdown of results.)

Figure 4. Annual FTE job impacts by resource type in the CLEAN scenario less the BAU scenario



Note: Employment or jobs in this report are in full-time equivalents (FTEs), which translates to 2,080 hours of work per year. IMPLAN does not differentiate between "permanent" and "temporary" employment—jobs are reported in the year that they exist.

Labor costs at gas-fired power plants are primarily in operations and maintenance: The number of people employed at the plant does not change significantly if the plant is operating or not. Therefore, in our modeling, the direct jobs from gas generation only fluctuate when a unit is retired. To align with New Jersey's climate and energy commitments, gas-fired power generation is phased out over the next few decades in the CLEAN scenario and replaced with zero-emitting energy resources and battery storage capacity.

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[14] In June 2021, the New Jersey Board of Public Utilities awarded two offshore wind projects to Orsted and Atlantic Shores for a combined capacity of nearly 2.7 GW. Both projects are expected to be online by 2030 or earlier and will contribute to New Jersey's goal of 7.5 GW of offshore wind by 2035. Note: Since these projects were awarded after the development of the 2019 EMP, their capacity and resulting job and economic impacts were not captured in the analysis presented in this report. Source: New Jersey Wind Port. "Why New Jersey." State of New Jersey. Available at: https://nj.gov/windport/whynj/

In 2025, the CLEAN scenario creates 1,105 more direct jobs than the BAU (existing policy) scenario, as well as 204 more indirect jobs and 790 more induced jobs (see Table 1). By 2045, the CLEAN scenario creates over 21,600 more total jobs than the BAU scenario: 58 percent direct, 9 percent indirect, and 32 percent induced. In addition to job creation, the CLEAN scenario also results in an estimated $2,739 million more in state GDP (or overall economic activity) in 2045 than the BAU scenario. At the height of the clean energy transition in 2045, the labor income associated with New Jersey's job creation is an estimated $2,054 million more than the BAU scenario.

Direct jobs are at the site of the investment. For instance, the workers installing wind turbines on a wind farm count as "direct jobs."

Indirect jobs are associated with providing supplies and services for the investment. For instance, the workers producing wind blades used to build a wind turbine.

Induced jobs result from direct and indirect workers re-spending their wages in the local economy. For instance, jobs at restaurants patronized by wind farm technicians.

Table 1. Net annual impacts (jobs, state GDP, labor income) in the CLEAN scenario less the BAU scenario

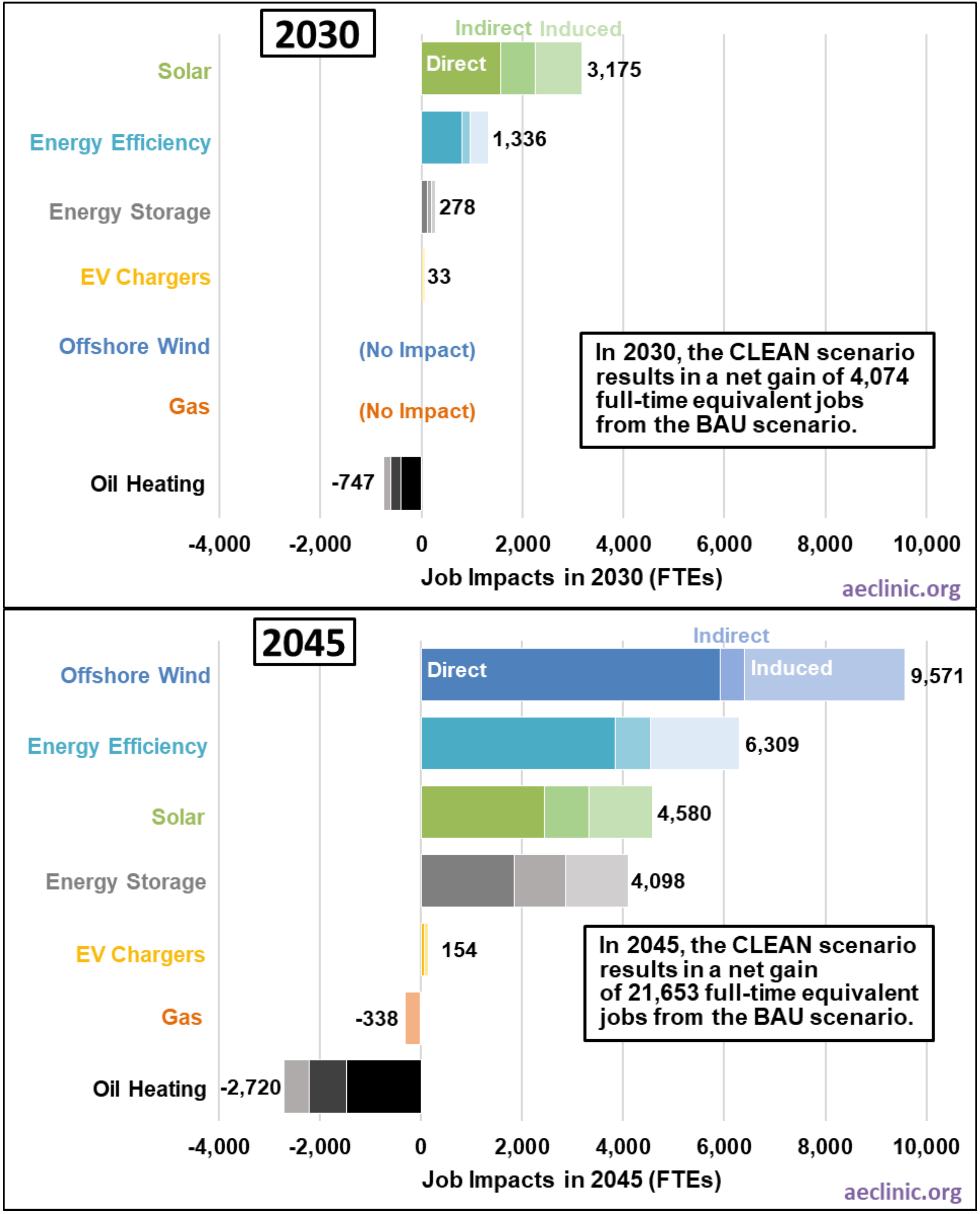
Total Impacts	Impact Type	2025	2030	2035	2040	2045	2050
Jobs *(FTEs)*	Direct	1,105	2,122	4,969	6,447	12,629	9,792
	Indirect	204	697	1,233	1,122	2,025	1,770
	Induced	790	1,255	2,845	3,539	6,999	5,523
	Total	**2,099**	**4,074**	**9,047**	**11,107**	**21,653**	**17,085**
State GDP *(2021$, millions)*	Direct	$164	$243	$574	$742	$1,754	$1,284
	Indirect	$29	$83	$140	$99	$215	$186
	Induced	$92	$135	$301	$361	$769	$589
	Total	**$285**	**$461**	**$1,014**	**$1,203**	**$2,739**	**$2,059**
Labor Income *(2021$, millions)*	Direct	$116	$231	$522	$690	$1,474	$1,117
	Indirect	$18	$52	$89	$66	$143	$119
	Induced	$52	$77	$171	$205	$437	$335
	Total	**$187**	**$359**	**$782**	**$961**	**$2,054**	**$1,571**

Note: See Appendix D: Economic Impacts Methodology for more details on how these results were developed.

In 2030, solar energy generation accounts for a majority of net annual jobs from the CLEAN scenario with 1,569 direct, 685 indirect, and 922 induced jobs for a total of 3,175 full-time jobs above and beyond that of the BAU (existing policy) scenario (see Figure 5 below). In this year, offshore wind and gas-fired power plants result in no job impacts—this is a result of there being no difference between the BAU and CLEAN scenarios for these resources. (This would likely differ if modeled with the full 7.5 GW of offshore wind that is now a target by 2035.) Conversions from oil heating to electric heat pumps in the CLEAN scenario cause a loss of nearly 750 jobs—mostly in fuel oil delivery—compared to the BAU scenario.

By 2045, offshore wind results in over 9,500 more jobs in the CLEAN scenario than the BAU (existing policy) scenario (see Figure 5 below). Energy efficiency, solar, and energy storage account for a majority of remaining positive job impacts with approximately 6,300, 4,600, and 4,100 more jobs, respectively. EV chargers result in a modest increase of 154 jobs over the BAU scenario. Gas-fired power generation results in a loss of 338 jobs, which includes 23 direct and 295 indirect jobs. Oil heating results in an additional 2,700 jobs lost.

Figure 5. Annual job impacts in 2030 and 2045 in the CLEAN scenario less the BAU (existing policy) scenario



Note: This analysis does not account for New Jersey's revised offshore wind goal of 7.5 GW by 2035, which would accelerate the deployment of offshore wind compared to the 2019 EMP. See Appendix D: Economic Impacts Methodology for more details on how these results were developed.

The CLEAN scenario creates 286,960 more job-years[15] (an average of about 11,000 jobs per year) than the BAU (existing policy) scenario over the 26-year period between 2025 and 2050 (see Table 2). The cumulative job gains from renewable energy production (154,461 added job-years), energy storage (60,541 added job-years), energy efficiency (117,348 added job-years), and EV charging (5,774 added job-years) is roughly 6.6 times higher than the job losses experienced in the gas power generation (5,210 lost job-years) and oil heating sectors (45,954 lost job-years). (Note that the underlying data for AEC's analysis is derived from New Jersey's 2019 EMP in 5-year snapshots. Due to the lack of annual data, AEC assumes that job impacts change on a linear (smooth) basis between each of the 5-year snapshots to estimate the cumulative job impacts over the entire analysis period.)

Table 2. Cumulative job impacts between 2025 and 2050 in the CLEAN scenario less the BAU scenario

Cumulative Job Impacts 2025-2050	Full-time equivalents (FTEs) in job-years			
	Direct	Indirect	Induced	TOTAL
Energy Efficiency	71,347	13,309	32,691	**117,348**
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EV Chargers	2,455	181	3,138	**5,774**
Gas	-360	-4,538	-312	**-5,210**
Oil Heating	-24,728	-12,622	-8,604	**-45,954**
TOTAL	**163,526**	**31,302**	**92,132**	**286,960**

Note: The underlying data for AEC's analysis is derived from New Jersey's 2019 EMP 5-year snapshot data. Due to the lack of annual data, AEC assumes that job impacts change on a linear (smooth) basis between each of the 5-year snapshots to estimate the cumulative job impacts over the entire analysis period.

IV. Core benefits of a clean energy transition

The strategies and investments that eliminate greenhouse gases and local air and water pollutants provide additional "co-benefits" for the residents of New Jersey (see Table 3). A clean energy transition requires large investments into clean energy industries and infrastructure, which will change and expand the energy sector and related sectors, creating thousands of new, quality jobs. As the shift away from fossil fuel energy sources greatly reduces air and water pollution, benefits to New Jersey's natural environment and public health and safety are expected to multiply.

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[15] A "job-year" is the number of "jobs per year" added up across multiple years (i.e., one job-year is the equivalent of one person working full-time for one year). For example, a worker that has the same full-time job for 5 years has one job but 5 job-years.

Table 3. Core benefits of a clean energy transition

Because a clean energy transition…	it will…	by…
Invests in clean energy industries	Create job opportunities	Generating safe, quality career options
Reduces air and water pollution	Protect the environment	Curbing contamination of natural ecosystems
Minimizes the use of fossil fuels	Improve public health and safety	Decreasing the risk of chronic illnesses

Creates job opportunities

A clean energy transition will stimulate the New Jersey economy by creating job opportunities, improving job quality, and boosting productivity. Recent research studies widely agree that a clean energy transition leads to an increase in jobs in the energy sector and elsewhere in the economy.[16] A 2022 study conducted by the Union of Concerned Scientists (UCS) (along with local environmental justice groups) finds that the expected additional job growth in a 100 percent clean energy transition is expected to be considerably larger than the total jobs lost in the fossil fuel sector—leading to a net job increase of nearly 200,000 job-years between 2020 and 2040 for the states of Massachusetts, Michigan and Minnesota.[17] A 2021 meta-analysis published by the climate policy think tank Energy Innovation estimates that a clean energy transition would create 500,000 to 1 million new jobs per year, nationwide.[18] Research published by the World Resources Institute in 2021 finds that, per million dollars invested, clean energy investments generate more jobs than fossil fuel investments.[19] The increase in green jobs will raise individual and business incomes; moreover, these new jobs will be free of fossil fuel-related health and safety hazards, conferring additional benefits to workers. With strong labor standards, unions, and training, clean energy jobs can further boost their quality with competitive wages and benefits, fewer occupational safety hazards, and specialized training.

While a clean energy transition generates a net increase in total jobs, it also leads to the elimination of fossil fuel industry jobs; as noted in a 2021 report from the Brookings Institution, it will be essential to provide adequate resources to ensure that workers in these jobs are retrained and rehired in clean energy jobs where possible.[20] With a concerted focus on communities that are reliant on fossil fuel jobs (such as those employed

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[16] (1) Brown, T., Bicknell, C., and Nystrom, S. 2015. *Focus on Energy Economic Impacts 2011-2014*. Cadmus. Prepared for Focus on Energy. Available at: https://focusonenergy.com/sites/default/files/WI%20FOE%202011%20to%202014%20Econ%20Impact%20Report.pdf; (2) Phadke, A., et al. 2020. *The 2035 Report: Plummeting solar, wind, and battery costs can accelerate our clean electricity future*. UC Berkeley Goldman School of Public Policy. Available at: http://www.2035report.com/wp-content/uploads/2020/06/2035-Report.pdf?hsCtaTracking=8a85e9ea-4ed3-4ec0-b4c6-906934306ddb%7Cc68c2ac2-1db0-4d1c-82a1-65ef4daaf6c1; (3) Griffith, S., and Calisch, S. 2020. *No Place Like Home: Fighting Climate Change (and Saving Money) by Electrifying America's Households*. Rewiring America. Available at: https://www.rewiringamerica.org/policy/household-report.

[17] García, P., et al. April 2022. *On the Road to 100 Percent Renewables: States Can Lead an Equitable Energy Transition*. Union of Concerned Scientists (UCS), COPAL, GreenRoots, and the Michigan Environmental Justice Coalition. Available at: https://www.ucsusa.org/resources/road-100-percent-renewables p.10.

[18] Esposito, D. 2021. *Studies agree 80 percent clean energy by 2030 would save lives and create jobs at minimal cost.* Energy Innovation. Available at: https://energyinnovation.org/wp-content/uploads/2021/09/Studies-Agree-80-Percent-Clean-Electricity-by-2030-Would-Save-Lives-and-Create-Jobs-at-Minimal-Cost.pdf

[19] Jaeger, J., et al. 2021. *The green jobs advantage: How climate-friendly investments are better job creators*. World Resources Institute. Available at: https://files.wri.org/d8/s3fs-public/2021-10/the-green-jobs-advantage-how-climate-friendly-investments-are-better-job-creators.pdf?VersionId=_4g3pkXM5qB8_DEy1MhhbF8AloDhqGUY

[20] Tomer, A., Kane, J.W., and George, C. 2021. *How renewable energy jobs can uplift fossil fuel communities and remake climate politics.* Brookings Institution. Available at: https://www.brookings.edu/research/how-renewable-energy-jobs-can-uplift-fossil-fuel-communities-and-remake-climate-politics/

in gas stations, petroleum refineries, and liquid fuel delivery companies) or are economically neglected, a clean energy transition can empower these communities with safe, well-paying jobs and technical skills training. A transition to clean energy jobs can also provide tangible health benefits to workers in fossil fuel jobs; for example, based on the results of a meta-analysis of 22 studies conducted by researchers in Iran, gas station employees are disproportionately susceptible to liver and kidney diseases due to exposure to toxic chemicals from gasoline and could avoid these adverse health impacts if employed in clean energy jobs.[21] In addition, the California State government warns that exposure to petroleum can lead to cancer, birth defects, and other reproductive harms, so workers in refineries likewise stand to benefit from a clean energy job transition.[22]

The 2021 *Net Zero America* study, conducted by researchers at Princeton University, finds that a net-zero transition could expand New Jersey's electric supply workforce (including generation, transmission and distribution of electricity) alone by 67 percent, from 45,000 jobs in 2021 up to 75,000 jobs in 2050; these new jobs would also bring in billions of dollars in wages for workers and millions in tax revenue for the State.[23] Research from the International Renewable Energy Agency (IRENA) confirms that a clean energy transition will yield higher economic growth, relative to business-as-usual fossil-fuel investments.[24] According to the International Labour Organization, accelerated economic growth could—if allocated into the right investments and targeted toward benefits for lower-income residents—fund opportunities for further job creation and generate widespread increases in the standard of living.[25]

Protects the environment

Transitioning away from fossil fuels and toward clean energy resources will substantially reduce emissions and pollution in New Jersey, thereby protecting its natural resources and ecosystems. Fossil fuel processing, transmission, distribution, and consumption in the electric, transportation, and manufacturing sectors result in the release of harmful pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter into the surrounding air and water.[26] These chemical byproducts, along with fossil fuel spills from pipeline leaks, can have disastrous environmental consequences, leading to the exacerbation of climate change, the contamination of natural resources, and the destruction of ecosystems and habitats. Moreover, noise pollution from gas-powered vehicles and industrial facilities causes harmful disruptions to the natural environment.

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[21] Moghadam, S.R., et al. 2020. "Effect of occupational exposure to petrol and gasoline components on liver and renal biochemical parameters among gas station attendants, a review and meta-analysis. *Reviews on Environmental Health 35* (4). Available at: https://doi.org/10.1515/reveh-2019-0107

[22] California Office of Environmental Health Hazard Assessment. N.d. "Petroleum Products: Environmental Exposure from Refineries." *Proposition 65 Warnings*. Available at: https://www.p65warnings.ca.gov/fact-sheets/petroleum-products-environmental-exposure-refineries

[23] These job counts do not include those in energy efficiency, electric vehicles, or appliances. Source: Larson, E., et al. 2021. *Net-Zero America: Potential Pathways, Infrastructure, and Impacts*. Princeton University. Available at: https://netzeroamerica.princeton.edu/the-report.

[24] International Renewable Energy Agency (IRENA). n.d. *Broad Benefits of Energy Transition towards 2050*. IRENA. Available at: https://unfccc.int/sites/default/files/resource/3.43%20IRENA%20Nagata.pdf.

[25] International Labour Organization (ILO). N.d. "Employment-rich Economic Growth." Available at: https://www.ilo.org/global/topics/dw4sd/themes/employment-rich/lang--en/index.htm

[26] Coal-fired power plants, of which there are two still operating in New Jersey, produce additional air and water pollutants including heavy metals. New Jersey's last two coal plants, Logan and Chambers, are scheduled to shut down by May 31, 2022, with an expected savings to customers of up to $30 million. Source: Wade, W. March 23, 2022. "New Jersey's Last Coal Plants to Close as State Goes Green." *Bloomberg*. Available at: https://www.bloomberg.com/news/articles/2022-03-23/new-jersey-s-last-coal-plants-to-close-as-state-goes-green

Switching from fossil fuels to renewable resources can mitigate these harms. A 2021 study conducted by Clean Energy Futures found that sharply reducing fossil fuel use in the U.S. economy can lower emissions of SO_2, NO_x, and mercury by 71 to 96 percent.[27] Emission reductions of this scale will substantially lower the incidence of acid rain, soil damage, and water contamination, in turn delivering major protective benefits for New Jersey's coastal and aquatic ecosystems. Moreover, the avoidance of gas leaks and oil spills from fossil fuel infrastructure will further protect New Jersey's natural environment.

Improves public health and safety

By reducing pollution, a clean energy transition will lead to significant public health gains in New Jersey, including cleaner air and water, a reduced burden of chronic disease, and far fewer premature mortalities. If robust, inclusively-minded policy ensures that the siting of pollution reductions intentionally targets communities burdened by the historic legacies and modern costs of pollution, the resulting public health benefits will manifest most strongly in Black, Indigenous, and people of color (BIPOC) and low-income communities, making major strides to combat persistent health disparities.

With a shift toward clean energy, New Jersey will see dramatic reductions in harmful fossil fuel byproducts, including pollutants like particulate matter, SO_2, NO_x, and toxic emissions like mercury, leading to improved air quality.[28] Communities located near power plants, refineries, highways, ports, and other sources of these pollutants will see the greatest reduction in exposure to air pollution in a clean energy transition. A 2022 UCS study finds that in the twenty-four United States Climate Alliance member states (which includes New Jersey) a 100 percent clean energy transition can lead to a 75 and 88 percent decrease in NO_x and SO_2 emissions, respectively, between 2020 and 2040 compared to the estimated reductions in NO_x and SO_2 emissions of 18 and 27 percent over the same time period under a "No New Policy" scenario.[29] A 2021 study published in the journal *Science Advances* finds, for instance, that BIPOC are disproportionately exposed to particulate matter pollution and would thus benefit disproportionately from improvements in air quality resulting from a clean energy transition.[30] In addition to eliminating outdoor emissions by vehicles, factories, and power plants, a clean energy transition will also improve *indoor* air quality and reduce indoor emissions through the electrification of household appliances.[31] Eliminating reliance on fossil fuels—including gas—will also protect New Jersey families from gas leaks and resulting explosions.[32]

Reductions of several key air pollutants in both indoor and outdoor settings will yield cumulative benefits, especially for BIPOC and low-income communities, directly addressing systemically rooted and intersectional health inequities. As air quality improves, New Jersey can expect a reduction in the incidence of related health issues, including asthma attacks, heart attacks, respiratory illness, lung cancer, birth defects, and premature

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[27] Clean Energy Futures. 2021. *An 80x30 Clean Electricity Standard: Carbon, Costs, and Health Benefits*. Harvard University T.H. Chan School of Public Health. Available at: https://cdn1.sph.harvard.edu/wp-content/uploads/sites/2343/2021/07/CEF-80x30-7.15.21.pdf.

[28] García, P., et al. April 2022. p.9.

[29] Ibid.

[30] Tessum, C., et al. 2021. "$PM_{2.5}$ polluters disproportionately and systemically affect people of color in the United States." *Science Advances, 7* (18). Available at: https://www.science.org/doi/10.1126/sciadv.abf4491

[31] Cochran, J., and Denholm, P, eds. 2021. *The Los Angeles 100% Renewable Energy Study*. National Renewable Energy Laboratory. Available at: https://www.nrel.gov/docs/fy21osti/79444-ES.pdf

[32] Jerde, S., and Myles, M. January 16, 2019. "2 homes destroyed, 13 damaged in powerful natural gas explosion." *NJ.com*. Available at: https://www.nj.com/passaic-county/2016/10/firefighters_on_scene_of_apparent_house_explosionpowerful_explosion_levels_paterson_house_rocks_neighborhood.html

deaths, most often in BIPOC and low-income communities.[33] In Newark, for instance, a city in which 70 percent of residents are Black and more than 25 percent live below the federal poverty line, the childhood asthma rate is three times higher than the national average, due to the dense concentration of fossil fuel-based pollution sources in and around the city.[34] Eliminating this pollution would greatly reduce the asthma rate, saving hundreds of lives and substantial medical costs every year. In total, Princeton University's 2021 *Net Zero America* study estimates that a net-zero transition would avoid 10,000 to 17,000 premature deaths and save up to $150 billion in New Jersey, cumulatively through the year 2050, due to reductions in air pollution.[35]

V. Conditional benefits of a clean energy transition

Depending on the design and implementation of a clean energy transition in New Jersey—including the specific elements included in the transition—there are several additional potential benefits that could be realized, including enhanced grid resilience, lower energy bills, optimized land use, expanded transportation options, and a contribution to redressing historical inequalities (see Table 4). To fully achieve these conditional benefits, the clean energy transition must prioritize equitable outcomes from start-to-finish by thoughtfully and intentionally determining what elements are included in the design, how those elements are integrated, and who is involved in the decision-making process.

Table 4. Conditional benefits of a clean energy transition

If a clean energy transition…	it can…	by…
Prioritizes community input start-to-finish	Redress historical inequalities	Providing opportunities and resources for all
Employs flexible resources	Lower energy bills	Reducing peak demand and transmission costs
Uses sustainable community microgrids	Enhance grid resilience	"Islanding" from the larger electric grid
Strategically sites clean energy resources	Optimize land use	Repurposing "brownfields" for development
Focuses on the needs of every community	Expand transportation options	Creating accessible and safe modes of transport

Contribute to redressing historical inequalities

If the clean energy transition prioritizes the needs and input of overburdened communities, then progress can be made in redressing historical inequalities.

A clean energy transition, if planned thoughtfully and inclusively from start-to-finish, can contribute to redressing historical inequalities across New Jersey. At its worst, the state's current infrastructure and its associated human outcomes in BIPOC and low-income communities—including disproportionately high

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[33] Clean Energy Futures. 2021.

[34] Tigue, K. January 24, 2022. "As States Move to Electrify their Fleets, Activist Demand Greater Environmental Justice Focus." *Inside Climate News*. Available at: https://insideclimatenews.org/news/24012022/electric-vehicles-environmental-justice/

[35] Larson, E., et al. 2021. "Net-Zero America: State-level health, employment, and land use impacts." Princeton University. Available at: https://netzeroamerica.princeton.edu/img/State%20Summaries.pdf

exposure to pollution and resulting rates of asthma, cancer, and chronic disease[36]—demonstrate the inequitable results of societal planning (or lack of planning) that is not inclusive and that historically sought to locate unwanted land uses in communities of color. Studies show that decarbonization can yield substantial economic growth, and if State decisionmakers actively seek community input on investment priorities, the additional revenue can be invested in a way that counteracts systemically entrenched social inequalities. If the State promotes inclusive practices in its decision making and invests in social programs and services, the beneficiaries of which are predominantly BIPOC and low-income individuals and communities, New Jersey can expect to see improved health, economic, and social outcomes in overburdened populations.

Due to the decreased reliance on fossil fuels to meet energy needs, a clean energy transition would result in a loss of fossil fuel-related jobs such as those in power plants, refineries, pipeline construction, and gas stations.[37] Allocating funding toward retraining and rehiring displaced workers in these fossil fuel-related industries, therefore, would greatly strengthen the communities that are dependent on fossil fuel industry jobs, which might otherwise be left behind in a clean energy transition without thoughtful planning.

The clean energy transition can also improve the inclusivity of New Jersey's overall economy. A 2021 paper published by the World Resources Institute notes that new jobs in public transit infrastructure have a knock-on effect of leading to even more public transport and walking and cycling paths, which have the added effect of making the clean energy economy more productive and inclusive.[38] By expanding access to public transit, a clean energy transition will vastly improve mobility options for people who cannot afford a car, those who have geographic constraints, and those who have physical disabilities.

In addition, employing the use of sustainable community microgrids in a clean energy transition would allow local communities to play decision-making roles in energy processes, such as construction and maintenance,[39] which would especially empower communities who bear the worst consequences of fossil fuel use and who are systemically disenfranchised and disempowered from these decisions.

With investments in new jobs in solar, offshore wind, and energy efficiency, a clean energy transition can also offer job and health benefits to environmental justice communities, particularly if job training, retraining, and hiring is targeted toward communities that face disproportionate rates and risks of unemployment, pollution, and related adverse health effects.

Lower energy bills

If the clean energy transition employs flexible electric resources, then it can result in lower energy bills.

A clean energy transition that employs flexible resources such as battery energy storage, demand response, and virtual power plants can lower electric bills for New Jersey residents and businesses. Without these

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[36] New Jersey Department of Environmental Protection, Office of Environmental Justice. March 17, 2022. "What is Environmental Justice?" *NJ DEP.* Available at: https://www.nj.gov/dep/ej/#

[37] Tomer, A., Kane, J.W., and George, C. 2021. *How renewable energy jobs can uplift fossil fuel communities and remake climate politics.* Brookings Institution. Available at: https://www.brookings.edu/research/how-renewable-energy-jobs-can-uplift-fossil-fuel-communities-and-remake-climate-politics/

[38] Jaeger, J., et al. 2021. *The green jobs advantage: How climate-friendly investments are better job creators*. World Resources Institute. Available at: https://files.wri.org/d8/s3fs-public/2021-10/the-green-jobs-advantage-how-climate-friendly-investments-are-better-job-creators.pdf?VersionId=_4g3pkXM5qB8_DEy1MhhbF8AloDhqGUY

[39] Castigliego, J.R., T. Stasio, and E. Tavares. 2021. *Conditional Benefits of Sustainable Community Microgrids*. Applied Economics Clinic. Available at: https://aeclinic.org/publicationpages/2021/5/20/conditional-benefits-of-sustainable-community-microgrids

flexible resources, energy bills can impose serious burdens on ratepayers from peak demand charges and inflated transmission costs.[40] To combat these potential economic burdens, battery systems can be used to capture and store energy from renewable sources for use at peak times, reducing electric demand when generation is the most expensive, and thus reducing electric bills. In addition, the use of sustainable community microgrids places electric generating sources close to end-use customers, substantially increasing the efficiency of transmission and thus reducing its cost.[41]

A recent report published by the University of California-Berkeley found that wholesale energy costs from a 90 percent clean grid in 2035 would be lower than costs of a fossil-fuel dominated grid in 2020.[42] Similarly, research by the World Resources Institute finds that switching to renewable sources of energy will reduce the energy system's dependence on fossil fuels with volatile prices, leading to greater stability in power prices.[43] If electric utility companies pass on these cost savings to their customers, the reduction in electric costs would disproportionately benefit BIPOC and low-income communities in New Jersey, and those with higher energy burdens (higher energy bills relative to their incomes). A 2020 American Council for an Energy-Efficient Economy (ACEEE) report notes that in the Mid-Atlantic, half of all low-income households spend more than 9.4 percent of their income on energy, and half spend less.[44] The comparable number across all households is just 3.4 percent.

State-sponsored outreach and assistance programs—such as the New Jersey Universal Service Fund or Comfort Partners, which offer electricity bill reductions and credits to income-eligible residents—have a critical role to play in ensuring adequate and affordable energy access in low-income, BIPOC, and overburdened communities. A clean energy transition must ensure that such programs are adequately scaled up and rolled out across the state.[45]

Enhance grid resilience

If the clean energy transition uses sustainable community microgrids, then grid resilience can be enhanced.

A clean energy transition that employs sustainable community microgrids can provide enhanced grid resilience in New Jersey by permitting "islanding" from a larger electric grid to ensure independence from any interruptions to the electric system overall.[46] In contrast, a transition that does not include sustainable community microgrids and remains entirely reliant on the larger electric grid is susceptible to service interruptions and their resulting costs.

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[40] Ibid.

[41] Ibid.

[42] Phadke, A., et al. 2020. *The 2035 Report: Plummeting solar, wind, and battery costs can accelerate our clean electricity future.* UC Berkeley Goldman School of Public Policy. Available at: http://www.2035report.com/wp-content/uploads/2020/06/2035-Report.pdf?hsCtaTracking=8a85e9ea-4ed3-4ec0-b4c6-906934306ddb%7Cc68c2ac2-1db0-4d1c-82a1-65ef4daaf6c1. p.21.

[43] Jaeger, J., Gonçalves, T., Harsono, A., and Bird, L. 2022. "Renewable Energy Shouldn't Be Blamed for Spiking Energy Prices –It's the Solution." World Resources Institute. Available at: https://www.wri.org/insights/why-renewable-energy-solution-high-prices.

[44] American Council for an Energy-Efficient Economy (ACEEE). September 2020. "How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burdens across the U.S." Available at: https://www.aceee.org/research-report/u2006 p. 39

[45] 1) State of New Jersey Department of Community Affairs. N.d. "Universal Service Fund (USF)." Available at: https://www.nj.gov/dca/divisions/dhcr/offices/usf.html. 2) New Jersey Office of Clean Energy. N.d. "Comfort Partners." Available at: https://njcleanenergy.com/residential/programs/comfort-partners/comfort-partners

[46] Castigliego, J.R., T. Stasio, and E. Tavares. 2021. *Conditional Benefits of Sustainable Community Microgrids*. Applied Economics Clinic. Available at: https://aeclinic.org/publicationpages/2021/5/20/conditional-benefits-of-sustainable-community-microgrids

A sustainable community microgrid is:

- powered by renewable energy and balanced by flexible resources like distributed generation and batteries,
- allows for meaningful community participation in its development, and
- endeavors to distribute its economic and environmental benefits to residents and local businesses in the most equitable manner possible.

Sustainable community microgrids can seamlessly transition between operating modes to ensure the availability of energy during times of peak demand or potential service disruptions, thereby preventing losses of power. This benefit is particularly critical for emergency facilities such as medical centers and hospitals, as well as overburdened communities who tend to experience more disruptions in electric services and bear disproportionate impacts as a result. For example, avoiding power outages can ensure the continuous operations of businesses with hourly employees, preventing temporary shutdowns and resulting lost wages for workers. A transition that excludes sustainable community microgrids leaves New Jersey residents and workers vulnerable to outages that can spread across the state, resulting in hours-long power losses that can be dangerous to those relying on electric-powered medical equipment or refrigerated medicines, and costly to households, businesses, and other facilities throughout the state.[47]

Optimize land use

If the clean energy transition strategically sites clean energy resources, then it can repurpose "brownfields" and optimize land use.

A clean energy transition in New Jersey will entail repurposing some land to make space for renewable energy infrastructure such as solar panels and battery storage equipment. According to Princeton's *Net Zero America* study, the share of land currently impacted by large-scale solar development within New Jersey is less than 1 percent.[48] While this share may be small in absolute terms, the locations chosen for these renewable resources can have broader implications for the state's communities and natural environment. Building new clean energy infrastructure on forestlands or other "undeveloped" green spaces can have damaging effects on ecosystems within these settings. In contrast, placing solar and wind construction in "brownfields," such as former fossil fuel plants, factories, refineries, pipelines, and on road verges can conserve New Jersey's natural ecosystems while repurposing damaged lands, some of which served former uses that are no longer necessary under a clean energy transition.[49] Depending on the scope of investments in public transit and housing infrastructure, an energy transition may have additional land use impacts in New Jersey. For instance, expanding the state's public transit infrastructure would require additional land use, and the use of this land should be planned thoughtfully and inclusively.

In its land use choices, the State must include impacted communities in planning processes and decision making to ensure that the energy transition benefits all New Jersey residents, especially marginalized, BIPOC, and low-income residents.

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[47] Johnson, T. August 10, 2020. "Utilities Have Spent Billions, But Storms Still Cut Power to Many in NJ." *NJ Spotlight News*. Available at: https://www.njspotlightnews.org/2020/08/utilities-have-spent-billions-but-storms-still-cut-power-to-many-in-nj/

[48] Larson, E., et al. 2021. "Net-Zero America: State-level health, employment, and land use impacts." Princeton University. Available at: https://netzeroamerica.princeton.edu/img/State%20Summaries.pdf

[49] 1) New Jersey Future. August 6, 2019. "Comments on Solar Siting Element of Energy Master Plan." Available at: https://www.njfuture.org/wp-content/uploads/2019/08/NJF-Comments-on-Solar-Siting.pdf. 2) New Jersey Conservation Foundation. N.d. "Land Conservation." Available at: https://www.njconservation.org/land-conservation/

Expand transportation options

If the clean energy transition focuses on the needs of all communities, then it can create accessible and safe modes of transportation.

If a clean energy transition thoughtfully and equitably accounts for the needs of every community, it can boost all New Jersey residents' quality of life by developing robust and inclusive public and active transportation infrastructure. A comprehensive green transportation agenda goes beyond electric vehicle policies—aimed primarily at middle-class residents, with the exception of car and ride share programs—to focus on transportation solutions that benefit lower-income residents who rely on public transportation and safe active transportation corridors. Investments in green public transit and active transportation infrastructure, meanwhile, can generate benefits for all members of the community by providing an accessible, affordable, viable means of transport. In addition, increased investment in and use of public transit will reduce traffic on New Jersey's roads and highways, which claims an average of 86 hours from each New Jersey commuter every year,[50] which will provide clearer paths for emergency vehicles and delivery drivers while also allowing commuters to spend their travel time more productively.[51]

A decarbonization strategy that includes investment in expanded public transit and walking/biking infrastructure could confer additional safety benefits as well. According to the U.S. Bureau of Transportation Statistics, 38,824 of the 40,867 transportation fatalities nationwide in 2020 were highway-related while railroad and transit passengers accounted for 1,035 fatalities total.[52] Shifting infrastructure and funding priorities toward public transit and cleaner forms of transportation not only reduces emissions and provides associated public health benefits but can also save lives on New Jersey's streets.

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[50] Feigenbaum, B., and Purnell, S. 2021. "New Jersey Ranks 50th in the Nation in Highway Performance and Cost-Effectiveness." *The Reason Foundation*. Available at: https://reason.org/policy-study/26th-annual-highway-report/new-jersey/

[51] Economic Development Research Group. 2020. *Economic Impact of Public Transportation Investment: 2020 Update*. Economic Development Research Group, Prepared for American Public Transportation Association. Available at: https://www.apta.com/wp-content/uploads/APTA-Economic-Impact-Public-Transit-2020.pdf

[52] U.S. Bureau of Transportation Statistics (BTS). n.d. "Transportation Fatalities by Mode." *BTS*. Available at: https://www.bts.gov/content/transportation-fatalities-mode

Appendix A: Caveats

This section provides some additional insight into modeling decisions and data limitations that are important to understanding the findings of this analysis. First and foremost: This is an analysis of the jobs and economic activity that would occur in the CLEAN scenario, but not in a no-policy business-as-usual scenario. These are "net" differences that include both losses and gains from CLEAN policy measures as an approximation of the 2019 EMP's "Least Cost" scenario. To be clear, AEC's findings do not capture all energy jobs in New Jersey; rather, our results are limited to the differences between two future scenarios: "clean energy transition policy" and "no new policy" futures. One practical upshot of the style of analysis is that jobs from certain energy activities do not appear in our results because they are projected to be exactly the same in both scenarios: for example, nuclear power plants and onshore wind turbines.

Another modeling detail that provides important context for interpreting these results is AEC's use of current-day New Jersey industries to understand and predict jobs and other economic impacts through 2050. Today, for example, New Jersey has no automobile manufacturing industry and, therefore, may not benefit from new jobs associated with the rapid increase in EV acquisition predicted in the CLEAN scenario. Those using this analysis to inform policy prescriptions would do well to keep this in mind: New Jersey does not have EV automobile manufacturing today but could make the choice—through policy actions—to attract and support such an industry. The same could be said of many "green" industries. More spending and job creation from the actions represented in the EMP could take place in New Jersey if made a priority in policy and public investment.

Additional caveats concern job gains and losses relevant to the CLEAN scenario but not captured in this analysis, and other methodological gaps between the original energy sector modeling performed for the 2019 EMP report and our subsequent jobs analysis as presented in this report.

Job gains and losses not quantified

- **Gas station jobs:** As New Jersey shifts away from gasoline- and diesel-powered vehicles and towards EVs, public transit, and active transit (bicycling, walking), the future of the state's gas stations is uncertain. New Jersey's status as an all "full-service" state makes it difficult to isolate these jobs in economic data and makes the results of other green transport analyses less useful as a guide to a methodology for quantifying their losses over time. Lost gas station jobs are not included in this analysis, but in the opposite direction, jobs associated with installing, upgrading or operating EV charging stations are also omitted.
- **Public transit jobs:** Improvements to public transit infrastructure, access and operations are not quantified in New Jersey's 2019 EMP, but are a critical area for investment in any just transition plan. New public transit-related jobs in the CLEAN scenario are not captured in this analysis; nor are jobs in building out new active transit corridors such as bike lanes and multi-use (non-motorized vehicle) paths.
- **Transmission line jobs:** Electrification of buildings and vehicles creates increased demands on the electric transmission (long-distance) and distribution (local) lines; at the same time, new renewable generation sites and the proliferation of distributed generation (e.g., rooftop solar panels) may change the pattern of how much electricity is needed where. Evolved Energy's modeling, on which the 2019

EMP report relies, allowed for the possibility of new transmission lines needed to bring in renewable generation from out of state, but concluded that this was not necessary in the "Least Cost" plan (an updated version of which is presented in this report as the "CLEAN scenario"). Nonetheless, more detailed transmission and distribution modeling may reveal a need for additional investment and jobs in New Jersey that are not captured in this analysis.

- **Gas plant retirement jobs:** In this analysis gas power plant jobs follow shrinking gas generation over time. This treatment, however, is more akin to a real-life energy sector practice of "moth-balling" than actual plant retirement. Zero generation means zero jobs. Jobs gains and losses related to plant decommissioning and repurposing are omitted.
- **Gas distribution system jobs:** The CLEAN scenario in this report contemplates a 43 percent reduction in building sector gas use and a 100 percent reduction in gas-fired electric generation by 2050. The 2019 EMP does not, however, discuss the cost savings possible from a shrinking gas distribution system. These economic impacts are conditional: If the gas system is reduced more or less proportionally throughout the state, every local distribution pipeline will be needed until 2050. If instead, the gas system is strategically trimmed, branch by branch, there is the potential for significant savings in repairs and maintenance, which, however, will come at the cost of jobs. New Jersey's strategy for managing the distribution system as it carries less and less gas is not apparent in the EMP or its supporting documents, and these potential job losses are not included in this analysis.
- **Job categories that do not exist in New Jersey:** The analysis presented in this report focuses exclusively on jobs and economic activity gained and lost in New Jersey. The impacts of New Jersey's clean energy transition on other states are not quantified. This means that job gains and losses in industries not present in New Jersey today are absent from our job totals, including EV automobile manufacturing, gas extraction, and gas refining for fuels used within New Jersey.

Lost, and found, in translation

This report translates the results of the 2019 EMP's "Least Cost" scenario into economic impacts in jobs, state GDP, and labor income from salaries and wages. While these economic impacts provide information critical to good decision making on public investments and policy priorities, the EMP was not produced with this translation in mind. The following caveats point to recommendations for steps to be taken in future iterations of the EMP.

- **Peak load:** Maximum annual electric use is a key factor in any energy analysis, particularly in an era of burgeoning electrification and increased use of flexible resources (such as battery storage and "demand response" programs) to balance supply and demand on the grid. Future EMPs would benefit from a transparent account of the development of peak load forecasts and direct presentation of the selected forecasts. Important in this forecasting effort is the relationship between state energy efficiency requirements, battery, heat pump and EV adoption, and expected customer demand. Capacity resources must be modeled as sufficient (after taking into account capacity "credits" assigned to renewables and batteries) to meet peak load plus the reserve margin required by the grid operator, PJM.
- **Renewable capacity factors:** The expected operations (hours per year, or "capacity factor") of renewable resources are an impactful assumption in any energy analysis. Realistic renewable capacity factors determine the extent to which gas resources must be maintained only as a backup and of how

much out-of-state wind and solar must be purchased. Future EMPs would benefit from calibration of capacity factors with industry sources and the presentation of capacity factors by scenario within the EMP report.

- **Gas CCs vs gas CTs:** Different types of gas-fired power plants require different spending and labor in their operations and maintenance. Future EMPs would benefit from a clear distinction between (as a minimum) gas "combined cycle" (CC) plants and gas "combustion turbine" (CT) plants.
- **Use of biogas and new gas buildout:** The EMP's "Least Cost" scenario includes the conversion of gas-fired power plants to burn upgraded biogas (called "renewable" natural gas) and hydrogen starting in 2045 and amounting to 6 percent of total generation by 2050, as well as the addition of roughly 6,000 MW of new gas generation (called "firm capacity") over the modeling period. AEC has revised the CLEAN scenario presented in this report to exclude both of these modeling choices. Our analysis of the current state and projected future of biogas and hydrogen blended with gas for use in gas distribution systems and power plants strongly suggests that the case for their feasibility, safety, and affordability has yet to be made.[53] AEC has replaced biogas and hydrogen and eliminated that need for additional gas-fired capacity by adding additional battery storage: 4-hour batteries through 2030, 8-hour batteries from 2030 through 2040, and 10-hour batteries in the final 10 years in the modeling period. The choice to invest in energy storage has the advantage of providing in-state jobs in battery manufacture and installation. Future EMPs would benefit from an assessment of the feasibility and cost of as-yet-untried energy "solutions".
- **Building and transportation spending:** Clean energy investments in the buildings and transportation sectors are an important source of potential new green jobs and essential to achieve desired emission reduction levels. Good modeling of these jobs requires detailed information on spending broken down by specific activity or industry. Future EMPs would benefit from disaggregated spending reported for, at a minimum: heat pumps, building shell improvements, efficient appliances, EVs, private charging equipment, public or commercial charging stations, and investments in public transit and active transit.
- **Emissions reporting:** The 2019 EMP reports estimated emissions by sector for the year 2018 and projected emissions throughout the modeling period for the Least Cost scenario by fuel type but not by sector.[54] Future EMPs would benefit from detailed emissions reporting on all key scenarios, including the business-as-usual scenario, and by sector. Further disaggregation by sector facilitates decision makers' understanding of what industries and emission reduction actions have greater or lesser impacts. The CLEAN scenario presented in this report has somewhat lower emissions than the 2019 EMP's "Least Cost" scenario in years leading up to 2050.

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[53] Stasio, T., Castigliego, J.R., Alisalad, S., Stanton, E.A. March 2022. *Decarbonizing Building Heat in Massachusetts*. Applied Economics Clinic White Paper, AEC-2022-03-WP-01. Prepared on behalf of HEET. Available at: https://aeclinic.org/publicationpages/2022/4/4/decarbonizing-building-heat-in-massachusetts

[54] New Jersey Board of Public Utilities (NJ BPU). 2020. *2019 New Jersey Energy Master Plan: Pathway to 2050*. Available at: https://www.nj.gov/emp/docs/pdf/2020_NJBPU_EMP.pdf p.23

Appendix B: Electric Sector Adjustments and Cost Methodology

AEC's analysis evaluates the economic impacts associated with New Jersey's clean energy transition. All results from this analysis are presented as differences between the "BAU" (existing policy) and "CLEAN" (with clean energy transition policy) scenarios to estimate the economic impacts that result from New Jersey's EMP "Least Cost" scenario above and beyond that of the no policy scenario. AEC's modeling is conducted at the state-level and looks at "snapshot" years between 2025 and 2050 in five-year intervals. Results for each year represent annual (not cumulative) impacts.

Scenario analysis

AEC based its jobs and economic impact modeling on New Jersey's *2019 Energy Master Plan* (EMP)[55], which was developed through modeling from Evolved Energy Research. We developed two scenarios based on Evolved Energy's Technical Appendix to the EMP[56], together with personal communications with staff at Evolved Energy[57] and Rocky Mountain Institute (RMI)[58] (contracted by New Jersey Board of Public Utilities to conduct the EMP):

- **Reference 2 Scenario:** The EMP's "Reference 2" Scenario represents existing policies and renewable portfolio standard (50 percent by 2030), but does not exceed the requirements currently mandated by the state.[59] Electric capacity is taken directly from Evolved Energy's model reporting, however, for the Reference 2 scenario generation and capacity factors are inferred from the "Reference 1" scenario capacity factors. AEC development of costs and shares of gas technologies for the Reference 2 Scenario are identical to that of AEC's CLEAN scenario, described below. In the findings presented in this report, the Reference 2 scenario is referred to as "**Business-As-Usual**" or "**BAU**".

- **AEC Adjusted Least Cost Scenario:** The EMP's "Least Cost" Scenario considers all options across the transportation, buildings, and electric sectors to meet state goals of economy-wide emissions reductions of 80 percent below 2006 levels, and carbon neutrality in the electric sector by 2050 at the lowest possible cost. AEC has made several important adjustments to Evolved Energy's Least Cost Scenario in order to update its assumptions and provide the level of detail necessary for inputting it into our jobs and economic impact modeling. In the findings presented in this report, the AEC Adjusted Least Cost scenario is referred to as **"CLEAN"**.

As defined in the EMP, New Jersey's goal of 100 percent clean energy by 2050 is based on in-state generation. Specifically, this target focuses on achieving total carbon-neutrality within the electricity generation, transportation, and buildings sectors.[60] AEC's CLEAN scenario not only assumes 100 percent clean energy resources for New Jersey's in-state generation, but also accounts for emissions-free solar and wind imports.

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[55] New Jersey Board of Public Utilities. 2020. *2019 New Jersey Energy Master Plan*. Available at: https://nj.gov/emp/docs/pdf/2020_NJBPU_EMP.pdf

[56] Evolved Energy Research. 2019. *New Jersey 2019 IEP Technical Appendix*. Available at: https://www.nj.gov/emp/pdf/New_Jersey_2019_IEP_Technical_Appendix.pdf

[57] Personal communication with Jeremy Hargreaves at Evolved Energy Research on March 7, 2022. [Excel Spreadsheet]

[58] Personal communication with Charles Teplin at Rocky Mountain Institute on March 17, 2022. [Excel Spreadsheet]

[59] Evolved Energy Research. 2019. *New Jersey 2019 IEP Technical Appendix*. Available at: https://www.nj.gov/emp/pdf/New_Jersey_2019_IEP_Technical_Appendix.pdf p. 8

[60] State of New Jersey. N.d. "About the Energy Master Plan." Energy Master Plan. Available at: https://www.nj.gov/emp/energy/

Electric sector data and assumptions

Capacity adjustments:

- Peak load by scenario was back calculated by applying PJM's required Installed Reserve Margin[61] of 14.9 percent for delivery year 2022/2023 to the total amount of capacity credits.
- Capacity credits (PJM Electric Load Carrying Capabilities) were applied to the annual capacities for energy storage (82 percent, 4-hour batteries), offshore wind (37 percent), and solar (36 percent) in each scenario (see Generation adjustments***:***
  - Annual demand by scenario was used as reported in the EMP.
  - Solar and offshore wind capacity factors are adjusted to align more closely with values from Lazard v.15.0. The selected capacity factors for solar and offshore wind are 23 percent and 51 percent, respectively.
  - Solar and offshore wind generation as reported in the EMP are replaced by calculations based on Evolved Energy's capacity amounts and AEC's adjusted capacity factors.
  - Wind imports are scaled down such that total generation matches annual demand.
  - The use of batteries as capacity resources results in maximum (assuming battery cycling 300 times per year) efficiency losses due to charging and discharging on the order of less than 1 percent in 2025 up to 5 percent in 2050. We have not adjusted for these potential losses in this analysis.
- Figure 6).[62]
- Gas is phased out linearly starting in 2035, such that all gas is retired by 2050. Note that small differences in gas capacity over time in both scenarios appear to be modeling artifacts and not consistent with expected generation levels.
- All biogas is removed from the capacity mix (this change impacts only 2045 and 2050).
- 4-hour, 8-hour, and 10-hour batteries are added starting in 2025 to provide enough capacity to match peak load plus the PJM reserve margin of 14.9 percent.[63] All batteries are assumed to have a 20-year lifetime.
- Since data on gas-fired power plants was not disaggregated by technology type in the EMP, AEC estimated the relative shares for gas combined cycle (CCs) and combustion turbines (CTs) by calculating the proportion of total gas-fired generators for each technology type (55 percent for CCs and 45 percent for CTs) in New Jersey based on 2020 data from Energy Information Administration (EIA).[64]

Generation adjustments:

  - Annual demand by scenario was used as reported in the EMP.
  - Solar and offshore wind capacity factors are adjusted to align more closely with values from Lazard v.15.0.[65] The selected capacity factors for solar and offshore wind are 23 percent and 51 percent,

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[61] PJM. 2021. "2021 Reserve Requirement Study." Available at: https://www.pjm.com/-/media/committees-groups/committees/pc/2021/20211005/20211005-item-05b-2021-pjm-reserve-requirement-study.ashx

[62] PJM. 2021. "2024/2025 BRA ELCC Class Ratings." Available at: https://www.pjm.com/-/media/planning/res-adeq/elcc/elcc-class-ratings-for-2024-2025.ashx

[63] PJM. 2021. "2021 Reserve Requirement Study." Available at: https://www.pjm.com/-/media/committees-groups/committees/pc/2021/20211005/20211005-item-05b-2021-pjm-reserve-requirement-study.ashx

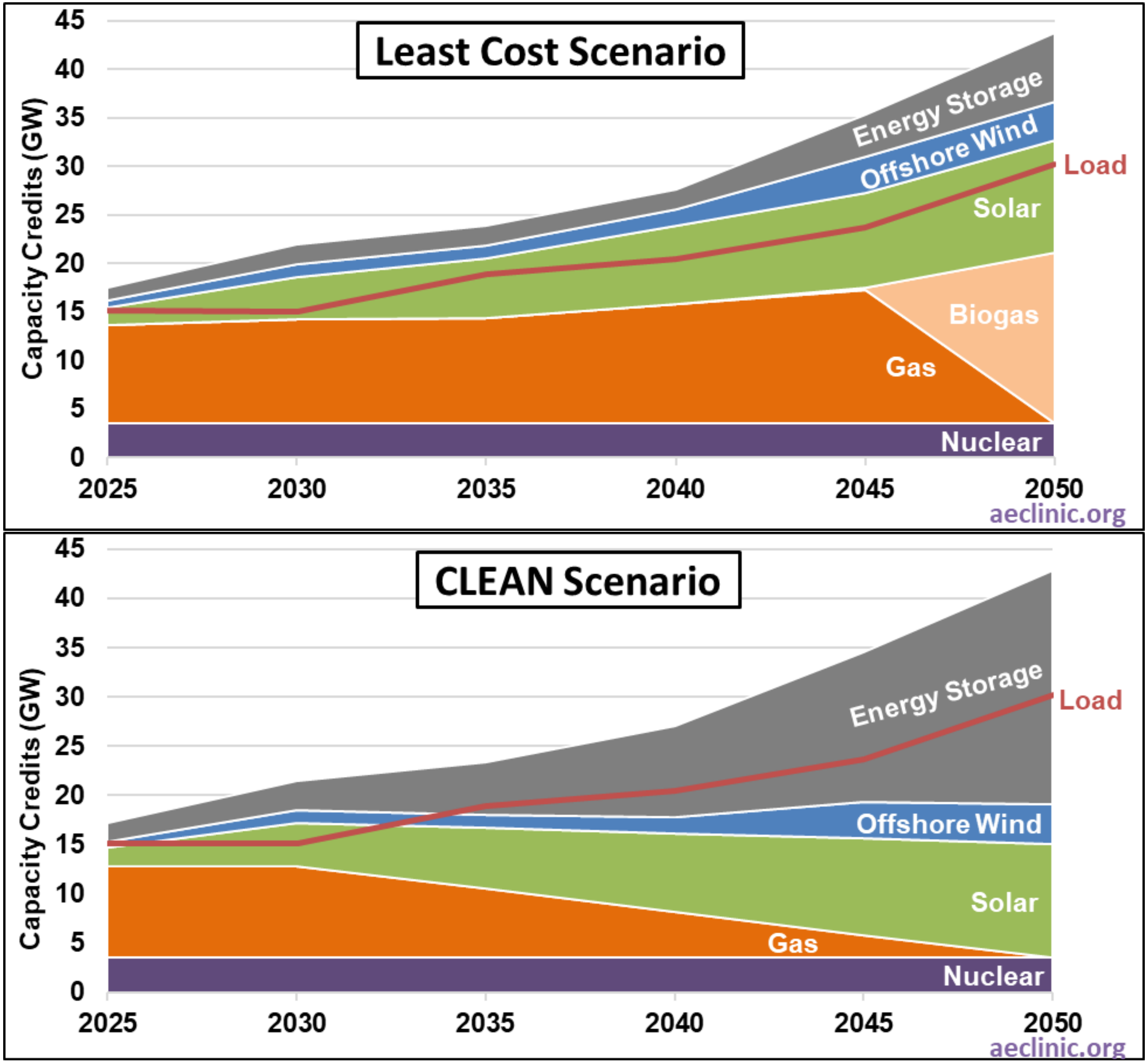
[64] U.S. EIA. 2020. *Form EIA-860 - Generators, Operable.* Available at: https://www.eia.gov/electricity/data/eia860/

[65] LAZARD. 2021. Lazard's Levelized Cost of Energy Analysis--Version 15.0. Available at: https://www.lazard.com/media/451881/lazards-levelized-cost-of-energy-version-150-vf.pdf

respectively.

- Solar and offshore wind generation as reported in the EMP are replaced by calculations based on Evolved Energy's capacity amounts and AEC's adjusted capacity factors.
- Wind imports are scaled down such that total generation matches annual demand.
- The use of batteries as capacity resources results in maximum (assuming battery cycling 300 times per year) efficiency losses due to charging and discharging on the order of less than 1 percent in 2025 up to 5 percent in 2050. We have not adjusted for these potential losses in this analysis.

Figure 6. Capacity credits (GW) for "Least Cost" and "Adjusted Least Cost" (or "CLEAN") scenarios



Cost data:

- Capital expenditures (CAPEX costs) and fixed operation and maintenance costs (FOM) from National

Renewable Energy Laboratory's (NREL) 2021 Annual Technology Baseline[66] were compiled for years in the analysis period for offshore wind, solar, gas combined cycle, gas combustion turbine, and 4-hour, 8-hour, and 10-hour batteries.

- Variable operation and maintenance costs (VOM) from NREL's 2021 Annual Technology Baseline[67] were collected for years in the analysis period for gas combined cycle and gas combustion turbine.

Appendix C: Cost Methodology for Buildings and Transportation Sectors

EV charging infrastructure costs

AEC estimated the economic impacts of installing public charging infrastructure that would facilitate the electrification of New Jersey's vehicle fleet. This involved several steps, including estimating: (1) the number of EVs that would be on the road; (2) the number of public chargers needed to serve that fleet of EVs; and (3) the cost of installing these chargers. (Note that AEC did not utilize costs presented in the EMP for EV charging infrastructure because these costs were not disaggregated from other transportation-related expenditures (e.g., incremental costs of EVs).) These steps are explained in more detail below:

1. Our estimate of the number of electric vehicles relied on New Jersey's existing fleet mix of cars and trucks (including light, medium and heavy-duty), projections of growth in car and truck travel, and the growing share of New Jersey electric vehicle stock provided in the EMP report (see Table 5 below).[68] The existing fleet mix was provided by the Federal Highway Administration (FHWA) and a report on electrification of the fleet in New Jersey.[69] We then projected the increase in cars and trucks in the state using the projected increase in vehicle miles traveled (VMT) from the Energy Information Administration's Annual Energy Outlook (EIA AEO).[70] Finally, the projected share of electric vehicle stock assumed in the EMP was applied to the total stock to arrive at an estimate of the number of electric light-duty automobiles, light-duty trucks, medium-duty trucks, and heavy-duty trucks in New Jersey from 2025 through 2050.
2. Our estimate of the number of public chargers needed was based on the relationship between electric vehicles and chargers projected by the International Council of Clean Transportation (ICCT) in their

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[66] NREL. 2021. Annual Technology Baseline (ATB) Spreadsheet. Available at: https://atb.nrel.gov/electricity/2021/data

[67] NREL. 2021. Annual Technology Baseline (ATB) Spreadsheet. Available at: https://atb.nrel.gov/electricity/2021/data

[68] Evolved Energy Research, *New Jersey 2019 IEP: Technical Appendix*, Table 6, November 29, 2019. Available at: https://www.nj.gov/emp/pdf/New_Jersey_2019_IEP_Technical_Appendix.pdf. Note: The report only provides the share of electric vehicle stock for each decade. We assumed linear growth between these years to estimate the stock in the interim years—For instance, 2025 is the average of the stock in 2020 and 2030.

[69] The current amount of auto and trucks registered in NJ: FHWA, State Motor Vehicle Registrations 2020. Available at: https://www.fhwa.dot.gov/policyinformation/statistics/2020/mv1.cfm. The mix of light, medium and heavy-duty trucks in NJ: Warner et al., *Full Market Vehicle Electrification in New Jersey*, Figure 6.0, Gabel and Associates, October 7, 2020. Available at: http://www.chargevc.org/wp-content/uploads/2020/10/ChargEVC-Full-Market-Electrification-Study-FINAL-Oct-7-2020.pdf

[70] EIA AEO 2017, Table 7: Transportation Sector Key Indicators and Delivered Energy Consumption. Available at: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=7-AEO2017&cases=ref2017&sourcekey=0. The percentage growth in VMT for light duty vehicles was applied to existing light duty autos and trucks; percentage growth in commercial and freight truck VMT was applied to existing medium and heavy-duty trucks, respectively. Note that this same version of the AEO was relied upon in the EMP's projections of electric vehicles (see *New Jersey 2019 IEP: Technical Appendix* at page 110).

estimate of the infrastructure required for aggressive electrification in the United States.[71] We relied on the study's implied ratio of electric vehicles to each of the two types of fast chargers (Level 2 and Direct Current) through 2030. We then extrapolated that data to assume continued growth in vehicles per charger as the fleet expands after 2030.

3. Finally, we estimated the costs of Level 2 and Direct Current (DC) chargers, relying on the ICCT's survey of these costs across major metropolitan areas in the United States.[72] This study also provides a useful breakdown of charger costs in terms of labor, hardware, and other materials.

Table 5. Share of electric vehicles in New Jersey as modeled in the 2019 EMP

Scenario	Vehicle Type	2020	2030	2040	2050
Reference 2	Light Duty Auto EV	0.2%	0.3%	0.8%	1.1%
	Light Duty Truck EV	0.02%	0.02%	0.03%	0.04%
	Medium Duty Truck EV	0.0%	0.0%	0.0%	0.0%
	Heavy Duty EV	0.0%	0.0%	0.0%	0.0%
Least Cost	Heavy Duty EV	0.1%	11.7%	42.5%	49.9%
	Light Duty Auto EV	0.2%	26.3%	81.8%	95.4%
	Light Duty Truck EV	0.2%	23.5%	80.6%	95.4%
	Medium Duty Truck EV	0.1%	13.9%	55.2%	74.6%

Source: Evolved Energy Research, New Jersey 2019 IEP: Technical Appendix, Table 6, November 29, 2019. Available at: https://www.nj.gov/emp/pdf/New_Jersey_2019_IEP_Technical_Appendix.pdf.

Building electrification and energy efficiency costs

AEC estimated the economic impacts of appliance upgrades and energy efficiency activities that would facilitate the electrification of New Jersey's building stock using the building sector portion of demand-side equipment costs from Evolved Energy's modeling for the 2019 EMP.[73] Since the demand-side equipment costs reported by Evolved Energy were not disaggregated between the buildings and transportation sectors, AEC estimated the relative shares using the "Appliances" (i.e., buildings sector) and "Cars" (i.e., transportation sector) breakdown of scenario costs[74] reported in the 2019 EMP. These buildings sector shares were then multiplied by the demand-side equipment costs for both the Reference 2 and Least Cost scenarios to estimate buildings-related costs. These costs were then used in AEC's economic impacts modeling for building electrification and associated energy efficiency measures.

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[71] Bauer et al., *Charging Up America: Assessing the Growing Need for U.S. Charging Infrastructure*, ICCT White Paper, Table A1 and page 4, July 2021. Available at: https://theicct.org/sites/default/files/publications/charging-up-america-jul2021.pdf

[72] The costs for each charger type (i.e., Level 2 and DC Fast chargers) used in this analysis were estimated by averaging the costs across multiple charger configurations. For Level 2 chargers, the average cost (~$5,900 per charger) was calculated using the cost breakdowns for one and two chargers per site. For DC Fast chargers, the average cost (~$98,300 per charger) was calculated using the cost breakdowns for the 50- and 150-kW power levels. Note: Both costs presented above are in 2019 dollars. Source: Nicholas, Nicholas, M. August 2019. *Estimating electric vehicle charging infrastructure costs across major U.S. metropolitan areas,* ICCT Working Paper. Available at: https://theicct.org/publication/estimating-electric-vehicle-charging-infrastructure-costs-across-major-u-s-metropolitan-areas/

[73] Personal communication with Jeremy Hargreaves at Evolved Energy Research on March 7, 2022. [Excel Spreadsheet]

[74] Personal communication with Charles Teplin at Rocky Mountain Institute on March 17, 2022. [Excel Spreadsheet]

Appendix D: Economic Impacts Methodology

AEC used IMPLAN[75], a regional economic impact model, to estimate the total impacts to employment, labor income, and state economic output resulting from carrying out New Jersey's 2019 EMP "Least Cost" scenario.[76] IMPLAN provides key economic data for 546 industries for a customized region (in this case the entire state of New Jersey), and models interactions between these industries based on the flow of goods, services, and workers from industry to industry and in and out of that region. The model then produces customized "multipliers" that estimate the ripple effects of spending on a given industry in the user-specified area. For instance, building a new wind farm is primarily performed by an engineering/construction firm but relies on other industries for supplies,[77] and the firm's workers spend their wages at local businesses.

AEC utilized the resource mixes from the BAU (existing policy) and CLEAN scenarios as a basis for the economic impact analysis described in this report All economic impacts presented in this report are relative to (that is, changes from) the business-as-usual scenario. For this reason, the impact of the clean energy transition scenario can be interpreted as **"what would happen under CLEAN policies over and above what would have happened without it."** The economic impact of building or operating resources outside of New Jersey is not included in this analysis. (Note that IMPLAN does not differentiate between "permanent" and "temporary" employment—jobs are reported in the year that they take place.)

Achieving a clean energy transition in New Jersey results in new economic activity from the following:

- **Construction or installation of new resources and infrastructure:** Building a new energy resource requires hiring short-term workers and purchasing materials needed for the project. For instance, a new wind farm that is built as a result of CLEAN policies would generate a positive impact from construction activity in the short-term. Conversely, if something would have been built in the business-as-usual scenario and is not built in the CLEAN policy scenario, this would lead to negative economic impacts since the construction activity was foregone.
- **Operation of existing and new resources:** Energy resources require fuel, operations and maintenance in order to produce energy services for customers. These activities require long-term jobs, materials and services. For instance, a field technician that maintains wind turbines.

The total economic impact of these activities are modeled in three separate categories (see Figure 7 below):

- **Direct impacts:** These represent the jobs at the site of the investment. For instance, the workers installing wind turbines on a wind farm count as "direct jobs," as would operations and maintenance (O&M) workers.
- **Indirect impacts:** These represent the jobs from providing supplies and services for the investment. For instance, the workers producing wind blades used to build a wind turbine are classified as "indirect jobs."
- **Induced impacts:** These represent the jobs associated with direct and indirect workers re-spending their wages in the local economy. For instance, jobs at restaurants patronized by wind farm technicians.

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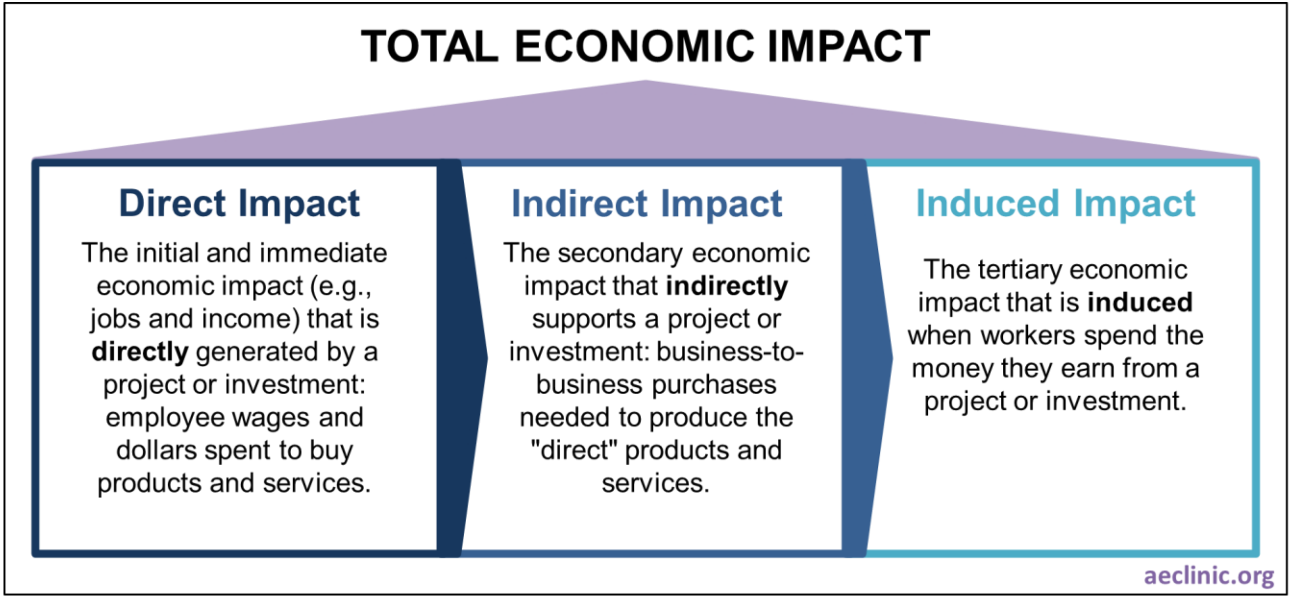
[75] http://www.implan.com/

[76] Employment or jobs in this report are in full-time equivalents (FTEs)

[77] IMPLAN modeling accounts for geographic variability in availability of locally produced and sold materials.

Figure 7. Types of economic impact



TOTAL ECONOMIC IMPACT

Direct Impact

The initial and immediate economic impact (e.g., jobs and income) that is **directly** generated by a project or investment: employee wages and dollars spent to buy products and services.

Indirect Impact

The secondary economic impact that **indirectly** supports a project or investment: business-to-business purchases needed to produce the "direct" products and services.

Induced Impact

The tertiary economic impact that is **induced** when workers spend the money they earn from a project or investment.

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To calculate the economic impact of achieving a clean energy transition in New Jersey, we mapped the economics activities identified through our review of the 2019 EMP to IMPLAN’s 546 industries. Some EMP activities correspond one-for-one with IMPLAN’s pre-set industries; other activities do not and therefore require additional research and analysis to identify spending patterns and map those patterns on to IMPLAN industries. In some cases, we modified IMPLAN’s spending pattern to improve its accuracy (based on other, more specific, data sources). For instance, the IMPLAN sector “electric power generation - fossil fuel” was modified to develop a spending pattern that was more specific to O&M of a gas-fired power plant.

In other cases, we developed our own spending pattern maps for activities that are not easily discerned in IMPLAN data such as: construction and O&M of new energy resources (including offshore wind, utility-scale solar, and battery storage), as well as installation and other activities associated with building and transportation electrification (e.g., energy efficiency upgrades, EV charging infrastructure). These spending patterns were based on resource-specific research, including past economic impact studies. AEC determined both the proper industry to use in IMPLAN for each type of material and worker, and the percentage of total project costs that would be allocated to this industry. Further detail is provided below by resource and activity.

General assumptions

The following assumptions were used as defaults in our economic impact analysis and apply if not otherwise specified in this methodology:

- **Coal, nuclear, and onshore wind generation.** The final two coal-fired power plants in New Jersey are slated for retirement in May 2022. According to New Jersey’s 2019 EMP, the state’s current nuclear and onshore wind resources are expected to remain in operation through 2050. No economic impacts from any of these resources are estimated in our analysis since there were no changes in these activities between the BAU (existing policy) and CLEAN scenarios.
- **Timing of impacts.** In this analysis, economic impacts reflect when each activity is taking place. For each five-year interval, construction spending was assumed to be spread out evenly across the previous five years. Annual O&M spending occurs as long as each resource operates.

- **Direct wages.** An average wage for each resource activity was taken from New Jersey-specific data on industry wages from the U.S. Bureau of Labor Statistics (BLS).[78]
- **Labor compensation and wages.** The IMPLAN model works from "labor compensation" which includes wages, benefits, and taxes. IMPLAN offers data for each of the 546 industries to translate wages into labor compensation.
- **Full-time equivalents and employment.** IMPLAN presents "employment" as a headcount of number of workers in each industry; this method counts full and part-time workers as equivalent. The job impacts in this report are presented in terms of "full-time equivalents" (FTEs)—that is 2,080 hours of work per year. We translated employment into FTEs using sector-specific factors from IMPLAN.
- **Inflation.** State GDP and labor income impacts are presented in terms of real (inflation-adjusted) 2021 dollars.

AEC's IMPLAN customization

IMPLAN's 546 sectors do not include sectors specific to several industries critical to a clean energy transition, including: offshore wind, solar, battery storage, EV charging infrastructure, and building electrification and energy efficiency measures. For these "missing" industries, AEC constructs detailed spending pattern maps used to supplement our IMPLAN analysis.

Offshore wind

Offshore wind installations require materials necessary to construct the turbine itself (i.e., rotor nacelle assembly, tower) as well as the substructure, foundation, and electrical infrastructure (including underwater cables). The cost breakdown for offshore wind installation, including labor costs, is based on NREL's *Cost of Wind Energy* report,[79] which outlines the levelized cost of energy assumptions for a fixed-bottom offshore wind project. Each cost component was translated into the relevant North American Industry Classification System (NAICS) code, and following that, the relevant IMPLAN industry.

Materials for offshore wind installation fall into several IMPLAN industries including:

- Turbine and turbine generator set units manufacturing
- Power, distribution, and specialty transformer manufacturing
- Fabricated structural metal manufacturing

IMPLAN industries for labor for offshore wind installation include:

- Construction of new power and communication structures
- Architectural, engineering, and related services

Annual O&M for offshore wind included IMPLAN industries such as "construction of new power and communication structures," "electric power transmission and distribution," and "scenic and sightseeing transportation and support activities for transportation." The latter sector includes port and harbor operators that are required to transport supplies and workers to the site.

Solar

Utility-scale solar photovoltaics (PV) installations require materials necessary to construct the module,

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[78] U.S. Bureau of Labor Statistics. 2020. Quarterly Census of Employment and Wages. "All Industry Aggregations, New Jersey 2020 Annual Averages, All Establishment Sizes." Available at: https://data.bls.gov/cew/apps/data_views/data_views.htm

[79] Stehly, T. and P. Duffy. Revised January 2022. "2020 Cost of Wind Energy Review." National Renewable Energy Laboratory. Available at: https://www.nrel.gov/docs/fy22osti/81209.pdf

inverter, and electrical and structural balance of systems. The cost breakdown for solar PV installation, including labor costs, is based on NREL's 2021 *U.S. Solar Photovoltaic System and Energy Benchmarks* report,[80] which provides a breakdown of costs for different solar PV systems. Each cost component was matched to the relevant IMPLAN industry.

Materials for solar PV installation fall into several IMPLAN industries including:

- Semiconductor machinery manufacturing
- Sheet metal work manufacturing
- Wiring device manufacturing
- Other electronic component manufacturing

IMPLAN industries for labor for solar PV installation include:

- Construction of new power and communication structures
- Architectural, engineering, and related services

Following the IMPLAN industries specified in an economic impact study performed for the Coolidge solar project in Vermont,[81] O&M labor was assigned to "maintenance and repair construction of nonresidential structures, while O&M materials included "insurance agencies, brokerages, and related activities," "employment and payroll of state govt, non-education" (for state and local permit fees), and "all other miscellaneous electrical equipment and component manufacturing" (for replacement of inverters).

Battery storage

Most of the spending on the installation and operations of battery storage is composed of the battery and hardware. The cost breakdown for battery storage installation, including labor costs, is based on NREL's documentation on utility-scale battery storage for its 2021 Annual Technology Baseline,[82] which provides a breakdown of energy storage system costs for lithium-ion batteries. Installation labor and material cost breakdowns were calculated separately for short (4-hour) and long (8- and 10-hour) duration batteries.

Materials for battery storage installation fall into several IMPLAN industries including:

- Storage battery manufacturing
- Sheet metal work manufacturing
- Wiring device manufacturing
- Other electronic component manufacturing

IMPLAN industries for labor for battery storage installation include:

- Construction of new power and communication structures
- Architectural, engineering, and related services

Annual O&M for battery storage included similar IMPLAN industries as noted above. The spending breakdown among IMPLAN industries for battery storage annual O&M was based on the Massachusetts' 2016 *State of*

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[80] Ramasamy, V. et al. 2021. "U.S. Solar Photovoltaic System and Energy Cost Benchmarks." National Renewable Energy Laboratory. Available at: https://www.nrel.gov/docs/fy22osti/80694.pdf

[81] Tommy Vitolo, PhD, Maximilian Chang, Tyler Comings, and Avi Allison. Economic Benefits of the Proposed Coolidge Solar I Solar Project. Synapse Energy Economics. Prepared for Coolidge Solar I, LLC. November 3, 2015. p.9-12. http://www.synapse-energy.com/sites/default/files/Coolidge-Solar-Report-15-104.pdf

[82] National Renewable Energy Laboratory. 2021. "Utility-Scale Battery Storage." Available at: https://atb.nrel.gov/electricity/2021/utility-scale_battery_storage

Charge study.[83]

Gas-fired power plants

Although new gas-fired power plants are not anticipated in either the BAU (existing policy) or CLEAN scenarios, the O&M of existing plants is accounted for throughout these plants' lifetimes.

While O&M for renewable resources is nearly all fixed costs ("fixed O&M" or "FOM"), little to no non-fuel variable costs ("non-fuel variable O&M" or "non-fuel VOM"), and no fuel costs, gas-fired resources have substantial FOM and VOM. For gas-fired power plants, AEC modeled FOM and non-fuel VOM separately. Because New Jersey has no gas extraction activities, fuel costs are excluded from our modeling.[84] Labor costs at gas-fired power plants are primarily FOM: the number employed at the plant does not change significantly if the plant is operational. Therefore, in our modeling, the direct jobs from gas generation only fluctuate when a unit is retired. For FOM costs, we used a combination of the default IMPLAN "electric power generation – fossil fuel" industry[85] and a Brattle Group study on the economics of gas plants.[86] The Brattle study provided a breakdown of labor spending as a percentage of all FOM for gas-fired combined-cycle (CC) and combustion turbine (CT) plants separately.[87]

Spending on non-labor FOM included the "electric power transmission and distribution" and "pipeline transportation" industries, among others. Non-fuel VOM spending was modeled as "basic organic and inorganic chemical manufacturing" industries.

EV infrastructure

At present, EVs are not manufactured in New Jersey and their economic activity, therefore, is not considered in this analysis; however, the shift towards more EV adoption will necessitate the addition of supporting infrastructure—primarily charging stations. Two types of public charging infrastructure were considered in this analysis: (1) Level 2, and (2) direct current (DC) fast chargers.

The cost breakdown for EV charging infrastructure installation, including labor costs, is based on a 2019 working paper prepared for the International Council on Clean Transportation (ICCT).[88] The installation costs vary on a per-charger basis depending on the power level and chargers per site. To provide a general cost breakdown for each technology, AEC conducts the following calculations:

- **Level 2 chargers:** Averages data on the hardware, labor, materials, and permitting costs for one and two chargers per site.
- **DC fast chargers:** Averages data on the hardware, labor, materials, and permitting costs for 50 kW and

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[83] Massachusetts Department of Energy Resources, et al. 2016. "State of Charge: Massachusetts Energy Storage Initiative." Available at: https://www.mass.gov/doc/state-of-charge-report/download. p. 221

[84] U.S. Energy Information Administration. October 2021. "New Jersey: State Profile and Energy Estimates." Available at: https://www.eia.gov/state/analysis.php?sid=NJ

[85] To estimate spending on FOM for gas-fired power plants, AEC removed IMPLAN industries associated with fuel spending (e.g., fossil fuel extraction, rail and truck transportation) from the default IMPLAN "electric power generation – fossil fuel" industry's spending matrix. These industries are not associated with the fixed O&M costs required to run gas-fired power plants.

[86] Newell, S.A. et al. 2018. "PJM Cost of New Entry Combustion Turbines and Combined-Cycle Plants." Brattle. Prepared for PJM Interconnection LLC. Available at: https://www.brattle.com/wp-content/uploads/2021/05/13896_20180420-pjm-2018-cost-of-new-entry-study.pdf p.30-32

[87] AEC averages the FOM costs associated with gas-fired CCs and CTs to yield spending shares for labor and materials of 16 and 84 percent, respectively.

[88] Nicholas, M. 2019. *Estimating electric vehicle charging infrastructure costs across major U.S. metropolitan areas*. International Council on Clean Transportation. Available at: https://theicct.org/publication/estimating-electric-vehicle-charging-infrastructure-costs-across-major-u-s-metropolitan-areas/

150 kW power levels for one charger per site.

Materials for EV charger installation fall into several IMPLAN industries including:

- All other miscellaneous electrical equipment and component manufacturing
- Electronic computer manufacturing
- Power, distribution and specialty transformer manufacturing
- Other communication and energy wire manufacturing

IMPLAN industries for labor for EV charger installation include:

- Construction of new power and communication structures
- Maintenance and repair construction of nonresidential structures
- Electric power transmission and distribution

AEC did not account for the positive, yet small, impact of jobs related to operating EV charging stations after they are built, which would be difficult to estimate with precision.

Building electrification and energy efficiency activities

Building sector spending in the EMP scenario is focused on building electrification and energy efficiency activities, which include appliance upgrades and electrification of end-uses (e.g., space and water heating, cooking, etc.), building shell and air sealing investments (e.g., windows, insulation, etc.), smart controls (e.g., thermostats), among others. The cost breakdown for buildings electrification and energy efficiency activities, including labor costs, is based on IMPLAN industry breakdowns provided in a 2020 article published in the journal MethodX.[89] To provide a general spending pattern, AEC took the average between the residential and commercial energy efficiency patterns.

AEC reassigned the MethodX "construction" portion of spending to the following IMPLAN industries:

- Maintenance and repair construction of residential structures
- Maintenance and repair construction of nonresidential structures

AEC also reassigned the MethodX "program administration" portion of spending to the following IMPLAN industries:

- Local government electric utilities
- * Employment and payroll of state govt, other services

Estimating economic impacts from oil heating

The drastic reduction in oil heating in the EMP scenario will mean loss in associated employment—primarily in the delivery of oil to homes and businesses. To estimate this impact, we assumed that the current oil delivery jobs in the state would decrease in proportion to the amount of heating oil sold. As a baseline, BLS data provides employment data for fuel dealers in New Jersey in 2020: a total employment of 2,142.[90] The direct job impact in future years was estimated using the incremental change in oil heating fuel sold from 2020 in the

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[89] Brown, M., Soni, A., and Li, Y. 2020. "Estimating employment from energy-efficiency investments." MethodsX, Volume 7. https://doi.org/10.1016/j.mex.2020.100955

[90] Bureau of Labor Statistics. *Quarterly Census of Employment and Wages. Private, All Industry Aggregations, New Jersey, 2020 Annual Averages, All Establishment Sizes.* Available at: https://data.bls.gov/cew/apps/table_maker/v4/table_maker.htm#type=11&year=2020&qtr=A&own=5&area=34000&supp=0. The oil delivery jobs are based on the NAICS code 454310 (fuel dealers).

EMP relative to the BAU (existing policy scenario). For instance, relative to the BAU, oil heating sales in the EMP are projected to decrease by an additional 46 percent in 2035 compared to 2020 levels; thus, the direct job impact was a reduction of 46 percent in the current oil delivery jobs: a loss of 1,455 jobs (or 1,268 FTEs). We then calculated all other economic impacts using the multipliers from IMPLAN for the relevant sector: "Retail - Nonstore retailers".[91]

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[91] IMPLAN. "546 Industries, Conversions, Bridges, & Construction - 2020 Data." Available at: https://support.implan.com/hc/en-us/articles/4411706125467-546-Industries-Conversions-Bridges-Construction-2020-Data. We used IMPLAN sector 413 (non-store retailers) which includes the NAICS code 454310 for fuel dealers.

Appendix E: Detailed Economic Impact Results

Table 6. CLEAN annual FTE job impacts by resource type compared to the BAU (existing policy) scenario

Jobs (FTEs)	Impact Type	2025	2030	2035	2040	2045	2050
Energy Efficiency	Direct	730	812	2,890	3,938	3,836	3,927
	Indirect	136	151	539	735	716	733
	Induced	334	372	1,324	1,804	1,758	1,799
	Total	**1,200**	**1,336**	**4,753**	**6,477**	**6,309**	**6,459**
Solar	Direct	5	1,569	2,063	1,623	2,443	2,684
	Indirect	2	685	828	557	870	903
	Induced	3	922	1,149	823	1,266	1,345
	Total	**11**	**3,175**	**4,040**	**3,002**	**4,580**	**4,932**
Offshore Wind	Direct	0	0	0	977	5,926	2,172
	Indirect	0	0	0	83	468	-53
	Induced	0	0	0	524	3,178	1,172
	Total	**0**	**0**	**0**	**1,584**	**9,571**	**3,291**
Energy Storage	Direct	154	128	758	1,132	1,846	2,480
	Indirect	80	66	427	633	1,009	1,352
	Induced	101	85	511	766	1,243	1,674
	Total	**336**	**278**	**1,697**	**2,531**	**4,098**	**5,506**
EV Chargers	Direct	289	15	134	64	65	65
	Indirect	22	1	10	5	5	5
	Induced	377	17	170	80	84	84
	Total	**687**	**33**	**314**	**149**	**154**	**153**
Gas	Direct	0	0	-10	-19	-23	-32
	Indirect	1	-1	-128	-243	-295	-401
	Induced	0	0	-9	-17	-20	-28
	Total	**1**	**-1**	**-147**	**-279**	**-338**	**-461**
Oil Heating	Direct	-73	-402	-866	-1,268	-1,464	-1,504
	Indirect	-37	-205	-442	-647	-747	-768
	Induced	-25	-140	-301	-441	-509	-523
	Total	**-135**	**-747**	**-1,610**	**-2,356**	**-2,720**	**-2,794**
Total Job Impacts	Direct	1,105	2,122	4,969	6,447	12,629	9,792
	Indirect	204	697	1,233	1,122	2,025	1,770
	Induced	790	1,255	2,845	3,539	6,999	5,523
	Total	**2,099**	**4,074**	**9,047**	**11,107**	**21,653**	**17,085**

Table 7. CLEAN annual state GDP impacts by resource type compared to the BAU (existing policy) scenario

State GDP (2021$, millions)	Impact Type	2025	2030	2035	2040	2045	2050
Energy Efficiency	Direct	$99	$111	$394	$536	$522	$535
	Indirect	$22	$24	$86	$117	$114	$116
	Induced	$40	$45	$159	$217	$211	$216
	Total	**$161**	**$179**	**$638**	**$870**	**$847**	**$867**
Solar	Direct	$1	$230	$302	$237	$357	$392
	Indirect	$0	$99	$121	$83	$129	$135
	Induced	$0	$114	$146	$109	$166	$179
	Total	**$1**	**$443**	**$569**	**$429**	**$652**	**$706**
Offshore Wind	Direct	$0	$0	$0	$166	$1,007	$386
	Indirect	$0	$0	$0	$10	$58	-$7
	Induced	$0	$0	$0	$63	$382	$141
	Total	**$0**	**$0**	**$0**	**$239**	**$1,448**	**$521**
Energy Storage	Direct	$24	$22	$124	$195	$323	$448
	Indirect	$13	$11	$69	$102	$162	$217
	Induced	$12	$10	$61	$92	$150	$202
	Total	**$50**	**$43**	**$254**	**$389**	**$636**	**$867**
EV Chargers	Direct	$62	$3	$29	$14	$14	$14
	Indirect	$3	$0	$1	$1	$1	$1
	Induced	$45	$2	$21	$10	$10	$10
	Total	**$110**	**$5**	**$51**	**$24**	**$25**	**$25**
Gas	Direct	$0	$0	-$10	-$18	-$22	-$31
	Indirect	$0	$0	-$28	-$53	-$64	-$87
	Induced	$0	$0	-$8	-$15	-$18	-$24
	Total	**$0**	**$0**	**-$45**	**-$86**	**-$104**	**-$142**
Oil Heating	Direct	-$22	-$123	-$265	-$387	-$447	-$460
	Indirect	-$9	-$51	-$109	-$160	-$185	-$190
	Induced	-$7	-$36	-$78	-$114	-$132	-$136
	Total	**-$38**	**-$210**	**-$452**	**-$662**	**-$764**	**-$785**
Total GDP Impacts	Direct	$164	$243	$574	$742	$1,754	$1,284
	Indirect	$29	$83	$140	$99	$215	$186
	Induced	$92	$135	$301	$361	$769	$589
	Total	**$285**	**$461**	**$1,014**	**$1,203**	**$2,739**	**$2,059**

Table 8. CLEAN annual labor income impacts by resource type compared to the BAU (existing policy) scenario

Labor Income (2021$, millions)	Impact Type	2025	2030	2035	2040	2045	2050
Energy Efficiency	Direct	$70	$78	$278	$379	$369	$378
	Indirect	$15	$16	$58	$78	$76	$78
	Induced	$23	$25	$90	$123	$120	$123
	Total	**$108**	**$120**	**$426**	**$580**	**$565**	**$579**
Solar	Direct	$1	$176	$228	$174	$264	$287
	Indirect	$0	$65	$80	$57	$88	$93
	Induced	$0	$65	$83	$62	$95	$102
	Total	**$1**	**$305**	**$391**	**$293**	**$446**	**$482**
Offshore Wind	Direct	$0	$0	$0	$125	$765	$304
	Indirect	$0	$0	$0	$8	$44	-$5
	Induced	$0	$0	$0	$36	$217	$80
	Total	**$0**	**$0**	**$0**	**$169**	**$1,025**	**$379**
Energy Storage	Direct	$18	$15	$89	$135	$220	$298
	Indirect	$8	$6	$40	$59	$95	$127
	Induced	$7	$6	$35	$52	$85	$115
	Total	**$32**	**$27**	**$164**	**$246**	**$400**	**$540**
EV Chargers	Direct	$35	$2	$16	$8	$8	$8
	Indirect	$2	$0	$1	$1	$1	$1
	Induced	$26	$1	$12	$5	$6	$6
	Total	**$63**	**$3**	**$29**	**$14**	**$14**	**$14**
Gas	Direct	$0	$0	-$2	-$4	-$5	-$7
	Indirect	$0	$0	-$14	-$27	-$32	-$44
	Induced	$0	$0	-$4	-$8	-$10	-$14
	Total	**$0**	**$0**	**-$21**	**-$39**	**-$48**	**-$64**
Oil Heating	Direct	-$7	-$40	-$87	-$127	-$146	-$150
	Indirect	-$6	-$35	-$75	-$110	-$128	-$131
	Induced	-$4	-$21	-$44	-$65	-$75	-$77
	Total	**-$17**	**-$96**	**-$207**	**-$302**	**-$349**	**-$359**
Total Labor Income Impacts	Direct	$116	$231	$522	$690	$1,474	$1,117
	Indirect	$18	$52	$89	$66	$143	$119
	Induced	$52	$77	$171	$205	$437	$335
	Total	**$187**	**$359**	**$782**	**$961**	**$2,054**	**$1,571**