Estimating the Regional Economic Resiliency Benefits of Community Microgrids

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Estimating the Regional Economic Resiliency Benefits of Community Microgrids

Final Report

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Notice

Abstract

This report documents a pilot study that examines the use of regional economic impact analysis to improve understanding of the benefits that a community microgrid may offer in improving the resilience of electrical service. The study focuses on a microgrid that would serve the Village of Rockville Centre, one of several projects being evaluated for development under New York State Energy Research and Development Authority's (NYSERDA) NY Prize program. The analysis employs IMPLAN, a regional economic impact model, to characterize the economic activity that a microgrid would be able to sustain in the event of a regional power outage. It also examines the effect of different assumptions concerning the duration of the outage on the magnitude of potential benefits as well as the implications of different assumptions concerning the ability of local businesses to continue to operate in the absence of a microgrid.

The regional economic benefits of resiliency estimated in this pilot study represent avoided losses in market activity (i.e., monetary flows and jobs) across interrelated sectors of the regional economy. This information provides NYSERDA with additional perspectives on the benefits microgrids can provide. Based on the results of this pilot, Industrial Economics, Incorporated (IEc) offers NYSERDA recommendations on incorporating regional economic impact analysis into its assessment of NY Prize projects.

Keywords

Community Microgrid, Regional Economic Impact Analysis, Resiliency, NY Prize competition

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Acronyms and Abbreviations

BCA	benefit-cost analysis
EAL	Economic Activity Level
EPRI	Electric Power Research Institute
FEMA	Federal Emergency Management Agency
GDP	gross domestic product
IEc	Industrial Economics, Incorporated
IMPLAN	Impact Analysis for Planning Model
I/O	input-output
NAICS	North American Industry Classification System
RVC	Rockville Centre
WTP	willingness to pay

1 Introduction

An important element in transforming the State of New York's infrastructure to enhance its ability to withstand severe weather events is strengthening the existing electrical grid and making additional investments in the development of a more resilient energy system. This includes the launch of NY Prize, a $40 million competition to support the development of community microgrids throughout the State. Microgrids are electric distribution systems that can operate when connected to the larger grid but can also disconnect from it and operate as an independent power system during an emergency. This capability enables them to supply electricity to the facilities they serve when the conventional grid is down.

Industrial Economics, Incorporated (IEc) has been working with New York State Energy Research and Development Authority (NYSERDA) since 2013 to develop methods and tools to evaluate the benefits and costs of community microgrids. This memorandum describes the pilot test of a new tool, which is designed to measure the potential benefits of a microgrid in sustaining economic activity during an extended outage. Based on the results of this test, we offer NYSERDA recommendations on incorporating regional economic impact analysis into its assessment of NY Prize projects.

This report first provides background information on the NY Prize competition and IEc's work with NYSERDA to evaluate the relative costs and benefits of candidate projects (section I). Section II describes regional economic impact analysis, defining key concepts and analysis software. Section III outlines IEc's analytic approach, from a selection of the pilot study site to the presentation of findings from the analysis. Section IV identifies the lessons learned from the pilot study and the implications for future regional economic analyses of candidate projects. Attachment A provides the presentation that IEc delivered to NYSERDA regarding the methods for and results of this project, and Attachment B includes screenshots of the economic impact model.

2 Project Background, Objectives, and Summary Findings

The NY Prize competition encompasses three stages. Stage 1, which was completed in 2016, funded feasibility assessments for 83 candidate microgrid projects across the State. Stage 2, which is now underway, is funding the development of engineering design and financial plans for 11 projects. During stage 3, NYSERDA will support the construction of approximately three to five community microgrids.

Supporting the first two stages of NY Prize, IEc developed a spreadsheet model designed to assess the costs and benefits of candidate projects. IEc's benefit-cost analysis (BCA) model considers fixed and variable costs, energy generation and capacity cost savings, reliability improvements, power quality improvements, avoided environmental damages, and the benefits of maintaining service during extended power outages. This latter category represents the resiliency benefit of the microgrid. Consistent with the other benefit measures that the model incorporates, resiliency benefits are measured with respect to improvements in social welfare; in this case, costs such as increase in fatalities, fire damage, or crime that might ordinarily occur in the event of an extended outage, but which a microgrid would help to avoid (IEc, 2015). From an economics perspective, these avoided social welfare costs reflect the public's willingness to pay to avoid the power outage, which is a measure of economic value.

A recent report developed by researchers at Cornell University for the Electric Power Research Institute (EPRI) identifies several alternative methods for assessing resiliency benefits beyond the economic value approach employed in IEc's BCA model (Electric Power Research Institute, 2017). Some of the methods described (e.g., survey-based discrete choice experiments) are too time- and resource-intensive to be feasible within the timeframe of the NY Prize competition. However, the EPRI report highlights regional economic impact modeling as providing a potentially useful, additional perspective on the benefits of resiliency. As opposed to measures of economic value, regional economic analysis quantifies the economic impact of the candidate projects, which are measured as changes in economic activity in a specified region (e.g., sales, income, or employment). In light of this, IEc conducted a pilot study to accomplish the following:

- Demonstrate how an economic impact analysis of a community microgrid could be structured and conducted.
- Define the assumptions required and uncertainties associated with this type of analysis.
- Determine the level of effort required to replicate such an analysis for candidate microgrid sites.

IEc's pilot study focused on the Rockville Centre microgrid project, which would serve a substantial number of commercial facilities in this Nassau County community. Rockville Centre is one of the 11 projects NYSERDA is funding during stage 2 of NY Prize. The general findings of the pilot are as follows:

- Economic activity is high within the area that would be served by the microgrid. IEc's analysis suggests that on an average day, the facilities the microgrid would serve account for the following levels of economic activity in Nassau County:
    - $5 million in total sales
    - $3.1 million in value added (i.e., regional GDP)
    - $1.8 million in labor income, sufficient, on an annual basis, to support an average of approximately 32 jobs
- Successful operation of the microgrid in the event of a major outage would help to avoid the loss of some, if not all, of this economic activity.
- The regional economic analysis tool that IEc has developed requires assumptions about the level of economic activity that a microgrid would sustain over the course of an outage. Given the uncertainty regarding these assumptions, the model is flexible and can evaluate impacts of different user-specified outage scenarios with variable assumptions for the duration of the outage and level of economic activity sustained.
- The approach we have taken in this pilot study is replicable but will require effort to build a model reflective of the regional economy at each candidate microgrid site. Given the level of effort required, IEc recommends reserving this type of analysis for stage 3 of NY Prize, when a more limited number of projects will require analysis.

3 Defining Regional Economic Analysis

Commercial and industrial enterprises in a geographic region are interconnected in that they supply goods and services to each other as well as to consumers. Consequently, changes in one economic sector tend to have a proportionally greater impact on the regional economy as a whole. This is commonly referred to as a "ripple effect" or a "multiplier effect." Input-output (I/O) models provide a means of quantifying multiplier effects by capturing industry-to-industry market transactions, therefore allowing users to translate changes in productivity (e.g., sales) in a given economic sector or sectors into changes in demand for goods and services across the broader regional economy. IMpact analysis for PLANning (IMPLAN) is a regional economic model commonly used by state and federal agencies for policy planning and evaluation purposes. IMPLAN draws upon I/O data from several federal and state agencies, including the Bureau of Economic Analysis and the Bureau of Labor Statistics. These data describe the interrelationships between industry producers and consumers. IMPLAN combines these I/O data, which describe market monetary flows, with "social accounts" that describe non-market monetary flows, such as payments made between households or between households and governments. The IMPLAN data describing both the market and non-market monetary flows in a regional economy are generally characterized as a Social Accounting Matrix.[1]

IEc's regional economic analysis for NYSERDA relies on the IMPLAN model due to the significant precedence for its use by governments and for analyses of the benefits of avoided power outages. In addition, IMPLAN data are available across the United States at relatively refined spatial scales. IEc was therefore able to readily access recent IMPLAN Social Accounting Matrix data for all counties within New York State for use in this analysis.

1 Originally developed by the U.S. Forest Service and Federal Emergency Management Agency, the IMPLAN model is now owned by IMPLAN, based in Huntersville, NC. Visit www.implan.com for additional information.

Regional economic impacts can be described as direct, indirect, or induced, depending on the nature of the change:

- Direct effects represent the known (or predicted) changes in economic output attributable to a specific initial change in supply or demand. In the case of a microgrid, for example, the initial change would be the preservation of electric service during an outage for the facilities the project would serve. The direct effects would be the amount of economic activity (e.g., gross revenue) that the microgrid would be able to sustain at these facilities.
- Indirect effects are changes in output in industries that supply goods and services to those that are directly affected by the initial change. For example, a microgrid that enabled a supermarket to remain open might create economic benefits for the produce, meat, dairy, grocery, and dry goods wholesale vendors who serve the store.
- Induced effects reflect changes in household spending arising from changes in income (which are the result of direct and indirect effects). For example, a microgrid that permits individuals to continue to work during an extended outage might affect those individuals' income, and thus their spending on goods and services in the surrounding community.

The sum of the direct, indirect, and induced effects is the total estimated regional economic impact. These impacts are reported in terms of changes in economic output, value added, labor income, and employment by the sector within a specified region:

- **Output** represents the value of industry production (i.e., sales). Briefly, output is the sum of value added and "intermediate inputs," where intermediate inputs are the goods and services produced by one industry that will be incorporated into the production of another industry.
- **Value Added** is defined as the difference between an industry's or establishment's total output and the costs of its intermediate inputs. This measure is analogous in many ways to the measurement of gross domestic product (GDP) but at a regional level.
- **Labor Income** includes wages, worker benefits, and proprietor income. The impact of outages on this measure is a general indication of the effect of reduced economic activity on payments to the operators and employees of affected businesses.
- **Employment** refers to total annual average jobs. This includes self-employed and wage and salary employees, and all full-time, part-time and seasonal jobs, based on a count of full-time/part-time averages over twelve months.

One important caveat to the interpretation of I/O and Social Accounting Matrix-based models, such as IMPLAN, is that they are comparative static models. These models measure effects at a single point in time and do not account for longer-term adjustments that may occur in an economy over time in response to a stimulus or event, such as changes in the types of businesses operating in a particular area or changes in the location of businesses from which goods and services are purchased.

4 Pilot Study Analytic Approach

In advance of conducting the pilot study, IEc conducted a targeted literature review to identify studies that have applied regional economic methods to evaluate the impacts of power outages. The purpose of the literature review was to identify what frameworks and models were commonly used, as well as how the analyses measured the direct effects of an outage on economic productivity (i.e., the inputs to the regional economic impact analysis). The majority of the analyses employed the IMPLAN model. These studies focused on losses in economic activity due to power outages associated with hurricanes, blackouts, earthquakes, and terrorist events. The duration of the outages evaluated in the literature ranged from a few days to almost four months.

A common issue highlighted across these studies is whether and how to incorporate the resiliency of an economy to an outage. The definition of resiliency put forth by Sanstad (2016) is, "the capacity of consumers, firms, and markets to temporarily adjust, adapt, or otherwise compensate for the loss of electricity in ways that mitigate economic impacts." A few studies attempt to account for resiliency, reducing the extent to which an outage resulted in economic activity losses (see, for example: Kunz et al., 2013; Rose et al., 2007; Rose et al., 2005; and Rose et al., 1997). Some of these studies estimate resiliency based on surveys of businesses to determine how a 100 percent loss in power affected business operations during an outage (see, for example: Burrus et al., 2002 and Rose et al., 1997). Other studies either do not incorporate a resiliency factor or test hypothetical assumptions for resiliency, noting that the lack of information to inform an assumption is a limitation of the study (see Greenberg et al., 2007).

The literature review found that resilience of an economy to an outage event is not only site-specific, but also industry-specific, event-specific, and potentially even business-specific. The literature did not identify common assumptions for factoring resiliency into a regional economic analysis of power outages. Based on these literature review findings, IEc developed the pilot study economic impact model to allow for user-specified assumptions for resiliency of the economy as a whole, if that information should be available. However, even absent a data-driven assumption for resiliency, the model allows users to compare relative impacts of specified outage scenarios across candidate sites.

4.1 Selection of Pilot Study Site

To select one of the 11 stage 2 projects for the pilot test effort, IEc established the following criteria: first, we focused on identifying a project that would serve a substantial number of industrial or commercial facilities, in addition to critical service providers; second, we focused on sites that had settled on a proposed microgrid design and that could answer questions about the microgrid and the facilities to be served. Based on these criteria, IEc selected the proposed Village of Rockville Centre (RVC) microgrid.

The proposed RVC microgrid is located in the Village of Rockville Centre, New York (the “Village”), a 3.2 square mile community on Long Island, in Nassau County. The microgrid is designed to serve a mix of facilities, including a number of critical service providers, over 500 commercial customers, and almost 3,000 residential customers. Most relevant to this case study is the significant number of commercial customers, including supermarkets, drug stores, gas stations, and other commercial facilities.

Table 1 provides an overview of the customers and facilities that would be served by the proposed RVC microgrid as well as identifies the facilities for which we estimated direct impacts of power outages. These 535 facilities support an estimated 8,000 employees and at least $1.2 billion in annual output.

Table 1. Facilities Served by Proposed RVC Microgrid

Facility/Customer Type	Number in Microgrid
Commercial	519
Non-EMS Medical	5
Hospital and EMS Medical	11
Government	4
Police	1
Fire	2
Water	3
Traffic Signals	15
Residential	2,962

Following selection of the pilot study site, IEc's analytic approach to modeling the resiliency benefits of the proposed RVC microgrid involved gathering and processing input data, conducting economic impact modeling in IMPLAN, developing outage scenarios in coordination with the Village's Electric Department, and modeling the economic impacts associated with these outage scenarios. The final product is a spreadsheet model that allows a user to specify an outage scenario, and then estimates the corresponding resiliency benefits (i.e., "economic impacts") that would be provided by the proposed microgrid.

4.2 Step 1: Develop IMPLAN Inputs

Inputs to IMPLAN are entered as changes in output (sales) for each affected industry sector.[2] Thus, in order to develop scenarios and run IMPLAN, IEc sought information about the industry sector and output of each facility served by the proposed RVC microgrid. In this case, the project proponents were not able to provide data for the specific facilities that would be served by the microgrid, nor were they able to give a precise breakdown of the 519 commercial facilities by economic sector. Given the lack of detailed information available, IEc instead applied a "scaled representation" approach. This approach makes assumptions about the type and output of each facility based on county-level data available from IMPLAN and the U.S. Census Bureau's County Business Patterns. Specifically, the approach assumes that the distribution of commercial activity in Nassau County is representative of the commercial activity for the facilities served by the proposed microgrid.

The relevant worksheets within the MS Excel spreadsheet model include the following:

- **IMPLAN Industry Map:** Maps industry descriptions to IMPLAN industry codes.
- **RVC Microgrid:** Identifies the facilities served by the RVC microgrid and maps them to two-digit North American Industry Classification System (NAICS) codes, six-digit NAICS codes, and corresponding IMPLAN codes.[3]
- **Nassau County Business Patterns:** Contains the U.S. Census Bureau's 2015 County Business Patterns data for Nassau County. It also contains the "scaled representation" calculations that IEc used to distribute the RVC microgrid's facilities across two-digit NAICS codes.

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2 The IMPLAN sectoring scheme (or "industrial classification scheme") breaks out 536 different industry sectors. Each IMPLAN industry sector has a corresponding code or number, which maps directly to a six-digit NAICS code.

3 The North American Industry Classification System (NAICS) is currently the standard used by federal statistical agencies to categorize establishments by industry. Industries are represented by progressively more detailed numeric codes, ranging from two to six digits.

- **Nassau County IMPLAN Data:** Contains IMPLAN data on employment, output, and other economic measures, by IMPLAN industry sector for Nassau County. It also contains the second phase of IEc's "scaled representation" calculations, including (1) mapping IMPLAN's economic data for Nassau County to six-digit NAICS codes; (2) distributing the RVC microgrid's facilities across relevant six-digit NAICS codes and corresponding IMPLAN industry codes; (3) estimating the annual employment and annual output per RVC microgrid facility.
- **IMPLAN Inputs:** Excerpts only IMPLAN industry codes that are estimated to have corresponding facilities in the RVC microgrid. For each relevant IMPLAN industry code, the worksheet calculates the estimated output per day. These estimates for output per day across the relevant industry sectors serve as the inputs to the IMPLAN model.

4.3 Step 2: Model A Scalable, One-Day Outage for RVC in IMPLAN

IEc modeled a one-day outage "shock" that would cause a complete shutdown of all RVC microgrid facilities (i.e., a 100 percent loss of economic activity for one day). This "simple case" analysis assumes the following:

- Economic activity is evenly distributed throughout the year, so that the change in output modeled for each affected industry sector is, on average, 1/365th of the estimated annual output for that sector.
- Without the RVC microgrid, 100 percent of facilities served by the microgrid would lose power for the day. Further, these facilities would lose 100 percent of economic activity for the day, and would not be able to make up for this lost economic activity after the outage.
- With the RVC microgrid, all facilities would maintain full service and would continue operations.

IEc used the IMPLAN Pro software to model the regional economic impacts to Nassau County as well as to the rest of New York State.

The results for the simplified, one-day outage scenario are summarized in the following tables and are presented in the "IMPLAN Outputs" worksheet of the spreadsheet model. Because the IMPLAN model describes linear relationships across economic sectors, these results may be scaled to evaluate different outage duration scenarios.

Table 2 summarizes the regional economic benefits of the RVC microgrid in terms of avoided losses of economic activity in Nassau County. The results suggest that for the specified, one-day outage scenario, the microgrid could preserve total value added of more than \$3.1 million and economic output of over \$5.0 million.

Table 2. Regional Economic Benefit of Microgrid, One-Day Outage Scenario

Impact Type	Employment (Job-Years)	Labor Income ($)	Total Value Added ($)	Output ($)
Direct Effect	18.5	$1,016,028	$1,801,497	$2,878,631
Indirect Effect	7.0	$416,186	$704,062	$1,188,481
Induced Effect	6.6	$354,718	$618,039	$965,535
Total Effect	32.1	$1,786,932	$3,123,597	$5,032,647

For this one-day outage scenario, Table 3 highlights the top ten economic sectors affected, ranking them by total value added to Nassau County. These results are largely a reflection of our "scaled representation" approach, which distributed the RVC microgrid's "commercial facilities" across industry sectors according to the distribution of commercial activity in Nassau County.

Table 3. Top Ten Sectors Benefitting from Microgrid, One-Day Outage Scenario (According to Value Added Per Day)

Economic Sector	Employment (Job-Years)	Labor Income ($)	Total Value Added ($)	Output ($)
Real estate	3.8	$107,578	$419,185	$645,839
Wired telecommunications carriers	0.3	$80,792	$231,096	$303,658
Monetary authorities and depository credit intermediation	0.4	$30,680	$186,968	$220,248
Insurance agencies, brokerages, and related activities	1.2	$90,697	$158,923	$274,948
Legal services	0.9	$79,076	$154,487	$194,701
Insurance carriers	0.5	$42,334	$139,178	$241,139
Wholesale trade	0.5	$52,949	$93,479	$133,942
Owner-occupied dwellings	0.0	$0	$86,083	$132,707
Hospitals	0.6	$73,283	$83,696	$125,950
Management of companies and enterprises	0.6	$61,875	$75,714	$134,210
All other sectors	23.3	$1,167,668	$1,494,788	$2,625,305

Some regional economic impacts associated with the RVC microgrid would "leak" out of Nassau County to surrounding areas in New York State. Table 4 captures these leakage impacts for the simplified, one-day outage scenario. The results suggest that the microgrid could sustain total value added of more than $172,000 and economic output of over $292,000 in the rest of New York State.

Table 4. Average Regional Economic Benefit of Microgrid to the Rest of New York State, One-Day Outage Scenario

Impact Type	Employment (Job-Years)	Labor Income ($)	Total Value Added ($)	Output ($)
Direct Effect	0.0	$0	$0	$0
Indirect Effect	0.7	$66,929	$115,424	$198,470
Induced Effect	0.5	$32,837	$56,923	$94,020
Total Effect	1.2	$99,766	$172,348	$292,490

4.4 Developing Outage Scenarios

As previously noted, it may not always be reasonable to assume that an outage of a given duration results in a 100 percent loss in economic activity for the full duration of the outage. Accordingly, IEc defined outage scenarios for the proposed RVC microgrid, coordinating with the Village of Rockville Centre's Electric Department. The Electric Department provided information about historical storms and other extended outages in the RVC area, including outage durations, geographic scope, system recovery, and the frictional period needed to get fully up and running after an outage. Ultimately, the department recommended modeling outages lasting three, five, and seven days as the likely impacts of a major storm. In addition, the Electric Department recommended incorporating scaling factors into the spreadsheet model to account for other variables, such as phased-in recovery of power across the system, the economy's ability to maintain some level of economic activity without power, and the economy's ability to make up for lost economic activity following an outage event.

In order to maintain modeling flexibility, IEc incorporated the scaling factors recommended by RVC into the spreadsheet model as assumptions to be specified by the user. The scaling factors allow the user to move beyond the "simplified" assumption of 100 percent loss of economic activity for the entire duration of an outage. The user can specify up to three outage periods, each of a given duration, measured in days. For each of these periods, the user can then specify the following scaling factors:

- Recovery Factor: This reflects the percent of all businesses whose power has been restored during the period of interest.
- Resiliency Factor: This reflects the percent of normal economic activity maintained by businesses without power or, alternatively, the percent of lost economic activity that businesses without power can recover following the outage event.

Based on these inputs, the model calculates an "overall economic activity level" during the period of interest, using the following equation:

Overall Economic Activity Level = %Recovery + [%Resiliency * (100% - %Recovery)]

Table 5 describes how the overall economic activity level for a given outage period varies according to the recovery factor and resiliency factor for that outage period. This tabular visualization of the overall economic activity level is also available in the "% Economic Activity Level" worksheet in the spreadsheet model.

Table 5. Overall Economic Activity Level

		Resiliency Factor										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Recovery Factor	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	10%	10%	19%	28%	37%	46%	55%	64%	73%	82%	91%	100%
	20%	20%	28%	36%	44%	52%	60%	68%	76%	84%	92%	100%
	30%	30%	37%	44%	51%	58%	65%	72%	79%	86%	93%	100%
	40%	40%	46%	52%	58%	64%	70%	76%	82%	88%	94%	100%
	50%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
	60%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%	100%
	70%	70%	73%	76%	79%	82%	85%	88%	91%	94%	97%	100%
	80%	80%	82%	84%	86%	88%	90%	92%	94%	96%	98%	100%
	90%	90%	91%	92%	93%	94%	95%	96%	97%	98%	99%	100%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Based on the duration and overall economic activity level ("EAL") for each outage period, the spreadsheet model then calculates a weighted average economic activity loss, measured in days, for the overall outage. This is calculated as follows:

$$\textbf{Weighted Average Economic Activity Loss} = \sum_{k=0}^{n} [\boldsymbol{Duration} * (\mathbf{100}\% - \%\boldsymbol{EAL})]$$

Table 6 demonstrates how the "outage inputs" table in the spreadsheet tool might be estimated for a "sample" seven-day outage. In the table, as in the spreadsheet tool, the user inputs are shaded in orange. This inputs table is available in the "Inputs + Outputs" worksheet in the spreadsheet model.

Table 6. Input Table for an Example Seven-Day Outage

Outage Period	Outage Duration (Days)	% Overall Economic Activity Level	% Recovery Factor	% Resiliency Factor
#1	3	0%	0%	0%
#2	2	50%	50%	0%
#3	2	63%	50%	25%
Total	**7**	--	--	--

4.75	Weighted Average Economic Activity Loss (Days)

For this sample seven-day outage, the first outage period—which lasts three days—has no economic activity (a 100 percent loss). In the second outage period, which lasts for days four and five, the region regains 50 percent of its economic activity. In the final outage period, which lasts days six and seven, the region is operating at 63 percent of its baseline economic activity level. For the entire seven-day outage, the weighted average economic activity loss is equivalent to a total loss of 4.75 days of economic activity. The spreadsheet model scales the results for the one-day outage up to account for a weighted average economic activity loss of 4.75 days.

4.5 Regional Economic Benefits of RVC Microgrid, Alternative Outage Scenarios

To illustrate the implications of employing different scaling factors, IEc conducted a sensitivity analysis for the seven-day outage scenario. This analysis modeled one seven-day outage with a 100 percent economic activity loss, and three other seven-day outage scenarios that each had outage periods with varying assumptions across the recovery and/or resiliency factors. Table 7 summarizes the sensitivity analysis scenarios for the seven-day outage.

Table 7. Sensitivity Analysis Scenarios for Seven-Day Outage

Outage Scenario	Weighted Average Economic Activity Loss (Days)	Scenario Description
Scenario 1	7.00	Assume 100 percent economic activity loss.
Scenario 2	6.50	Assume after five days, 25 percent resiliency factor.
Scenario 3	5.00	Assume after three days, 50 percent recovery factor.
Scenario 4	4.75	Assume after three days, 50 percent recovery factor; and after five days, 25 percent resiliency factor.

The “Inputs + Outputs” worksheet in the spreadsheet model contains both the inputs and outputs for the outage scenario modeling. As described previously, based on user inputs for duration, recovery factor, and resiliency factor for each outage period, the spreadsheet model will estimate a total weighted average economic activity loss (measured in days). The model then scales the results of the one-day outage scenario to match the weighted average for the user’s input scenario. Results are reported in terms of regional economic contributions to the local study area (Nassau County) as well as leakage impacts to the rest of New York State.

To provide additional context, we modeled the economic impacts of outages lasting three, five, and seven days, all with the simplified assumption of a 100 percent loss of economic activity in the absence of the RVC microgrid. For each scenario, the spreadsheet model linearly scales the results of the one-day outage to match the scenario’s weighted average economic activity loss (measured in days). For each of these scenarios, Table 8 summarizes the economic impacts within Nassau County, while Table 9 displays the “leakage” impacts for the rest of New York State. Similar to the one-day outage scenario, the majority of the regional economic contributions are concentrated in Nassau County. For this local study area, the RVC microgrid could preserve $9.4 million to $21.9 million in total value added, and $15.1 million to $35.2 million in total economic output. For the leakage impacts to the rest of New York State, the microgrid could sustain total value added, ranging from $0.5 million to $1.2 million and total economic output ranging from $0.8 million to $2.0 million.

Table 8. Three, Five, and Seven-Day Outage Scenarios—Regional Economic Benefits of the RVC Microgrid to Nassau County

Outage Scenario	Employment (Job-Years)	Labor Income ($)	Total Value Added ($)	Output ($)
Three-Day Outage	96.3	$5,360,796	$9,370,791	$15,097,941
Five-Day Outage	160.5	$8,934,660	$15,617,985	$25,163,235
Seven-Day Outage	224.7	$12,508,524	$21,865,179	$35,228,529

Table 9. Three, Five, and Seven-Day Outage Scenarios—Regional Economic Benefit of the RVC Microgrid to the Rest of New York State

Outage Scenario	Employment (Job-Years)	Labor Income ($)	Total Value Added ($)	Output ($)
Three-Day Outage	3.6	$299,298	$517,044	$877,470
Five-Day Outage	6.0	$498,830	$861,740	$1,462,450
Seven-Day Outage	8.4	$698,362	$1,206,436	$2,047,430

Figure 1 provides a graphical representation of the RVC microgrid's economic impacts to Nassau County across the three, five, and seven-day outage scenarios. These bar charts also reinforce the idea that the results are linearly scaled from the one-day outage scenario.

IEc also modeled the sensitivity analysis scenarios for the seven-day outage (with variable assumptions for recovery and resilience). Figure 2 shows the regional economic contributions of the RVC microgrid to Nassau County across the different sensitivity scenarios. The results show that using the scaling factors can potentially lead to more nuanced estimates of the economic impacts of the RVC microgrid. For example, without the scaling factors, scenario 1 assumes that a seven-day outage with a full loss of economic activity would result in a total value-added loss of $21.9 million and lost economic output of $35.2 million. In contrast, scenario 4, which incorporates scaling factors for the percent of businesses that regain power during the outage and the percent of businesses without power that maintain economic activity, finds that a seven-day outage could instead result in a total value-added loss of $14.8 million and lost economic output of $23.9 million.

Figure 1. Scaled Results for Three, Five, and Seven-Day Outage Scenarios—Regional Economic Benefit of RVC Microgrid to Nassau County, Assuming 100% Loss of Economic Activity

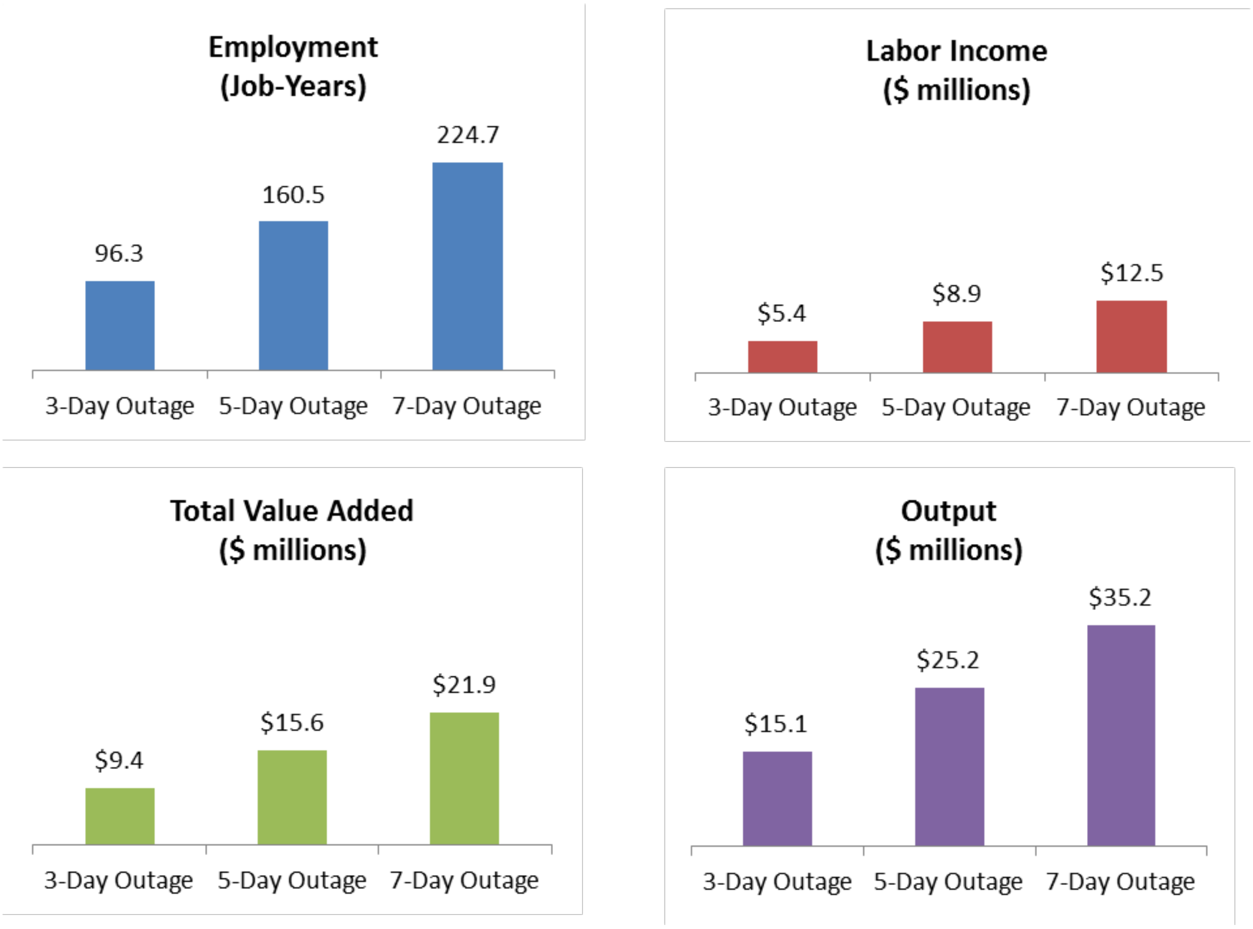
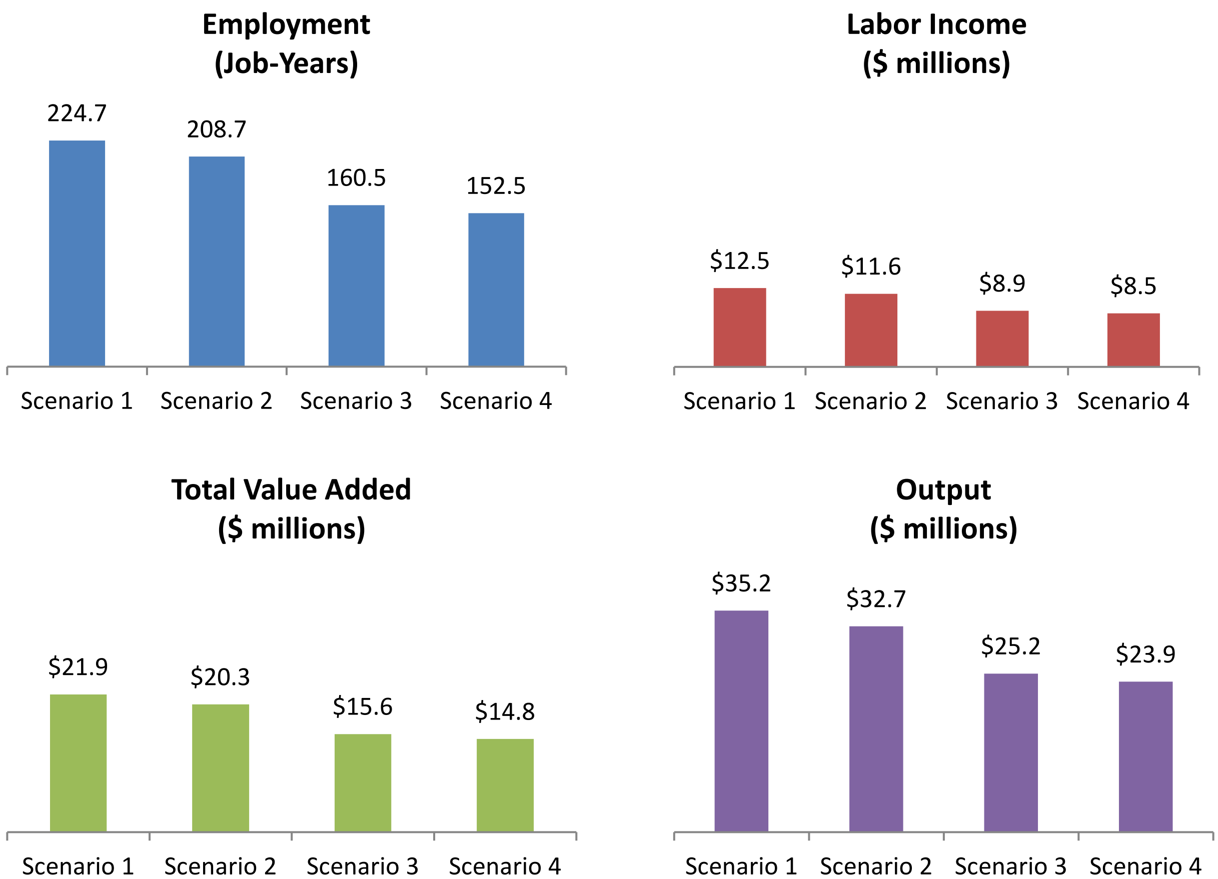


Figure 2. Sensitivity Analysis Results for Seven-Day Outage Scenarios—Regional Economic Benefit of RVC Microgrid to Nassau County, Incorporating Scaling Factors



5 Lessons Learned, Limitations, and Recommendations

Because regional economic impact analysis is designed to capture market transactions, it is best suited to evaluating microgrids that would serve a relatively large number of commercial and industrial enterprises (as opposed to residences and critical service providers). At a basic level, the regional economic analysis of community microgrid projects requires information on the nature of the businesses (commercial and industrial) and institutions covered. Ideally, this would include numbers and sizes (in terms of average annual sales) of businesses by the economic sector (NAICS code). Absent this information, IEc employed a scaled representation approach for the pilot study, assuming representation of economic sectors proportional to the broader county-level mix for Nassau County. More information on the businesses covered by the grid, however, would improve the precision of the IMPLAN results and reduce the level of effort require to develop the direct impacts to input into IMPLAN.

In addition to requiring information on the nature and size of businesses covered by the grid, IEc's approach relies on a proportionality of losses assumed, effectively assuming economic activity is distributed evenly over the course of a year in order to determine the direct impact of a one-day outage. While even distribution of economic activity over time is often not the case, this is the most practical assumption given uncertainty regarding how the economic activity is distributed across the weeks and months, as well as when a hypothetical outage may occur.

Finally, the resiliency and recovery factor assumptions employed to model outage scenarios represent a key uncertainty. While IEc's model incorporates sufficient flexibility to analyze the sensitivity of results to different assumptions, real data to inform the assumptions for these factors are limited. Nevertheless, the model results, even as a simple demonstration assuming a 100 percent loss in economic activity for a one-day outage, provide useful insight into the relative regional economic benefits across the projects.

Table 10 compares the findings of the regional economic impact analysis (right column) with the findings provided by the IEc's BCA model. The economic impact analysis finds that by sustaining power during a one-day outage, a microgrid could mitigate or avoid losses of as much as $5 million in total sales, $3.1 million in value added (i.e., regional GDP), and labor income that would be sufficient, on average, to sustain 32.1 jobs for a year. This is in comparison with social welfare benefits of approximately $9.7 million per day.

As noted previously, the economic benefits estimated in this pilot study represent avoided losses in market activity (i.e., monetary flows and jobs) across interrelated sectors of the regional economy. These metrics do not reflect other economic values of resiliency, such as willingness to pay (WTP) for avoiding outages and maintaining critical services. Thus, the regional economic benefits are distinct from, and not a substitute for or add to , the resiliency benefit values provided by IEc's BCA model. The analysis simply provides NYSERDA with additional perspectives on how people and communities can benefit from the presence of microgrids.

Table 10. Comparing Results of Social Welfare and Regional Economic Impact Analyses of Microgrid Benefits

Current Model	Proposed Economic Impact Analysis Approach
ICE Calculator Metric: • Economic value-based (social welfare) • Willingness to Pay (WTP)	**IMPLAN Metric:** • Economic activity-based • Measures of productivity (jobs, sales, income)
Values of critical service providers included (FEMA methods)	Critical service providers evaluated in terms of economic productivity
WTP to avoid 1-day outage (*519 commercial businesses + 5 non-EMS medical facilities*): • $9.7 million	Regional economic impact of a 1-day outage (*519 commercial businesses + 16 medical facilities*): • $5.0 million in total sales • $3.1 million in regional GDP • 32.1 average annual jobs

While the flows of dollars and jobs across industries are more limited indicators of value than WTP (i.e., they don't reflect inconvenience factors and other losses or perceived losses associated with business closures), they are relatively straightforward metrics for the general public to understand, which may be advantageous to NYSERDA in the context of outreach.

Finally, this approach to evaluating regional economic benefits of resiliency is replicable across projects but requires effort to account for site-specific variability in the mix of economic sectors and levels of economic activity a microgrid would support. Given the level of effort required to develop a similar tool for other sites, we expect this type of analysis would be best suited in the context of NY Prize, stage 3, providing additional information on the benefits of projects that advance to the construction phase of the program.

6 References

Burrus Jr., R.T., Dumas, C.F., Farrell, C.H., and Hall Jr., W.W. (2002). Impact of low-intensity hurricanes on regional economic activity. Natural Hazards Review, 3(3), 118-125.

Electric Power Research Institute (2017). "Measuring the Value of Electric System Resiliency: A Review of Outage Cost Surveys and Natural Disaster Impact Study Methods," Technical Update 3002009670, January 2017.

Greenberg, M., Lahr, M., and Mantell, N. (2007). Understanding the economic costs and benefits of catastrophes and their aftermath: A review and suggestions for the U.S. Federal Government. Risk Analysis, 27(1), 83-96.

Industrial Economics, Inc. February 23, 2015. Assessing the Benefits and Costs of Developing a Microgrid: Model User's Guide. Prepared for the New York State Energy Research and Development Authority. NYSERDA Contract No. 30192.

Kunz, M., Muhr, B. Kunz-Plapp, T., Daniell, J.E., Khazai, B., Wenzel, F., Vannieuwenhuyse, M., Comes, T., Elmer, F., Schroter, K., Fohringer, J., Munzberg, T., Lucas, C., and Zschau, J. (2013). Investigation of superstorm Sandy 2012 in a multi-disciplinary approach. Natural Hazards and Earth System Sciences, 13, 2579-2598.

Rose, A., Oladosu, G., and Liao, S.Y. (2007). Business interruption impacts of a terrorist attack on the electric power system of Los Angeles: Customer resilience to a total blackout. Risk Analysis. DOI: 10.1111/j.1539-6924.2007.00912.x.

Rose, A., Oladosu, G., and Salvino, D. (2005). Economic impacts of electricity outages in Los Angeles: The importance of resilience and general equilibrium effects. In M.A. Crew and M. Spiegel (Eds.), Obtaining the Best from Regulation and Competition (pp. 179-210). Boston: Kluwer Academic Publishers.

Rose, A., Benavides, J., Chang, S.E., Szczesniak, P., and Lim, D. (1997). The regional economic impact of an earthquake: Direct and indirect effects of electricity lifeline disruptions. Journal of Regional Science, 37(3), 437-458.

Sanstad, A. H. (2016). Regional Economic Modeling of Electricity Supply Disruptions: A Review and Recommendations for Research. - Report Number: LBNL-1004426.

Attachment A. Use of Economic Impact Analysis to Estimate resiliency Benefits: Pilot Text for NY Prize

Attachment A

IEc

Use of Economic Impact Analysis to Estimate Resiliency Benefits:

Pilot Test for NY Prize

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May 31, 2018

Agenda

- Background and Purpose
- Overview of Economic Impact Analysis
- Pilot Test Approach and Results
- Model Demonstration
- Discussion

Background and Purpose

Overview:

- IEc has been working with NYSERDA since 2013 to develop methods to evaluate the benefits and costs of community microgrids.
- Efforts to date have culminated in development of a spreadsheet model designed to support NYSERDA's NY Prize program.

Resiliency Benefits:

- IEc's current BCA model estimates the social welfare costs that a microgrid would help to avoid in the event of a major outage.
  - Critical Service Providers: FEMA methods
  - Other residential, commercial and industrial facilities: DOE ICE Calculator
- EPRI (2017) identified methods for providing additional perspective on resiliency benefits, including **economic impact modeling** (e.g., employment, sales, GDP, etc.).

Economic Impact Analysis

- Economic impact analysis measures changes in economic activity.
- Metrics are indicators of economic productivity presented either by sector or in the aggregate across a specified region, including:
  - Economic output (revenue)
  - Value-added (GDP)
  - Income
  - Employment
  - Tax impacts
- Economic impact models estimate the **multiplier effects** (ripple effects) associated with a “shock” to an economy. The multiplier effects reflect impacts to multiple economic sectors that are linked through the supply chain.

Pilot Test

- The IEc pilot test focuses on **economic impact modeling**.
- The objective is to address the following questions:
  1. How would an economic impact analysis be structured and conducted?
  2. What information would it provide beyond that currently provided by IEc's model?
  3. How quickly could the analysis be completed, and at what cost?

Pilot Test Approach

- Select project for pilot test
- Define outage scenario
- Estimate direct impacts (inputs to IMPLAN model)
- Employ IMPLAN model to calculate multiplier effects
- Outage scenario modeling options
- Interpret results:
    - Uncertainty
    - Scalability
    - Transferability

Pilot Study Site Selection Criteria

- Considered 11 projects participating in Stage 2 of NY Prize.
- Pilot study site should serve a substantial number of industrial or commercial facilities, in addition to critical service providers.
- Interest and support of project applicant.

Selection of RVC as the Case Study Site

- Selected the Rockville Centre microgrid site. The geographic scope of the regional economic impact analysis for this case study is Nassau County, NY.

- We estimate that the facilities served by the RVC project support at least 8,000 employees and $1.2 billion in annual output.

Facility Type	Number in Microgrid
Non-EMS Medical	5
Hospital and EMS Medical	11
Government	4
Police	1
Fire	2
Water	3
Commercial	519
Traffic Signals	15
Residential	2,962

Scenario Development

- Communication with RVC Electric Department
- RVC recommends modeling 3, 5, and 7-day outages as the likely impact of a major storm.

SIMPLE REPRESENTATION:

Without the microgrid: Assume 100% loss in economic activity during an outage

With the microgrid: Assume the facilities would retain full service and continue operations

IMPLAN Model

- I/O Model: IMpact Analysis for PLANning (**IMPLAN**)
- Regional impact model most commonly used by state and federal agencies for policy planning and evaluation purposes
- Also commonly applied in power outage literature
- Draws upon BEA and BLS data, among other sources
- Translates changes in expenditures into changes in demand for inputs from interrelated industries
- Functions are linear, results are scalable

Analytic Approach

MODEL INPUT

- **Direct effects:** Changes in economic activity of a particular industry as a result of a change in demand for or sales of the goods and services the industry provides.

MODEL OUTPUT

- **Indirect effects:** Changes in the output of industries that supply goods and services to those industries directly affected.
- **Induced effects:** Changes in household consumption arising from changes in employment and associated income that result from direct and indirect effects.

Metrics:

- Employment
- Labor Income
- Value Added
- Output

IMPLAN Inputs

Inputs calculated as **changes in output** for affected businesses:

1. Rely on U.S. Census data for Nassau County to assign the unidentified "commercial" businesses to particular economic sectors. This assumes the distribution of commercial activity county-wide is representative of RVC.
2. Rely on IMPLAN data to estimate total annual output and employment for affected facilities.
3. Assuming economic activity is evenly distributed across the year, calculate the contribution of a single day's activity at the affected facilities to annual output and employment.
4. Total loss of this contribution – i.e., a complete shutdown of affected facilities during a 1-day outage – is the "shock" modeled in IMPLAN.
5. Impacts of a total loss of economic activity during a 3, 5, or 7-day outage can be estimated by linearly scaling the results.

Economic Impacts of a 1-Day Outage, 100% Economic Activity Loss

Study Area (Nassau County):

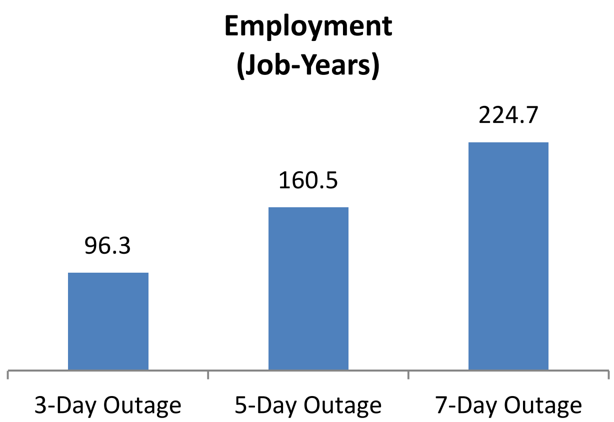
Impact Type	Average Annual Employment (Job-Years)	Labor Income	Total Value Added	Output
Direct Effect	18.5	$1,016,028	$1,801,497	$2,878,631
Indirect Effect	7.0	$416,186	$704,062	$1,188,481
Induced Effect	6.6	$354,718	$618,039	$965,535
Total Effect	**32.1**	**$1,786,932**	**$3,123,597**	**$5,032,647**

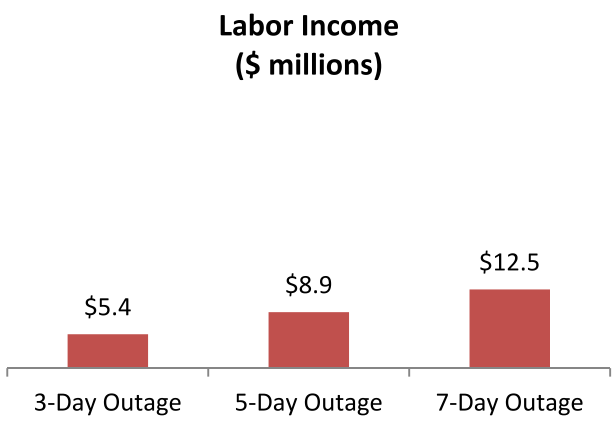
Rest of NY State:

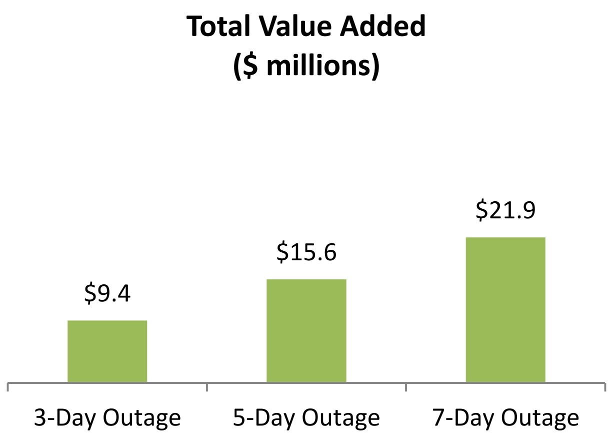
Impact Type	Average Annual Employment (Job-Years)	Labor Income	Total Value Added	Output
Direct Effect	0.0	$0	$0	$0
Indirect Effect	0.7	$66,929	$115,424	$198,470
Induced Effect	0.5	$32,837	$56,923	$94,020
Total Effect	**1.2**	**$99,766**	**$172,348**	**$292,490**

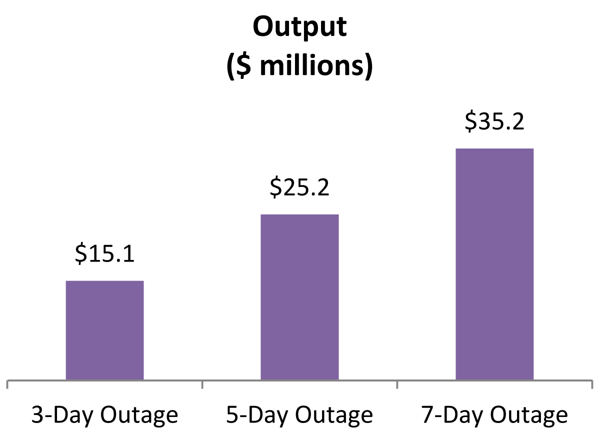
Scaled Results for Additional Outage Scenarios

Total impacts for 3, 5, and 7-day outages, assuming 100% economic activity loss:









Outage Scenario Modeling Options

- Do not have to assume 100% economic activity loss for the entire outage.
- A user can break up an outage into multiple "outage periods," with each period having a unique:

  Recovery Factor = % of all businesses with power.

  Resiliency Factor = % of normal economic output maintained by businesses without power OR % of lost economic output businesses can recover following the outage event.

- Each outage period can then be assigned an overall economic activity level.

  Overall Economic Activity Level = % Recovery + [% Resiliency * (1 - % Recovery)]

Overall Economic Activity Level

		Resiliency Factor										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Recovery Factor	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	10%	10%	19%	28%	37%	46%	55%	64%	73%	82%	91%	100%
	20%	20%	28%	36%	44%	52%	60%	68%	76%	84%	92%	100%
	30%	30%	37%	44%	51%	58%	65%	72%	79%	86%	93%	100%
	40%	40%	46%	52%	58%	64%	70%	76%	82%	88%	94%	100%
	50%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
	60%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%	100%
	70%	70%	73%	76%	79%	82%	85%	88%	91%	94%	97%	100%
	80%	80%	82%	84%	86%	88%	90%	92%	94%	96%	98%	100%
	90%	90%	91%	92%	93%	94%	95%	96%	97%	98%	99%	100%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Outage Scenario Modeling Options (Cont.)

- We have developed a spreadsheet tool that facilitates modeling of different outage scenarios.
- The tool calculates a **weighted average economic activity loss** based on the duration and overall economic activity level (EAL) for each outage period.

$$\text{Weighted Average Economic Activity Loss} = \Sigma\,[\text{Duration} * (1 - \%\ \text{EAL})]$$

Outage Period	Outage Duration (Days)	% Overall Economic Activity Level	% Recovery Factor	% Resiliency Factor
#1	3	0%	0%	0%
#2	2	50%	50%	0%
#3	2	63%	50%	25%
Total	**7**	--	--	--

4.75	Weighted Average Economic Activity Loss (Days)

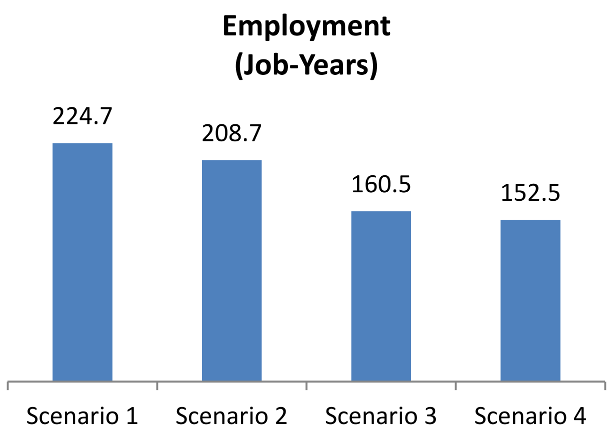
Scenario Results – Sensitivity Analysis

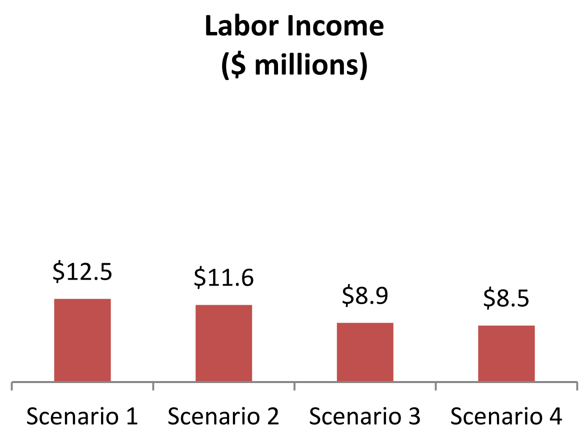
Sensitivity analysis for 7-day outage, assuming:

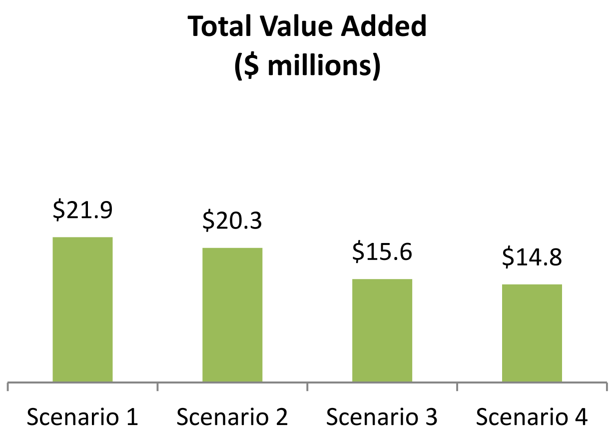
Outage Scenario	Weighted Average Economic Activity Loss (Days)	Description
Scenario 1	7.00	Assume 100% economic activity loss.
Scenario 2	6.50	Assume after five days, 25% resiliency factor.
Scenario 3	5.00	Assume after three days, 50% recovery factor.
Scenario 4	4.75	Assume after three days, 50% recovery factor; and after five days, 25% resiliency factor.

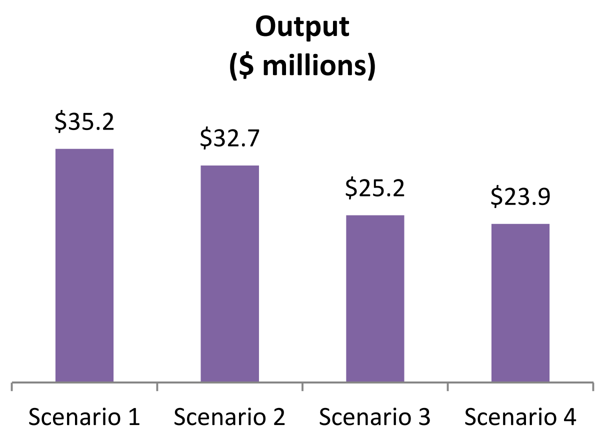
Scenario Results – Sensitivity Analysis (Cont.)

Total impacts for 7-day outage scenarios (study area):









Key Information Gaps and Limitations

- **Characterization of affected businesses:**
  - Analysis requires development of assumptions for assigning facilities and businesses to IMPLAN sectors.
  - Focus is on commercial and industrial business as opposed to government institutions and critical services (fire, police).
  - Analysis would be simplified and results more precise with data on NAICS codes for facilities served by the microgrid.
- **Assumptions regarding proportionality of losses:**
  - Approach assumes economic productivity for businesses is distributed evenly over time and that productivity losses are proportional to the duration of an outage.
  - Model can build in flexibility to integrate resiliency factors; however, data are limited to inform the assumptions for these factors.
- **Assumptions regarding efficacy of microgrid in avoiding outages:**
  - Case study assumes microgrid would avert outages and economic losses.
  - This is a general limitation of broader resiliency benefits assessments, but could be addressed by incorporating a "probability of failure" variable into the analysis.

Additional Information Provided through Economic Impact Analysis

Current Model	Proposed Economic Impact Analysis Approach
ICE Calculator Metric: • Economic value-based (social welfare) • Willingness to Pay (WTP)	**IMPLAN Metric:** • Economic activity-based • Measures of productivity (jobs, sales, income)
Values of critical service providers included (FEMA methods)	Critical service providers evaluated in terms of economic productivity
WTP to avoid 1-day outage (*519 commercial businesses + 5 non-EMS medical facilities*): • $9.7 million	Regional economic impact of a 1-day outage (*519 commercial businesses + 16 medical facilities*): • $5.0 million in total sales • $3.1 million in regional GDP • 32.1 average annual jobs

- Productivity metrics are not additive with WTP metrics; the economic impact analysis results are not intended as a substitute for the ICE calculator findings.
- Flows of dollars in markets and jobs are more limited indicators of value than WTP- don't reflect inconvenience factors and other losses or perceived losses associated with business closures.
- However, they are relatively straightforward metrics for the general public to understand.

Attachment B. Screenshots of Economic Impact Model for RVC

Attachment B. Screenshots of Economic Impact Model for RVC

One-Day Outage Scenario, 100% Economic Activity Loss

Outage Inputs:

**This outage inputs table allows a user to break up an outage into up to three periods, with each period having a different % overall economic activity level depending on % resiliency and % recovery factors.*

Outage Period	Outage Duration (Days)	% Overall Economic Activity Level	% Recovery Factor	% Resiliency Factor
#1	1	0%	0%	0%
#2	0	0%	0%	0%
#3	0	0%	0%	0%
Total	**1**	--	--	--

Overall Economic Activity Level = % Recovery + [% Resiliency * (1 - % Recovery)]
Recovery Factor = % of all businesses with power
Resiliency Factor = % level of productivity for businesses without power, OR
% level of productivity that businesses without power
can make up for following the outage event.

1.00 Weighted Average Economic Activity Loss (Days)

Outage Outputs:

Regional Economic Contribution to Nassau County: *(Study Area)*

Impact Type	Job-Years	Labor Income	Total Value Added	Output
Direct Effect	18.5	$1,016,028	$1,801,497	$2,878,631
Indirect Effect	7.0	$416,186	$704,062	$1,188,481
Induced Effect	6.6	$354,718	$618,039	$965,535
Total Effect	32.1	$1,786,932	$3,123,597	$5,032,647

Top Ten Sectors by Total Value Added for Study Area:

Sector	Job-Years	Labor Income	Total Value Added	Output
Real estate	3.8	$107,578	$419,185	$645,839
Wired telecommunications carriers	0.3	$80,792	$231,096	$303,658
Monetary authorities and depository credit intermediation	0.4	$30,680	$186,968	$220,248
Insurance agencies, brokerages, and related activities	1.2	$90,697	$158,923	$274,948
Legal services	0.9	$79,076	$154,487	$194,701
Insurance carriers	0.5	$42,334	$139,178	$241,139
Wholesale trade	0.5	$52,949	$93,479	$133,942
Owner-occupied dwellings	0.0	$0	$86,083	$132,707
Hospitals	0.6	$73,283	$83,696	$125,950
Management of companies and enterprises	0.6	$61,875	$75,714	$134,210

Regional Economic Contribution to the Rest of New York State: *(Rest of State)*

Impact Type	Job-Years	Labor Income	Total Value Added	Output
Direct Effect	0.0	$0	$0	$0
Indirect Effect	0.7	$66,929	$115,424	$198,470
Induced Effect	0.5	$32,837	$56,923	$94,020
Total Effect	1.2	$99,766	$172,348	$292,490

Seven-Day Outage Scenario, Incorporating Resiliency and Recovery Assumptions

Outage Inputs:

**This outage inputs table allows a user to break up an outage into up to three periods, with each period having a different % overall economic activity level depending on % resiliency and % recovery factors.*

Outage Period	Outage Duration (Days)	% Overall Economic Activity Level	% Recovery Factor	% Resiliency Factor
#1	3	0%	0%	0%
#2	2	50%	50%	0%
#3	2	63%	50%	25%
Total	**7**	--	--	--

Overall Economic Activity Level = % Recovery + [% Resiliency * (1 - % Recovery)]
Recovery Factor = % of all businesses with power
Resiliency Factor = % level of productivity for businesses without power, OR % level of productivity that businesses without power can make up for following the outage event.

4.75 Weighted Average Economic Activity Loss (Days)

Outage Outputs:

Regional Economic Contribution to Nassau County: *(Study Area)*

Impact Type	Job-Years	Labor Income	Total Value Added	Output
Direct Effect	87.9	$4,826,133	$8,557,111	$13,673,497
Indirect Effect	33.3	$1,976,884	$3,344,295	$5,645,285
Induced Effect	31.4	$1,684,911	$2,935,685	$4,586,291
Total Effect	152.5	$8,487,927	$14,837,086	$23,905,073

Top Ten Sectors by Total Value Added for Study Area:

Sector	Job-Years	Labor Income	Total Value Added	Output
Real estate	18.1	$510,996	$1,991,129	$3,067,735
Wired telecommunications carriers	1.4	$383,762	$1,097,706	$1,442,376
Monetary authorities and depository credit intermediation	1.9	$145,730	$888,098	$1,046,178
Insurance agencies, brokerages, and related activities	5.7	$430,811	$754,884	$1,306,003
Legal services	4.3	$375,611	$733,813	$924,830
Insurance carriers	2.4	$201,087	$661,096	$1,145,410
Wholesale trade	2.4	$251,508	$444,025	$636,225
Owner-occupied dwellings	0.0	$0	$408,894	$630,358
Hospitals	2.9	$348,094	$397,556	$598,263
Management of companies and enterprises	2.9	$293,906	$359,642	$637,498

Regional Economic Contribution to the Rest of New York State: *(Rest of State)*

Impact Type	Job-Years	Labor Income	Total Value Added	Output
Direct Effect	0.0	$0	$0	$0
Indirect Effect	3.3	$317,913	$548,264	$942,733
Induced Effect	2.4	$155,976	$270,384	$446,595
Total Effect	5.7	$473,889	$818,653	$1,389,328

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975.

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