NRG Dunkirk Repowering Project

Economic Impact Analysis

Final Report

Prepared for NRG Energy

by

Longwood Energy Group

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CONTENTS

Summary

Longwood Energy Group (LEG), leading a team that includes Cambridge Energy Solutions, Newton Energy Group, and Economic Development Research Group, analyzed the impact of the Dunkirk repowering project on the New York wholesale electricity market and the New York State economy. This report presents the results of the study.

NRG Energy has proposed to repower the 540 MW Dunkirk coal-fired plant in western New York State with a 440 MW combined cycle gas turbine (CCGT) by mid-2017. This project, first proposed in 2011, offers a number of tangible economic benefits to the people of New York, including electricity ratepayers, other consumers, and citizens at large. As an added benefit the plant provides specific environmental benefits to the region by dramatically reducing air emissions.

The LEG analysis found that, among other benefits, repowering the plant with a CCGT will reduce the wholesale cost of electricity in the region and state—savings that can be passed along to ratepayers by their utilities. Over the 10 years covered by the analysis, repowering the plant—as opposed to retiring it—is projected to decrease wholesale electric energy prices by an average of $1.11/MWh. The decrease in wholesale energy prices is even more pronounced in the vicinity of Dunkirk: $2.35/MWh. This will stimulate the state's economy in virtually all sectors, generating jobs and economic activity, and increasing the gross state product. In addition, during the three years of construction, the project will directly create hundreds of well-paying jobs and associated economic benefits. By decreasing the cost of power produced in New York, this project will increase the likelihood that the power used by New Yorkers is produced within the state, for the benefit of its people and labor force.

The Dunkirk CCGT plant will provide enough power to supply approximately 11 percent of the projected 2018 demand in western New York and about two percent of total projected 2018 demand for New York State. This additional supply will reduce the need for generation from other power plants that would have higher pollutant emissions and operating costs. It would also help eliminate the need for expensive, long-distance transmission projects that provide little or no long-term economic benefits.

The LEG analysis projected wholesale power prices for three representative years over a 10-year period, for scenarios with and without the repowered Dunkirk plant in service, quantifying the expected reduction in wholesale power prices and wholesale electricity costs, as well as production costs and emissions that would result from the power supplied by the project. Additionally, the projected wholesale power cost reductions and expected expenditures on construction, operations, and maintenance (O&M) for the repowered plant were used to project the benefits to the regional and state economies.[1]

- **Repowering Dunkirk, as opposed to retiring it, will reduce the annual wholesale cost of electric energy for New York consumers by $142 million** on average over a 10-year period, saving over $1.4 billion in total over the period. Of this amount, $45 million per year, and over $455 million over the entire period, will accrue to ratepayers in the vicinity of Dunkirk.
  - The repowered plant will lower the price of electricity in the New York wholesale market by $1.11 on average over 10 years.
  - Reliance on out-of-state generation will also be reduced with a savings for the state of $39 million annually.
- **The project will deliver additional savings in wholesale costs of installed capacity of $159 million per year and nearly $1.6 billion over a 10-year period**. It will also produce savings in the wholesale costs of installed capacity in the vicinity of Dunkirk of approximately $42 million per year, or $417 million over the same 10-year period.
  - The price of installed capacity will be reduced, on average, by $0.89/kW-year for summers over the same period; winter installed capacity prices will be reduced by $0.78/kW-year on average.
- **Combined, energy and capacity cost savings will exceed $300 million per year, over $3 billion in total**.

[1] The prices, costs, and savings presented in this report are in today's dollars.

- **The project will increase the gross state product over the same period of operations an average of $348 million per year,** of which $136 million would accrue in the vicinity of Dunkirk. Significant economic benefits also accrue in the three-year construction period beginning in 2014.
- **During the construction phase, the project will generate over 300 jobs per year**, most of which will be in the vicinity of Dunkirk. **Once the plant begins operations, it will generate on average over 3,540 jobs per year**, of which about 1,390 would be in the vicinity of Dunkirk.
- The project will reduce the emissions of New York State's power production considerably because the Dunkirk CCGT will displace operation of the state's most inefficient generators. **Building the new Dunkirk plant will decrease New York generators' aggregate annual SOx emissions by as much as 6 percent, NOx by as much as 4.5 percent, and CO2 by as much as 1.3 percent.**

	Dunkirk Region (Zones A & B)	Total New York State
Energy Cost Savings		
Annual	$45 million/year	$142 million/year
10-Year Total	$455 million	$1.4 billion
Capacity Cost Savings		
Annual	$42 million/year	$159 million/year
10-Year Total	$417 million	$1.6 billion
Macroeconomic Benefits		
Gross Regional Product, 10 Years Operations	+ $136 million/year	+ $348 million/year
Total Jobs During Construction[2]	+ 248 on average	+ 308 on average
Total Jobs During 10 Years Operations[3]	+ 1,390/year on average	+ 3,540/year on average

[2] Average increase in jobs (direct, indirect, and induced) resulting from construction spending from 2014-2017; does not include jobs added due to O&M spending.

[3] Average increase in jobs (direct, indirect, and induced) resulting from ratepayer benefits and O&M spending from 2018-2027.

Approach

Electric power in New York State is bought and sold through a competitive wholesale market. The New York wholesale electricity market is operated by NYISO, the New York Independent System Operator, which is responsible for reliably managing and maintaining the flow of electricity across the State's power grid. New York utilities and other load-serving entities own and operate almost no generating capacity, but instead purchase wholesale power on the competitive market, the costs of which are ultimately recovered through the retail rates charged to end-use customers, referred to as ratepayers. Most electricity customers in New York pay regulated retail rates closely tied to expected wholesale power costs, which are therefore a good measure of electricity costs for New York ratepayers.

Wholesale power costs include two principal components: energy costs and capacity costs. Energy is the cost of actual delivered electricity. Capacity costs are payments made to generators to ensure that there is always enough generating capability or "installed capacity" to support the demand, or "load," plus a reserve margin. This is because generators' energy market revenues alone are insufficient to cover costs. The price of energy is determined on the NYISO spot (day-ahead and real-time) market, which reacts to immediate needs, while the market price of capacity is determined in periodic, longer-term auctions run by the NYISO.

The LEG analysis estimated the savings from repowering Dunkirk by projecting the energy and capacity components of wholesale power costs for the state with and without the Dunkirk CCGT in service. The analysis also estimated the production cost savings, and the impact on the cost of power flowing between New York and its neighbors. Finally, the projected energy and capacity cost savings, along with projected construction and O&M spending, were used to project the benefits of repowering Dunkirk to the regional economy, in terms of gross regional product and jobs created.

Energy cost and emissions reduction analysis

The power produced by the Dunkirk CCGT is expected to lower prices by displacing higher-cost generation. The plant is also expected to reduce emissions because its modern, efficient generation will displace higher-emission generation.

As in other coordinated power markets, power in New York is priced hourly and by location, with the market price set by the offer from the most expensive generating facility needed to meet demand. The repowering project's impact on prices and emissions can be analyzed by comparing two future possibilities: one in which the existing Dunkirk coal plant is replaced by a new combined cycle plant, and the other in which Dunkirk is retired.[4] In each hour that the prices in a scenario with Dunkirk repowered are lower than the prices in a scenario with Dunkirk retired, electricity costs will be reduced.

The variable operating cost of the repowered Dunkirk plant, largely determined by its high efficiency and the low cost of natural gas, will be competitive relative to existing generation resources, and the plant's electricity will be offered at a price that reflects that low cost. As a result, the new Dunkirk plant will displace higher-cost generation and the associated emissions in most hours of the year, resulting in a lower market price and reduced total emissions by the generating fleet.

The analysis estimated these price decreases and emission decreases for each hour of each of three representative years: 2018, 2020, and 2025. By interpolating the results for intervening years and extrapolating the 2025 results for 2026-2027, the analysis projected reductions for each year from 2018 through 2027.[5]

[4] Because Dunkirk serves certain reliability needs, the modeled scenario in which Dunkirk is retired must include certain transmission upgrades needed to address those same needs in the absence of Dunkirk. In the repowering scenario, it is assumed that one peaking unit at Dunkirk remains in place for reliability purposes until the repowering is complete. Certain upgrades determined by National Grid to be necessary during the continued operation of the existing Dunkirk plant are assumed to be in place in both scenarios.

[5] The plant is expected to enter service in mid-2017. The simulation results presented in this section begin with the first full year of operation (2018), although results for 2017 were included as inputs to the macroeconomic analysis.

The projections rely on publicly available data, including the following key input assumptions:

Fuel prices. Natural gas and oil prices are based on regional monthly forward curves published by SNL Financial, and the Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2013, early release issued December 2012.[6] The SNL forecast through 2019 is used, after which annual increases in the EIA forecast are used to calculate subsequent monthly values from the SNL forecast for 2019.

Demand growth. Electricity demand growth assumptions are as projected by NYISO in its *2012 Load & Capacity Data*, Version 3, released in April 2012. Because NYISO projects load growth only through 2022, the analysis assumes annual demand growth for subsequent years to remain constant at 2021-2022 levels.

Generation additions and retirements. Future thermal generation units are added to meet regional capacity requirements, and future renewable generation (predominantly wind) is added from the NYISO Interconnection Queue to meet the New York state renewable portfolio standard (excluding newly proposed solar energy requirements). The analysis uses NYISO data on announced retirements.[7]

Emission permit prices. The analysis uses emission permit prices from the STARS (The U.S. EPA's "Science to Achieve Results") 2012 low emission prices scenario.

For impacts on wholesale electric energy prices, the analysis uses DAYZER, a detailed economic security-constrained dispatch and production-costing model for electricity networks developed by Cambridge Energy Solutions. The DAYZER model uses specified cost-based offers for each generator in the market, as well as a representation of New York's transmission system, to find the least-cost dispatch of power plants and calculate hourly prices for electricity for each location in the NYISO market. This process, equivalent to the one used by NYISO in its operation of the power system and wholesale market, was performed for each of the scenarios: with Dunkirk repowered, and with Dunkirk retired. In each hour, the total wholesale energy cost for each of the NYISO load zones is calculated as the product of the zonal location-based market price (LBMP) and the zonal load.

Capacity cost reduction analysis

Installed Capacity (ICAP) prices in the New York system are established for three locations (ICAP zones): New York City, Long Island and Rest of State. The Rest of State ICAP zone accounts for the requirements of load zones A through I and for approximately 17% of load served in Zone J (New York City). This analysis assumes that repowering Dunkirk will affect capacity prices only in the Rest of State.

Load serving entities procure their installed capacity requirements through the auctions and bilaterally, under both long- and short-term contracts. Their capacity needs must be met separately for each of two seasons, or capability periods: the summer capability period, from May to October, and the winter capability period, from November through April. Installed capacity is first procured for all six months of each period through the strip auction. During the strip auction, capacity is procured for an entire capability period.

The strip auction is followed by subsequent monthly and spot auctions, which take place every month. During the monthly auction, capacity can be procured for each remaining month of the capability period. Finally, during the monthly spot auction, buyers can procure any remaining capacity needs for that month or sell excess capacity. Prices in the spot auction are determined by the administratively set demand curve depicted in Figure 1 below.

As this figure shows, the spot auction price depends on the level of capacity available in that month, in terms of "unforced capacity" (UCAP), a measure of installed capacity adjusted to account for generation outages. When more capacity is

[6] http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2013).pdf

[7] http://www.nyiso.com/public/markets_operations/services/planning/documents/index.jsp?docs=interconnection-studies/other-interconnection-documents. Additionally, Danskammer units 1-4 are assumed to retire.

added to the system, the capacity price declines as shown in Figure 2.

To assess the impact of the Dunkirk repowering on capacity prices and associated ratepayer costs, the LEG team first developed a forecast of the demand curve and then computed capacity prices under two scenarios: 1) with Dunkirk repowered and 2) with Dunkirk retired. The analysis estimates potential savings in capacity costs by multiplying the reduction in capacity prices observed in the repowering scenario by the installed capacity requirements in the Rest of State capacity zone. Of those savings, 25% were assumed to be unattainable by load-serving entities with long-term contracts at prices determined prior to (and therefore unaffected by) the capacity spot price reductions.

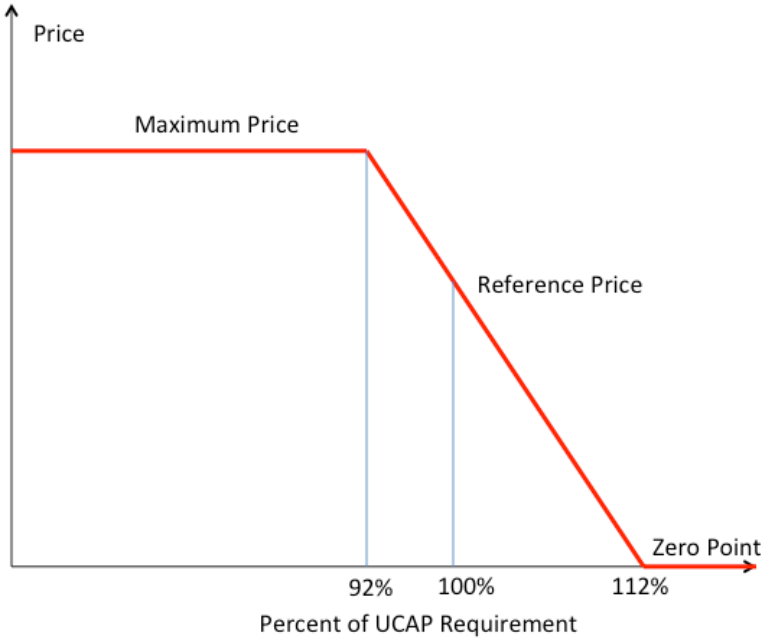

Figure 1. Capacity spot price formation mechanism

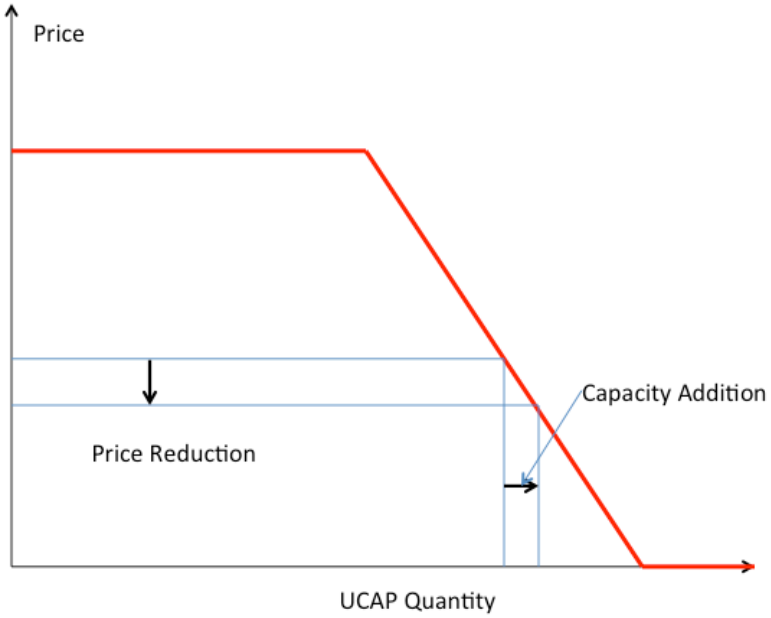

Figure 2. Impact of capacity addition on capacity price.

Macroeconomic analysis

The analysis uses PI+, a 23-sector model developed by Regional Economic Models, Inc., to project the economic impacts, relative to the base case, on gross state product or gross regional product (GRP), industry sales, and employment. These benefits reflect the direct effects of the repowering and the subsequent multiplier effects captured within the dynamically adjusting annual forecasting framework of the REMI system. The model was configured using a representation of three sub-regions: the western part of the state in the vicinity of Dunkirk, New York City and Long Island, and the remainder of the state.

Projected changes in wholesale electricity prices for 2017-2027 were allocated by customer segment, and along with short-term facility construction and on-going O&M spending, introduced into the REMI model.

The model generates annual estimates of the total impact (direct plus multiplier responses) by region, from any specific policy initiative (or infrastructure investment) compared to the base case—which in this case is Dunkirk retired and any transmission upgrades required in the absence of the repowered plant.

The repowering's benefits to the state's economy occur chiefly because of (i) the construction phase spending between 2014 into 2017, (ii) beginning mid-2017, the annual operations and maintenance (O&M) spending, and (iii) the ratepayer benefits due to reductions in the energy and capacity portions of the wholesale energy cost that result from a more efficient generating unit joining the generating fleet.

Construction and O&M cost assumptions

The following figures summarize the construction and O&M cost assumptions provided by NRG and used in the three-region REMI forecasting model. These within-region expenditures are considered to be *direct effects* for the scenario, and it is these (along with the direct effects of the electricity cost savings) that cause subsequent *economic multiplier effects*. The direct *plus* the multiplier effects define the *total impact* in a year for the metric of interest.

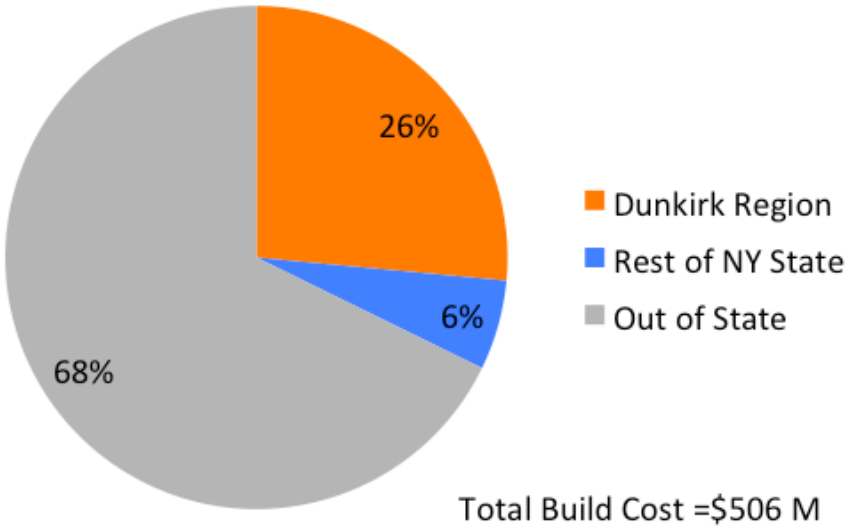

Figure 3. Allocation of construction budget by region (2012$).

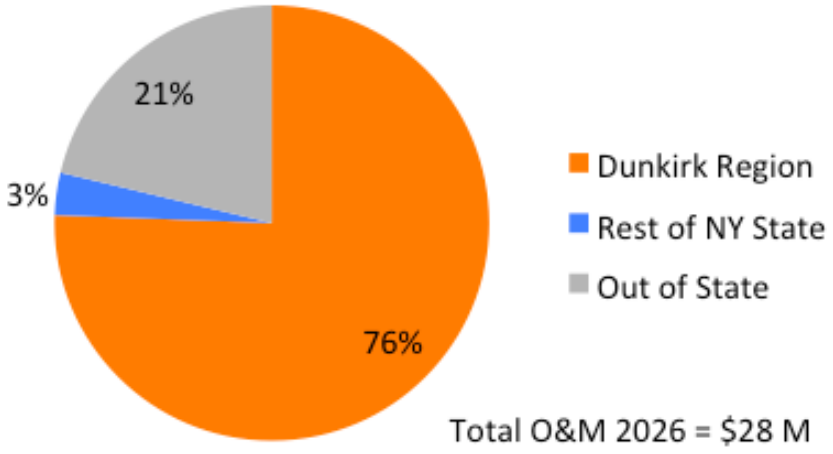

Figure 4. Allocation of Annual O&M requirements by region (2012$).

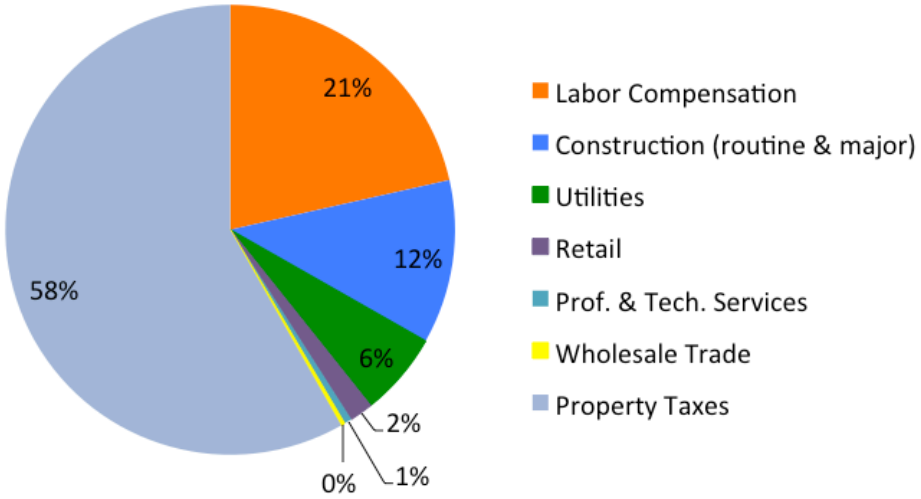

Figure 5. O&M spending by Industry for the Dunkirk region for 2026 (2012$).

Results

Energy price reductions

Figure 6 shows estimates of the decrease in the average New York wholesale power prices resulting from repowering Dunkirk, compared to retiring the plant. Over the 10 years covered by the analysis, wholesale energy prices would be an average of $1.11/MWh lower with the plant repowered than with it retired. The effect on wholesale electricity prices is even more pronounced for western New York, close to the generator, as shown in Figure 7. The average price reduction over the period for the region in the vicinity of Dunkirk is $2.35/MWh. [8]

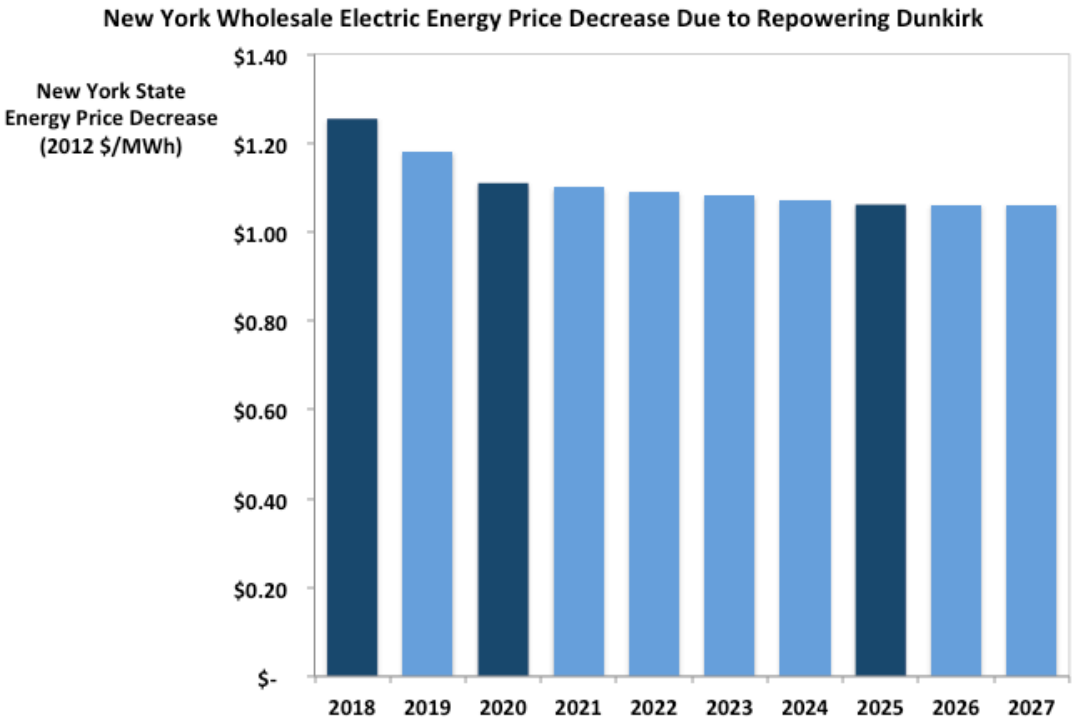

Figure 6. Impact of repowering Dunkirk on wholesale electricity (energy) prices. Simulated years are in dark blue.

[8] This region is defined here, for the purposes of the energy and capacity cost impact analysis, as NYISO load zones A and B. For the purposes of the macroeconomic analysis, the region is roughly the same, consisting of Chautauqua, Cattaraugus, Erie, Wayne, Livingston, Genesee, Niagara, Orleans, Allegany, Ontario, Monroe, and Wayne counties.

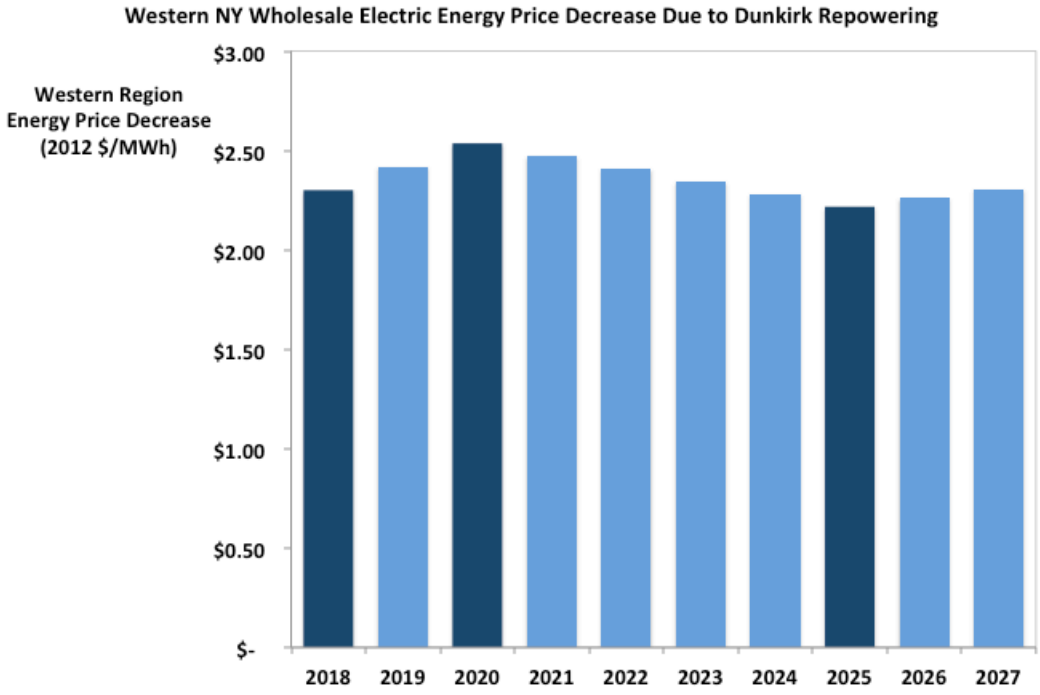

Figure 7. Impact of repowering Dunkirk on wholesale electric energy prices in the western New York / Dunkirk region. Simulated years are in dark blue.

Wholesale energy cost reductions

The expected savings in electricity costs associated with the forecasted reduction in wholesale energy market prices are shown in Figure 8. The cost savings in today's dollars range between $138 million and $158 million annually, totaling $1.4 billion over the 10-year period.[9] Of these, $45 million per year, or $455 million accrued to the western region of the state.[10] Savings differ across the three modeled years due to several factors, including the addition of wind generation between 2018 and 2020 to meet the RPS, the addition of new generating capacity added to meet regional demand growth, and changes in the difference between gas and coal prices. Moreover, the addition of the CCGT's output creates a surplus, which initially puts downward pressure on energy prices, which then rise as demand growth absorbs the surplus.

Another measure of societal impact and economic efficiency is production cost, which is generators' cost to produce the electricity (variable costs, predominatly fuel). The LEG analysis showed that repowering Dunkirk results in average production cost savings of $28 million/year, totalling $281 million over the 10-year analysis time horizon.[11]

Additionally, because of the project's impact on system prices and dispatch, the cost of energy purchased (and value of energy sold) across New York's borders with its neighbors will change, reflecting a reduced reliance on out-of-state

[9] A reduction of 25 percent in the projected savings is reflected in these totals to account for savings assumed to be unattainable by load-serving entities with long-term contracts at prices determined prior to (and therefore unaffected by) the energy price impacts.
[10] Zones A (West) and B (Genesee).
[11] Note that because the generation cost is a component of wholesale energy costs, the savings are not additive.

generators. The analysis showed the predominant impact to be a decrease in the cost of imports, with a net decrease of approximately $39 million per year, totalling over $394 million over the 2018-2027 period.[12]

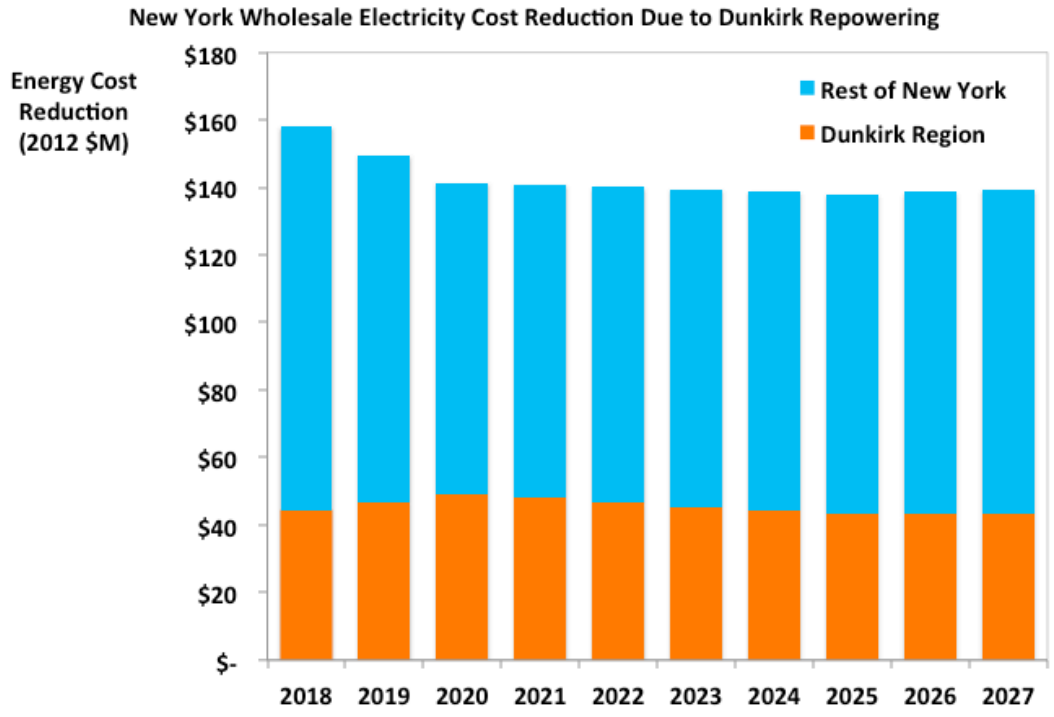

Figure 8. Impact of repowering Dunkirk on wholesale electric energy costs.

Capacity cost reductions

The impact of repowering Dunkirk on capacity prices in the Rest-of-State capacity region is shown in Figure 9 below. Repowering Dunkirk is estimated to reduce Rest-of-State summer capacity prices by approximately $0.89/kW-month on average with small variations around this number. The average reduction in Rest-of-State winter capacity prices is approximately $0.78/kW-month and varies over time between $0.27/kW-month and $0.93/kW-month.

Estimated annual state-wide capacity cost reductions through 2023 are presented in Figure 10 below. As in the energy cost analysis, the capacity analysis assumes that only 75% of the modeled capacity price impact will be realized by load-serving entities and the consumers they serve; the cost savings listed here and shown in Figure 10 account for the assumed 25% reduction in impact.

Statewide savings in wholesale costs of installed capacity amount to $159 million per year (in today's dollars), or nearly $1.6 billion over the 10 years from 2018 through 2027. Savings in the wholesale costs of installed capacity for the two load zones in the vicinity of Dunkirk (zones A and B) are estimated at $42 million per year, or approximately $417 million over the same 10-year period.

[12] Price decreases at New York's borders caused by the repowering reduce the cost of imports (predominantly) and the revenues associated with exports, with a net cost decrease overall. Because this analysis includes the simplifying assumption that cross-border flows were unaffected by the repowering project, the effects of the repowering and associated price changes on import and export quantities are not accounted for.

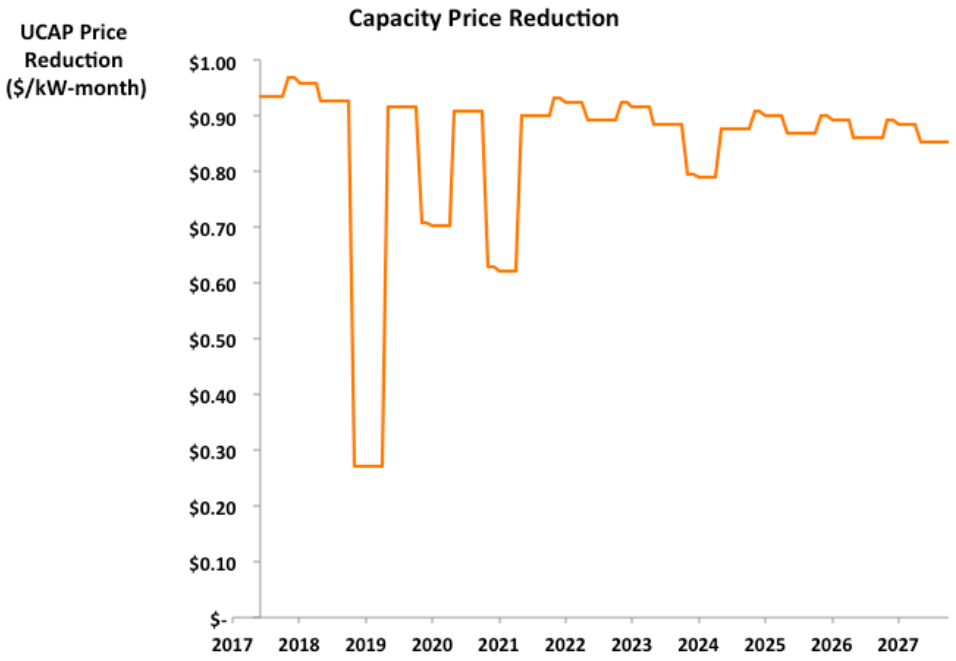

Figure 9. Capacity price reductions in Rest-of-State zone with Dunkirk repowered (2012$).

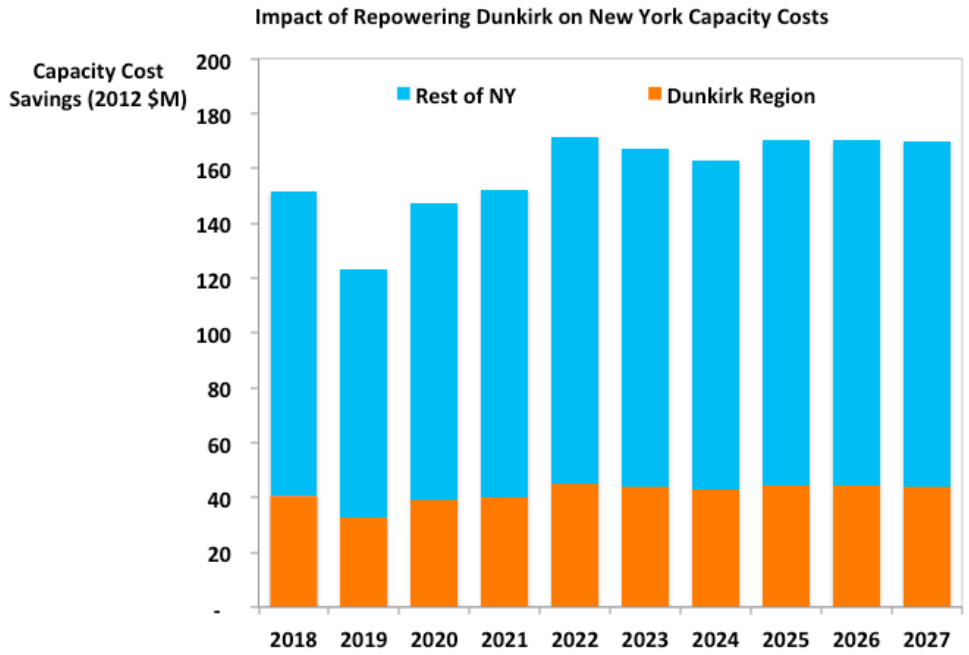

Figure 10. Estimated annual capacity cost reduction.

Emissions reductions

The projected reductions in the emissions of New York's generating fleet due to the Dunkirk repowering are shown in Figure 11. The annual reduction in CO_2 emissions ranges between 0.5 and 1.3 percent, averaging 0.8 percent and totaling 2.6 million metric tons over the 10-year period. Statewide annual NOx emissions are reduced between 2.4 and 4.5 percent,

averaging 3.2 percent and totalling over 5,000 metric tons over the 10-year period. Annual SOx emissions are reduced between 2.1 and 6 percent, averaging 3.5 percent and totalling over 4,800 metric tons.

The statewide emissions reductions due to the Dunkirk repowering vary across the three modeled years primarily due to the changing generation mix over the time period. That is, as the supply mix shifts toward more efficient natural gas fired plants and renewables, the reduction attributable to Dunkirk decreases.

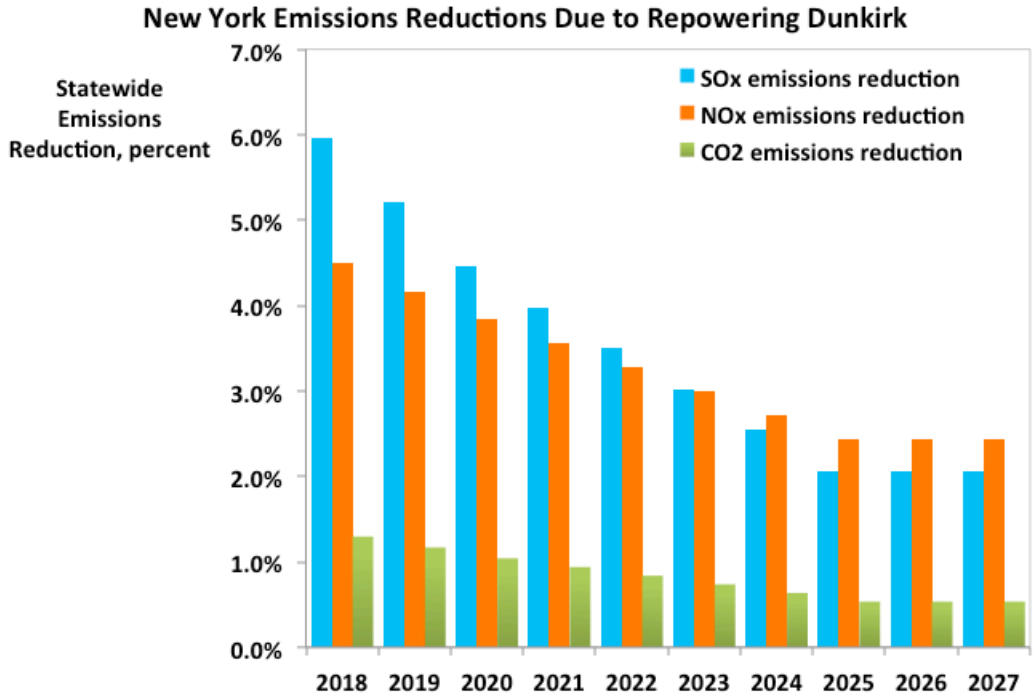

Figure 11. Statewide emissions reductions resulting from repowering Dunkirk.

Benefits to the regional economy

Repowering Dunkirk will create jobs in three ways:

Direct jobs, created at firms involved with the project

Indirect jobs, created at firms that provide goods and services used by the firms involved directly in the project

Induced jobs, created elsewhere in the economy as increases in income from the construction spending, O&M spending, and ratepayer benefits lead to additional increases in spending by workers and firms

Figure 12 shows that repowering Dunkirk will create thousands of jobs in New York State and in the sub-region around Dunkirk, relative to the base case.[13] Over the period illustrated by the figure, the regional economy in the plant's vicinity will add on average 1,200 jobs, as a result of involvement in the project's construction phase, a key role in fulfilling ongoing O&M activities, and its ratepayers (in all customer-segments) benefiting from lower rates. Statewide, the resulting benefit averages more than 2,850 jobs over the period, and over 3,540 per year over 10 years of operations, of which about 1,390 are in the vicinity of Dunkirk. These impacts are predominantly due to reductions in electricity costs, as the customer savings exert a beneficial influence on the economy.

[13] Again, this sub-region in the vicinity of Dunkirk corresponds approximately to NYISO load zones A and B.

Figure 13 presents the forecast of impacts by region based on dollars of gross state and regional product, effectively the value added. Not surprisingly, the pattern is similar to that observed for employment impact, with a 10-year average statewide impact of nearly $350 million per year (2012$), of which $136 million are seen in the region around Dunkirk.

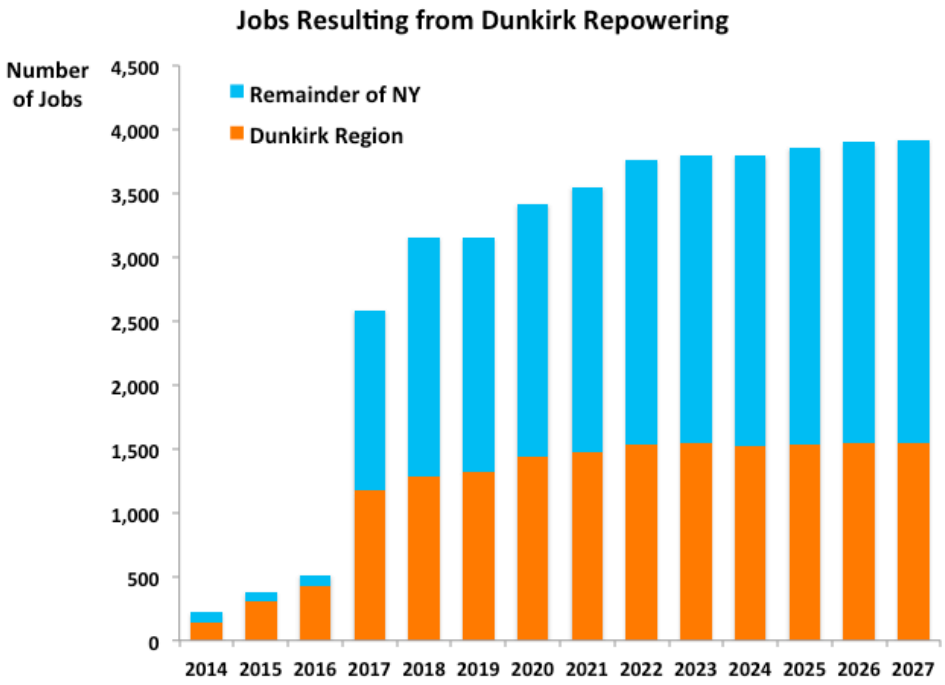

Figure 12. Projected annual impact on jobs.

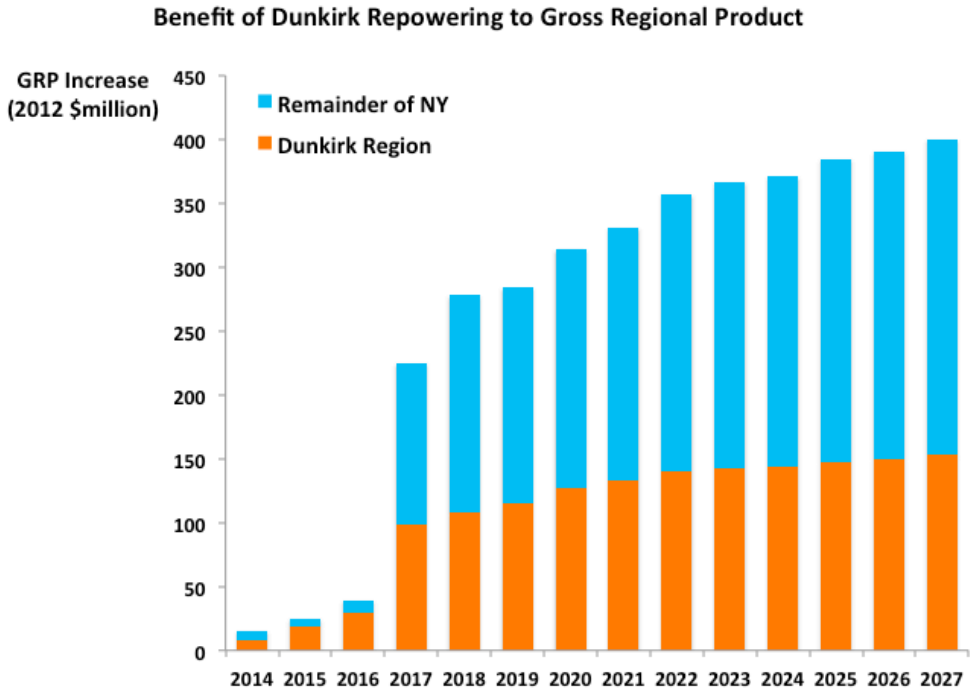

Figure 13. Projected annual impact on gross regional product.

The average annual GRP impact and job additions for the construction period and 10 years of operations are summarized in Table 1. Table 2 illustrates the cumulative benefits over 10 years, focusing on the effect of O&M spending and ratepayer benefits. As the table shows, over the 10-year timeframe, the persistence and the scale of ratepayer benefits associated with the repowered plant are responsible for bolstering the regional economies the most.

TABLE 1. AVERAGE ANNUAL ECONOMIC BENEFITS OF REPOWERING DUNKIRK

	Dunkirk Region (Zones A & B)	Total New York State
Macroeconomic Benefits		
Gross Regional Product, 10 Years Operations	+ $136 million/year	+ $348 million/year
Total Jobs During Construction[14]	+ 248 on average	+ 308 on average
Total Jobs During 10 Years Operations[15]	+ 1,390/year on average	+ 3,540/year on average

TABLE 2. CUMULATIVE ECONOMIC BENEFITS, 10 YEARS OF OPERATION

	Dunkirk Region (Zones A & B)	Total New York State
Cumulative Increase In Gross Regional Product (2012$), 2018-2027		
O&M Spending	+ $393 million	+ $413 million
Ratepayer Benefit	+ $968 million	+ $3.1 billion
Total	+ $1.4 billion	+ $3.5 billion
Cumulative Job Years, 2018-2027		
O&M Spending	+ 3,020	+ 3,160
Ratepayer Benefit	+ 10,900	+ 32,300
Total	+ 13,900	+ 35,400

Figure 14 profiles the distribution of job impacts by industry in 2022 (when ratepayer benefit is at a maximum). This provides insight into which industries, as electricity consumers, become more competitive as a result of lower outlays on electricity purchases, reducing these industries' relative cost of doing business and allowing for market share growth in local and/or export markets. A part of these industry-specific job gains is also attributable to increased consumer spending when households spend less on electricity. The pronounced job impact in health care services and retail activities points to higher spending by existing households due to their lower electricity bills. The pronounced increase in state and local government jobs is the result of a projected increase in regional population that the REMI model captures when the employment opportunities increase, and when the cost of living moderates to make gains in real income. Both of these effects signal inward economic migration of the working age cohorts. When this happens, the labor force expands, putting downward pressure on the labor input cost to employers in New York state, also facilitating market share growth on top of the impact of reduced electricity costs in the commercial and industrial segments. Part of the construction sector's job increase is explained by stimulated economic activity in each of these regions, which signals the need for more buildings, and other physical plant.

[14] Average increase in jobs (direct, indirect, and induced) resulting from construction spending from 2014-2017; does not include jobs added due to O&M spending.

[15] Average increase in jobs (direct, indirect, and induced) resulting from ratepayer benefits and O&M spending from 2018-2027.

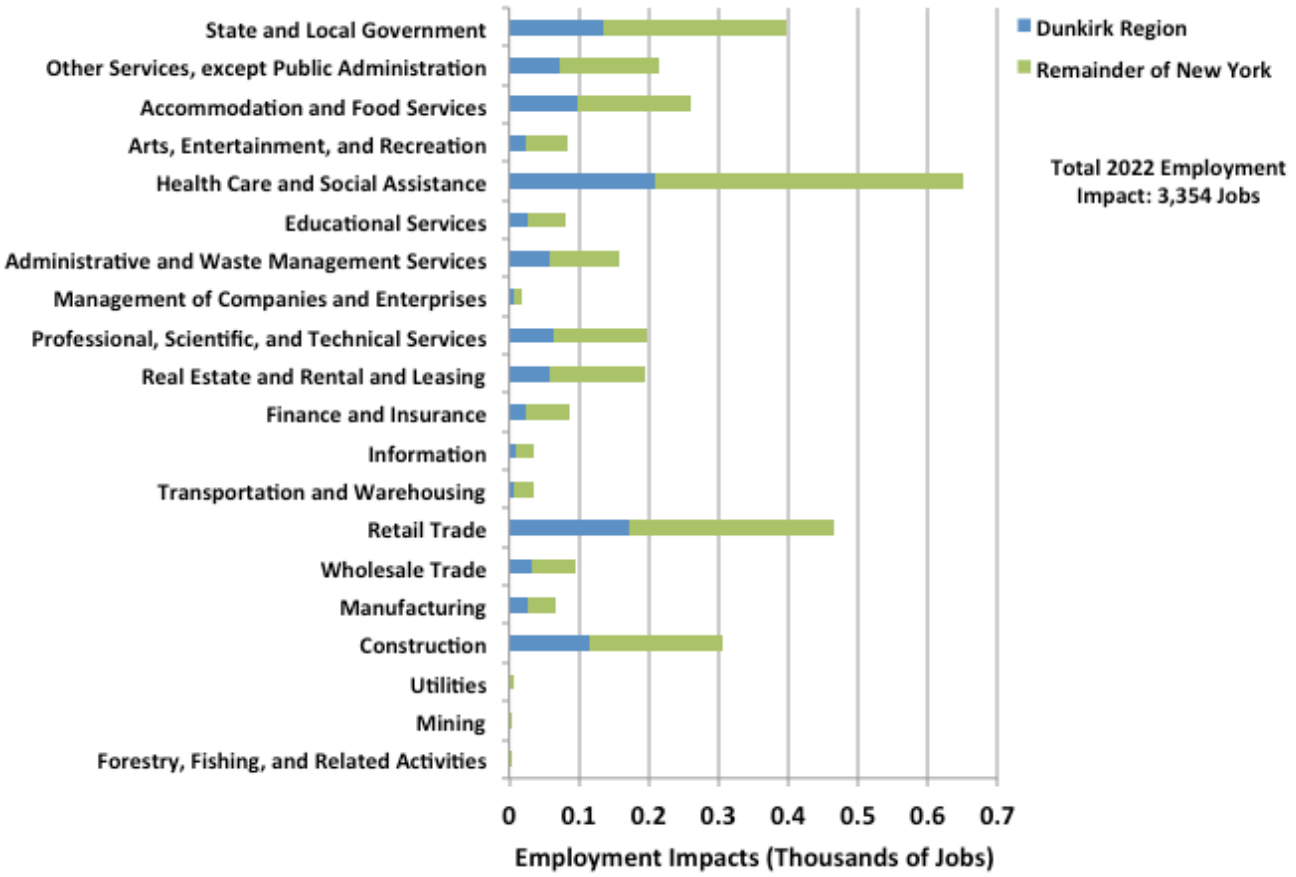

Figure 14. Jobs resulting from the ratepayer benefit, by region and industry, for 2022, the year of maximum impact.