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# Economic Development Benefits of the Proposed Astoria Replacement Project

**Prepared for:**

**Astoria Gas Turbine Power LLC**

***Submitted by:***
Navigant, a Guidehouse Company
1200 19th Street NW
Suite 700
Washington, DC 20036
guidehouse.com

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## DISCLAIMER

This report was prepared by Navigant Consulting, Inc., n/k/a Guidehouse Inc. ("Navigant"),[1] for Astoria Gas Turbine Power LLC ("Astoria"). The work presented in this report represents Navigant's professional judgment based on the information available at the time this report was prepared. Navigant is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report. NAVIGANT MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings and opinions contained in the report.

[1]On October 11, 2019, Guidehouse LLP completed its previously announced acquisition of Navigant Consulting Inc. We recently renamed Navigant Consulting Inc. as Guidehouse Inc.

# 1. EXECUTIVE SUMMARY

Astoria Gas Turbine Power LLC ("Astoria") is proposing to modify its previously permitted 1,040 MW project to replace twenty four nearly 50-year-old Pratt & Whitney ("P&W") combustion turbines and seven recently retired Westinghouse combustion turbines at Astoria with a new, state-of-the-art, H-class simple cycle combustion turbine generator ("CTG") (the "Astoria Replacement Project"). The need for the Replacement Project is driven by the anticipated impacts of climate change policies and regulatory frameworks that are pushing modernization and decarbonization of the New York Independent System Operator ("NYISO") and especially the New York City generation fleet.

This report was prepared by Navigant, a Guidehouse company ("Navigant"), at the request of Astoria to assist with the evaluation of direct, indirect, and induced jobs, associated earnings, output and economic value added that will result from the proposed Astoria Replacement Project. This project is further defined in Section 2.1 below. This analysis evaluates the resulting economic benefits in New York State.

In New York State, as shown in Table 1, the Value Added that is attributable to Construction and O&M spending for the potential project is approximately $156 million in the construction phase (starting in 2021) and approximately $10.6 million on an annual basis in the operations phase (in 2020 dollars). The project will support an estimated 1,022 local job-years[2] during the construction phase and approximately 73 additional local annual jobs related to O&M spending during the operations phase.

Navigant analyzed New York Zone J wholesale electricity prices with and without the Astoria Replacement Project. With the project, over the course of 12 years covered in the analysis (2024-2035), power prices in Zone J are lower by an annual average $0.22/MWh in 2020$, resulting in $155.7 million total energy cost savings over the 12-year period. When the total cost savings of $155.7 million is divided over the 12-year period, it averages out to $12.98 million savings annually (in 2020$), but there are annual differences based on the forecast of the Zone J energy price.

The average reduction in New York Zone J capacity prices from Summer 2023 to Winter 2027/28 is approximately $2.82/kW-month (in 2020$), resulting in an estimated $1.3 billion of total capacity cost savings (in 2020$) over the first five years of operation.

[2] Job-years during the construction phase are defined as full-time equivalent (FTE) jobs multiplied by the number of construction years.

**Table 1. Summary of Socioeconomic Benefits in New York State**

| Benefits Categories | Jobs | Value Added (2020 USD Millions) |
|---|---|---|
| Construction Phase (Total) | 1,022 | $155.6 |
| Operations Phase (Annual) | 73 | $10.6 |
| NYC Ratepayer Benefits – Energy Cost Savings (12-year Total) | N/A | $155.7 |
| NYC Ratepayer Benefits – Capacity Cost Savings (5-year Total) | N/A | $1,337 |

Notes: Construction period related jobs are full-time equivalent for the 24 months (an annual average of approximately 510 full-time equivalent jobs). Plant workers includes operators, maintenance, administration and management. Economic impacts during the "Operations Phase" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with any property tax payments or spending of plant "profits" unless noted.

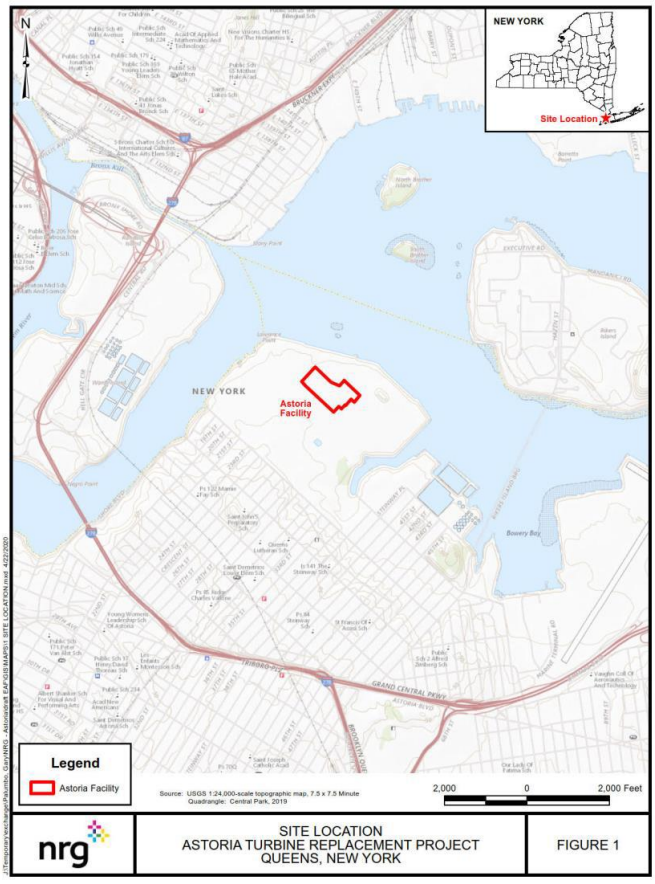
# 2. INTRODUCTION

## 2.1 Project Definition

The Astoria Replacement Project is being developed at the approximately 15.7-acre Astoria Gas Turbine Facility ("the Facility") located at 31-01 20th Ave., Astoria, Queens County, New York, situated within a large 600+ acre complex (referred to as the "Astoria ConEd Complex") shown in Figure 1. The Facility currently consists of 31 older, dual-fuel (natural gas and ultra-low sulfur kerosene) combustion turbine generators ("CTGs") including 24 Pratt & Whitney ("P&W") turbines and seven retired Westinghouse turbines, with a combined nameplate rating of 646 megawatts ("MW").

Astoria is proposing to modify its previously approved project. The Project will replace the 50-year-old P&W and previously retired Westinghouse CTGs at the Facility with a new, state-of-the-art, dual fuel, simple cycle combustion turbine generator unit. The proposed replacement unit (General Electric 7HA.03 or equivalent) has a nominal generator output of approximately 437 MW.

**Figure 1. Astoria Replacement Project Site Location**



## 2.2 Analysis Approach

Navigant prepared this evaluation of direct, indirect, and induced jobs, associated earnings, output and economic value added that will result from the Astoria Replacement Project, as defined in Section 2.1 above. Direct jobs and economic impact are those resulting from on-site labor and professional services; indirect are a result of local revenues, equipment, and supply chain impacts; and induced are local expenditures from those receiving payments within the first two categories.

To assess the economic value that will result from the development of the proposed project, Navigant conducted an analysis using the Jobs and Economic Development Impact ("JEDI") Natural Gas Model. The JEDI Natural Gas Model[3] is an economic modeling tool developed by the National Renewable Energy Laboratory ("NREL") that allows users to demonstrate the economic impact to a given state or region of the construction and operation of a natural gas power plant.

Navigant used the JEDI model to estimate the jobs and economic development benefits that will result from this project. The primary source for the model inputs was Astoria, who provided capital and operating budgets including costs, employment, and percent local data that are specific to the proposed project.[4] Navigant then integrated this data into the JEDI model format.

[3] Available here: https://www.nrel.gov/analysis/jedi/natural-gas.html

[4] Although Guidehouse did not do a detailed due diligence on the data provided by Astoria, our independent review of the data indicates that the values are consistent with what we could expect for a project of this magnitude and we did not find any apparent anomalies in the data.

# 3. METHODOLOGY

## 3.1 JEDI Model

The JEDI models rely on the widely recognized and well-known input/output (I/O) multiplier data provided by the Minnesota Impact Analysis for Planning (IMPLAN) Group. The suite of JEDI models includes biofuels, coal, concentrating solar power, natural gas, solar photovoltaics, land-based wind, offshore wind, and marine/hydrokinetic power.[5] JEDI uses a methodology similar to 'analysis by parts' to simulate a customized natural gas industry with the IMPLAN multipliers by aggregating industry sectors into relevant categories for natural gas power plants.[6] Please refer to Appendix A for more information on the JEDI models.

JEDI requires detailed estimates of project expenditures and the share of each individual expenditure line item that is procured locally. These data must be developed for both the construction and operations period of the plant life cycle. This analysis evaluates resulting impacts for the construction and operations of the Astoria Replacement Project.

JEDI requires expenditure data that approximates the expected engineering, material, and office costs as well as labor requirements for proposed infrastructure projects to estimate the economic impact within the New York State economy. JEDI captures all monetary transactions for expenditures and consumption. Inputs to JEDI include projected capital and operational costs and the percentage local assumptions for each line item. In this report, percentage local means the percentage of expenditures that will occur in the state of New York.

JEDI's outputs include estimates of the effects of a change in one or several economic activities on the regional, state, or local economy. Under the JEDI framework, economic activities include Jobs, Earnings, Output, and Value Added.

**Direct jobs** are defined as on-site labor and professional services. On-site labor is given in job-years. Job-years are defined as full-time equivalent (FTE) jobs multiplied by the number of construction years. Construction jobs are given as FTE job-years since they are spread over a multi-year construction period. Some construction jobs will last only a portion of a year while others may last the entire expected construction period of two years. Operations jobs are given as annual FTE jobs over the entire operating period.

**Indirect jobs** are driven by the increase in demand for goods and services from direct on-site project spending including business and companies like construction material and component suppliers, analysts and attorneys involved with project feasibility assessments or contract negotiations, equipment or replacement part manufacturers and others.

**Labor Earnings** encompass the additional earnings (wages and employer paid benefits) associated with the additional local jobs.

**Gross Output** is the sum value of all goods and services at all stages of production (i.e., as a raw material and as a finished product) resulting from the project.

[5] NREL's JEDI models are publicly available spreadsheet tools that apply state-specific IMPLAN year 2014 multipliers. The JEDI analysis tools were developed by NREL in conjunction with MRG & Associates. For more information on the JEDI tools, see Appendix A or https://www.nrel.gov/analysis/jedi/

[6] The 14 categories include: 1. Agriculture 2. Construction 3. Electrical equipment 4. Fabricated metals 5. Finance, insurance, and real estate 6. Government 7. Machinery 8. Mining 9. Other manufacturing 10. Other services 11. Professional services 12. Retail trade 13. Transportation, communication, and public utilities 14. Wholesale trade

**Value Added** is the best indicator of economic development benefits to the local economy. The sum total of value added of all enterprises and self-employed in a given state comprises that state's GDP. These values are the sum of earnings from capital and labor or the difference between total gross output and the cost of intermediate inputs. It is comprised of payments made to workers, proprietary income, other property type income, indirect business taxes, and taxes on production and imports less subsidies.

These terms are further defined in Appendix A. Table 2 shows the categories of economic benefits including jobs and investment impacts and ratepayer benefits that are included in the analysis, along with examples of expenditures in each category.

**Table 2. Categories of Economic Benefits**

| Impact Categories | Construction | Operations |
|---|---|---|
| Direct | • Project development (engineering, design, permitting, surveys, and other professional services)<br>• Onsite labor including contractors and crews hired to construct the plant | • Onsite labor for operation and maintenance of the plant (plant technicians, operators, management, and administration) |
| Indirect | • Turbine and supply chain (inter-industry purchases of materials, equipment, manufacturing, and other services) | • Local revenue (sales taxes and ROI for local owners)<br>• Supply chain (components, off-site labor) |
| Induced | Increased spending of household earnings from project development and on-site labor impacts as well as turbine and supply chain impacts. This includes increased business at local restaurants, hotels, and retail establishments, childcare providers and service providers. | |

## 3.2 JEDI Model Assumptions

- Astoria provided Navigant with the raw cost, employment, and percent local data for New York State as the primary inputs to the JEDI model. Data was provided in three basic categories: construction costs, labor costs, and operations & maintenance (O&M) costs.

- Capital expenditures are expected to occur during the construction period 2021-2023 for the project according to the project schedules. Total capital expenditures excluding financing costs are expected to be approximately $379 million.

- Plant operation is modeled over a 17-year period beginning in 2023 and continuing through 2040. All operation and maintenance costs are averaged over total years of operation and assumed to be the same for each year. Operations and maintenance costs are expected to total approximately $28.6 million per year during this period (in constant 2020$).

- Based on Astoria's provided data, 100% of the operations and maintenance staff are assumed to be local. Power plant onsite full-time labor potentially consists of contractors, daily operations staff, administration, and management. The average wage for all plant workers during the operations phase is $64.27 per hour in 2020$ with a payroll overhead of 39.5%.

- Land lease parameters and property taxes are excluded from this analysis.

Sales tax during the operations phase is assumed to be 8.5%, representing the total state and city sales tax rate in New York City. Sales tax during construction is estimated to be $2.1 million in 2020$ because much of the equipment is exempt from sales tax.

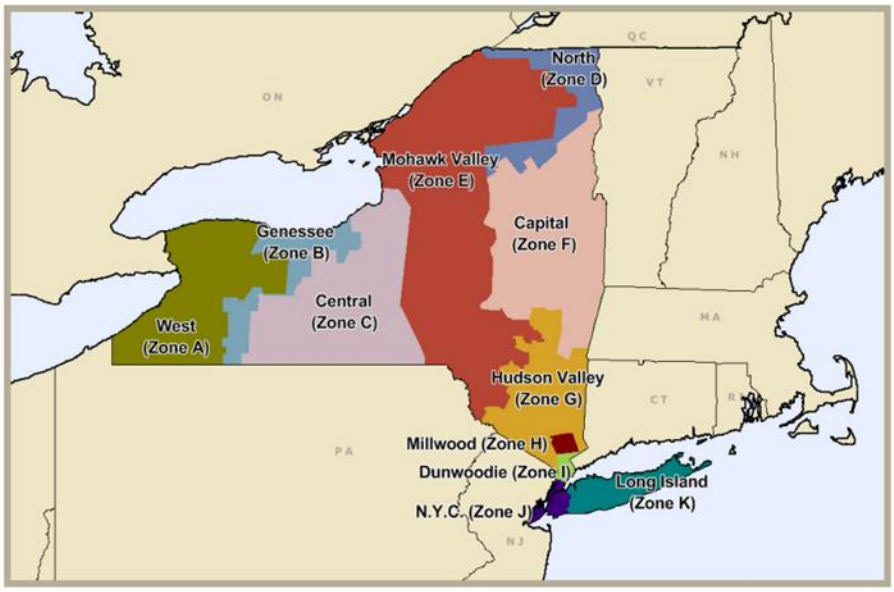
## 3.3 Ratepayer Benefits Modeling Assumptions

The Astoria Replacement Project will displace high cost generation and reduce overall system costs in NYISO. Key assumptions related to ratepayer benefits are presented and discussed in this section.

**Gas prices**

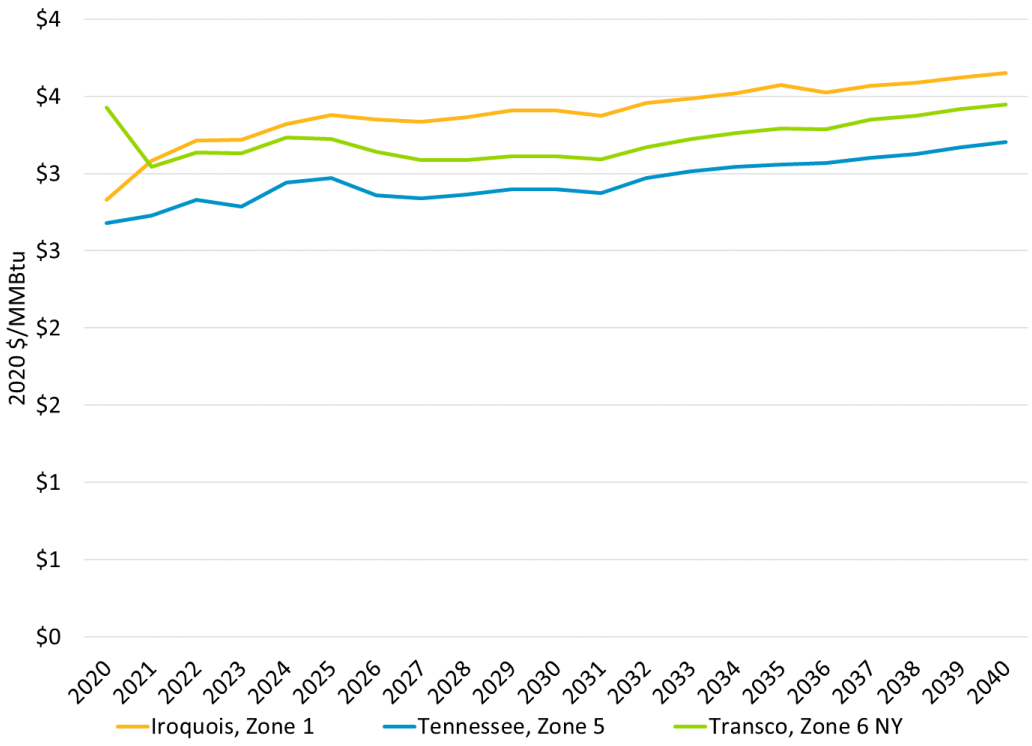
NYISO covers several major gas market trading points, including Transco Zone 6 (NY), which is used as a price index for New York City, and Tennessee Zone 5, which represents the price of Appalachian gas delivered to consumers in the central-eastern areas of New York along the Tennessee Gas Pipeline (TGP). Figure 2 shows all the NYISO zones including New York Zone J pertaining to NYC. All three New York gas price streams only see modest growth over the forecast period, shown in Figure 3.

**Figure 2. NYISO Load Zone Map**




*Source: Federal Energy Regulatory Commission*

**Figure 3. NYISO Average Annual Natural Gas Prices (2020 $/MMBtu)**



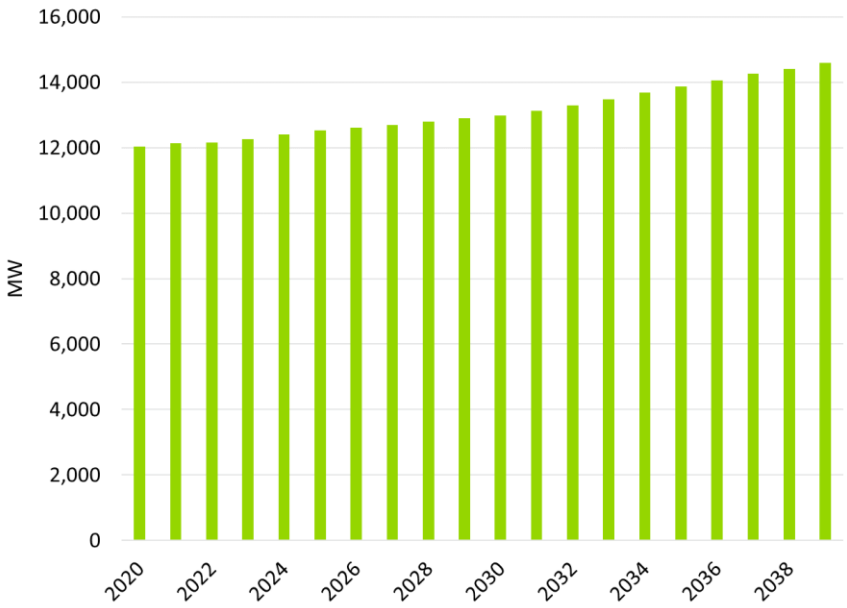

*Source: Navigant Analysis*

**Demand growth**

Peak load in New York Zone J is forecast to gradually rise from ~11.9 GW in 2020 to 14.6 GW by 2040, as seen in Figure 4.[7] As New York Zone J's load increases and thermal capacity retires, there will be challenges to meeting the City's reliability needs with the necessary peaking capacity.

[7] Unlike the NYISO Gold Book, these peak load values are prior to incorporating the impacts from energy efficiency and demand response.

**Figure 4. New York Zone J Peak Demand (MW)**




*Source: Navigant Analysis*

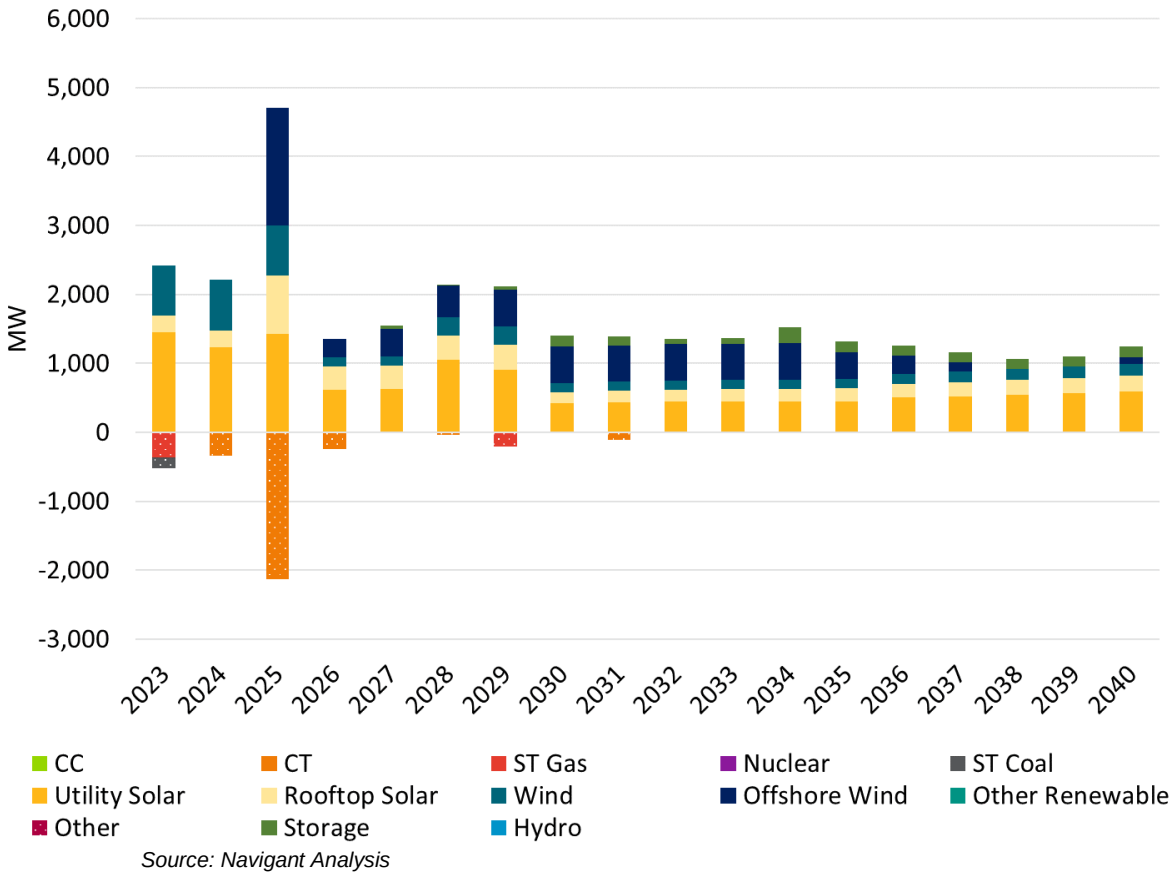
**Generation additions and retirements**

Navigant's forecast of capacity additions and retirements (shown in Figure 5) incorporates announced and generic solar and wind additions, which, if permitted and constructed as expected, are anticipated to help New York meet its obligations under the Regional Greenhouse Gas Initiative ("RGGI") and the CLCPA.

The steady addition of distributed solar throughout the forecast, driven by the CLCPA's goal of 6 GW of photovoltaic solar by 2025, further helps to meet reserve margin targets. Approximately 3.5 GW of rooftop solar is forecasted to come online through 2030 as a key element of decarbonization. Navigant forecasts 6.4 GW of offshore wind by 2035 connecting to New York Zone J and Long Island, which is significant given that none of New York State's electricity currently comes from offshore wind. The two nuclear generators at Indian Point Units 2 and 3 are set to retire in 2020[8] and 2021, respectively, with a combined capacity of 2,045 MW. Approximately 1.5 GW of aging CT capacity, mostly used for peaking needs, is forecasted to retire by 2026 due to stricter NOx emissions regulations in New York State.

[8] Indian Point Unit 2 was retired in April 2020.

**Figure 5. NYISO Capacity Additions and Retirements (MW)**

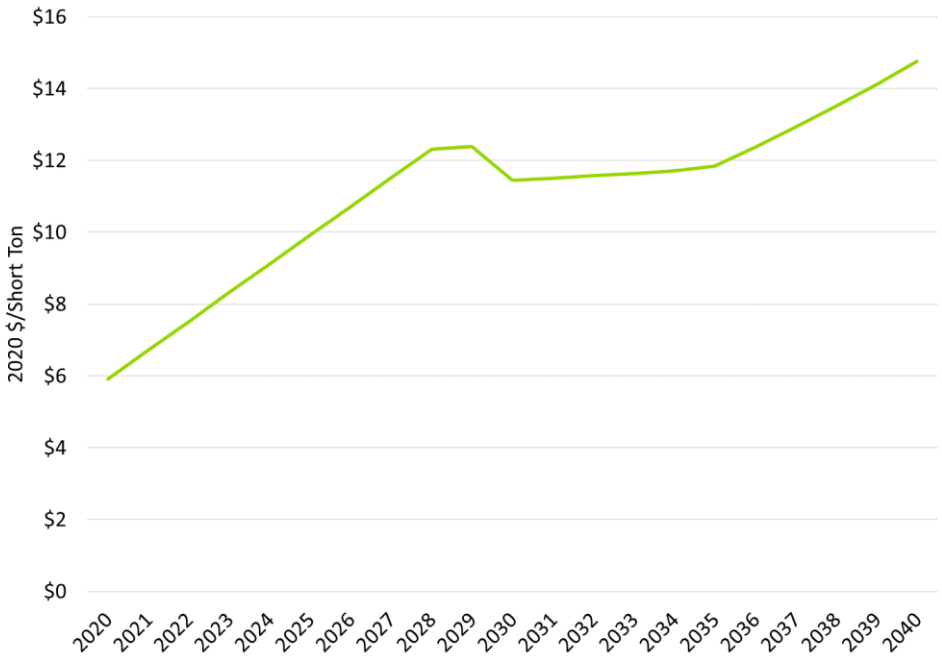



*Source: Navigant Analysis*

**Emissions allowance prices**

Navigant's emissions price assumptions are based on careful review of past policy proposals and recent judiciary, regulatory, and political developments. Navigant uses its proprietary POM tool to forecast $CO_2$ emissions prices for the RGGI region. RGGI prices in 2020$ increase from just under $6/ton in 2020 to nearly $12/ton in 2029 before leveling off, driven by the 30% decrease in allowances set between 2020 and 2030. RGGI prices rise in the latter years of the forecast, reaching approximately $15/ton by 2040 in 2020$.

**Figure 6. Average Annual RGGI $CO_2$ Emissions Allowance Prices (2020 $/Short Ton)**




*Source: Navigant Analysis*

In order to assess the operations of the Astoria Replacement Project within the NYISO market, Navigant used PROMOD IV ("Promod"), a widely adopted production cost model to find the least cost dispatch of power plants and calculate hourly prices for each location in NYISO.

Promod incorporates demand, generating operational characteristics, fuel prices, emissions prices, and transmission grid constraints to simulate system hourly operation in order to minimize the total operating cost while ensuring that generation and load are matched. The security constrained unit commitment and security constrained economic dispatch that are performed by the model are designed to mimic system operator commitment and dispatch. The key outputs of the simulation are the hourly details of system operation including generation by unit and the hourly locational marginal prices at each node.

# 4. RESULTS

## 4.1 New York State Economic Impacts from Construction and O&M Spending

A summary of the project's potential overall economic benefits for New York State including jobs and Value Added related to project spend during the construction and operation phases is shown in Table 3.

**Value Added**. The total New York State Value Added from the project is $155.6 million during the expected two-year construction phase and $10.6 million per year in 2020$ during the operations phase.

Based on the JEDI analysis, the project is expected to account for a total of 1,022 job-years in the construction phase and 73 FTE jobs on an annual basis during the operations phase. These additional jobs result from the increased spending in New York State.

**Direct jobs**. The project will result in 538 FTE local direct job-years in the development and construction phase and 13 FTE local direct annual jobs in the operations phase. 538 FTE job-years during the 2-year construction phase is equivalent to 269 jobs each lasting 2 years. "Local" is defined by jobs in New York State.

**Indirect jobs**. The project will result in 261 FTE local indirect job-years in the construction phase and 43 FTE local indirect annual jobs in the operations phase.

**Induced jobs**. The project will result in 223 FTE local induced job-years in the construction phase and 17 FTE local induced annual jobs in the operations phase.

**Table 3. Summary of Jobs and Investment Impacts in New York State**

| Benefits Categories | Impact Categories | Jobs | Value Added (2020 USD Millions) |
|---|---|---|---|
| Construction Phase (Total) | Direct | 538 | $96.4 |
| | Indirect | 261 | $31.8 |
| | Induced | 223 | $27.4 |
| | **Total** | **1,022** | **$155.6** |
| Operations Phase (Annual) | Direct | 13 | $2.3 |
| | Indirect | 43 | $6.1 |
| | Induced | 17 | $2.2 |
| | **Total** | **73** | **$10.6** |

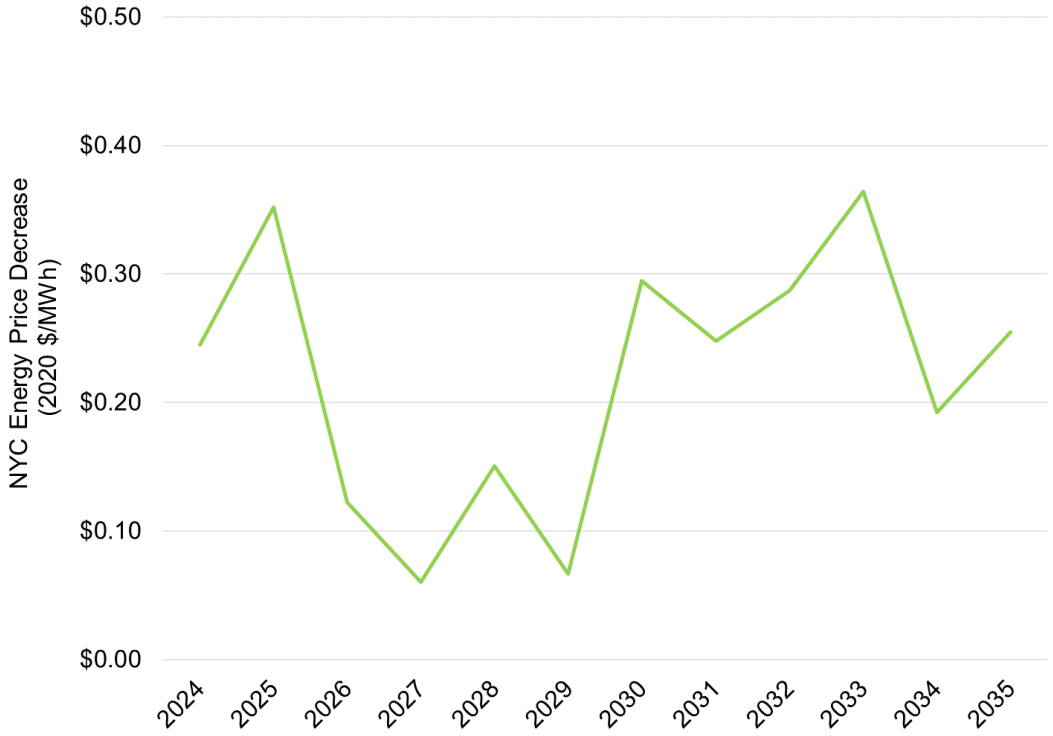
Notes: Labor Earnings total to $126.1 million in the construction phase and $7.2 million per year in the operations phase in year 2020 dollars. Local Gross Output is estimated as $210.9 million in the construction phase and $15.1 million annually in the operations phase in year 2020 dollars. Construction period related jobs are full- time equivalent for the 24 months (an annual average of approximately 510 full-time equivalent jobs). Plant workers includes operators, maintenance, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits". Totals may not add up due to independent rounding.

## 4.2 New York Economic Impacts from New York City Ratepayer Benefits

### *4.2.1 Energy Results*

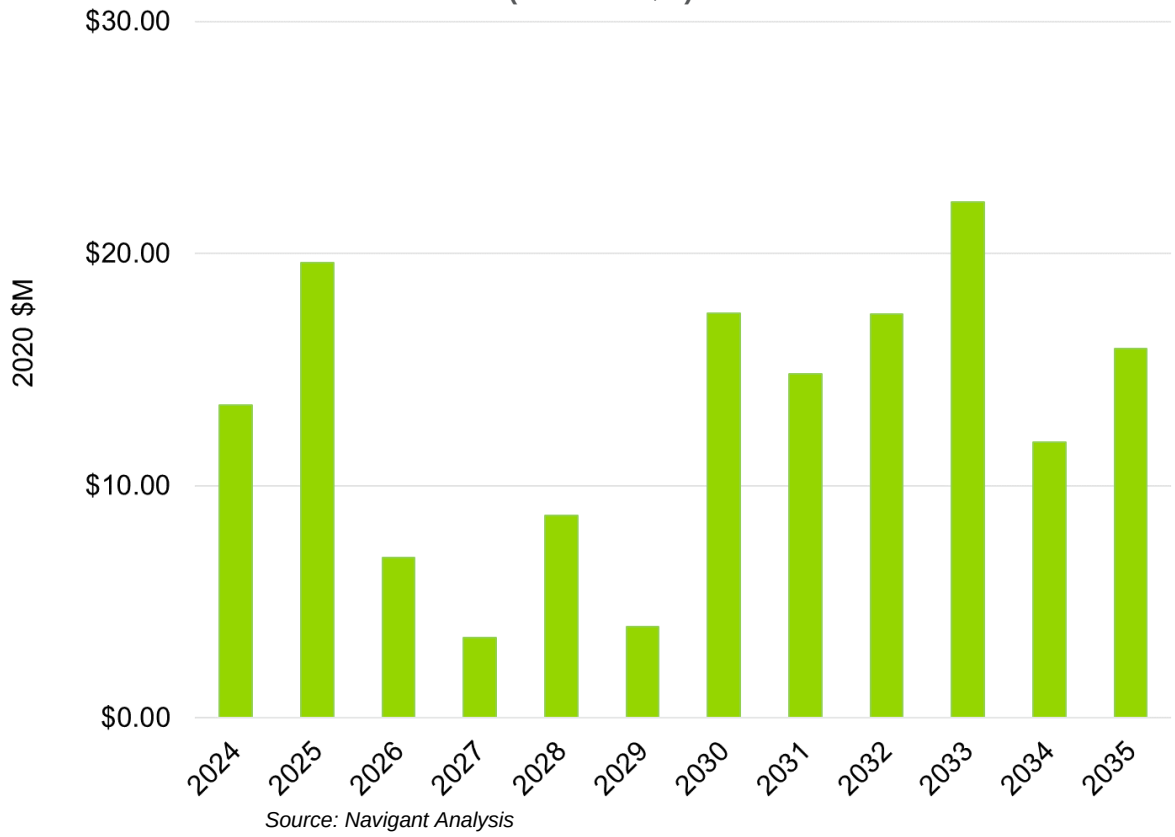
Figure 7 shows the estimated reduction in all-hours energy prices in New York Zone J resulting from the Astoria Replacement Project. Over the course of 12 years covered in the analysis (2024-2035), the power prices in New York Zone J are lower by an annual average of $0.22/MWh in 2020$ with the project in the resource mix. The expected energy cost savings due to the reduction in the wholesale energy prices are shown in Figure 8. The total energy cost savings is $155.7 million over the 12-year period. When the total cost savings of $155.7 million is divided over the 12-year period, it averages out to $12.98 million savings annually (in 2020$), but there are annual differences depending on the New York Zone J energy price.

**Figure 7. New York Zone J Wholesale Energy Price Decrease due to Astoria Replacement Project (2020 $/MWh)**




*Source: Navigant Analysis*

**Figure 8. Energy Cost Reduction Value Due to Astoria Replacement Project, 2024-2035 (Real 2020 $M)**



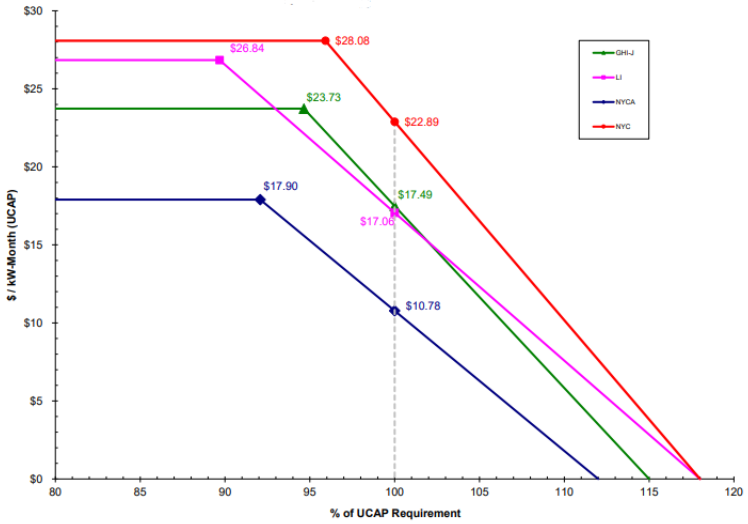

*Source: Navigant Analysis*

### *4.2.2 Capacity Results*

To ensure that there are sufficient resources available to meet the projected load, NYISO administers a capacity market. Capacity auctions occur each month, split into summer (May-October) and winter (November-April) periods. Generation, imports, and demand-side resources (SCRs) are eligible to bid into the capacity auctions, but capacity imports from other markets must have firm transmission for the commitment period. Capacity can be bought and sold through three separate auctions, the most forward-looking of which is a strip auction where capacity is procured for the following six-months.

Since 2003, NYISO has implemented a demand curve methodology to determine the capacity price paid to generators. The demand curve is updated every 3 years and escalated annually by the Handy-Whitman construction index. New York City's most recent Summer 2019 demand curves are shown in Figure 9. If the available capacity or UCAP for a given region is at 100% of the required capacity, the capacity price paid to generators should equal the Cost of New Entry (CONE), represented with the vertical dotted line. Net CONE is intended to be the levelized cost of a new combustion turbine less the expected energy and ancillary service revenues. Put another way, if demand and supply are in perfect balance, the capacity price will be sufficient to provide a reasonable return to a new peaking plant. As seen in Figure 9, the high costs of building in New York Zone J mean that the Net CONE for this zone is set well above the Net Cone for other regions. Net CONE for New York Zone J is set at $22.89/kW-month for the summer period, compared to $10.78/kW-month for rest-of-state (ROS/NYCA), $17.06/kW-month for Long Island, and $17.49 for G-J. Because New York City is transmission constrained, the NYISO also has Locational Minimum Installed Capacity (LCR) requirements for the New York Zone J area, which is set at 86.6% for the 2020-2021 capability year.

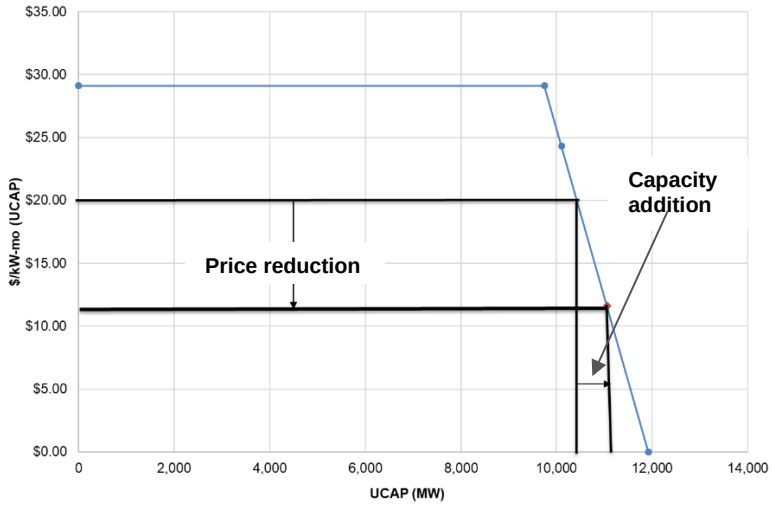
**Figure 9. Summer 2019 Demand Curve (Nominal $)**




*Source: NYISO ICAP Translation of Demand Curve (Summer 2019)*

To assess the impact of the Astoria Replacement Project on capacity prices in New York Zone J, prices were forecasted using the latest demand curve as shown in Figure 10 with and without the project. As more capacity is cleared due to the Astoria Replacement Project, capacity prices decrease in New York Zone J. The savings are calculated by multiplying the reduction in capacity prices and the difference in cleared capacity in New York Zone J.

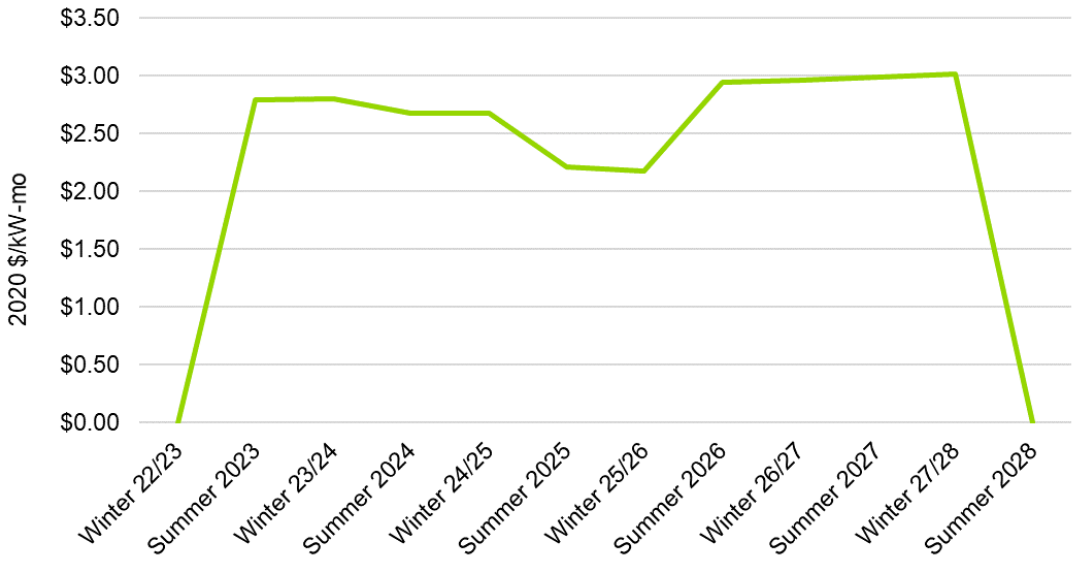
**Figure 10: Capacity Price Demand Curve**




*Source: Navigant Analysis*

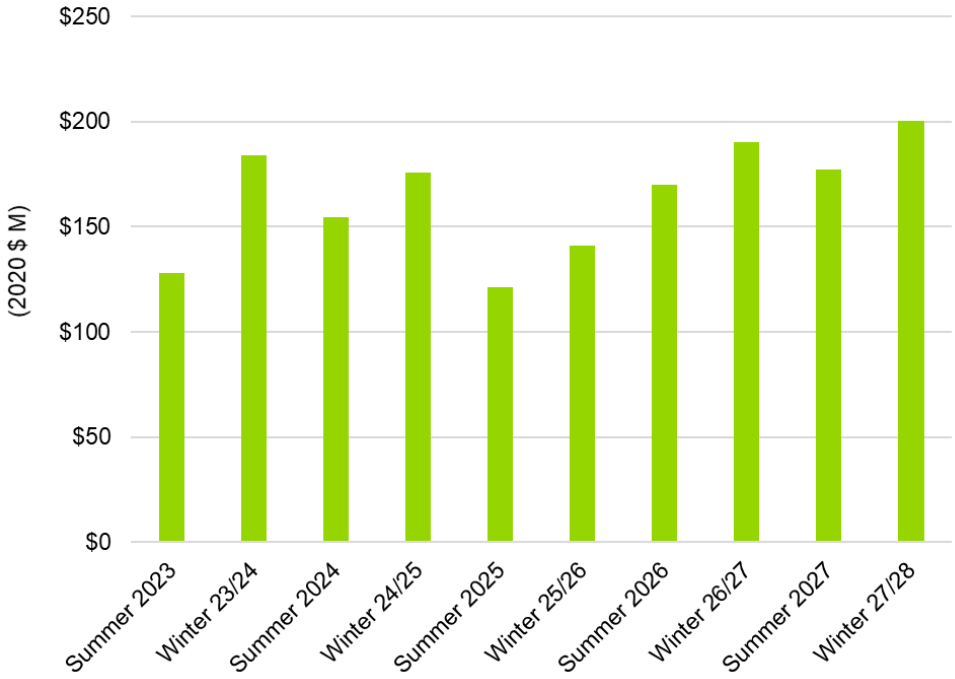
As shown in Figure 11, the average reduction in New York Zone J capacity prices from Summer 2023 to Winter 2027/28 is approximately $2.82/kW-month (in 2020$). Capacity prices with and without the Astoria Replacement Project converge beginning in Summer 2028 as new capacity is added to the system and the market reaches equilibrium. Capacity cost savings are estimated to be $1.3 billion (in 2020$) over the first five years of operation, and the estimated annual savings are shown in Figure 12.

**Figure 11. New York Zone J Capacity Price Reduction (2020 $/kW-mo)**




*Source: Navigant Analysis*

**Figure 12: Capacity Cost Reduction due to Astoria Replacement Project (Real 2020 $M)**




*Source: Navigant Analysis.*

# 5. SUMMARY OF PROJECT BENEFITS

## 5.1 Benefits from Construction and O&M Spending

In New York State, approximately $379 million will be spent locally over the two-year construction phase, and $28.6 million will be spent locally on an annual basis over the twenty-year operation phase. According to the JEDI model results, this spending will result in approximately 1,022 job-years and $155.6 million value added during the construction phase, and 73 FTE jobs and $10.6 million value added per year during the operation phase.

## 5.2 Ratepayer Benefits

Over the course of 12 years covered in the analysis (2024-35), power prices in New York Zone J are lower by an annual average of $0.22/MWh in 2020$ with the project in the resource mix, resulting in expected $155.7 million total energy cost savings over the 12-year period. When the total cost savings of $155.7 million is divided over the 12-year period, it averages out to $12.98 million annually (in 2020$), but there are annual differences depending on what the Zone J energy price is. The average reduction in New York Zone J capacity prices from Summer 2023 to Winter 2027/28 is approximately $2.82/kW-month (in 2020$), resulting in an estimated $1.3 billion of total capacity cost savings (in 2020$) over the first five years of operation.

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# Appendix A. BACKGROUND ON JEDI MODEL

Economic development occurs when a specific area or region of interest secures new sources of investment and when at least a portion of those investments is captured by local businesses and individuals. Economic development analysis seeks to track new investments in a specific location, distinguish different types of expenditures in those regions, and then examine the impact of those investments in the given locality. For those expenditures that are local, the impacts entail the initial investment plus potential downstream effects in the supply chain and in the consumer and retail sectors of the economy. If an expenditure associated with a given project is not captured locally, it is treated as economic leakage and has no economic development value for the region of interest.

Economic development activity is typically estimated using input-output (I/O) models. I/O models apply historical relationships between demand (i.e., specific expenditures within a given sector of the economy) and the resulting economic activity to estimate how new expenditures will affect economic development metrics.

Although some I/O models incorporate dynamic elements, many are static—they measure inter-industry relationships for a given time period—and linear—they assume that any change in demand, regardless of magnitude, has the same proportional result. However, the inter-industry relationships utilized in I/O modeling tend to change only gradually over a long period of time, and I/O modeling is a widely used methodology for measuring economic development activity.

NREL has developed a set of I/O models known as the Jobs and Economic Development Impacts (JEDI) models. The JEDI models are Excel-based models that estimate the economic impacts of constructing and operating power plants, fuel production facilities, and other projects at the local (usually state) level. These models rely on the widely recognized and well known I/O multiplier data provided by the Minnesota IMPLAN Group. The JEDI model suite includes biofuels, coal, concentrating solar power, natural gas, solar photovoltaics, wind, offshore wind, and marine/hydrokinetic power.[9] The Natural Gas JEDI model is specifically tailored to natural gas power plants and calculates the economic impact to a given region of the construction and operation of a natural gas project.

## A.1 Model Inputs

The JEDI Natural Gas Model works in a similar way to other models in the JEDI family, allowing the user to specify general characteristics about the project such as nameplate capacity, capacity factor, heat rate, fuel costs, etc., as well as specific cost components that are part of the construction or operations phase of the project.

Calculations can be based either on the entered cost data or on default inputs, which are derived from industry norms. The model asks for several categories of expenditure as well as the percentage of expenditures that will happen locally (in this case meaning in the state of New York). If project-specific inputs are not available, the model comes with default inputs so a result can be generated with incomplete data.

[9] NREL's JEDI models are publicly available spreadsheet tools that apply state-specific IMPLAN year 2014 multipliers. The JEDI analysis tools were developed by NREL in conjunction with MRG & Associates. For more information on the JEDI tools, see https://www.nrel.gov/analysis/jedi/

JEDI model defaults are based on interviews with industry experts and project developers.[10] Economic multipliers contained within the model are derived from Minnesota IMPLAN Group's IMPLAN regional input-output software and state data files. The IMPLAN database contains county, state, zip code, and federal economic statistics which are specialized by region, not estimated from national averages and can be used to measure the effect on a regional or local economy of a given change or event in the economy's activity. IMPLAN is based on input-output tables, employment and wage data, data on trade flows, and data on how personal income is spent. Input-output tables are compiled at the national level by the Bureau of Economic Analysis (BEA), an agency within the Department of Commerce. State and county specific input-output tables are derived by adjusting the BEA national tables by adjusting the distribution of production among industries, based on employment data by industry, and deriving imports and exports to and from the state through a combination of the input-output relationships and trade flow data.

## A.2 Model Outputs

Based on project-specific inputs from the user, the model estimates job creation, earnings, and output (total economic activity) for a given power generation project. This includes the direct, indirect, and induced economic impacts on the state economy associated with its construction and operation phases. By determining the regional economic impacts and job creation for a proposed power facility, the JEDI Natural Gas Model can be used to answer questions about the economic impacts of a natural gas power plant in a given state, region, or local community.

NREL's JEDI models present outputs for the following economic metrics:

- *Jobs* – Additional jobs resulting from the increased final spending.
- *Earnings* – The additional earnings (wages and employer paid benefits) associated with the additional jobs.
- *Output* – The additional output that drives the increase in jobs. Output is defined more broadly than other metrics of economic activity, including value added or GDP; output is the sum value of all goods and services at all stages of production (i.e., as a raw material and as a finished product).
- *Value Added* – The difference between total gross output and the cost of intermediate inputs. It is the sum total of earnings of capital and labor, comprised of payments made to workers, proprietary income, other property type income, indirect business taxes, and taxes on production and imports less subsidies. The sum total of value added of all enterprises and self-employed in a state comprises that state's GDP.

JEDI models classify results into three categories: direct, indirect, and induced. Direct results are defined as on-site labor and professional services. These are the impacts from dollars spent on labor by companies engaged in development and on-site construction and operation of power generation and transmission. These results do not include materials—only labor. With its exclusive emphasis on labor, JEDI's first tier of impacts is narrower than typical direct economic impacts. Companies or businesses that fall into this category include project developers, environmental and permitting consultants, road builders, concrete-pouring companies, construction companies, tower erection crews, crane operators, and O&M personnel.

Indirect effects are reported in JEDI as local revenues, equipment, and supply chain results. These results are driven by the increase in demand for goods and services from direct on-site project spending. Businesses and companies included in the second tier of economic activity include construction material

[10] Default values are based on analysis of proprietary data provided by NREL, Navigant, Green Giraffe Energy Bankers, Ocean & Coastal Consultants, and the U.S. Department of Labor Bureau of Labor Statistics. In those instances where data from the sources was not an exact match for the system parameters, the best available information was used to derive appropriate values.

and component suppliers, analysts and attorneys who assess project feasibility and negotiate contract agreements, banks financing the projects, all equipment manufacturers (i.e., blade manufacturers), and manufacturers of replacement and repair parts.

Induced effects are the third and final category and are driven by the local expenditures of those receiving payments within the first two categories. These are often associated with increased business at local restaurants, entertainment, and retail establishments, as well as childcare providers or any other entity affected by the increased economic activity and spending occurring in the first two tiers.

JEDI model results are displayed in two different time periods: construction and operations. Construction period results are inherently short-term. Jobs are defined as full-time equivalents (FTE), or 2,080-hour units of labor. (One construction period job equates to one full-time job for one year.) Equipment manufacturing jobs, such as tower manufacturing, are included in construction period jobs as it is ultimately new construction that drives equipment manufacturing. All employment related to the construction of the project is reported in FTE. Operations period results are long-term, for the life of the project, and are reported as annual FTE jobs and economic activity. Operation period impacts continue to accrue throughout the operating life of the facility.

JEDI results are not intended to be a precise forecast; they are an estimate of potential activity resulting from a specific set of projects or scenarios. In addition, JEDI results presuppose that projects are financially viable and can be justified independent of their economic development value. Importantly, results generated by the JEDI models are gross (not net) results. They do not consider potential increases or decreases in electricity rates resulting from investments in new infrastructure, nor do they consider whether the respective projects displace economic activity elsewhere.