NRG Astoria Repowering Project

Economic Impact Analysis

Final Report

Prepared for NRG Energy

by

Longwood Energy Group

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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 Astoria 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 its 600 MW Astoria gas/oil-fired plant in New York City by replacing the plant's seven oil-fired peaker units (100 MW) with a 520 MW combined cycle gas turbine (CCGT) by mid-2016. This project, first proposed in 2006, offers a number of tangible economic benefits to the people of New York State and New York City, including electricity ratepayers, other consumers, and citizens at large.

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, replacing the seven turbines with a CCGT—as opposed to retiring them—is projected to decrease wholesale electricity prices significantly, saving ratepayers $2.9 billion over 10 years. Savings within New York City will be a significant portion. 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 its three years of construction, the project will directly create hundreds of well-paying jobs, with the majority in New York City and nearby Long Island, and will generate 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.

The Astoria CCGT plant will provide enough power to supply approximately 3.4 percent of the projected 2017 demand in downstate New York and about 1.6 percent of total projected 2017 demand for New York State. This additional supply will reduce the need for generation from other power plants that would have higher operating costs and would have produced higher emissions. 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 over a 10-year period, for scenarios with and without the repowered Astoria plant in service, quantifying the expected reduction in wholesale power prices and wholesale electricity costs, as well as production cost decreases 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]

- **Replacing the Astoria peakers with a CCGT, as opposed to retiring them, will reduce the annual wholesale cost of electricity for New York consumers by $294 million** on average over a 10-year period, saving over $2.9 billion in total over the period. Of this amount, $189 million per year, and over $1.9 billion over the entire period, will accrue to ratepayers in New York City.
- **The $2.9 billion 10-year savings will result from a $1.1 billion reduction in the cost of electric energy, and a $1.8 billion reduction in the cost of installed capacity**.
- **The project will reduce the annual wholesale cost of electric energy for New York consumers by $114 million** on average over a 10-year period. Of this amount, $55 million per year, and nearly $550 million over the entire period, will accrue to ratepayers in New York City.
    - The repowered plant will lower the price of electricity in the New York City load zone by $1.26 on average over 10 years.
    - Reliance on out-of-state generation will also be reduced with a savings for the state of $15 million annually.

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

- **The $1.8 billion in installed capacity savings all occur by early 2021, for an average of $299 million per year, of which $223 million per year will accrue to New York City ratepayers**.
  - The price of installed capacity in New York City will be reduced, on average, by $3.04/kW-year for summers over 2016-2020; winter installed capacity prices over 2016-2021 will be reduced by $2.81/kW-year on average.
- **The project will increase the gross state product over a 10-year period of operations an average of $312 million per year,** of which $207 million would accrue in New York City and Long Island. Significant economic benefits also accrue in the three-year construction period beginning in 2014.
- **During the construction phase, the project will generate over 695 jobs per year**, most of which will be in New York City and Long Island. **Once the plant begins operations, it will generate on average about 3,070 jobs per year**, of which about 1,800 would be in New York City and Long Island.

	New York City	Total New York State
Energy Cost Savings		
Annual	$55 million/year	$114 million/year
10-Year Total	$548 million	$1.1billion
Capacity Cost Savings		
Annual, through Spring 2021	$223 million/year	$299 million/year
Total	$1.3 billion	$1.8 billion

	New York City & Long Island	Total New York State
Macroeconomic Benefits		
Gross Regional Product, 10 Years Operations	+ $207 million/year	+ $312 million/year
Total Jobs During Construction[2]	+ 484 on average	+ 695 on average
Total Jobs During 10 Years Operations[3]	+ 1,800/year on average	+ 3,070/year on average

[2] Average increase in jobs (direct, indirect, and induced) resulting from construction spending from 2014-2016; 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 2016-2025.

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 Astoria by projecting the energy and capacity components of wholesale power costs for the state with and without the Astoria 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 Astoria to the regional economy, in terms of gross regional product and jobs created.

Energy cost analysis

The power produced by the Astoria CCGT is expected to lower prices by displacing higher-cost generation. The plant is also expected to reduce emissions from the generating fleet as a whole, 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 required to meet the load. The repowering project's impact on prices can be analyzed by comparing two future possibilities: one in which the seven existing Astoria oil-fired peakers are replaced by a new combined cycle plant, and the other in which those peakers are retired.[4] In each hour that the prices in a scenario with the new CCGT are lower than the prices in a scenario without it, electricity costs will be reduced.

The variable operating cost of the repowered Astoria 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 Astoria 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 for each hour of each of six representative years: 2016-2020, and 2025.[5]

The projections rely largely 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

[4] Under both scenarios, the seven Westinghouse oil-fired peakers (100 MW total) of 1970 vintage, are assumed to retire, and the remaining 24 Pratt & Whitney dual-fuel peakers would remain in place.

[5] The plant is expected to enter service in mid-2016.

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 the NYISO report 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).[7] The analysis uses NYISO data on announced retirements.[8]

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 two scenarios described above. 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" (ROS). 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). In this study, LEG analyzed the impact of repowering Astoria on capacity prices in Zone J and in Rest of State and anticipated no effect on capacity prices in Zone K (Long Island).

Load-serving entities, which provide electric service to end-users and wholesale customers, 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

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

[7] The 2013 version of the NYISO's *Load and Capacity Data* ("Gold Book") was released while this study was already underway. Because the methodology used to determine certain Gold Book capacity projections for Special Case Resources (SCRs) had been revised since the 2012 version, those SCR assumptions were drawn from the newer document.

[8] http://www.nyiso.com/public/markets_operations/services/planning/documents/index.jsp?docs=interconnection-studies/other-interconnection-documents, as of January 2013.

auction, buyers can procure any remaining capacity needs for that month or sell excess capacity. Prices in the Spot Auction for each location are determined by the administratively set demand curves depicted in Figure 1.[9]

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. The level of UCAP is presented in relative terms with respect to the projected locational UCAP requirement. The demand curve for the ROS is determined in terms of UCAP requirements for the entire New York Control Area (NYCA). When more capacity is added to the system at a specific location, the capacity price for that location declines as shown in Figure 2. It is important to note that when capacity is added in New York City—as is the case with Astoria repowering—it affects the capacity balance in both New York City and NYCA. Capacity prices are therefore affected in both New York City and ROS.

To assess the impact of the Astoria repowering on capacity prices in New York City and ROS, and the associated ratepayer savings, we first developed a forecast of the demand curves for both New York City and NYCA. We then computed capacity prices under the same two scenarios used in the energy cost analysis: 1) with the proposed Astoria CCGT, and 2) without the CCGT. The potential savings in capacity costs consist of two components—savings due to reduction in Zone J capacity price, and savings due to reduction in the ROS capacity prices. We estimated each component by multiplying the reduction in capacity prices observed in the repowering scenario by the installed capacity requirements in the affected 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.

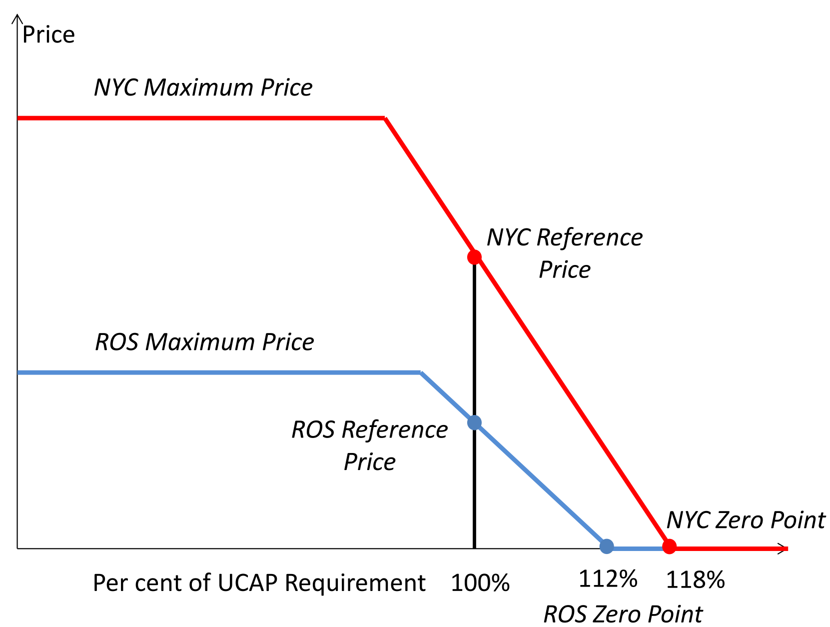

Figure 1. Capacity spot price formation mechanism

[9] The figure shows demand curves for New York City and Rest of State but not for Long Island, since the latter is not relevant for this study.

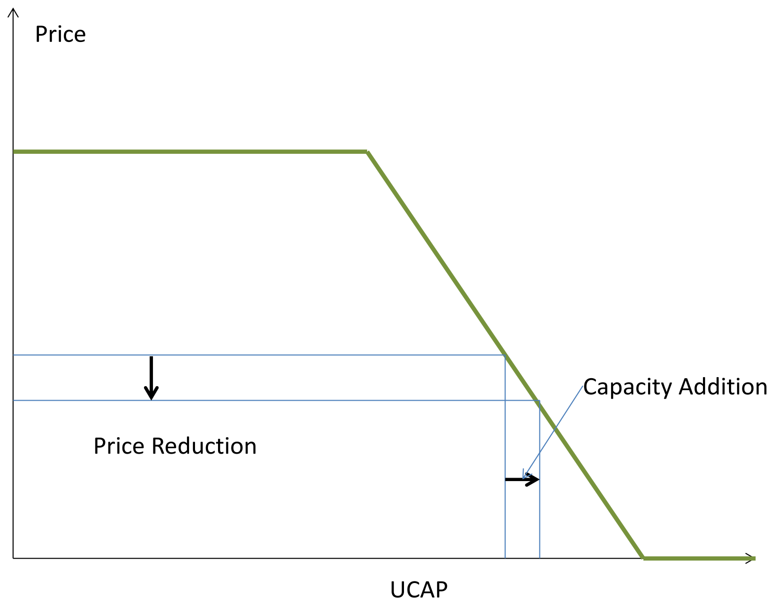

Figure 2. Impact of capacity addition on capacity price.

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: New York City and Long Island together, the westernmost part of the state (NYISO load zones A and B), and the remainder of the state.

Projected changes in wholesale electricity prices for 2016-2025 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 simply the retirement of the seven oil-fired peaker units, without construction of the new combined cycle facility.

The repowering project's benefits to the state's economy occur chiefly because of (i) the construction phase spending between 2014 into 2016, (ii) beginning 2015, the annual operations and maintenance (O&M) spending, and (iii) the ratepayer benefits (commencing 2016) 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.

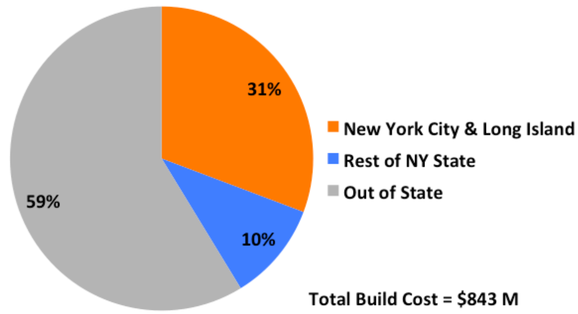

Figure 3. Allocation of construction budget by region (2012$).

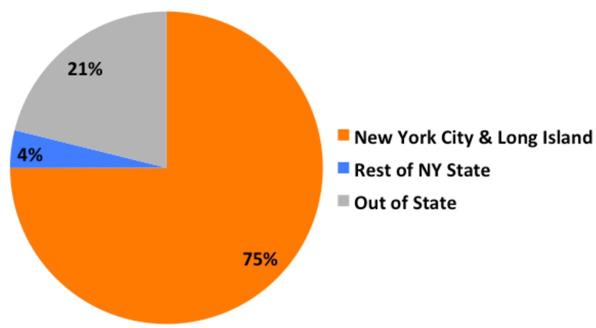

Figure 4. Allocation of 2021 O&M requirements by region (2012$).

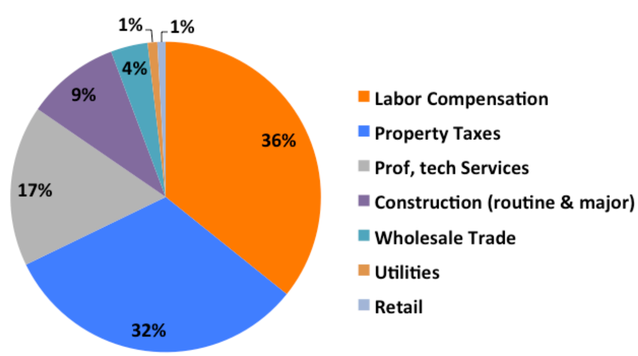

Figure 5. O&M spending by Industry for the Astoria region for 2021 (2012$).

Results

Energy price reductions

Figure 6 shows estimates of the decrease in the average New York wholesale power prices resulting from replacing the seven Astoria Westinghouse turbines with a CCGT, compared to retiring them. Over the 10 years covered by the analysis, wholesale energy prices would be an average of $0.96/MWh lower with the plant repowered than with it retired. The effect on wholesale electricity prices is even more pronounced for New York City, close to the generator, as shown in Figure 7; the average price reduction there is $1.36/MWh.

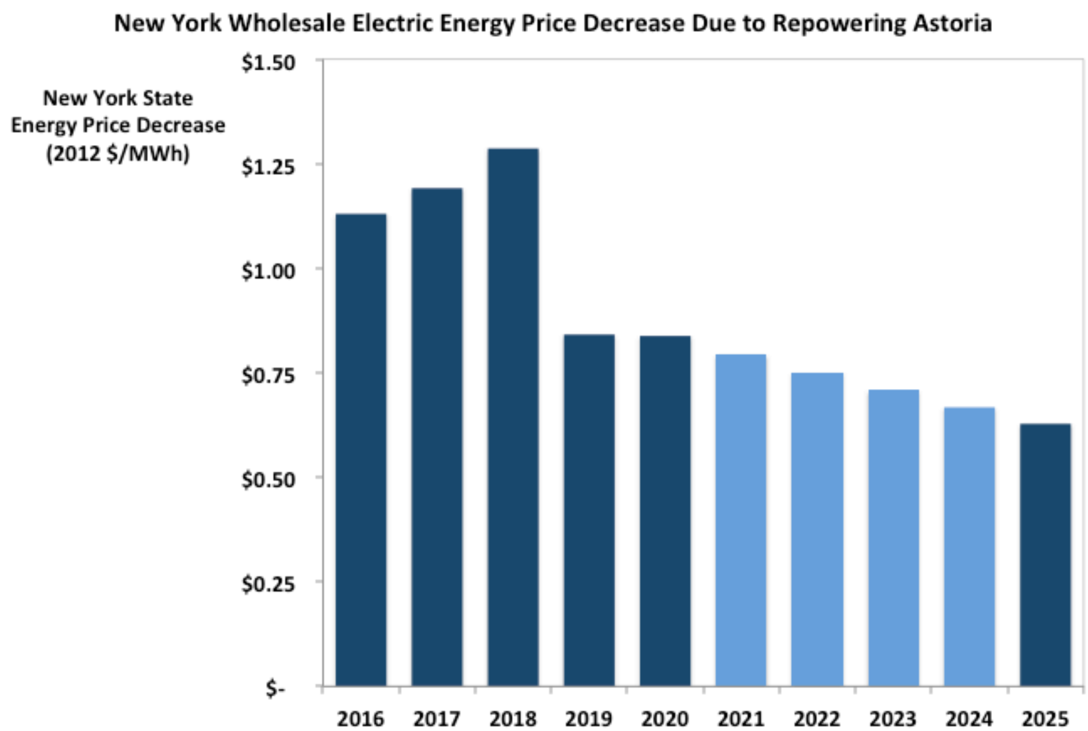

Figure 6. Impact of repowering Astoria on wholesale electricity (energy) prices. Interpolated years are in light blue.

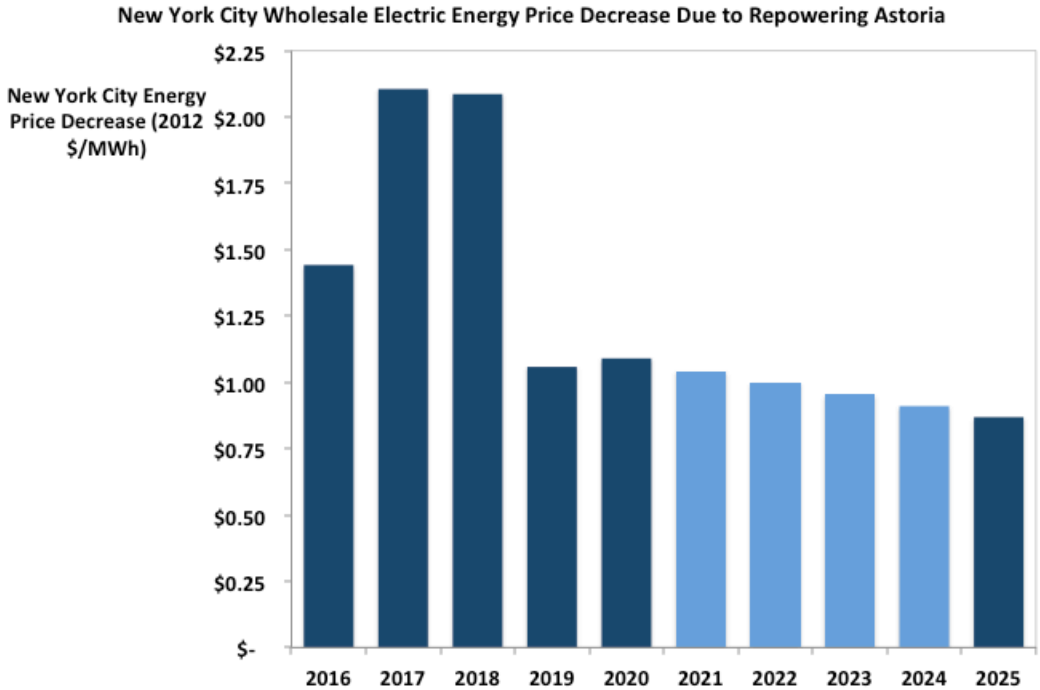

Figure 7. Impact of repowering Astoria on wholesale electric energy prices in New York City. Interpolated years are in light blue.

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 $82 million and $165 million annually, totaling $1.1 billion over the 10-year period.[10] Of these, $55 million per year, or $548 million, accrued to New York City. Savings differ across the modeled years due to several factors, including the addition of wind generation between 2016 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 the generators' cost to produce the electricity (variable costs, predominatly fuel). The LEG analysis showed that repowering Astoria results in average production cost savings of $22 million/year, totalling $225 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 generators. The analysis showed the predominant impact to be a decrease in the cost of imports, with a net decrease of approximately $15 million per year, totalling over $153 million over the 2016-2025 period.[12]

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[10] 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.

[11] Note that because the generation cost is a component of wholesale energy costs, the savings are not additive.

[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

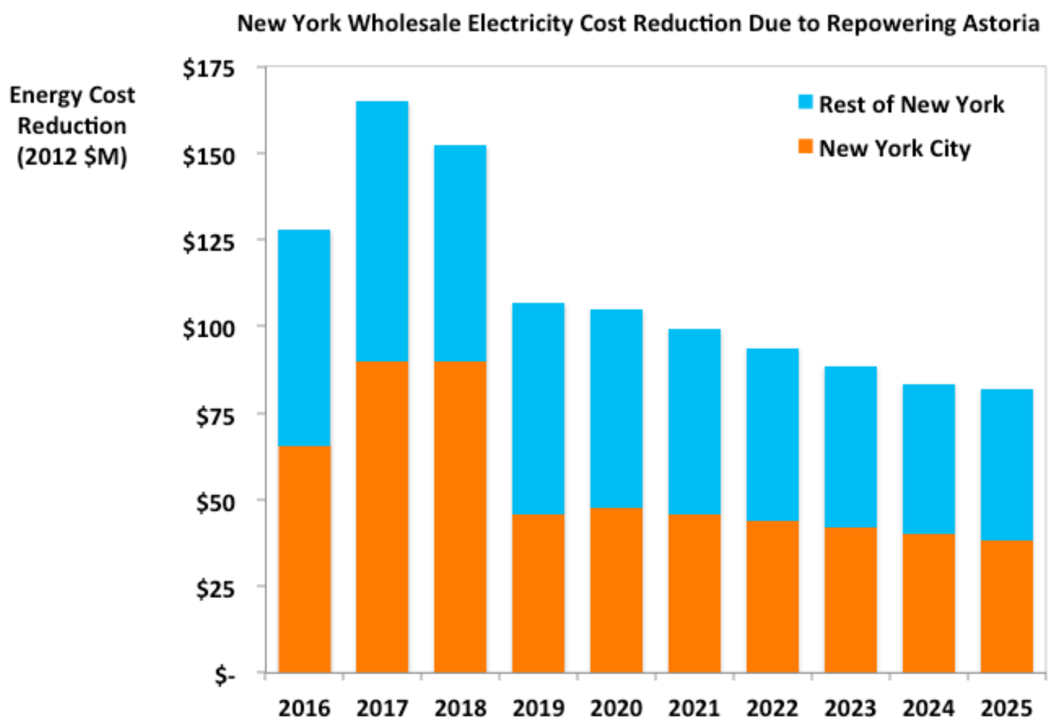

Figure 8. Impact of repowering Astoria on wholesale electric energy costs.

Capacity cost reductions

The impacts of repowering Astoria on capacity prices in New York City and ROS are shown in Figure 9 and Figure 10.

From summer 2016 and through winter 2020/2021, repowering Astoria is estimated to reduce New York City capacity prices by approximately $2.90/kW-month on average. During the same period, capacity prices in ROS are projected to decline on average by $0.60/kW-month. The impact of repowering Astoria on capacity prices all but disappears beginning in the 2021 summer capability period because capacity prices converge under the two scenarios.

Estimated annual state-wide capacity cost reductions through 2021 are presented in Figure 11 below. As explained above, we assume that only 75% of the capacity price impact will be realized by load-serving entities and the consumers they serve; the cost savings listed here and shown in Figure 11 account for the assumed 25% reduction in impact.

Statewide savings in the wholesale costs of installed capacity amount to $299 million per year, or nearly $1.8 billion through 2021. Savings in the wholesale costs of installed capacity for New York City are estimated at $223 million per year, or approximately $1.4 billion over the same period.

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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.

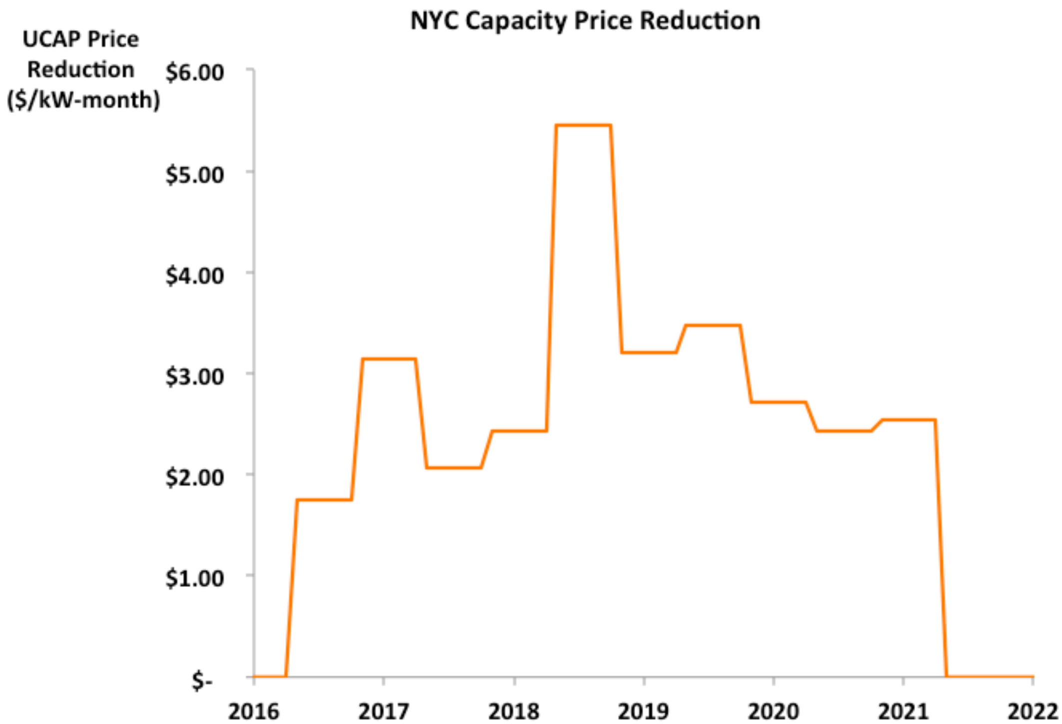

Figure 9. Capacity price reductions in New York City with Astoria repowered (2012$).

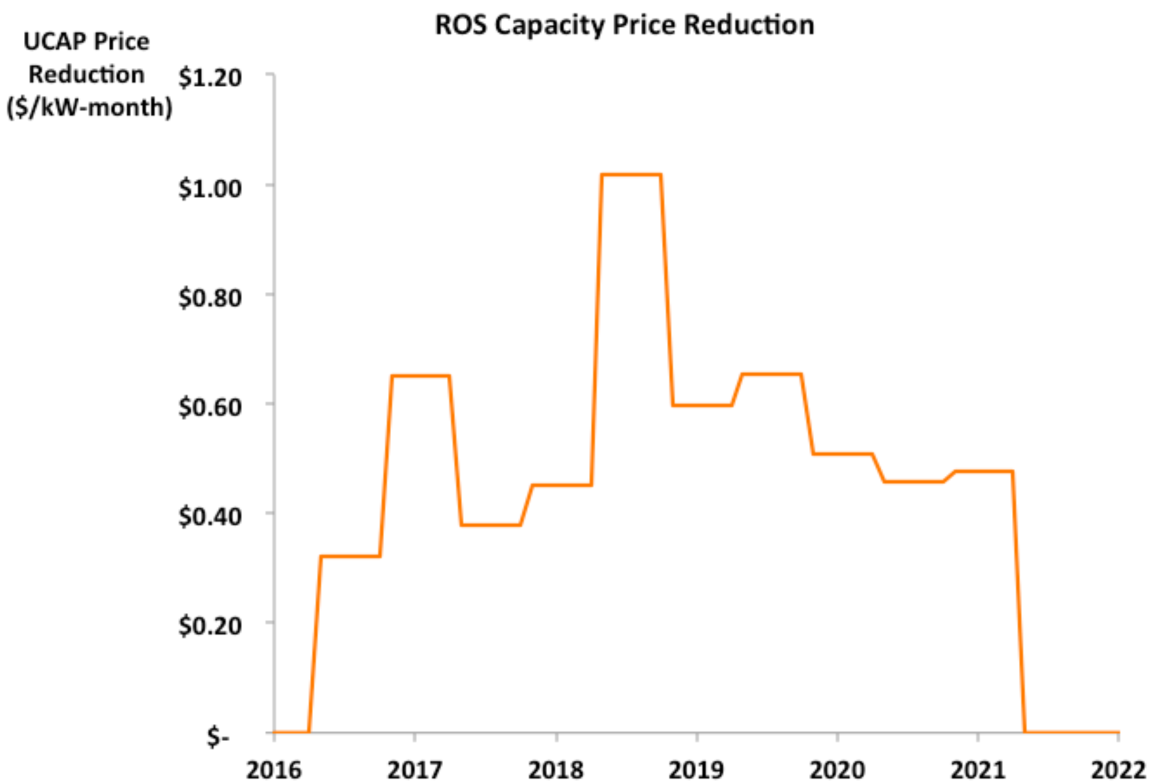

Figure 10. Capacity price reductions in ROS with Astoria repowered (2012$).

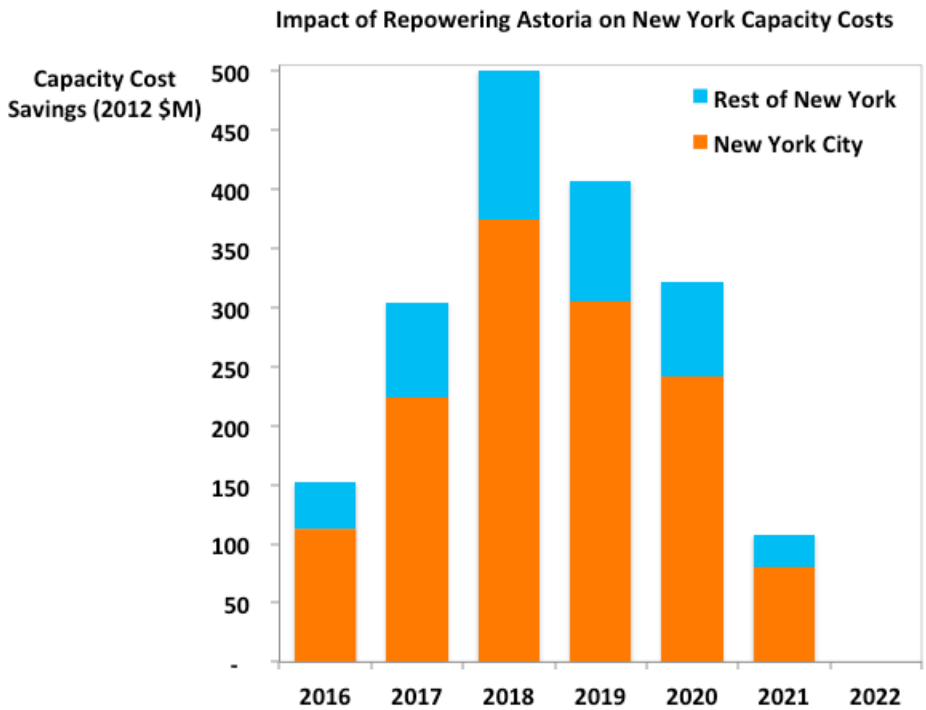

Figure 11. Estimated annual capacity cost reduction with Astoria repowered.

Benefits to the regional economy

Repowering Astoria will create jobs in three ways:

> **Direct jobs**, created at organizations involved with the project
>
> **Indirect jobs**, created at organizations that provide goods and services used by other organizations 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 Astoria will create thousands of jobs in New York State and in the sub-region around Astoria, relative to the base case.[13] Over the period illustrated by the figure, the regional economy in the plant's vicinity will add approximately 19,500 job-years, 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 amounts to 32,800 job-years over the period, averaging 3,070 per year over 10 years of operations, of which about 1,800 are in New York City and Long Island. These benefits are predominantly due to reductions in electricity costs, as the customer savings exert a beneficial influence on the economy.

Figure 13 presents the forecast of impacts by region based on dollars of gross state and regional product, effectively the value added, over the construction and operations phases. Not surprisingly, the pattern is similar to that observed for employment impact. Over the 10-year period of operations from 2016-2025, the increase in gross state product is $312 million per year, of which $207 million are seen in the region around Astoria. These average annual impacts are primarily due to the persistence of ratepayer benefits, and secondarily due to O&M spending.

[13] Again, this sub-region corresponds approximately to NYISO load zones J and K—New York City and Long Island.

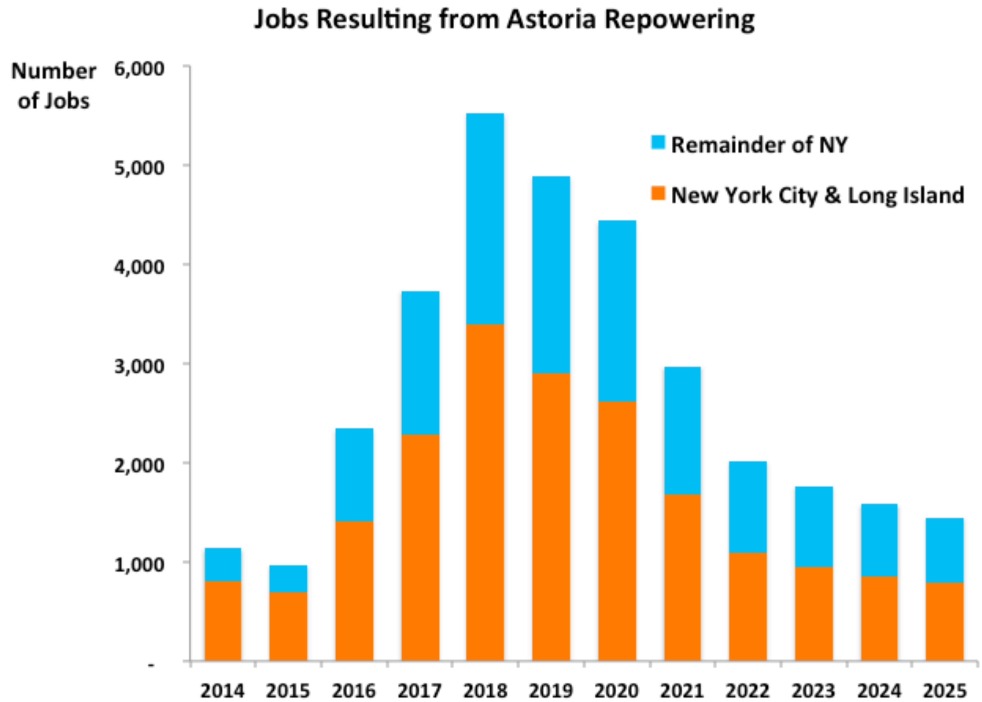

Figure 12. Projected annual impact on jobs.

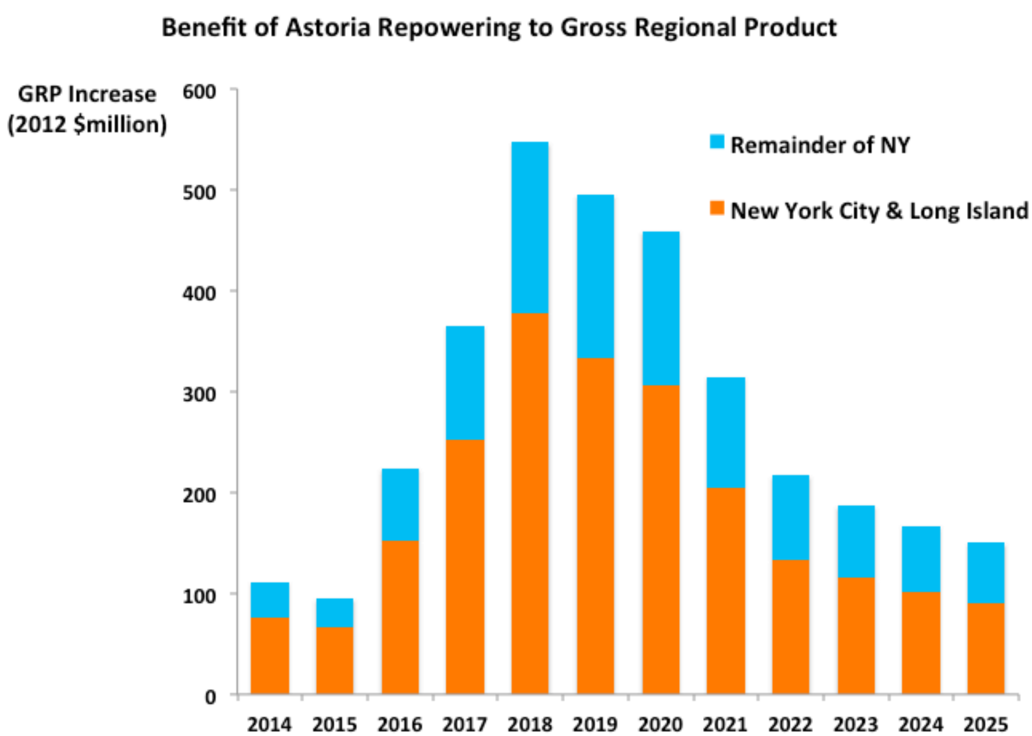

Figure 13. Projected annual impact on gross regional product.

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 of operations, 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 ASTORIA

	New York City & Long Island	Total New York State
Macroeconomic Benefits		
Gross Regional Product, 10 Years Operations	+ $207 million/year	+ $312 million/year
Total Jobs During Construction[14]	+ 484 on average	+ 695 on average
Total Jobs During 10 Years Operations[15]	+ 1,800/year on average	+ 3,070/year on average

TABLE 2. CUMULATIVE ECONOMIC BENEFITS, 10 YEARS OF OPERATION

	New York City & Long Island	Total New York State
Cumulative Increase In Gross Regional Product (2012$), 2016-2025		
O&M Spending	+ $219 million	+ $229 million
Ratepayer Benefit	+ $1.85 billion	+ $2.89 billion
Total	+ $2.1 billion	+ $3.1 billion
Cumulative Job Years, 2016-2025		
O&M Spending	+ 1,370	+ 1,490
Ratepayer Benefit	+ 16,600	+29,200
Total	+ 18,000	+ 30,700

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 2014-2016; 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 2016-2025.

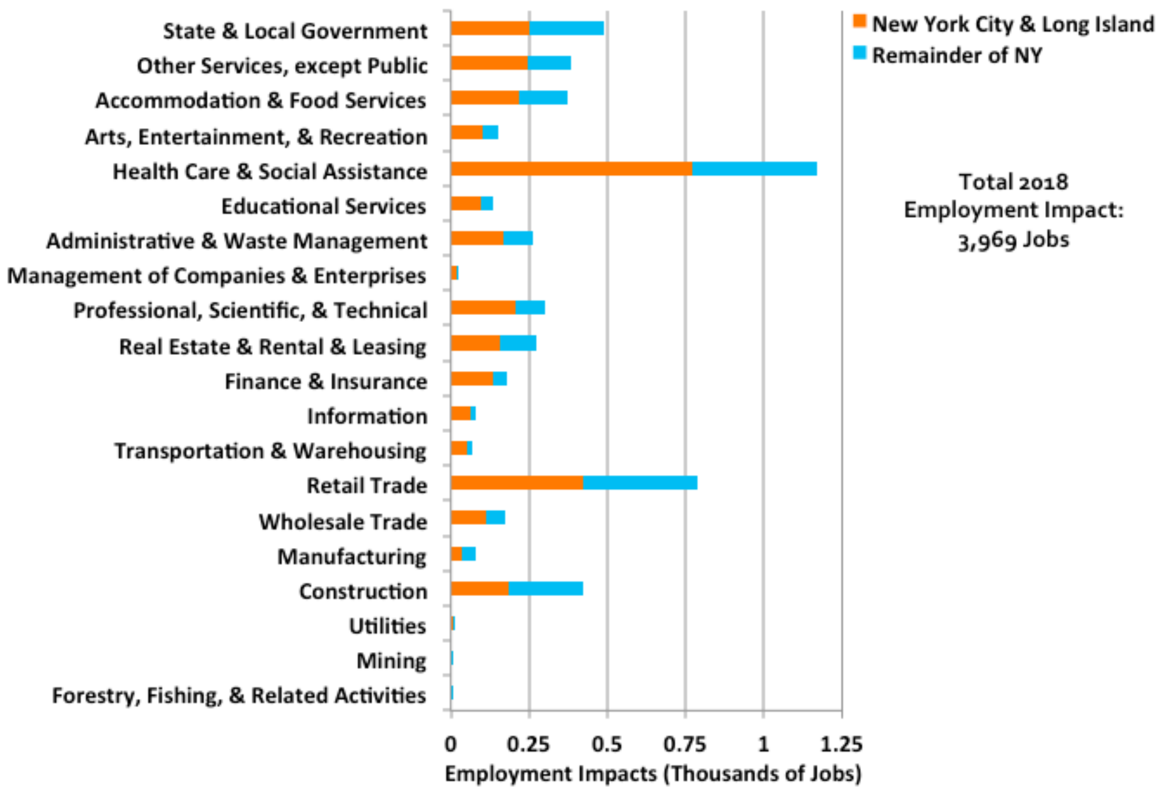

Figure 14. Jobs resulting from the ratepayer benefit, by region and industry, for 2018, the year of maximum impact.