An Evaluation of a Smart Grid Program

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ABSTRACT

The New York State Energy Research and Development Authority (NYSERDA)'s Smart Grid program promotes modernization of the state's electric grid by funding research and technology development projects that can be implemented at the utility scale. Since 2008, the Smart Grid program has provided $6 million in funding for grid modernization projects implemented by Central Hudson, a large electric utility. The funding supported a range of projects, including development of a microgrid to prevent outages at a facility providing care to children with critical health issues, and multiple phases of research and development related to grid automation and the integration of renewable resources. The purpose of the evaluation was to conduct a rigorous study of the impacts of Smart Grid funding on the utility's grid modernization efforts and develop findings that can benefit other utilities and similar programs.

The evaluation applied a mixed-methods design to quantify the key benefits that resulted from Central Hudson's and NYSERDA's funding of grid modernization improvements, including improved grid reliability, economic cost savings, and avoided CO_2 emissions. Total benefits of public funding for the utility's smart grid improvements, including economic, reliability and environmental benefits, were quantified to be approximately $77 million. After subtracting NYSERDA's $6 million investment, the net societal benefit of public funding is $71 million; for each $1 of public funding, the utility is expected to achieve approximately $12.83 in economic, reliability, and environmental benefits.

Introduction

NYSERDA's Smart Grid program promotes modernization of New York State's electric grid by funding research and technology development projects that can be implemented at the utility scale. Through these projects, the program aims to: increase grid efficiency by encouraging real-time data collection and management; reduce costs associated with integrating renewable energy sources; and improve the ability of the grid to predict, withstand and recover from power outages.

Examples of smart grid technologies include remote sensing devices for monitoring grid conditions in real-time, tools enabling two-way communication between a utility's operations center and various points on the grid, and automated controls for optimizing grid performance. These technologies and devices are relatively new and are evolving quickly.

Central Hudson Gas & Electric (Central Hudson) is one of New York State's seven electric utilities; its service territory includes the Mid-Hudson River Valley from north of New York City to Albany County. Since 2008, NYSERDA's Smart Grid program has funded eight Central Hudson grid modernization projects through a competitive solicitation process. Central Hudson received approximately $6 million from NYSERDA across the eight awards (Figure 1). NYSERDA funding supported a range of projects, including development of a microgrid to prevent outages in Denning, NY, and multiple phases of research and development related to grid automation and the integration of renewable resources. Specifically, Central Hudson received support for the development and demonstration of:

- Automated transmission and distribution management systems;
- Superconducting fault current limiters, which prevent problems associated with faults in power lines by detecting and rerouting power flow around the fault; and
- Sensors, smart inverters and other monitoring and power controls to aid the efficient integration of renewable energy resources into the power grid.

Four of the eight projects are completed, while the others, which relate to the integration and optimization of renewable energy, are ongoing. The evaluation focuses primarily on the four closed projects, but all eight projects provide a basis for the qualitative insights in the case study.

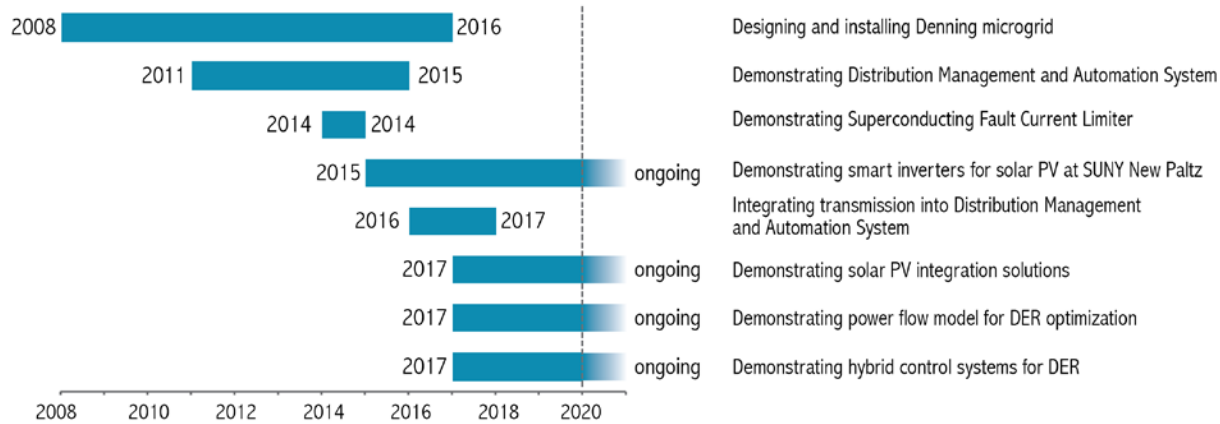

Figure 1. NYSERDA Smart Grid program awards to Central Hudson

This case study quantifies the key benefits that resulted from Central Hudson's and NYSERDA's funding for Central Hudson's grid modernization improvements, including improved grid reliability, economic cost savings, and avoided CO_2 emissions. Qualitative benefits related to knowledge sharing across utilities including Central Hudson, National Grid and Con Edison are noted but not quantified. Information for this case study was collected through interviews with Central Hudson, National Grid and Con Edison staff, review of NYSERDA's and Central Hudson's project materials, and supplementary research.

Methodology

Reliability for electric utilities is typically measured using two indices: (1) CAIDI, the Customer Average Interruption Duration Index, which represents the average outage duration that any customer would expect to experience over the course of a year; and (2) SAIFI, the System Average Interruption Frequency Index, which represents the average number of interruptions a customer would expect to experience in that year. Electric utilities across the country commonly track and report CAIDI and SAIFI to state public utility commissions. These metrics allow utilities and regulators to monitor reliability performance and take corrective actions when necessary to improve performance. Because reliability can be affected by weather and other elements beyond the control of the utility, CAIDI and SAIFI are reported in two ways: *including* or *excluding* the impacts of major storms. To better compare across utilities that are in different parts of the state and therefore experience different weather, this case study considers CAIDI and SAIFI *excluding* major storms.

The value of Central Hudson's improved reliability was estimated using the U.S. Department of Energy's (DOE) Interruption Cost Estimate (ICE) Calculator, an online tool designed to calculate the economic benefits associated with investments to improve grid reliability.[1] The ICE Calculator combines information the user provides on the characteristics of the electric grid being evaluated (e.g., state where the grid is located, number of residential and non-residential customers, and standard reliability metrics) with underlying estimates of the cost of service interruptions for different types of customers to calculate the value of avoiding power interruptions. The ICE Calculator was run with information on Central Hudson's customer base and two standard

[1] The ICE Calculator (https://icecalculator.com/home) is an electric reliability planning tool developed by Lawrence Berkeley National Laboratory and Nexant, Inc. This tool is designed for electric reliability planners at utilities, government organizations, and other entities that are interested in estimating interruption costs and/or the benefits associated with reliability improvements in the United States.

reliability metrics (SAIFI and CAIDI) for 2006 and 2017 to estimate the value of the improvements. The year 2006 was selected as the baseline year in order to estimate the holistic benefits of Central Hudson's investments in grid modernization, which began in the early 2000s, before NYSERDA's projects started. Because this case study examines the benefits of both the utility's own investments in grid modernization and NYSERDA's investments in Central Hudson's grid modernization efforts, the baseline year of 2006 was chosen to capture investments that Central Hudson made prior to the NYSERDA-funded projects. Given the time lag between initial efforts and the realization of benefits, NYSERDA program staff confirmed 2006 as an appropriate baseline. (As discussed below in the Results section, the analysis separately considers the portion of these benefits that can be attributed to the NYSERDA-funded projects.) The analysis considered the two measures, CAIDI and SAIFI, to estimate the benefits of reliability improvements to Central Hudson's grid.

The economic benefits of Central Hudson's planned investments in distribution automation were calculated using information from the utility's July 2014 rate case (Central Hudson 2014). In the rate case, costs are estimated at $46.3 million over the five-year financial planning period, with an additional $5 million to be incurred after that period. Because the rate case does not describe the distribution of these costs over time, two scenarios were considered: one in which costs are conservatively incurred in the first year of each period, and a second in which costs are evenly distributed over each period. Benefits result from reduced electricity generation ($5.9 million annually, or $29.5 million over five years) and two avoided capital projects ($2.7 million each annually, or $13.5 million each over the five-year planning period) summing to $11.3 million annually. Because it is not specified in the rate case, it is assumed that the equipment lifespan is 20 years, which would be reasonable for this type of capital investment, and the analysis extends the $5.9 million cost savings across a 20-year period. The discount rate was selected based on the overall weighted average cost of capital (WACC) for Central Hudson as identified in the utility's 2017 rate case. Central Hudson calculated its overall WACC as 6.99% in 2019, rising slightly to 7.07% in 2020 and 7.14% in 2021 (Central Hudson 2017). These values suggest that a discount rate of 7% is appropriate. However, to test the sensitivity of results to the discount rate used, a discount rate of 8% was also applied, which should provide a conservative estimate of net benefits (see the Results section).

To estimate avoided CO_2 emissions associated with reductions in energy consumption, a CO_2 emissions rate of 0.553 tons per MWh was used (NYS DPS 2018). Reductions in CO_2 emissions for the years 2019-2038 (corresponding to the assumed 20-year lifespan of grid modernization equipment) were valued using the social cost of carbon values calculated by the Interagency Working Group on Social Cost of Greenhouse Gases (2016). For each year, the Interagency Working Group estimates the social cost of carbon using three discount rates: 2.5%, 3% (central estimate), and 5% per year. This case study uses the central estimate, which has been adopted by New York State, and also shows the 2.5% estimate for illustrative purposes. The Interagency Working Group presents all values in 2007 dollars. These values were converted to 2019 dollars using the price deflators used with the Federal Reserve Economic Data (FRED) Consumer Price Index. The present value of the 20-year reduction in CO_2 emissions were then calculated. Regional Greenhouse Gas Initiative (RGGI) compliance costs were netted out to avoid double counting, using the methodology developed by the New York State Department of Public Service. CO_2 figures were converted to CO_2e using a conversion factor of 485.12 lbs-CO_2/MWh to 485.92 lbs-CO_2e/MWh.

Results

Central Hudson reported that its initial investments in smart grid prior to 2008 were motivated by reliability concerns within its service territory. Reliability in Central Hudson's service territory significantly improved between 2006 and 2016 as a result of NYSERDA's and Central Hudson's smart grid investments and smart grid technologies maturing, and Central Hudson's motivations to modernize its grid expanded to include providing cost savings and other benefits to customers and working towards New York State's renewable energy goals, which calls for greatly increasing the amount of renewable energy generation. Achieving these goals requires utilities to integrate smart grid monitoring and control technologies and tools in their operations.

The projects supported by NYSERDA funding helped Central Hudson to modernize its grid and achieve significantly greater efficiencies in grid operations. Following the NYSERDA-funded demonstration of a distribution management and automation system, Central Hudson invested in full-scale transmission and distribution automation. This technology allows Central Hudson to optimize the operation of its transmission and distribution systems – thus avoiding unnecessary generation, reducing fossil fuel consumption and emissions – and eliminate and/or defer costly capital upgrades. The Denning, NY microgrid has also demonstrably improved the reliability of electric service for customers in that area by reducing the number of outages. The specific benefits resulting from the NYSERDA-funded projects are discussed in the following sections.

Reliability Benefits

Reliability at Central Hudson has improved since its earliest grid modernization investments in the early 2000s, as reflected in improved standard reliability metrics including SAIFI and CAIDI. Reliability improvements continued with Central Hudson's first NYSERDA award in 2008, and the utility has continued to improve since then (Figure 2). Although Central Hudson still lags the other New York State utilities in standard reliability metrics, it has shown the most pronounced improvement over the last decade (Figure 3).

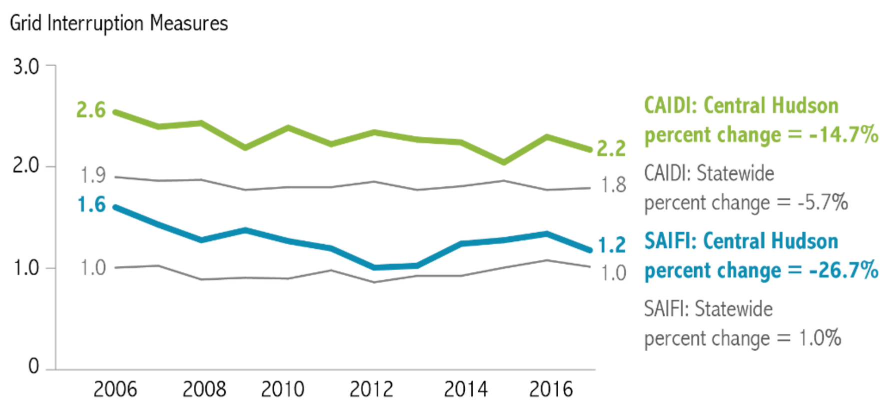

Figure 2. Reliability at Central Hudson compared to statewide average. Statewide averages are presented here excluding data from Con Edison, in order to highlight trends for utilities most similar to Central Hudson. *Source:* New York State Department of Public Service Electric Reliability Performance Reports 2006-2017.

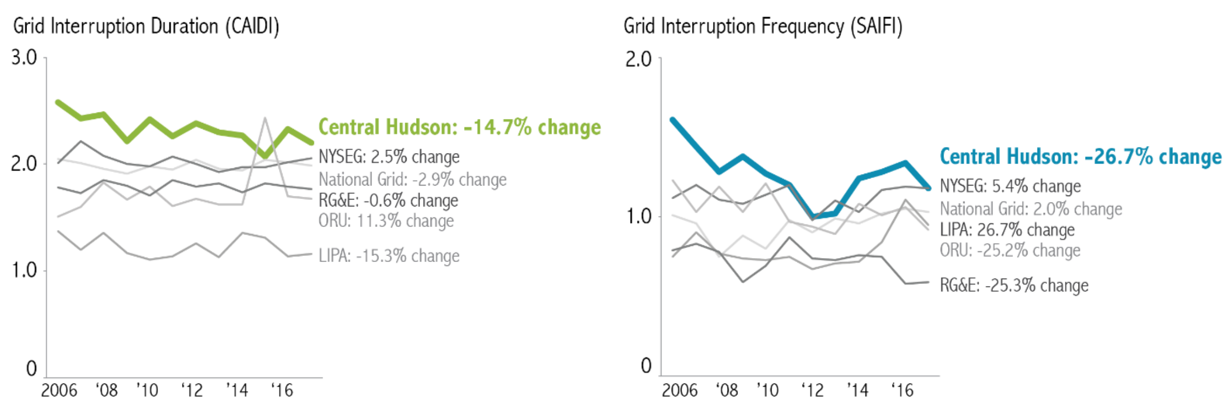

Figure 3. Reliability at Central Hudson compared to other utilities. *Source:* New York State Department of Public Service Electric Reliability Performance Reports 2006-2017.

The dollar value of reliability improvements is estimated using the ICE Calculator, an online tool that calculates the cost to different types of customers based on standard reliability metrics for a given electric utility. As shown in Table 1, the ICE Calculator estimates the value of reliability improvements in Central Hudson's service territory to be $19.4 million in benefits to customers between 2006 and 2017 (valued in 2019$). Reliability benefits may continue into the future, but future reliability benefits were not quantified for this study.

Table 1. Estimated value of avoided grid interruptions (measured in CAIDI and SAIFI)

Measuring Grid Reliability			
Grid Reliability Metric	2006	2017	Percent Change
SAIFI: Central Hudson (interruptions per customer)	1.61	1.18	-26.7%
SAIFI: Statewide (interruptions per customer)	1.00	1.01	1.0%
CAIDI: Central Hudson (hours)	2.58	2.20	-14.7%
CAIDI: Statewide (hours)	1.92	1.81	-5.7%
Economic Value of Grid Reliability Improvements			
Scenario	2006 Impact (2019$, millions)	2017 Impact (2019$, millions)	Change in Annual Impact (2019$, millions)
ICE Calculator Valuation	$79.1	$59.7	$19.4
100% Attribution			$19.4
61.2% Attribution (improvements beyond statewide average) Derivation: Percentage decrease in statewide CAIDI, 2006-2017: 5.7 Percentage decrease in Central Hudson CAIDI, 2006-2017: 14.7 Proportion of improvements that are beyond statewide average: 61.2% = 100 - (5.7 / 14.7)			$11.9
37.4% Attribution (10% reduction due to automation) Derivation: Percentage decrease in Central Hudson SAIFI, 2006-2017: 26.7 Percentage decrease in Central Hudson SAIFI due to automation: 10 Proportion of improvements that are due to automation: 37.4% = 10 / 26.7			$7.3

Source: Analysis based on New York State DPS Electric Reliability Performance Reports 2006-2017, and the U.S. DOE's ICE Calculator

The full value of this improvement is not attributable solely to Central Hudson's and NYSERDA's funding presented in this case study. Central Hudson first received funding from NYSERDA for smart grid investments in 2008, but reliability at Central Hudson began improving before that time. Additionally, reliability also improved between 2006 and 2017 at other New York State utilities and across the state as a whole, suggesting that some of Central Hudson's improvements may have been enabled by factors other than NYSERDA's support and may have occurred even in the absence of NYSERDA funding.

This case study attempts to isolate the impacts of NYSERDA's and Central Hudson's investments apart from what could have been expected to occur based on the statewide average improvements.

- Between 2006 and 2017, the statewide average change in CAIDI was -5.7%; SAIFI remained nearly constant.[2] This suggests that approximately 38.8% of Central Hudson's CAIDI improvement (-5.7% change statewide, divided by -14.7% change at Central Hudson) could have been explained by changes occurring statewide, in parallel with other utilities.
- The remaining 61.2% (100% minus 38.8%) could therefore represent improvements unique to Central Hudson.

[2] Statewide averages presented here exclude data from Con Edison, which operates a distribution network very different from that of other utilities, in order to highlight trends at utilities most similar to Central Hudson. The Department of Public Service commonly reports statewide averages both including and excluding Con Edison to enable these comparisons.

- Applying this 61.2% adjustment factor to the total benefits from the ICE Calculator, it is estimated that $11.9 million in avoided interruption costs could be attributable to Central Hudson's and NYSERDA's funding, beyond improvements that would have occurred otherwise.

Grid performance depends on many factors, making it challenging to attribute reliability improvements specific investments. However, Central Hudson estimates that its portfolio of investments in transmission and distribution automation have prevented outages for 10% of its customers each year. Assuming this reduction maps to a 10% reduction in SAIFI (a measure of outage frequency, rather than CAIDI, which is a measure of outage duration), the evaluation team compared Central Hudson's total reduction in SAIFI to this 10% figure to estimate the portion of reliability benefits that could be attributable to specific investments in transmission and distribution automation.

- Between 2006 and 2017, SAIFI at Central Hudson decreased by 26.7%. Because Central Hudson reports that its smart grid investments have prevented outages for 10% of its customers each year, 37.4% of the reduction can be attributed to investments in automation (-10% change due to automation, divided by -26.7% change overall).
- Applying this 37.4% adjustment factor to the total benefits from the ICE Calculator, it is estimated that $7.3 million in avoided interruption costs could be attributable to Central Hudson's and NYSERDA's investments in automation (Table 1, above).

The typical Central Hudson customer will experience an annual reduction in outage duration of about 45 minutes per year on average due to these smart grid investments.[3]

Central Hudson reported that NYSERDA played an important role in enabling Central Hudson's grid modernization efforts. According to Central Hudson, the greatest benefit of NYSERDA's funding was the support and encouragement to experiment with new tools and technologies that were not yet proven. By providing Central Hudson with the financial support to experiment, NYSERDA was able to minimize the utility's financial risk of innovating. Specifically, Central Hudson noted that NYSERDA's funding to demonstrate a distribution management system allowed the utility to gain confidence in the use of real-time analysis and to identify high-priority features for inclusion in the system that was ultimately selected. Central Hudson was able to develop expertise in real-time modeling and automation during the NYSERDA-funded demonstration project, and later went on to invest in full-scale transmission and distribution automation, which, as noted above, had a direct effect on grid reliability. Prior to receiving NYSERDA's first award in 2008, Central Hudson lagged other New York State utilities in reliability and has since narrowed that gap (Figures 2 and 3, above). Moreover, the investments that facilitated Central Hudson's "most-improved" status can be traced in large part to the new technologies and approaches that were first demonstrated and validated in the utility's NYSERDA-funded projects.

Economic Benefits

Central Hudson reported two examples of cost savings to the utility resulting from investments in smart grid improvements. The first example is a microgrid constructed with diesel generators in the remote town of Denning, NY, that cost Central Hudson $2 million to build (including NYSERDA's cost-share of $371,000); the investment avoided $3-4 million in expenditures that would have been required over a one-year period to provide the same level of reliability with conventional solutions (i.e., the construction of a new three-phase distribution line on an alternate route from the existing feed to the customer), resulting in net economic benefits of at least

[3] Calculated as the change in the index for SAIFI and CAIDI, adjusted for NYSERDA's attribution factor. For SAIFI, the calculation is 1.61 – [(1.61-1.18)*0.374] = 1.44918. For CAIDI, the calculation is 2.58 – [(2.58-2.20) *0.612] = 2.34744. Multiplying these values gives 3.4018631. (1.61*2.58) – 3.4018631 = 0.75 hour = 45 minutes.

$1 million.[4] Central Hudson reported this microgrid has been used 41 times since its installation in 2010, preventing more than 1,700 customer outages with an estimated total duration of 36,000 minutes (or 600 hours). This benefit is particularly significant because the microgrid serves a facility providing care to children with critical health issues.

A second example is the economic cost savings expected from Central Hudson's planned investments in distribution automation. Based on the investment summary included in Central Hudson's 2014 rate case, net benefits are estimated to be $40.7 million. The net benefits are calculated as the difference between investment costs incurred by Central Hudson for distribution automation and the economic cost savings resulting from those investments. Central Hudson's costs include $46.3 million in costs incurred over the five-year financial planning period of the rate case and $5.0 million in subsequent costs. Economic cost savings result from reduced energy consumption ($5.9 million annually) and two avoided capital upgrades ($2.7 million annually each over the five-year planning period), with the investment paying for itself within five years. This analysis assumes an equipment lifespan of 20 years and an economic discount rate of 7%, based on Central Hudson's overall weighted average cost of capital (Central Hudson 2017).[5] (Discounting is necessary to account for the time value of money – i.e., one dollar today is worth more than one dollar 20 years from now.) Figure 4 illustrates the accumulation of net benefits over time for Central Hudson's planned investments in distribution automation.

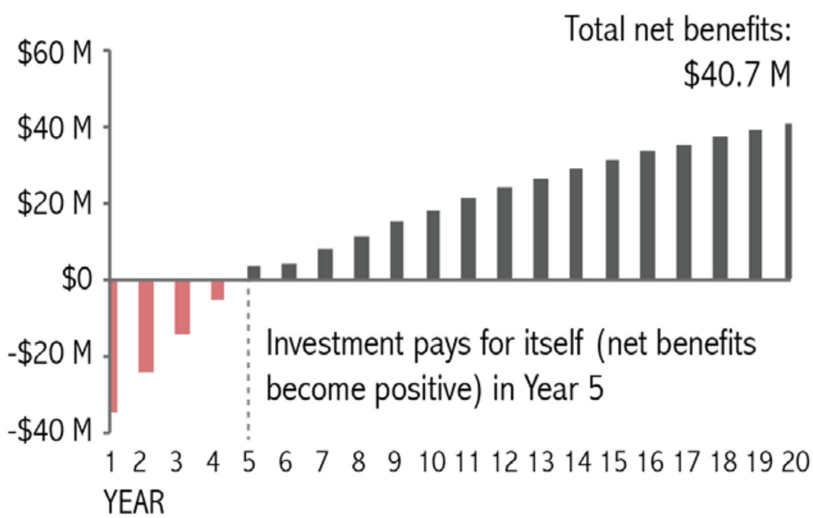

Figure 4. Economic benefits of Central Hudson's and NYSERDA's investments in distribution automation. *Source:* The analysis is based on the Central Hudson Rate Case 14-E-0318.

Adding the $40.7 million in net economic benefits from Central Hudson's planned investments in distribution automation to the $1 million in net economic benefits from the Denning microgrid project brings total estimated net economic benefits to $41.7 million.

Environmental Benefits

Investments in grid automation lead to emissions reductions through a process called Volt/VAR optimization, which reduces system losses and customer demand by lowering voltage to the minimum level

[4] The $1 million in net benefits is calculated as follows: $3-4 million in avoided expenditures minus $2 million to build the microgrid. Central Hudson's estimate of avoided expenditures is based on a preliminary estimate for constructing a redundant distribution feed on an alternate path to serve the customer. The range reflects that the estimate was preliminary without detailed engineering analysis and used rule of thumb costs per mile for distribution line construction. (Personal communication from Central Hudson, January 6, 2020.)

[5] A discount rate of 8% was also used to test the sensitivity of results to the discount rate. With an 8% discount rate, net benefits drop to $36.1 million.

demanded by customers in real-time and avoiding unnecessary generation and emissions. Without grid automation technologies that can monitor and adapt to changing conditions in real time, utilities are required to deliver power at higher voltages to ensure that unexpected changes, related to intermittent renewable power and other factors, do not reduce power quality for their customers. Emissions reductions associated with Volt/VAR optimization and corresponding avoided energy generation associated with investments in Central Hudson's distribution automation presented in Central Hudson's 2014 rate case were estimated using a marginal CO_2 emissions rate of 0.553 tons per MWh (NYS DPS 2018). The CO_2 emissions were subsequently converted to CO_2 equivalent (CO2e).[6]

Central Hudson estimates in its 2014 rate case an annual reduction in energy costs of $5.9 million associated with smart grid improvements. At an average cost of $0.08 per kWh, this translates to 73.8 million kWh of electricity avoided each year, and 1.5 million MWh avoided over 20 years. This reduction translates to 741,188 metric tons of CO_2e emissions avoided over 20 years,[7] which is equivalent to greenhouse gas emissions from approximately 160,000 passenger vehicles driven for one year (U.S. Environmental Protection Agency 2020).

Reductions in CO_2 emissions were valued using the social cost of carbon (SCC) – a measure of the value of the long-term societal damages resulting from emitting one ton of CO_2 in a given year. SCC is the standard method for valuing CO_2 emissions when the objective is to value societal benefits or costs associated with changes in CO_2 emissions. The U.S. Government Interagency Working Group on the Social Cost of Greenhouse Gases (Interagency Working Group) for 2019 estimated the SCC to be $50.55 per ton of CO_2 as their central estimate (using a 3% discount rate), and $75.21 per ton for 2019 as a higher estimate (using a 2.5% discount rate), both expressed in 2019$ (Interagency Working Group 2016). The SCC values escalate over time; the corresponding values in 2038 are $71.51 (central estimate, 3% discount rate) and $101.11 (2.5% discount rate). This case study uses the central SCC estimates for the years 2019-2038 in the calculations, but presents the higher estimate for sensitivity analysis.[8] Using the central estimates, the investment in Central Hudson's grid distribution automation would avoid $28.0 million in societal damages over 20 years, including economic, environmental, health, agriculture, and property damages among others (Table 2).

Table 2. Environmental benefits of distribution automation

Calculating Energy and Emissions Reductions		
Benefit	Value	
Annual reduction in energy consumption ($ millions)	$5.9	
Annual reduction in energy consumption (kWh, millions)	73.8	
20-year reduction in energy consumption (MWh, millions)	1.5	
Annual reduction in CO_2e emissions (metric tons)	37,059	
20-year reduction in CO_2e emissions (metric tons)	741,188	
Valuing Emissions Reductions		
Metric	Value	
	Central SCC	Higher SCC
Annual damages avoided, 2019 ($2019 millions, present value)	$1.9	$2.8
Annual damages avoided, 2019 – Net of RGGI ($2019 millions, present value)	$1.6	$2.5
20-year damages avoided – Net of RGGI ($2019 millions, present value)	$28.0	$45.4

Source: The analysis used social cost of carbon values from the August 2016 Technical Support Document of the U.S. Government Interagency Working Group on Social Cost of Greenhouse Gases.

[6] CO_2e is a common unit of measure for describing the global warming potential of different greenhouse gases. In New York State, average grid CO_2 emissions are 485.12 lbs-CO_2/MWh while average grid CO_2e emissions are slightly higher at 485.92 lbs-CO_2e/MWh. This conversion factor was used to convert CO_2 to CO_2e.

[7] Using the emissions factor cited above of 0.553 tons per MWh and the CO_2e conversion described above.

[8] The difference between the central estimate and higher estimate reflect the choice of social discount rate (3% and 2.5%, respectively).

The New York State Department of Public Service (DPS) advises that if the value of avoided CO_2 emissions is being summed together with the value of avoided electricity costs, it is important not to "double count" the projected RGGI compliance costs that are included in wholesale electricity price forecasts. Table 2 reports avoided environmental damages of $28.0 million over 20 years after RGGI compliance costs are subtracted.

Total Benefits of NYSERDA Funding for Central Hudson's Smart Grid Improvements

Economic, reliability, and environmental benefits presented in the previous sections are used to calculate total societal benefits, and these benefits are compared to NYSERDA's $6 million funding.

Total benefits of investments in Central Hudson's smart grid include the following:

- Economic cost savings: $41.7 million (includes $40.7 million in economic benefits of investments in distribution automation plus $1 million in net economic benefits from avoided capital expenditures associated with the Denning microgrid);
- Reliability benefits: $7.3 million; and
- Environmental benefits: $28.0 million over 20 years (using the central SCC value, net of RGGI).

Together, the economic, reliability, and environmental benefits represent $77.0 million in total benefits. After subtracting NYSERDA's $6 million in awards, the net societal benefit of NYSERDA's funding is $71.0 million (Figure 5). That is, for each $1 of NYSERDA funding, Central Hudson is expected to achieve approximately $12.83 in economic, reliability, and environmental benefits.

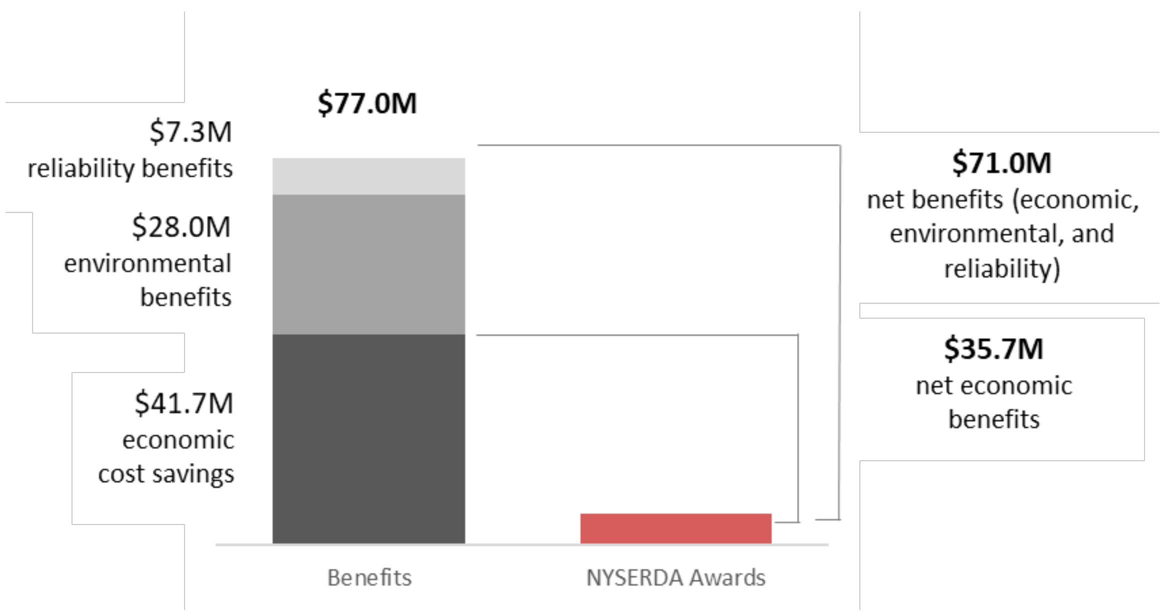

Figure 5. Summary of net benefits

Replications of Smart Grid Improvements Following Central Hudson's Example

The technologies demonstrated with NYSERDA awards were reported to have influenced future investments by Central Hudson and replications by other New York State utilities.

The first such replication was Central Hudson's own approach to improving reliability with microgrids. Based on the success of the Denning, NY, microgrid that Central Hudson developed with NYSERDA's support, Central Hudson now views microgrids as a practical method of boosting reliability in remote locations. Central Hudson and community partners identified four additional locations for potential microgrids that they proposed under NYSERDA's NY Prize microgrid design competition (NYSERDA 2020a) All four proposals were funded for feasibility studies in Stage 1, but did not progress to project design in Stage 2 (NYSERDA 2020b).

Central Hudson reported that it strives to be a leader in grid modernization among New York utilities and regularly shares the results of its experiences with other utilities. Con Edison and National Grid have learned from and adopted some elements of Central Hudson's smart grid strategy. For example, National Grid emulated Central Hudson's approach to grid communications (i.e., data sharing and/or remote control between a utility's operations center and various points on the grid) and load forecasting (i.e., modeling expected patterns in customer electricity demand) in its own efforts to roll out a distribution automation system.

Con Edison reported that Central Hudson set the standard for integrating Geographic Information Systems (GIS) into utility operations and enabling a deeper and more accurate understanding of how well the grid is functioning at specific locations. This improves utilities' ability to respond to issues and manage the integration of renewable energy in real-time. For example, GIS-enabled devices such as smart meters allow utilities to diagnose problems remotely without relying on customer reports or field examination by a utility technician. Con Edison is in the process of implementing its own enterprise-wide GIS, which it expects to complete by 2024. Con Edison has also deployed an online data portal for renewable energy developers that is the same as the tool used by Central Hudson.

Although differences in utility service territories and legacy equipment mean that every utility will ultimately need to develop a customized approach to smart grid development, both National Grid and Con Edison indicated that Central Hudson's efforts have inspired and informed their own grid modernization decisions and investments. All three utilities noted that the ability to share knowledge and learn from each other's approaches is facilitated in part by NYSERDA's support. All three utilities consider NYSERDA's facilitation of knowledge sharing as particularly important in keeping abreast of the quickly evolving technology and policy landscapes of grid modernization.

Conclusions

This case study quantified key benefits associated with Central Hudson's grid modernization improvements, including improved grid reliability, economic cost savings, and avoided CO_2 emissions. NYSERDA's support and funding allowed Central Hudson to demonstrate an automated distribution management system and gain confidence with real-time modeling and automation, thereby reducing technology risk and leading to Central Hudson's investment in full-scale transmission and distribution automation. This has resulted in significant reliability improvements, economic cost savings, and emission reductions in Central Hudson's service territory. The knowledge created through Central Hudson's projects has also influenced grid modernization investments by other New York State utilities.

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