Proposed Smart City
REV Demonstration Project
City of Schenectady

Case 14-M-0101
Reforming the Energy Vision

Niagara Mohawk Power Corporation d/b/a National Grid

March 26, 2018

Contents

Executive Summary

Communities across the country are developing smart-city[1] plans to more efficiently deliver existing services, expand the breadth of offerings available for residents, and reduce energy consumption. In New York, for example, the City of Schenectady (the "City" or "Schenectady"), led by Mayor Gary McCarthy, announced "the appointment of a Mayoral Smart City commission to take advantage of new technology for the superior delivery of government services and improved quality of life."[2] Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid" or the "Company") has partnered with the City to further those smart-city efforts by proposing this Reforming the Energy Vision ("REV") demonstration project (this "Project"). Together, the City and the Company will deploy and evaluate an advanced street lighting platform, which, as illustrated in Figure 1, will animate the market for smart-city technologies and services.

The Company and the City will implement this Project using a phased approach over three years involving approximately 4,275 street lights throughout Schenectady. Phase One includes the installation of LED street lights, network lighting control ("NLC") nodes,[3] and a primary Internet of Things ("IoT") network utilizing a Low-Power Wireless Personal Area Network ("6LoWPAN"), or comparable IEEE 802.15.4 network, in two zones of the City. The 6LoWPAN communication protocol is designed to establish a mesh network for remotely controlling LED street lights, while also laying the foundation for communicating with advanced meters and sending signals to smart-energy devices. The Company will also use Phase One to develop a detailed installation and commissioning process for the platform.

In Phase Two, the Company will install LED street lights, NLC nodes, and the 6LoWPAN/IoT network in the remaining zones. The Company will also evaluate the equipment installed in Phase One, testing its functionality, interoperability, and ability to deliver energy savings. During this phase, the Company with the support of project partners, AT&T-GE-Intel and CIMCON-CISCO-Itron-Presidio, will also install smart-city sensor nodes[4] and attachments. In addition, the City may separately deploy and own a broadband network capable of supporting devices that demand high bandwidth, like video cameras, sound detectors, and public Wi-Fi. National Grid will facilitate the City's broadband deployment by developing a standardized attachment agreement and electric service agreement. This approach will allow the City and the Company to test both a scalable customer-owned smart-city broadband business model and a Company-owned smart-city tariff business model.

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[1] *See* Nam, Taewoo & Pardo, Theresa, Center for Technology in Government, University at Albany, State University of New York, *Conceptualizing Smart City with Dimensions of Technology, People, and Institutions* (2011), p. 284 (Defining smart city, including the ability to use sensors and meters to capture, communicate, analyze, and use real-world data to improve city services.).

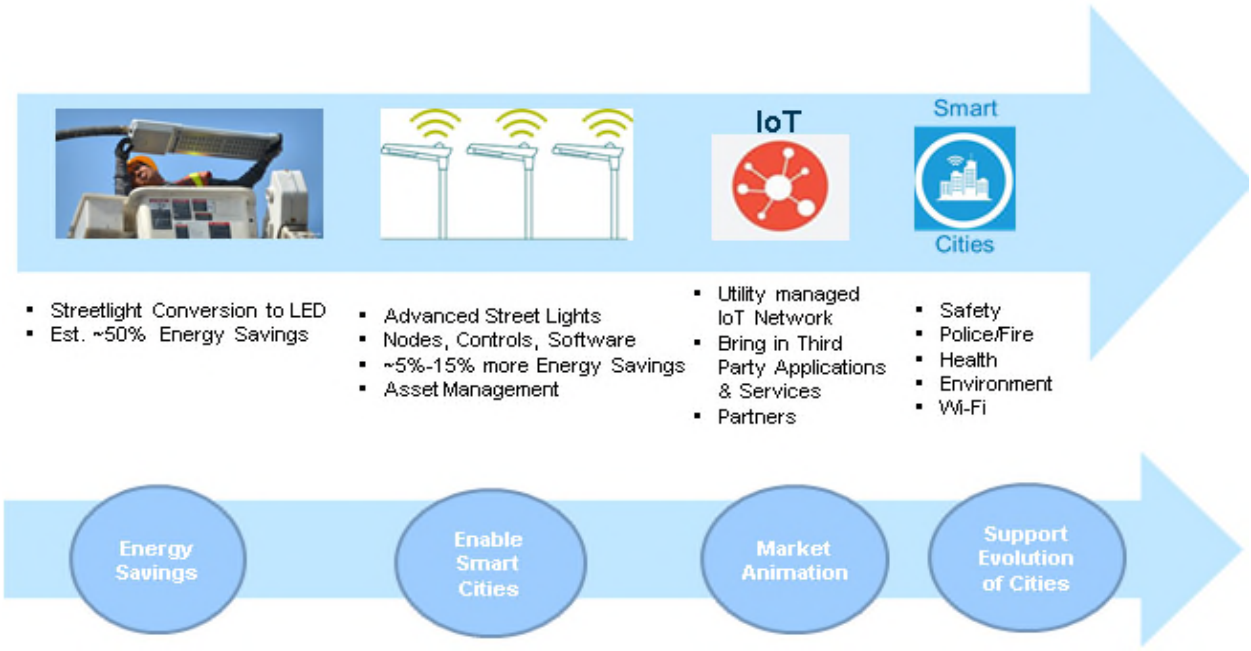
[2] City of Schenectady, Statement on the Smart City Advisory Commission available at http://www.cityofschenectady.com/335/Smart-City-Advisory-Commission.

[3] A lighting control node replaces a standard photocell node, and includes energy metering, monitoring, control, and data communications technology for external use.

[4] A smart-city sensor node includes energy metering for equipment other than the LED with integral sensors, such as environmental, position, or digital imaging sensors, as well as analytic software and communication technology.

In Phase Three, the Company and the City will expand the deployment of the advanced LED street lighting platform and smart-city devices, while also testing new business models and pricing options. Furthermore, the Company will offer additional third parties secure access to the 6LoWPAN/IoT mesh network for purposes of developing smart-city solutions. Through these efforts, the Company and its partners will gain valuable technical experience, testing lighting capabilities, customer usage, and energy measurements. If successful, the Company expects to propose new tariff offerings and platform services revenues ("PSRs")[5] enabling municipal adoption of advanced street lighting and smart-city technologies across National Grid's New York service territory.

Figure 1: Path to Animating the Smart City Market



Business Model Overview

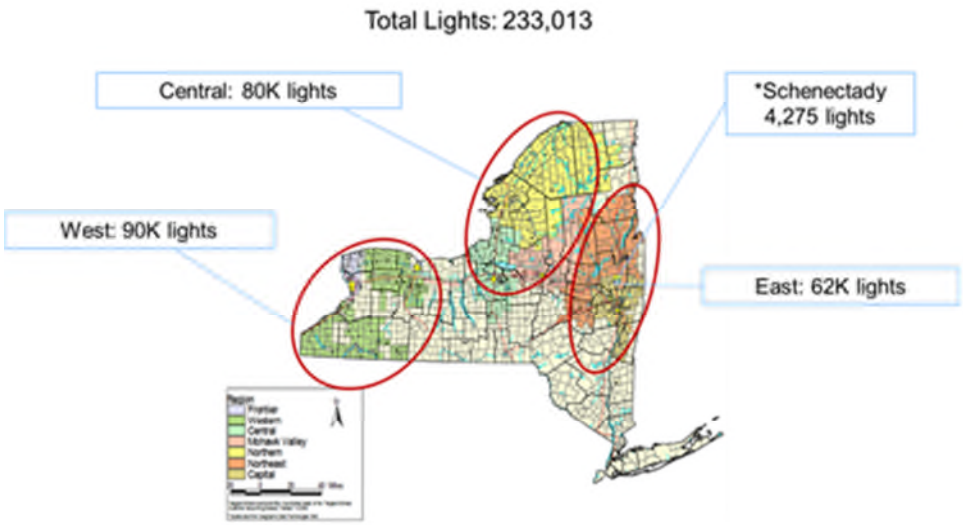
Market Opportunity

Schenectady, like other municipalities, is seeking new ways to cut costs, save energy, reduce carbon emissions, increase efficiencies, and expand the type of services it can provide for residents. One approach municipalities have considered to address these challenges is the deployment of various smart-city technologies and services. For such an approach to work, municipalities need a platform that can support the communications network necessary to run the technology. What's more, the platform must stretch across the entire municipal footprint.

[5] *See* Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, *Order Adopting a Ratemaking and Utility Revenue Model Policy Framework* (issued May 19, 2016) ("Track Two Order"), pp. 42-43 ("Staff stated that PSRs are particularly appropriate for demonstration projects, to provide experience to inform their design, and to help refine standards.").

This Project aims to test whether the Company's street lighting infrastructure can serve as such a smart-city platform.[6] It will include an analysis of the operational capabilities of the IoT network, LED lights, smart-city attachments, and the business models that may foster innovation and animate the smart-city market. As shown in Figure 2, if successful, the Company believes the more than 200,000 street lights that span its service territory could serve as the platform for the widespread adoption of smart-city technology.

Figure 2: National Grid Upstate New York Street Lighting Map



Challenges/Barriers

In the emerging smart-city market, three barriers appear to inhibit innovation and growth: operational capabilities, market uncertainty, and regulatory constraints.[7] This Project is designed to test solutions for overcoming each of the barriers.

1) **Operational Capabilities:** The IoT network and associated 6LoWPAN communications protocol, as well as the smart-city technologies contemplated in this Project are relatively new and unproven. They require technical expertise to operate, as well as field testing to understand any challenges that may arise during deployment. Furthermore, different manufacturers offer technology with different capabilities. It is unclear whether the varied systems can function together in one network. Finally, the Company needs to evaluate, measure, and verify that the chip-meters included in the NLC nodes and smart-city sensor nodes meet industry standards for accurate metering.

[6] This Project differs from similar initiatives in cities like San Diego and Atlanta, where local governments installed thousands of LED street lights and sensors to optimize parking, reduce congestion, enhance public safety, and cut energy costs. Unlike those projects, the Company and the City have partnered with AT&T-GE-Intel and CIMCON-CISCO-Itron-Presidio to test the functionality and interoperability of different technologies. The Company will also evaluate different business models and tariff offerings that could reduce costs and facilitate large-scale deployment of smart-city technologies.

[7] *See also* Black & Veatch, *Smart City/Smart Utility Report* (2017), pp. 14-16 ("Primary barriers inhibiting wide adoption of smart city systems grew in the year since Black & Veatch last surveyed cities, utilities and other stakeholders. Budget constraints, a lack of resources and expertise, and policy hurdles kept their top three positions as the tallest hurdles for organizations….").

2) **Market Uncertainty:** Smart-city market uncertainty creates two issues for municipalities. First, it limits the ability to attract funding and co-investment to pay upfront costs. Second, the lack of proper market signals limits innovation by third-party vendors, reducing partnership opportunities among municipalities, utilities, vendors, and community stakeholders that would otherwise be present in an animated market.

3) **Regulatory Constraints:** National Grid's current Lighting Tariff[8] does not include an offering for advanced street lights or a standardized attachment agreement. While municipalities could execute a license agreement with the Company that would allow attachments in some circumstances, those agreements require time consuming negotiations that may not properly reflect the full array of smart-city benefits. For example, the Lighting Tariff does not include a metered street light service classification that would allow municipalities to benefit from the enhanced functionality created by an advanced LED street light system. Likewise, the Lighting Tariff does not include a standard attachment fee or facility charge for NLC nodes or smart-city sensor nodes.

Proposed Solution

This Project seeks to use a phased approach to demonstrate options for overcoming the barriers to municipal adoption of smart-city technology. By evaluating the functionality and interoperability of the 6LoWPAN/IoT mesh network, smart-city technologies, and business models, the Company believes it can animate the smart-city market and meet municipal demands for this new technology. Specifically, the Company anticipates this Project will:

1) **Operational Capabilities:** Allow the Company and the City to understand the operational capabilities of the technology. This includes the type of smart-city applications the platform can support, the functional capabilities, and whether technologies from different manufacturers can coexist. In addition, National Grid believes it can use the 6LoWPAN/IoT mesh network to enhance its lighting service with advanced capabilities such as remote operations and energy-use monitoring.

2) **Market Uncertainty:** Lower investment costs and animate the smart-city market by enabling municipalities to realize energy savings from enhanced lighting controls (*e.g.*, dimming) and further empower them to invest those savings in new smart-city technologies. By animating the market, the Company also anticipates costs will come down and third-party vendors will be more inclined to pursue co-investment partnerships.

3) **Regulatory Constraints:** Lead to Lighting Tariff offerings, including facility charges and standardized attachment agreements, as well as PSRs, that could further help to address market uncertainty. For example, a metered street light service classification could assist municipalities in capturing additional energy savings from the advanced LED street light system. Likewise, a facility charge for the NLC nodes and smart-city sensor nodes, similar to existing luminaire facility charges, may reduce upfront costs. PSRs could also be developed to encourage further market innovation and animation.

[8] P.S.C. No. 214 – Outdoor Lighting Tariff ("Lighting Tariff").

Project Phases

As shown in the table below, this Project will proceed in phases, which may overlap. The Company further expects this Project to provide benefits beyond its three-year term.

Phase	Description
1 (10-12 months)	• Convert street lights in zones 1 and 2 to LED; • Install NLC nodes in zones 1 and 2; • Install secondary meters in zones 1 and 2; and • Install 6LoWPAN/IoT mesh network.
2 (12-14 months)	• Convert street lights in zones 3 and 4 to LED; • Install NLC nodes in zones 3 and 4; • Install Company-owned smart-city nodes and attachments; and • Install secondary meters in zones 3 and 4.
3 (12-18 months)	• Provide third-party access to 6LoWPAN/IoT mesh network.
1-3 (At City's Discretion)	• City deploys broadband network and smart-city attachments where required network infrastructure is installed.

Three Different Business Models

Business Model 1: Enhancing Company-Owned Infrastructure

The Company will install and own LED luminaires and NLC nodes on roadway street lights throughout the City. With this infrastructure, the Company will test the ability for the nodes to communicate over the 6LoWPAN/IoT mesh network, enable additional lighting functionality, enhance connectivity, and provide cost savings. The Company will also evaluate whether the network could support new technologies, such as advanced metering infrastructure ("AMI"). Based on the outcome of these tests, the Company will craft a lighting-controls tariff offering that provides customers the ability to remotely operate Company-owned LED street lights.

Business Model 2: Hybrid Company and Smart-City Vendor Shared Infrastructure

As shown in Figure 3 below, the Company will install a sample of smart-city sensor nodes on street light infrastructure that will communicate over the 6LoWPAN-enabled IoT network. These devices will allow the Company, along with third-party vendors, to test hybrid business models that offer ownership and network access options. The Company also intends to test third-party services as follows:

- The Company will provide network-only access to the City. Third-party vendors will install and maintain the hardware and provide software services to customers. This may include a sample of smart water meters, smart dumpsters, and vacant home sensors. The Company may introduce additional IoT devices based on market readiness and customer preferences during this Project. The data generated by the sensors will follow governance procedures established by the City, which will address data ownership, sharing, processing, presentment, analytics, disclosure, and protection requirements.

- The Company will also purchase a sample of smart-city attachments, such as environmental or parking sensors, enabling it to test a business model where the Company owns the hardware, the communications network, and the sensor data. As part

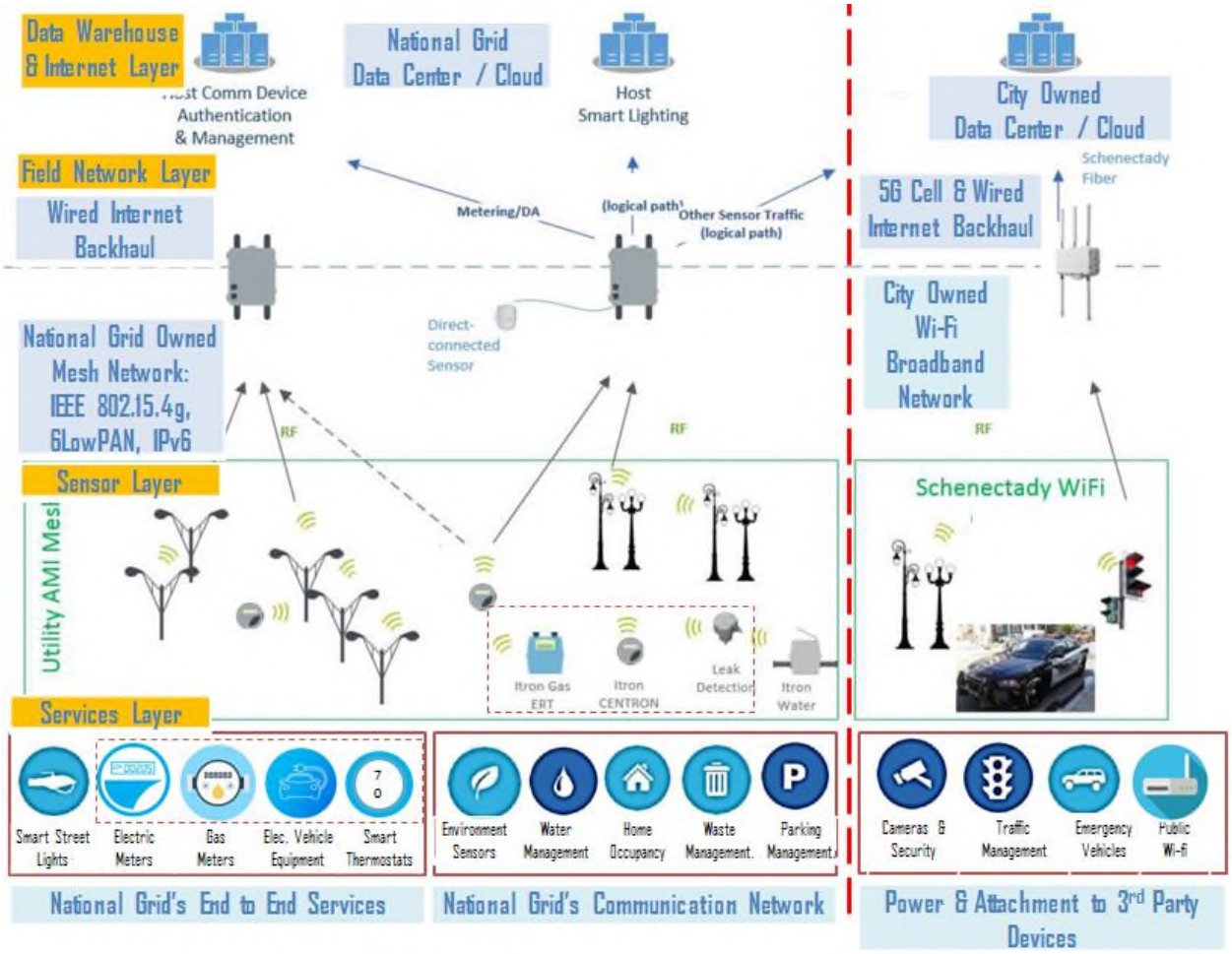
of this model, third-parties can purchase the sensor data in order to offer software services to customers.

With the findings of these test scenarios, the Company can develop two tariff offerings. The first, a smart-city tariff provision, could facilitate customer use of Company-owned smart-city attachments. The second would focus on expanding the smart-city provisions to enable third-party access to the 6LoWPAN-enabled IoT network.

Business Model 3: Support City-Owned Smart-City Infrastructure

The Company will support Schenectady's deployment of broadband infrastructure attached to Company-owned street light poles through the development of a standardized attachment agreement and an energy services agreement. The City-owned broadband network will be fully managed by the City and its telecommunications partners; electric service to the broadband attachments will be provided by the Company. Moreover, the cybersecurity, network performance, and maintenance responsibilities for the broadband system will be borne by the City and its partners. The broadband network is anticipated to carry public safety services like video imaging, sound detection, traffic management, and additional data analytics. The Company will not influence or access the data, or maintain the broadband network.

Figure 3: Illustration of Sensors and Services that Could Leverage the 6LoWPAN-Enabled IoT and City-Owned Broadband Network



Hypotheses to be Tested/Questions to be Answered

This Project will test whether National Grid, by offering software-enabled NLC nodes and/or smart-city sensor nodes on its LED street lighting platform, can facilitate the adoption of smart-city technology, animate the market for third parties to develop and provide smart-city services, and enhance street lighting functionality. With this proposal, the Company believes it can bridge the technological divide from its existing Lighting Tariff to the advanced smart-city capabilities municipalities are seeking to deploy. This Project will also help the Company determine what type of tariff offerings (*e.g.*, metered street lighting, standardized attachment agreements, intelligent node facility charges, or PSRs) and business models will motivate municipalities to adopt smart-city technology.

To test this hypothesis, this Project will demonstrate if National Grid develops an advanced LED street light platform offering capable of hosting smart-city technology and services, then:

- The Company will be able to provide customers enhanced lighting services (*e.g.*, dimming, advanced photometric controls, occupancy sensors, etc.) to increase LED street light energy savings by an estimated 5 to 15 percent.

- The Company can offer smart-city technology and attachments as a service.
- The new tariff offerings will facilitate the cost-effective deployment of smart-city technologies in municipalities across the Company's service territory.
- A Company-owned IoT network supported by the 6LoWPAN communications protocol can reduce barriers to entry for third-party IoT technologies.

This Project also seeks to answer the following questions:

- What are the benefits and costs of installing an advanced LED street lighting platform and what are municipalities willing to pay for the platform service?
- Can customers achieve further energy savings by utilizing advanced LED street lighting technology and a 6LoWPAN-enabled IoT network to control street lights?
- What business models can be introduced to animate the smart-city services market?
- Are smart-city attachments capable of operating across networks and do they function well with the Company's proposed platform technology?
- Can multiple parties (*i.e.*, municipalities, the Company, and/or third-party vendors), install multiple smart attachments on the same poles?
- Are municipalities interested in adopting an advanced LED street lighting platform that will enable smart-city technology and services?
- What are the opportunities and challenges in deploying a citywide communications network that is connected to the Company's existing data and billing platforms?

Approach

The Company and the City will use a phased approach to install approximately 4,275 LED luminaires, NLC nodes, smart-city sensor nodes, an IoT network using a 6LoWPAN communications protocol, and smart-city attachments across four zones (*see* Figure 4) throughout Schenectady. The City will also install and own a broadband network and additional attachments that require extra bandwidth to function. The Company will evaluate the functionality of the equipment, as well as the following potential revenue streams:

1. **NLC nodes:** National Grid will own the NLC nodes, which include chip-metering and lighting control components. The NLC nodes will allow the Company to test the functionality and accuracy of the node's metering components, as well as its ability to enable remote lighting adjustments (*e.g.*, dimming). National Grid will provide the City a bill credit for the net difference of the energy used as reported by the NLC node and the energy used as calculated under the Lighting Tariff. The Company will also test a facility charge for the nodes.

2. **6LoWPAN/IoT network:** The Company will own the 6LoWPAN-enabled IoT mesh network hardware and software required to provide access to data from the smart-city sensor nodes and attachments. The network will be deployed with the installation of the NLC nodes. The City will access the network through a secure portal, allowing remote operation of the LED street lights. The Company intends to recover 33 percent of the cost of the network from the City during year three of this Project.

3. **Smart-city sensor node:** The Company will own the smart-city sensor nodes that collect data from smart-city attachments. The nodes also meter energy used by the

street light pole attachments that are connected to it. The Company will test a business model where it licenses smart-city sensor nodes to the City after the City-owned broadband network is installed. The smart-city sensor nodes will allow the City to connect City-owned high bandwidth attachments that would operate over a broadband network.

4. **Additional smart-city attachments:** The Company will own a sample of smart-city attachments that operate on the 6LoWPAN/IoT mesh network. This sample will allow the Company to test a business model where it licenses the smart-city attachments to Schenectady. The Company plans to recover 20 percent of the cost of the smart-city attachments from the City during the third year of this Project.

5. **City-owned broadband:** The Company will support City installation of a high bandwidth broadband communication network using cellular and Wi-Fi technologies. The Company will use this Project to evaluate a standardized attachment agreement and energy services agreement that will facilitate this type of installation.

Scope

This Project is designed for citywide deployment throughout Schenectady. To test the technology and incorporate lessons learned, the Company and the City will divide the City into four zones (*see* Figure 4) and use a three-phased approach to install the LED luminaires, NLC nodes, smart-city sensor nodes, smart-city attachments, as well as broadband infrastructure. By initially focusing on two zones, the Company and the City will learn methods and best practices for installing and operating the new technology. Using the lessons from the first two zones, the Company will refine its approach and develop installation and commissioning procedures for deployment in the remaining zones.

Cybersecurity

The Company selected the 6LoWPAN network protocol for the primary wide-area network due to the built in advanced cybersecurity features. Each device will have its own unique network identification and the associated information packets will be encrypted from the sensor level or device level in AES128 Bit standard – the highest available standard for IoT communications. The protocol also incorporates efficient certificate management to authenticate each data packet. The Company will monitor and manage end-to-end security for the 6LoWPAN/IoT network and will create separate secure channels for different classes of sensors and devices. Furthermore, the network will not be opened for consumer-grade devices like cell phones or computers. The secondary broadband network for supporting consumer-grade devices will be implemented and managed by Schenectady and its telecommunication partners. National Grid will not be responsible for the secondary network other than providing power and attachment space on the existing street light infrastructure.

REV Project Principles Addressed

This Project supports the Commission's REV core objectives, as set forth in the Track One Order, particularly those objectives tied to enhanced customer knowledge and tools that support

effective management of energy bills, market animation, and carbon reductions.[9] The Company also anticipates this Project will meet the following REV demonstration project criteria:

3rd party partners	New Utility Business Model	Customer-Community Engagement	Identify Economic Value	Pricing and Rate Design	Transactive Grid	Scalability	Market Rules and Standards	Cost Effective	Timeframe
√	√	√	√	√	√	√	√	√	√

Specifically, this Project touches upon the following REV demonstration project principles:[10]

Partnership between utility and third-party vendors.

The City, the Company, and third-party vendor-partners AT&T-GE-Intel and CIMCON-CISCO-Itron-Presidio will contribute to planning, investment, and deployment of the advanced LED street light platform and smart-city technology. Together they will consider NLC node and smart-city sensor node capabilities, as well as software and hardware functionality that will be used to establish the advanced LED street light platform. In addition, the partners will evaluate various smart-city services and devices.

Identify questions to answer or problems on the grid and the market should respond with solutions.

The Company is seeking to bridge the current divide between its existing Lighting Tariff and the smart-city services many municipalities are looking to provide. National Grid believes it can overcome initial barriers by understanding the operational capabilities and business models that will enable it to offer municipal customers an advanced LED street lighting platform on which they can deploy smart-city technologies. With this innovative approach, the Company believes it can animate the smart-city market.

Delineate how the generated economic value is divided between the customer, utility, and third-party vendors.

The economic value of this Project will be divided as follows:

Customers:

- Energy savings from converting to LED street lights with added functionality;
- NLC nodes give greater insight into street light system status allowing for advanced asset management and remote functionality that can further reduce energy use;
- Administrative cost reductions from more efficient delivery of municipal services; and
- Potential partnerships to deliver expanded smart-city services to residents.

[9] Case 14-M-0101, *Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision*, ("REV Proceeding"), "Order Adopting Regulatory Policy Framework and Implementation Plan" ("Track One Order") (February 26, 2015), p. 4.
[10] *See id.*, p. 115 – 117, Appendix D.

Company:

- The Company will seek to recover the capital and operation and maintenance cost of the hardware (*e.g.*, nodes) and software required to enable the advanced LED street light platform[11] and its supporting systems including, network hosting fees, development, and integration of the software platform.
- If successful, the Company is likely to propose:
  - A facility charge for NLC nodes and smart-city sensor nodes and attachments;
  - Metered lighting service allowing customers to realize additional savings; and
  - A standardized attachment agreement for street lighting infrastructure.
- In addition, the Company may see new revenue opportunities from:
  - Providing new platform services to municipalities; or
  - Origination fees with third-party vendors seeking to provide smart-city services.[12]

Third-Party Vendors:

- Revenue for the software platform that connects the nodes;
- Opportunity to develop and sell new, innovative smart-city technologies;
- Leveraging participation/contribution in this Project for future collaborations; and
- Reduced cost and deployment time at scale using the Company's network.

Propose rules to create subsequently competitive markets and establish regulatory proposals to ensure safety, reliability, and consumer protection.

The Company will evaluate the functionality and interoperability of the attachments, as well as whether those attachments interfere with the safe and reliable delivery of electricity. In addition, the Company will work with the City and third-party vendors to understand how different business models may facilitate a market for smart-city technologies and services.

Inform pricing and rate design modifications.

Currently, no revenue model exists for NLC nodes or smart-city sensor nodes and the associated software. The Company will use this Project to develop and test an applicable revenue model for advanced LED street light platform applications, as well as a standardized attachment agreement for street lighting infrastructure. This includes facility charges or license options. The Company will also evaluate whether the chip-metered technology is accurate and compatible with National Grid's billing systems.

Market Attractiveness

Unique Value Proposition

The Company and the City believe that enabling smart-city services will allow for increased innovation, new technologies, and new business models that can better serve customers and residents. For the City, the value proposition of this Project is the decreased upfront cost of investing in advanced lighting control technology, reduced energy costs, and the improved

[11] The cost of replacing HID with LED luminaires will be recovered through the facility charge on the monthly utility bill in accordance with the Lighting Tariff.

[12] REV Proceeding, "Order Adopting a Ratemaking and Utility Revenue Model Policy Framework" ("Track Two Order") (May 19, 2016), pp. 47-50.

services the City will be able to offer. In addition, both the City and the Company will see value from enhanced awareness of the street lighting system and increased functionality.

For the Company, the value is tied to enhanced asset management capabilities, as well as potentially new revenue opportunities, such as facility charges, attachment fees, metered street light services, and PSRs. In addition, the Company may also find value from leveraging the functionality of the advanced LED street lighting platform with other utility initiatives (*e.g.*, using radio frequency communications for distribution modernization programs). Additional grid modernization initiatives that could benefit from the new platform include automated switching schemes, volt-VAR optimization, and AMI deployments.

Specific to AMI, the Company will use this Project to evaluate the potential AMI-related co-benefits and functionalities. For example, potential co-benefits may include migrating street lighting from an unmetered service to a metered service to help customers realize additional savings.[13] The advanced LED street lighting platform will also likely reinforce and strengthen AMI data routing by providing additional contact nodes, reducing communication hoop counts and minimizing urban concrete canyon effects.[14] The Company's AMI Business Case also outlined street light AMI benefits that align with many of the advanced LED street lighting value propositions discussed earlier:

- Preemptive maintenance, enabling timely repairs, avoiding outages, detecting elevated voltage conditions, and assisting with circuitry diagnostics;
- Accurate energy metering of smart-city technologies, such as: Wi-Fi routers and transmission devices, cameras, sensors (*e.g.*, motion, temperature, humidity, hazardous chemicals, radiation), distributed antenna and small-cell technology, interactive parking meters, vehicle charging, and emergency notification systems;
- Enhanced inventory information; and
- Active asset management and control.

Customer Segmentation

Located in New York's Capital Region, Schenectady is home to 66,135 residents.[15] It comprises 10.78 square miles, and is served by approximately 4,275 roadway street lights.[16] As of April 1, 2010, the City had 30,095 housing units with an owner occupancy rate of 47.9 percent.[17] Schenectady also had approximately 2,772 businesses as of 2012.[18] The four zones shown in Figure 4 include a diverse mix of residential and commercial customers including several low-to-moderate income neighborhoods.

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[13] Cases 17-E-0238 and 17-E-0239, Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Niagara Mohawk Power Corporation d/b/a National Grid for Electric Service, Testimony and Exhibits of Advanced Metering Infrastructure Panel, Exhibit __ (AMI-2), Electric and Gas Advanced Metering Infrastructure Business Case for Niagara Mohawk Power Corporation d/b/a National Grid (April 28, 2014), p. 46 of 52.

[14] *Id.*

[15] City of Schenectady Geography & Demographics *at* http://www.cityofschenectady.com/249/Geography-Demographics.

[16] *Id.*

[17] *Id.*

[18] *Id.*

Channels

The City is National Grid's partner-customer for this Project, and will serve as the primary point of contact and administration. As mentioned, Mayor McCarthy established the Schenectady Smart City Advisory Commission in 2016 to "work on a variety of technology and sustainability initiatives…."[19] Together the City, largely through the Schenectady Smart City Commission, and the Company will work with third-party vendor-partners AT&T-GE-Intel and CIMCON-CISCO-Itron-Presidio to implement this Project.

Scalability

The Company will use this Project to test several different technologies and business models, and to evaluate different software partners. This approach will allow the Company to select the most successful solutions that meet the needs of the City. If this Project is successful, the Company will also be well positioned to develop new tariff offerings and PSRs intended to facilitate the adoption of advanced LED street lighting platforms and the deployment of smart-city technologies throughout the Company's New York service territory.

Demonstration Plan

Statement of Work

This Project will be conducted in three phases over the course of three years by National Grid, the City, and their partners. In Phase One, the Company will install LED luminaires, NLC nodes, and a 6LoWPAN-enabled IoT network in two zones of the City. From this experience, the Company will develop a detailed installation and commissioning process. In Phase Two, the Company will install LED luminaires, NLC nodes, and the 6LoWPAN/IoT mesh network in the remaining zones, deploy smart-city sensor nodes and attachments throughout the City, and evaluate the functionality of the equipment installed in Phase One. In addition, the City will work with its partners to deploy a broadband network and high-bandwidth smart-city attachments. National Grid will facilitate the City's broadband deployment by developing a standardized attachment agreement and energy services agreement. In Phase Three, the Company and the City will expand secure access to the 6LoWPAN-enabled IoT mesh network to third parties for the purpose of developing additional smart-city solutions.

Metrics for Success

The Company will measure the success of this Project by considering the extent to which the installation of the LED luminaires, NLC nodes, smart-city sensor nodes, and 6LoWPAN/IoT mesh network:

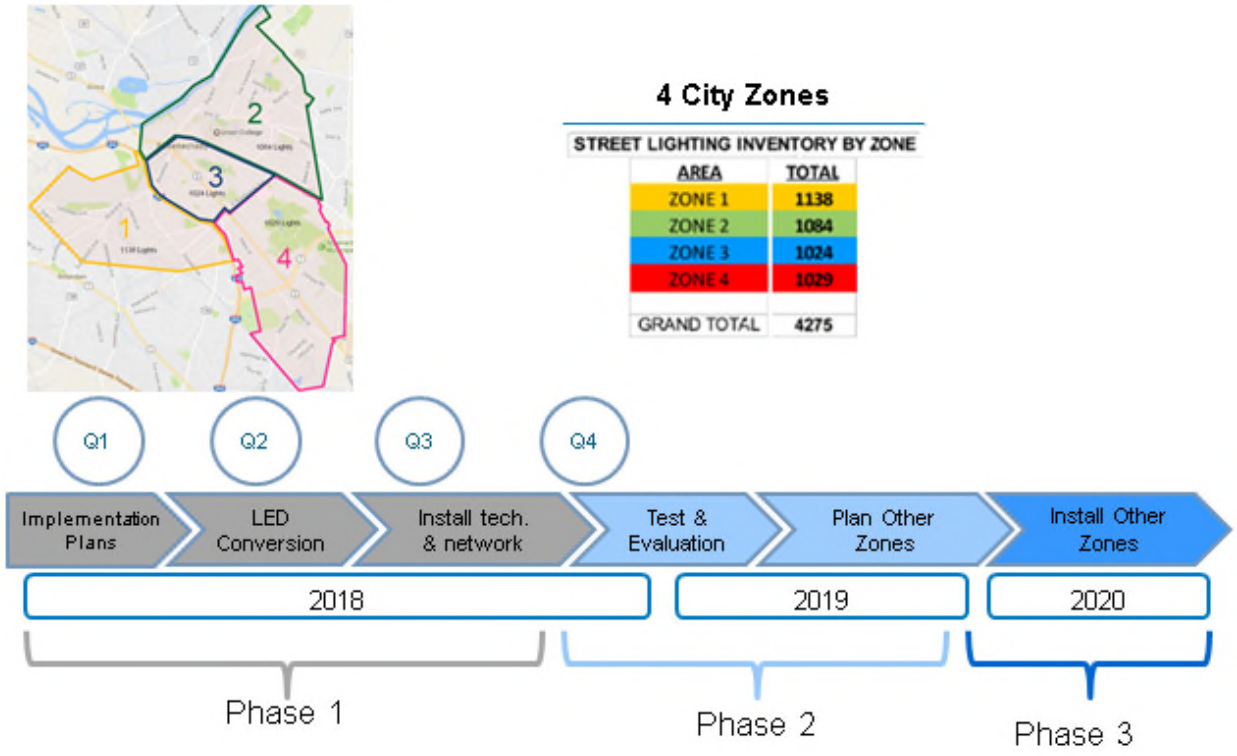
- Reduces energy consumption;
- Enhances LED lighting service and reduces maintenance costs;
- Increases the deployment of smart-city technologies and services;
- Enables innovation and partnerships with third-party market participants seeking to offer new services in the City using the advanced LED street lighting platform; and
- Is accepted by the public.

[19] City of Schenectady, Statement on the Smart City Advisory Commission available at http://www.cityofschenectady.com/335/Smart-City-Advisory-Commission.

Timelines, Milestone, and Data Collection

As detailed below, key milestones for Phase One include installation of the LED luminaires, NLC nodes, secondary meters, and the associated 6LoWPAN-enabled IoT mesh network in two zones. Likewise, in Phase Two, the Company will deploy the advanced LED street lighting platform in the remaining zones, test and evaluate the equipment installed, and install smart-city sensor nodes and attachments. Meanwhile, the City will work with its partners to deploy a broadband network for high-bandwidth smart-city attachments. In Phase Three, the Company will allow third-party access to the 6LoWPAN/IoT mesh network.

Figure 4: Map of City Zones



Phase One

Planning and Implementation

The Company and the City will work with project partners AT&T-GE-Intel and CIMCON-CISCO-Itron-Presidio to design each phase, develop work plans and budgets, and establish a governance structure. This effort will also include planning the network deployment, including network design, hardware procurement, and configuration. The Company will also ensure that data security standards are met, and that downstream applications are capable of operating with the new technology. As the technology is deployed, the Company will coordinate the project team to test the system, and train operators.

Installation

The Company will initially convert street lights in two zones to LED luminaires and install NLC nodes[20] and secondary metering, as well as an accompanying 6LoWPAN-enabled IoT mesh network. Together, the nodes and the network will allow the City to remotely control the LED luminaires, evaluate node metering capabilities, and provide the Company with asset management information, such as fault notification. The City and the Company will select zones with a diverse mix of residential and commercial street light uses in addition to low-to-moderate income neighborhoods where additional revitalization activities are occurring. The Company will also use Phase One to develop installation and commissioning procedures, and to investigate the requirements for integrating the node data into existing inventory and billing databases.

Lessons Learned

The Company expects to learn the following lessons in Phase One:

Key Elements	Learning Opportunities
Gain Technical and Field Deployment Experience	• Coordinate teams in different departments, including developing new work streams, to support an advanced LED street lighting business.
Installation Services	• Evaluate tariff offerings for installation services. • Develop installation and commissioning procedures. • Identify any necessary tariff modifications.
Test Lighting Software Capability	• Test capabilities and usability of lighting portal software. • Determine additional requirements to integrate NLC node data into Company systems/databases.
Cost Estimation	• Gain further understanding of costs associated with supporting the lighting controls and network infrastructure. • Evaluate monthly node facility charge. • Analyze business and ownership models. • Develop a lighting-controls tariff offering for Company-owned LED street lights.
Verify Energy Measurements	• Determine whether NLC node-based chip meters are capable of providing accurate commercial-grade energy measurements.

Phase Two

Installation

During Phase Two, the Company will convert the street lights in the remaining zones to LED luminaires, and install the NLC nodes and accompanying 6LoWPAN/IoT mesh network. In addition, the Company will install smart-city sensor nodes and smart-city attachments capable of operating on the 6LoWPAN/IoT mesh network. The Company and the City will evaluate the

[20] While intelligent NLC nodes may be installed on traditional high-intensity discharge ("HID") street lights, the advanced monitoring and control capabilities of the nodes are only compatible with LEDs.

technical performance of the different smart-city node models and smart-city attachments, selecting the best performing technology to deploy throughout the City. The Company will also install secondary meters to evaluate the metering capabilities of the smart-city devices. The City may also install broadband infrastructure to support high-bandwidth attachments, like cameras or public Wi-Fi, in areas where the requisite foundational infrastructure is in place.

Lessons Learned

The Company expects to learn the following lessons in Phase Two:

Key Elements	Learning Opportunities
Evaluate Customer Drivers and Barriers in Controlling Lighting	• Further understand customer scheduling patterns in different sections of the City. • Evaluate the City's staffing and training requirements for use of the smart-city nodes, as well as human factor variables that impact long-term savings. • Determine customer use and acceptance of the smart-city nodes and attachments.
Electric AMI and Smart Gas Meters	• Test a sample set (minimum of 10 units each) of electric AMI and smart gas meters to communicate via the 6LoWPAN-enabled (or comparable IEEE 802.15.4) IoT mesh network. • Determine whether the Company can harmonize standards, develop implementation protocols, and prepare for a future AMI deployment that leverages the connectivity of the advanced street lighting platform.
Utility Signal to Smart Energy Devices	• Test a sample of smart-energy products (*e.g.*, thermostats or electric vehicle charges) for compatibility with the IoT network. • Identify smart-city attachments capable of operating on 6LoWPAN/IoT mesh network.
Attachment Services	• Develop a standardized attachment agreement for street light infrastructure. • Evaluate whether different attachment agreements are needed for different types of smart-city devices and ownership models. • Develop tariff offering that enables customer-owned broadband infrastructure on Company-owned advanced LED street lighting platform.
Smart Device Ownership	• Explore the business model for Company ownership of select smart-city devices mounted on Company-owned poles. • Determine whether Company ownership offers a simpler procurement model and provides a reasonable rate of return. • Analyze and refine smart-city business and

	ownership models.
Evaluate Asset Health	• Test functionality of the advanced street lighting portal, including its ability to evaluate asset health and proactively track outages. • Identify City and Company benefits that are obtained due to asset management capabilities of NLC nodes and smart-city attachments.
Verify Energy Measurements	• Determine whether smart-city sensor node-based chip meters are capable of providing accurate commercial-grade energy measurements.

Phase Three

In Phase Three the Company will provide secure 6LoWPAN/IoT mesh network access to third-party vendors for purposes of developing new smart-city services, and recover a portion of the costs of the smart-city attachments and the 6LoWPAN/IoT network. The Company expects to learn the following lessons in Phase Three:

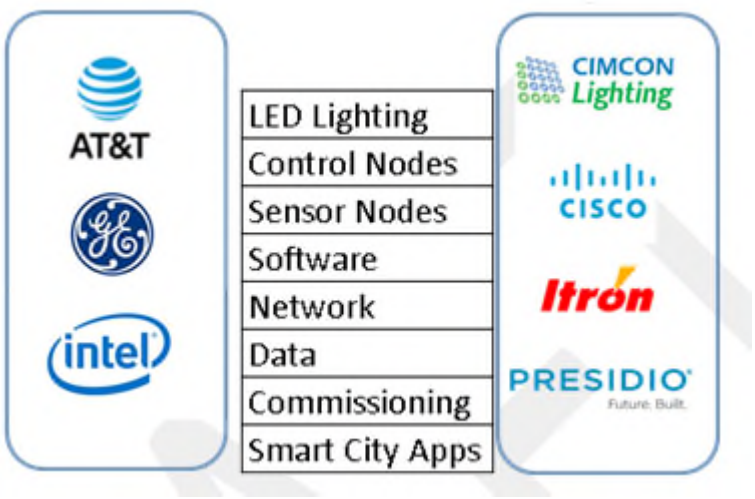
Key Elements	Learning Opportunities
6LowPan-Enabled IoT Mesh Network as Service	• Test new business models by offering IoT mesh network access to third-party vendors who develop smart devices, such as environmental sensors, vacant home finders, smart dumpsters, and other smart products that could use the network. • Analyze ability to securely provide multi-party access to the 6LoWPAN/IoT mesh network. • Determine "data ownership" protocols.
Customer Response	• Test new smart-city services that can be provided using innovative sensors, and provide a case study of benefits and customer acceptance. • Develop a suite of standard Company-owned smart-city service and product offerings.
Business Models and Pricing Options	• Test business models and pricing options including hybrid ownership of smart-city attachments. • Determine whether tariff offerings need to be expanded to include opportunities for third-party solutions. • Develop operating procedures, internal and customer training, and appropriate tariff filings to deploy the advanced street lighting platform and smart-city attachments at scale.

Third-Party Partners

The City and the Company conducted an extensive review of third-party vendors and, as shown in Figure 5, selected AT&T-GE-Intel and CIMCON-CISCO-Itron-Presidio as the vendor-partners. Since the market is still evolving and there are no clearly defined solutions, the

Company and the City will test several different technology suites to help identify products and business models that are scalable to other communities. National Grid believes this testing is crucial to understanding whether the advanced LED street light platform can accept different configurations of software and attachments, both open source and proprietary, from different vendors. Moreover, this multi-partner effort will help to determine which options are cost-effective, flexible, and scalable.

Figure 5: Smart City Technology Vendors in REV Demo



The two sets of partners provide complete solutions with different technologies and unique options. For example, the AT&T-GE-Intel approach includes LEDs, nodes, software, and smart-city applications from GE, network communications from AT&T, and data management from Intel. On the other hand, the CIMCON-Cisco-Itron-Presidio approach offers more flexibility in the LED lighting options that can function with CIMCON's NLC nodes. The CIMCON-CISCO-Itron-Presidio network also allows for design options that could be integrated with AMI networks and metering from Itron. Both of these partner teams also bring dozens of smart-city application partners to the table creating possibilities for further innovation. Finally, the selected partnership teams have agreed to investment contributions and in-kind services for this Project in the form of technology and professional services.

The Company and the City also expect additional partners will participate in this Project, including:

- City of Schenectady municipal government (*e.g.*, police, fire department, library, etc.)
- Residential and commercial customers in the City
- Ellis Medicine
- MVP Healthcare
- Clarkson Graduate School
- University of Albany
- Schenectady County Community College
- City of Schenectady School District

- Schenectady Smart City board of directors
- Other third-party technology vendors

Community Outreach/Community Engagement

National Grid and the City will explore options for a co-branded marketing campaign. The effort will have project-specific signage and include strategies to educate residents on the value of the advanced LED street lighting platform and how Schenectady plans to develop smart-city services.

Consumer Protections

The Company will adhere to all applicable consumer protection and data privacy laws.

Financial Elements/Revenue Model

This Project will test whether the Company can develop a business model that increases the pace and scale of the adoption of advanced LED street lights and smart-city technology, while also creating new revenue streams for the Company, municipalities, and third-party vendors. During the three-year project term, the Company will develop attachment and electric service agreements for the nodes, 6LoWPAN/IoT mesh network, and smart-city attachments. The Company will also test a monthly facility charge for the NLC nodes. Likewise, in year three of this Project, the Company intends to recover 33 percent of the cost of the IoT network from the City, as well as 20 percent of the cost of any Company-owned smart-city attachments. These amounts reflect reasonable costs during the term of this Project based on the typical rated life of the devices.

Some of the revenue streams (*e.g.*, facility charges, attachment fees, and energy charges) will continue beyond the three-year term. Furthermore, to the extent permitted by the Commission, the Company will seek to offset the budget impact of this Project by using the business models and tariff offerings developed herein to fully recover the costs of the nodes, smart-city attachments, and IoT network.

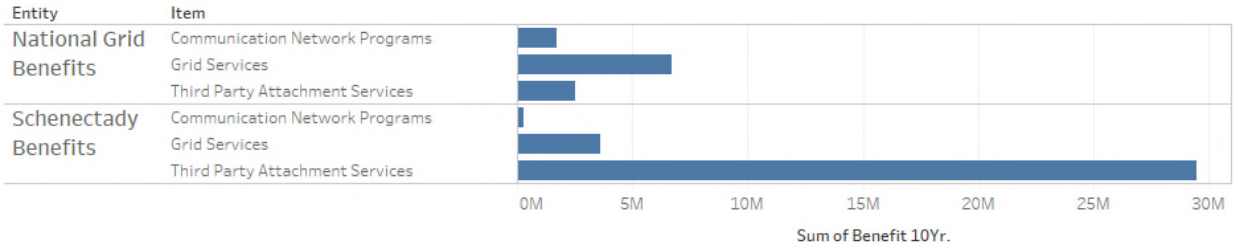
The Company developed preliminary business plans to understand the benefits, impact, and value of smart-city technologies for customers, the Company, and the City. Figure 6 provides a summary of potential benefits over a 10-year outlook.

New Utility Revenue Streams/Platform Service Revenues

The Company believes new utility revenue streams, including PSRs, could be developed as a result of the findings from this Project. Consistent with the Track Two Order, such revenues may include service fees and attachment fees associated with providing the advanced street lighting platform, as well as customer origination fees from facilitating connections between third-party market participants and customers.[21] Additional revenue opportunities may arise as the Company, the City, and third parties work together to implement this Project.

[21] Track Two Order, pp. 49-52.

Figure 6: Overview of Potential Revenue and Benefits



The potential revenue and benefits are broken into three categories: 1) communication network programs; 2) grid services; and 3) third-party attachment services. The communication network programs include extending the network to third-party providers, who can offer products like environmental sensors, water meters, home occupancy sensors, and parking sensors. Grid services include energy supply to IoT devices mounted on street light poles, city-wide deployment of smart street lighting, as well as network sharing for a small sample of electric and gas meters, electric vehicle chargers, and smart thermostat systems. The third-party attachment services are primarily camera and security devices and the high-bandwidth network to support such attachments. As part of this Project, the Company will test a business model where the Company owns the hardware (*i.e.*, smart-city devices) that attach to the street light fixtures, while the City will own and monetize the data from the devices.

Investment

The Company will own, install, operate, and maintain LED luminaires, NLC nodes, smart-city sensor nodes, smart-city attachments, secondary meters, and the 6LoWPAN/IoT mesh network. As part of its broadband deployment, the City will separately procure and install smart-city attachments and network upgrades from this Project's vendor-partners or other third parties.

Costs associated with the LED conversion are not included as part of this Project, as they will be recovered in accordance with the Lighting Tariff. Project costs will, however, include a portion of the NLC node costs, the smart-city sensor nodes and attachments, and the 6LoWPAN/IoT mesh network. The remaining amount will be recovered from the City. Additional revenues from attachment agreements and energy services agreements, including the potential for metered electric service, will be developed as part of this Project. Figure 7 provides a detailed breakdown of the incremental project cost elements that will be financed via the Company's REV demonstration project budget, as well as the offsetting revenues the Company anticipates receiving during the project term.

Figure 7: Project Cost Elements

Cost Elements	Gross Cost	Type	Annual Breakdown			Net Cost
			Year 1	Year 2	Year 3	
Network Lighting Control Nodes	$2,350,000	CapEx	$1,110,000	$1,060,000	-	$2,191,288
		OpEx	$70,000	$70,000	$40,000	
		Revenue	-	($56,112)	($102,600)	
Network	$1,105,000	CapEx	$195,000	$195,000	-	$904,000
		OpEx	$240,000	$255,000	$220,000	
		Revenue	-	-	($201,000)	
Sensors	$3,280,000	CapEx	$1,550,000	$1,550,000	-	$2,232,250
		OpEx	$70,000	$70,000	$40,000	
		Revenue	-	-	($1,047,750)	
TOTAL	$6,735,000		$3,235,000	$3,143,888	($1,051,350)	$5,327,538

If this Project is successful, the operation of the advanced LED street lighting platform, along with the smart-city technology and services, is likely to continue beyond the three-year term, and the Company would seek to include the Project elements in a revised tariff offering (*e.g.*, facility charges, attachment agreement, metered street light service, PSRs).

Returns & Cost Effectiveness

During the project term, costs exceed the anticipated revenues. However, the Company expects revenue streams to increase as the Company tests business models, develops standard attachment and energy services agreements, and smart-city costs come down through market animation. What's more, the Company and the City anticipate benefits to increase as lighting energy costs are reduced, municipal services are delivered more efficiently, and lighting asset management improves.

Preliminary Pro Forma (Appendix A – Confidential)

The Company worked with a consultant to prepare a preliminary pro forma, evaluating potential revenue, cash flow, and rate of return from new business models. In developing the preliminary pro forma, the Company excluded high- and low-end scenarios, using an intermediate scenario to develop the financial model with a 10-year outlook. The Company is looking to develop tariffs that can continue beyond the 3-year project term that will generate a positive cash flow and deliver approximately a 10 percent rate of return. The Company will continue to refine the business plans, costs of procuring and deploying the assets at scale, and monetizing various value streams, including network benefits, from stacking technology as part of the Project.

The preliminary pro forma incorporates assumptions for adoption of planned items in the Project and the ability to develop rate designs to capture all revenue streams and savings during the useful life of the equipment. The network sharing benefits and savings are based on assumptions for potential future roll out of new advanced grid services like AMI. The Company also believes further cost reductions are possible in a scaled-up offering due to economies of scale,

consolidation of technology, and maturity over time, making components cheaper, while sharing resources and reducing redundancies. The Company further expects new solution offerings will emerge over the next decade that may enhance these value streams. The data used to develop the pro forma includes business confidential information from equipment manufactures and solution providers. Therefore, the Company has filed the preliminary pro forma confidentially as Appendix A to this Plan.

Reporting

The Company will provide Department of Public Service ("DPS") Staff with quarterly progress reports. At a minimum, the reports will include an overview of progress against timeline/plan and results as they become available. The reports may also contain other updates or deviations from the initial details to allow flexibility and maximize potential for innovation and learning. Any changes related to costs shall remain within the overall budget for REV demonstration projects approved by the Commission. Furthermore, should a situation or activity arise that is not authorized by the Commission, the Company will include a description in the quarterly report and request such authorization through a petition to the Commission. National Grid looks forward to continued collaboration with DPS Staff throughout this Project.

Conclusion

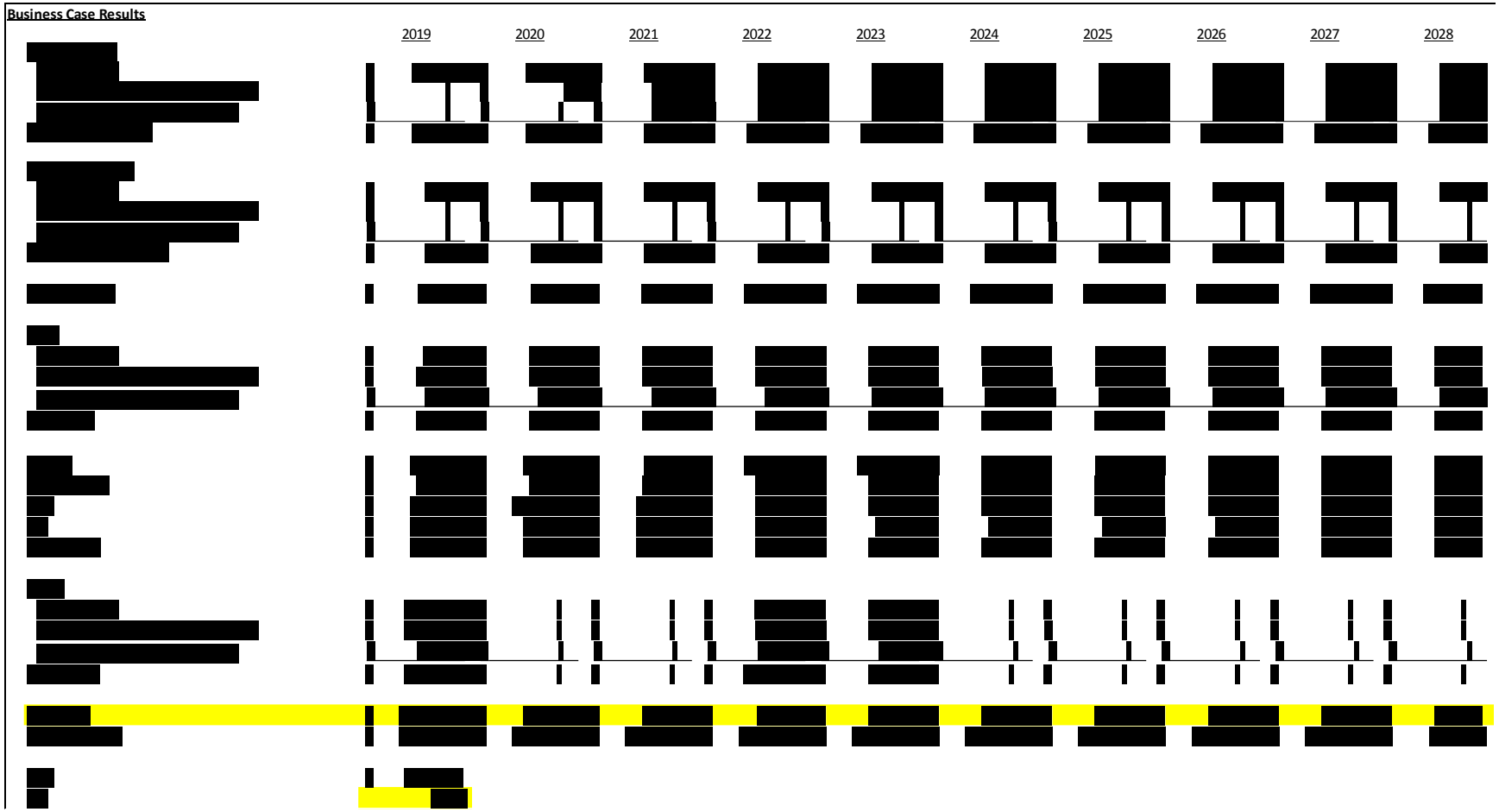
Post-Demonstration Qualitative and Quantitative Benefits

The Company anticipates Schenectady will see immediate qualitative benefits from this Project by advancing smart-city policy goals, while also achieving quantitative benefits through enhanced control of efficient LED street lights. Furthermore, by establishing an advanced LED street light platform, opportunities will arise for innovative partnerships with third-party market participants looking to provide smart-city technology and services. For its part, National Grid believes this Project could lead to new earnings opportunities that can be used with future advanced LED street light applications. Taken together, these benefits will cascade to residents throughout the City, who are expected to see more efficient delivery of existing services and new offerings geared at improving the quality of life. The leading-edge insights gleaned from this Project will also serve to inform the deployment of advanced street lighting and smart-city technology in other municipalities.

Plans to Scale

If successful, this Project will confirm that an advanced LED street light platform tariff offering is a benefit to municipalities. With approval from the Commission, the Company would work with those municipal customers who have expressed an interest in such functionality, to evaluate and adopt an advanced street lighting platform that enables the municipalities to deploy smart-city technology and services.

Appendix A – Preliminary Pro Forma* (Confidential)



* The information included in this preliminary pro forma was developed using confidential business information. It includes estimates and assumptions based on business plans and smart-city deployments contemplated as part of this Plan, and representing an intermediate financial scenario. The amounts are subject to change.