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Clean Energy Fund Investment Plan: Grid Modernization Chapter

Portfolio: Innovation & Research

Submitted by:

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9 Grid Modernization

NYSERDA will focus on enhanced grid visualization (advanced sensing, communications, diagnostics and controls), planning processes and advanced materials that accelerate realization of an advanced, digitally enhanced and dynamically managed "high-performing" electric grid. Initiatives will aim to build the capacity to integrate and dynamically manage loads, clean distributed energy resources (DER), and electric vehicles, thereby lowering the carbon intensity of energy usage and increasing customer engagement in energy markets including enabling the development of community-based energy systems such as microgrids. Such a grid will enable more efficient asset utilization (e.g., reduced operating margins, reduced power demands, reduced energy losses), reduced energy costs, improved reliability and resiliency to climate change induced weather events.

The first initiative described in this Chapter is the DER Interconnection initiative, due to the current processes and methods for interconnecting DER which are unable to keep pace with applications, as evidenced by the growing backlog of projects in interconnection queues across the state. The knowledge, techniques, and devices stemming from activity under this initiative will be key to addressing the current DER application backlog, avoiding future backlogs stemming from continued adoption of DER, and accelerating technology innovation that reduces the time, cost, and complexity of interconnecting DER.

The second initiative described in this Chapter is High Performing Grid which will investment in innovation focused on developing a digitally enhanced and dynamically managed or "high-performing" electric grid. This more comprehensive initiative moves beyond the singular and less complex question of DER interconnection to include innovation that focuses on dynamically integrating DER into the electric power system.

Program investments and activities will be informed via engagement with stakeholders and subject matter experts.

9.1 DER Integration

9.1.1 Overview

Present Situation	• Recent trends show continued growth in the number, size, and complexity of DER interconnection projects in NY. It is expected that this trend will continue based on distributed energy resources as an outgrowth of Reforming the Energy Vision (REV), the State Energy Plan, Clean Energy Fund, and NY-Sun activities. • The electric distribution system to which these DER will interconnect is operated using older planning tools/algorithms that do not utilize real time data and computational capacities of advanced technologies. Much of the system is operated using relatively passive electro-mechanical devices that do not dynamically communicate with themselves and concern themselves with managing one-way flow of power. Systematic improvements to grid investments and operations are possible at all levels of the grid. In particular,

	the adoption of new technologies will help maximize the integration of large quantities of DER. • As alternatives are developed, validation of technology performance is critical to obtain acceptance by an engineering and standards-based utility culture focused on safety and reliability. Under-utilized and emerging interconnection technologies need to be validated before they will be accepted for use in the electric grid.
Intervention Strategy	An Innovation Program is envisioned to support modernizing NY's electric grid. The overall Grid Modernization Innovation Program will be discussed in two investment plans (two Phases). This investment plan represents Phase I focusing on interconnection of distributed energy resources (DER). Phase II, to be filed at a later date, focuses on the broader range of grid modernization topics including innovation in sensing, communications, and diagnostics. This Phase I DER Interconnection investment plan focuses on innovation to support the interconnection of DER projects in the near term. The DER Interconnection Program strategy is to: • Advance the methods, technology, and industry knowledge that will reduce the cost, complexity, and time to interconnect DER. • Advance the methods, technology, and industry knowledge required to enable accelerated interconnection of DER in areas of high DER penetration on NY's electric grid. For a visual representation of this strategy, please reference the flow chart entitled "Logic Model: Grid Modernization – Phase 1: DER Integration," which can be found in Appendix A.
Goals	This Program is focused on supporting technical advances that will facilitate interconnection of DER projects that are currently seeking interconnection in NY. The knowledge, techniques, and devices stemming from this work will also contribute to managing these types of applications in the future as DER markets develop.
State Energy Plan/Clean Energy Standard Link	Innovation that increases grid capacity to interconnect and expand the use of clean distributed energy resources (DER) is a necessary component of a comprehensive strategy to achieve: • New York State Energy Plan greenhouse gas reduction goals • Improved affordability (by reducing need for capital investment in grid infrastructure) • Clean distributed energy resource deployment targets DER is expected to be a critical element of the Clean Energy Standard

9.1.2 Target Market Characterization

Target Market Segment(s)	Target market segment is NYS electric distribution utilities, DER developers, and grid technology companies developing DER interconnection/integration solutions.
Market Participants	Market participants include: • NY electric utilities • DER project developers

	• Grid-technology companies introducing interconnection/integration products and services • Regulators • National Labs / Department of Energy (DOE)
Market Readiness	Market participants have signaled their readiness, through the NYS Interconnection Technical Working Group, to work collaboratively towards solutions but to truly achieve success will require coordination, collaboration, and technology innovation which NYSERDA is well positioned to lead.
Customer Value	The Reforming the Energy Vision (REV) proceeding acknowledges that interconnection of DER is both fundamental to REV and continues to be a barrier to widespread DER adoption. From Case 14-M-0101, Reforming the Energy Vision, Order Adopting Regulatory Policy Framework and Implementation Plan (issued February 26, 2015): "*Staff Recognizes that burdensome, costly and time consuming interconnection requirements or procedures are a barrier to penetration of DER. The proposal also recognizes that safety and system reliability require appropriate interconnection requirements and that an appropriate balance between streamlining and protecting safety and reliability must be found." (pg.88)* *"In order for distributed generation to compete on an equal footing, interconnection with the grid must be enabled through technical rules and processes that are not only safe but also efficient and expeditious. New York has been a leader in this area, initially adopting Standardized Interconnection Requirements in 1999. Much progress remains to be made, however." (pg.91)* Innovation supporting DER interconnection is not occurring passively in the scope or scale needed to support the market growth currently occurring. If not directly addressed, interconnection challenges could present a large enough barrier to stall the solar market in NY much like what happened in Hawaii in 2014[1][2]. This intervention will support REV and accelerate customer value by supporting the resolution of technical and cost barriers to DER interconnection, thereby allowing greater deployment and lower interconnection costs. By supporting achievement of NY-Sun goals and State Energy Policy, these activities will contribute to: • Interconnection of 3,000 MW by 2023 • Nearly 4,000,000 MWH of PV production by 2020 and approximately 2 million tons of GHG reduction annually.

9.1.3 Stakeholder/Market Engagement

Stakeholder/Market Engagement and Customer Discovery	Recent / Ongoing Activities • Program focus and research activities will be informed by participation in the NYS Technical Interconnection Working Group (NYSERDA is currently co-Chair with DPS).

[1] http://www.renewableenergyworld.com/articles/2014/02/the-interconnection-nightmare-in-hawaii-and-why-it-matters-to-the-u-s-residential-pv-industry.html

[2] http://files.hawaii.gov/puc/4_Book%201%20%28transmittal%20ltr_DGIP_Attachments%20A-1%20to%20A-5%29.pdf

	• 2015 NYSERDA study, completed in partnership with DPS and EPRI, entitled *Interconnection of Distributed Generation in New York State: A Utility Readiness Assessment* • NYSERDA Staff has engaged in numerous interconnection conversations with DER trade associations (i.e. NYSEIA), individual project developers, the Joint Utilities, and research organizations studying interconnection. • Program focus and research activities will be informed by REV proceedings and participating stakeholder viewpoints. Routine engagement with Public Service Commission (PSC) staff will continue to align program focus with current public policy goals.

9.1.4 Theory of Change

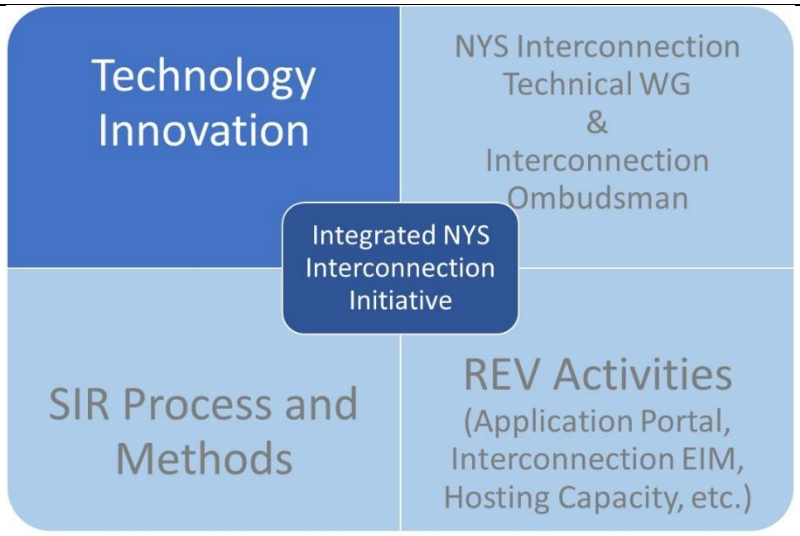
Technology Opportunities and Barriers Addressed	**Technology Opportunities** Advance the methods, technology, and industry knowledge that will reduce the cost, complexity, and time to interconnect DER including: • Identification and adoption of innovative technologies to support DER interconnection • Adoption of smart inverters in NY • Development and deployment of new technologies and analysis methods to support optimization of available distribution system capacity **Barriers Addressed** • Current grid is unable to support the increase and effective use of DER at the level necessary to support meaningful reduction in greenhouse gas (GHG) emissions (i.e. State Energy Plan (SEP) emissions reduction goals). o System limitations and technical uncertainties have contributed to a significant backlog of DER (photovoltaic) applications pending with the utilities • Validation of technology performance is critical to obtain acceptance by an engineering and standards-based utility culture focused on safety and reliability. • Degree of innovation being tested and/or applied is insufficient across the utilities and sharing of knowledge is not yet sufficient to accelerate pace of innovation. • Achievement of public policy goals for distributed resources (e.g., NY-SUN, combined heat and power (CHP), energy storage) is severely constrained by the long timelines, complexity, and cost of the present interconnection process. • Analysis of the gaps in technologies/tools for developing advanced grid systems is incomplete.
Testable Hypotheses	• If support is provided for validation and performance testing, then new DER technology and interconnection methods will be more readily accepted by the engineering and standards-based utility culture focusing on safety and reliability. • If research and product development are focused on problems common to all electric utilities, then adoption of innovation with respect to DER integration can be accelerated.
Activities (Resources)	• *Grid Modernization Roadmap* - Retain services of a consultant(s) to conduct a comprehensive analysis of gaps and roadmap for advancement of technology and

	tools necessary to support an advanced, integrated, high-performing grid that enables seamless valuation and control of non-wires alternatives. ○ Use gaps assessment to guide program research (priorities/work streams/use cases, budget, and schedule) necessary to accelerate pace of development of technologies, applications and utility capabilities. ○ Using the gaps assessment, collaborate with NYPA and the utilities, as necessary, on the development of a laboratory (AGILe) in New York to support grid modernization research that compliments plans and capabilities of the Grid Modernization Laboratory Consortium Testing Network. • *Interconnection Support* - Engage leading research/consulting organizations, in consultation with DPS and NYSERDA, to support the work of the NYS Interconnection Technical Working Group and the activities of the NYS Interconnection Ombdusmen at DPS and NYSERDA. • *Technology Innovation Funding Opportunities* - Provide funding opportunities in support of leading-edge utilities and grid technology companies to leverage existing capabilities and validate distribution system technologies and practices that support increased penetration of DER. ○ Issue competitive solicitations for project proposals across the continuum of technology development (early stage research/ proof of concept, product engineering and testing, and product demonstration) guided by needs assessment(s). ○ Issue RFPs or other calls for proposals jointly with utilities and DPS to addresses interconnection challenges common across the system. • *Fostering Coordination* - Develop a model for collaboration between NYSERDA, NYPA, DPS, NY utilities, and grid tech companies to ensure the Grid Modernization road mapping work is compatible with and complimentary to the development of Distribution System Implementation Plans (DSIP) consistent with PSC rules. Include in such process a mechanism to ensure various REV (REV Connects), NY Prize and CEF initiatives are integrated/aligned to make optimal use of time and resources. • Continue weekly meetings with DPS and NYPA regarding DER interconnection challenges in NY and continued leadership in the NYS Interconnection Technical Working Group.
Key Milestones	<u>Milestone 1 (Q3 2016)</u> • Contract with a consultant to conduct a comprehensive analysis of technology gaps and create a roadmap for advancement of the technology and tools necessary to support an advanced, integrated, high-performing grid in New York. <u>Milestone 2 (Q2 2017)</u> • Grid Modernization Roadmap complete. <u>Milestone 3 (Q3 2016)</u> • Contract with one or more research/consulting organizations to provide technical knowledge and support for DER interconnection improvements in New York. <u>Milestone 4 (Q3 2016)</u> • Launch a competitive program funding opportunity focused on innovation to reduce DER interconnection burdens in New York State. <u>Milestone 5 (Q1 2017)</u> • Contract with awardees selected under the funding opportunity focused on innovation to reduce DER interconnection burdens in New York State.

	Milestone 6 (Q3 2016) • Implement a model for collaboration between NYSERDA, NYPA, DPS, NY utilities, and grid tech companies to ensure the Grid Modernization road mapping work is compatible with and complimentary to the development of DSIPs consistent with PSC rules.
Goals Prior to Exit	The potential impact of this initiative includes faster, less costly, and less restrictive DER interconnection process and requirements that support DER deployment while maintaining the safety and reliability of NY's electric grid. Goals prior to exit include lower cost and increased certainty in the DER interconnection process and requirements that support DER deployment while maintaining the safety and reliability of NY's electric grid as evidenced by: • Statewide technical standards applicable to DER interconnection that utilize leading-edge processes, study methods, and innovative technical solutions • DER interconnection framework that addresses all DER applications in a timely manner which does not present a barrier to project deployment • Reduction of the frequency and magnitude of utility infrastructure upgrade costs

9.1.5 Relationship to Utility/REV

Utility Role/Coordination Points	This Program is an integral part of the single coordinated endeavor by NY State to address DER interconnection. As such, it is synchronized with manifold other activities both internal and external to NYSERDA. [see figure below] • Many program funded activities involve one or more utilities. • Program activities are closely integrated with the NYS Interconnection Technical Working Group (including representation from DPS, NYPA, PSEG-LI, all NY investor owned utilities, and from the DER development community). • Program activities are closely integrated with the work of NY's Interconnection Ombudspersons. • Program activities are closely integrated with NY Department of Public Service interconnection policy and activities. • Program activity has direct correlation with REV success. Program will leverage its relationship with PSC staff for the purposes of program planning and execution with the regulated utilities. • Program activities will consider and support related key policy imperatives, including REV Connects, REV Pilots, and NY Prize to ensure optimal leverage of time and resources.

	
Utility Interventions in Target Market	Utilities are, to a great extent, a customer of the program. Interventions are being driven by REV proceeding as well as increasing DER interconnection applications. Program activity with utility collaboration is expected to focus on accelerating development and use of technologies to accelerate DER interconnection and facilitate DER integration into the electric grid.

9.1.6 Budgets & Expenditures

An annual commitment budget for all activities included in this chapter is shown in Table 1. The annual expenditure projection is included in Table 2. Budgets and expenditures do not include Administration, Evaluation, or Cost Recovery Fee; these elements are addressed in the Budget Accounting and Benefits chapter filing. The budget as presented in the Budget Accounting and Benefits Chapter will serve as the basis for any subsequent reallocation request. The additional level of detail presented within the table below is intended for informational purposes only.

Table 1: Annual Innovation & Research Budget Allocation – Commitment Basis

Commitment Budget	2016	2017	2018	Total
Direct Incentives and Services	$3,800,000	$2,500,000	-	$6,300,000
Total	$3,800,000	$2,500,000	-	$6,300,000

Table 2: Annual Expenditures Projection

Expenditures	2016	2017	2018	2019	Total
Total	6%	42%	44%	8%	100%

9.1.7 Progress and Performance Metrics

Table 3 provides program Activity/Output indicators representing measurable, quantifiable direct results of activities undertaken in the initiative. Outputs are a key way of regularly tracking

progress, especially in the early stages of an initiative, before broader market changes are measurable. Outcome indicators can encompass near-term through longer-term changes in market conditions expected to result from the activities/outputs of an intervention. Outcome indicators will have a baseline value and progress will be measured periodically through Market Evaluation.

Table 3. Initiative Specific Metrics

Indicators[3]		Baseline (Before/Current)	2019 (Cumulative)	2022 (Cumulative)
Activity/Outputs	# of studies, demonstrations, and product development projects initiated	0	8	8
	# of studies, demonstrations, and product development projects completed	0	8	8
	# of companies supported or other partnerships with established manufacturers or grid technology companies	0	8	8
Outcomes	Adoption of lower cost methods and devices[4] to reduce DER interconnection costs	0	4	8
	Reduction in average cost to achieve interconnection for DG projects larger than 500 kW[5]	TBD	15%	25%
	DER deployment cost savings (via reduced interconnection costs)	TBD	$18,000,000	$30,000,000

In addition to the above outcomes, NYSERDA will also assess the following broad outcome:

- Faster, less costly, and less restrictive DER interconnection process

[3] TBD denotes that NYSERDA requires more data in order to quantify baseline/market metrics to the degree needed to measure against in the future. Baseline measurements of key market indicators are anticipated to occur soon following initiative approval and NYSERDA will update the information in this table as the information becomes available, which is anticipated within 9-12 months of initiative approval. A 0 (zero) denotes that the actual value is currently believed to be zero for baseline/market metrics.

[4] Lower cost methods and devices are advances such as alternatives to direct transfer trip, less expensive grounding bank configurations, and less restrictive flicker mitigation criteria.

[5] Progress and Performance Outcome data related to DER interconnection cost and is anticipated to be collected by NY-Sun, the NYS Department of Public Service, and the NY Joint Utilities. Collection of this data began in late 2015 and early 2016, depending on the source. The accuracy and completeness of this data are key to enabling assessment of this metric.

Benefits shown in Table 4 and Table 5 are direct, near term benefits associated with this initiative's projects. These benefits will be quantified and reported on a quarterly basis and will be validated through later evaluation.

Table 4. Direct Impacts

Primary Metrics[6]		2016	2017	2018	2019	TOTAL
Energy Efficiency	MWh Annual	-	-	-	-	-
	MWh Lifetime	-	-	-	-	-
	MMBtu Annual	-	-	-	-	-
	MMBtu Lifetime	-	-	-	-	-
	MW	-	-	-	-	-
Renewable Energy	MWh Annual	-	-	-	-	-
	MWh Lifetime	-	-	-	-	-
	MW	-	-	-	-	-
CO2e Emission Reduction (metric tons) Annual		-	-	-	-	-
CO2e Emission Reduction (metric tons) Lifetime		-	-	-	-	-
Customer Bill Savings Annual ($ million)		-	-	-	-	-
Customer Bill Savings Lifetime ($ million)		-	-	-	-	-
Private Investment[7] ($ million)		$3.35	$2.48	-	-	$5.825

Table 5. Annual Projected Initiative Participation

	2016	2017	2018	2019	Total
Participants[8]	3	5	5	-	13

9.1.8 Fuel Neutrality

Fuel Neutrality	This initiative is not being delivered on a fuel neutral basis.

[6] Impacts are expressed on a commitment-year basis, and are incremental additions in each year. Benefits are rounded to three significant figures. Totals may not sum due to rounding.

[7] This investment strategy is focused on facilitating DER interconnection and the nature of the projects anticipated to be undertaken is likely to yield modest direct private investment. Additional indirect private investment is anticipated from increased DER deployment as a result of reduced interconnection burdens.

[8] Note that total number of participants is greater than the number of companies supported as shown in Table 3. It is anticipated that some projects funded in this investment plan will involve project teams consisting of more than one organization (i.e. a grid technology company, DER project developer, and utility).

9.1.9 Performance Monitoring and Evaluation Plans

Performance Monitoring & Evaluation Plan	NYSERDA's approach to monitoring and assessing the effectiveness of the initiative and overall market development is described below. **<u>Test-Measure-Adjust Strategy</u>** • NYSERDA will monitor standard activity/output metrics including number of projects initiated and completed by type, private investment, etc. • For any new technology developments launched under the program, on a yearly basis, NYSERDA staff and contractor will reassess the Technology and Commercialization Readiness Levels for each project in the portfolio. • NYSERDA will conduct peer reviews of certain projects based on need. Examples – technical impasse, pivot point, critical milestone. • NYSERDA will assess the portfolio of projects annually with regard to goals, metrics, outputs and outcomes. **<u>Market Evaluation/Impact Evaluation</u>** • Market Evaluation will draw on the logic model and will include baseline and longitudinal measurement of key indicators of market success. • Baseline measurements of key performance indicators will occur soon following initiative approval and will address indicators including DER interconnection and deployment costs. In these areas, NYSERDA will first utilize existing information (e.g., solar balance of system cost study data including interconnection cost) and will fill gaps in information as needed and feasible for appropriate baselining. • Regular (e.g., annual or biennial) updates to key performance indicators and measurement of market change will occur once the initiative is underway. Sources of data include public and commercially available data, and primary data collection through surveys of key market actors. • A broad demonstration project impact evaluation will include projects from this area and will examine benefits of demonstration projects, rate of and success factors associated with replication, and benefits of replication projects. Cost savings will be quantified as part of this study.

9.2 High Performing Grid

9.2.1 Overview

Present Situation	• The electric distribution system is operated using older planning tools/algorithms that do not utilize real time data and computational capacities of advanced technologies. Much of the system is operated using relatively passive electro-mechanical devices that do not dynamically communicate with themselves and concern themselves with managing one-way flow of power. • Per the U.S. Department of Energy's (DOE's) Grid Modernization Multi-Year Program Plan (MYPP), "The current business-as-usual trajectory for the electricity industry will not result in a timely transition to a modern grid." Just as the MYPP recognizes a need for additional grid modernization activities, there is a further need for New-York specific research, development, and deployment to accelerate the realization of benefits for all New Yorkers. • Systematic improvements to grid investments and operations are possible at all levels of the grid and are an essential element of the transformation of the grid and related market development envisioned by the Reforming the Energy Vision (REV) initiative. In particular, the adoption of new technologies will: o help maximize the integration of distributed energy resources (DER), including electric vehicles (facilitating de-carbonization of the transportation sector over time) o improve overall system-wide efficiency in electricity delivery and use o enable the development of community-based energy systems such as microgrids, that can improve environmental performance while building energy system resiliency to climate change induced weather-events • As alternatives are developed, validation of technology performance is critical to obtain acceptance by an engineering and standards-based utility culture focused on safety and reliability. Under-utilized and emerging interconnection technologies need to be validated before they will be accepted for use in the electric grid.
Intervention Strategy	• An Innovation Program is envisioned to support and accelerate modernizing NY's electric grid. The overall Grid Modernization Innovation Program is comprised of two investment plans (two Phases), each guided by the goals for reforming the electric system under REV. Under the Phase I, DER Interconnection investment plan[9], investments are being targeted at technical advances to facilitate interconnection of DER that are currently seeking interconnection in NY. • This investment plan represents Phase II of the Grid Modernization Innovation Program, which targets investments on a broader range of grid modernization topics including innovation in: sensing, communications, controls and diagnostics, advanced materials and dynamic management of the grid and its interconnected elements, notably DER. In Phase II, the program expects to support innovation in: o sensing, communications, diagnostics and controls that optimizes the coordination of system elements in performing essential system management functions o development of advanced/improved products and materials that address physical asset protection and improved functionality o grid visualization, communication and control systems associated with the interoperability of DER in a manner that can be commonly applied across the utilities and promote consumer-based 3rd party engagement in the energy system that is sought through REV.

[9] The DER Interconnection investment plan received approval from the NYS Department of Public Service on May 23, 2016.

	• For a visual representation of this strategy, please reference the flow chart entitled "Logic Model: High Performing Grid" which can be found in Appendix A.
Goals	• The program will make investments in research that accelerates realization of an advanced, digitally enhanced and dynamically managed electric grid that results in more efficient asset utilization (e.g., reduced operating margins, reduced power demands, reduced energy losses) and improved reliability, and resiliency to climate change induced weather-events. Such investments are also expected to build the capacity to integrate and expand the use of clean distributed energy resources thereby increasing customer engagement in energy markets on a customer-by-customer basis, as well as enabling the development of community-based energy systems such as microgrids. • Program activity will focus on de-risking technologies by sharing in the costs of developing and testing technologies and new products, demonstrating their value to the utility system and supporting the development of standards for their application[10]. This will enable accelerated adoption and use by utility and non-utility market actors. The program will: o Invest across the full continuum of the innovation chain including research, proof of concept, product engineering, prototyping, modeling/simulation, and field testing. o Develop tools that can be used by multiple market participants to accelerate the build out of a modern and dynamically operated electric grid. o Leverage expertise residing across all innovation programs and apply rigor to all decisions on project funding at all stages in the continuum emphasizing acceleration of technological readiness and commercialization. o Involve stakeholders to the fullest extent practical in the planning and execution of the investment plan. This includes executing efficient mechanisms to sharing learnings with utilities and other critical stakeholders for the purpose of driving adoption.
State Energy Plan/Clean Energy Standard Link	The attributes of an advanced, dynamically managed electric grid are all essential components of any comprehensive strategy to achieve the goals of the New York State Energy Plan, Clean Energy Standard, and REV initiative: • greenhouse gas (GHG) reduction (by integrating clean distributed energy resources and reducing system losses) • improved affordability (by reducing needed capital investment in grid infrastructure) • greater use of clean distributed energy resources, including renewables (by creating a more flexible grid that can better integrate clean DER) • Improved service quality and resiliency (by increased outage avoidance and faster restoration times via advanced fault location, isolation, and service restoration)

9.2.2 Target Market Characterization

Target Market Segment(s)	The target market is electric transmission and distribution systems.

[10] Smart grid cyber security issues are not a specific focus area in this Investment Plan because there are existing considerable research efforts addressing this topic by the National Institute of Science and Technology and U.S. Department of Energy's Grid Modernization Multi-Year Program Plan.

Market Participants	Market participants include: • Electric utilities (investor-owned(IOU), municipals, cooperatives and authorities) • Grid-technology companies • Medium to large original equipment manufacturers (OEM) with a corporate strategic interest in renewable and/or distributed energy resources • DOE/National Laboratories • Universities and contract research organizations (e.g., Electric Power Research Institute (EPRI)) • New York State Smart Grid Consortium • DER project developers • Startup companies introducing cutting edge products and services. • New York Independent System Operator (NYISO)/New York Reliability Council • Standards setting committees
Market Readiness	• As a result of REV, utility investments in the grid are shifting to more clean, resilient, and affordable energy technologies and solutions which require performance validation to gain acceptance prior to widespread deployment by the utilities. Some of these technologies and solutions are likely common to multiple utilities and therefore offer the opportunity for collaboration to accelerate learnings and ultimately deployment. • New York is home to several leading higher-learning institutions with faculty and curriculum focused on electric power systems and renewable energy. Involvement of these types of institutions can support early stage/proof-of-concept research in smart grid technologies, as well as build workforce capabilities. • The DOE is engaging in similar research, development, and demonstration activities consistent with its Grid Modernization-MYPP. Robust engagement with DOE, additional research institutions, and other leading states in the area of grid modernization will be necessary to promote the setting of reasonable expectations with respect to goals, technology readiness and timing to adoption. Such engagement is also anticipated to result in better leverage of funding.
Customer Value	• Full realization of the potential benefits from grid modernization will require investment of large sums of capital over many years. NYSERDA intervention is expected to contribute to acceleration of these investments by de-risking research with utilities and product innovators and through varied technology transfer mechanisms, stimulating changes in public policy and regulation. • Estimates have the benefits from overall grid modernization in New York approaching $13 billion net of around $7 billion in costs. While not all of these benefits will be solely and directly attributed to advances in grid modernization (some will require additional policy interventions such as monetization of environmental externalities), the realization of most of these benefits will be highly correlated with the development and adoption of advanced grid technologies and systems. An example of some of the potential benefits that could be realized through NYSERDA interventions include: o Increased system-wide efficiency could result in a 3-5% reduction in electric delivery system losses or savings of 5-10m tons of carbon over 25 years (at a $20/ton value, benefits could be as high as $0.2 billion over 25 years). This same reduction in electric deliveries produces consumer savings on the order of $40m annually in avoided purchases. o Use of advanced distribution system management tools can improve avoidance of customer outages and facilitate more rapid restoration resulting in customer savings ranging between $1to 2 billion including reduced costs for utilities to respond to major storms.

	○ Nearly 4,000,000 MWH of PV production by 2020 and approximately 2 million tons of GHG reduction annually. If valued at $20/ton this equates to about $40M annually in GHG reductions. Based on a 20-year device life, approx. 40 million tons of reduced GHG is achievable. ○ Advanced technologies allow existing bulk power system assets to be better utilized increasing system deliverability of clean energy resources on the order of 1,000 MW resulting in reduction of 2m tons of GHG annually. ○ Cumulative GHG reductions associated with increased renewable energy deliverability measured in tens of millions of tons.

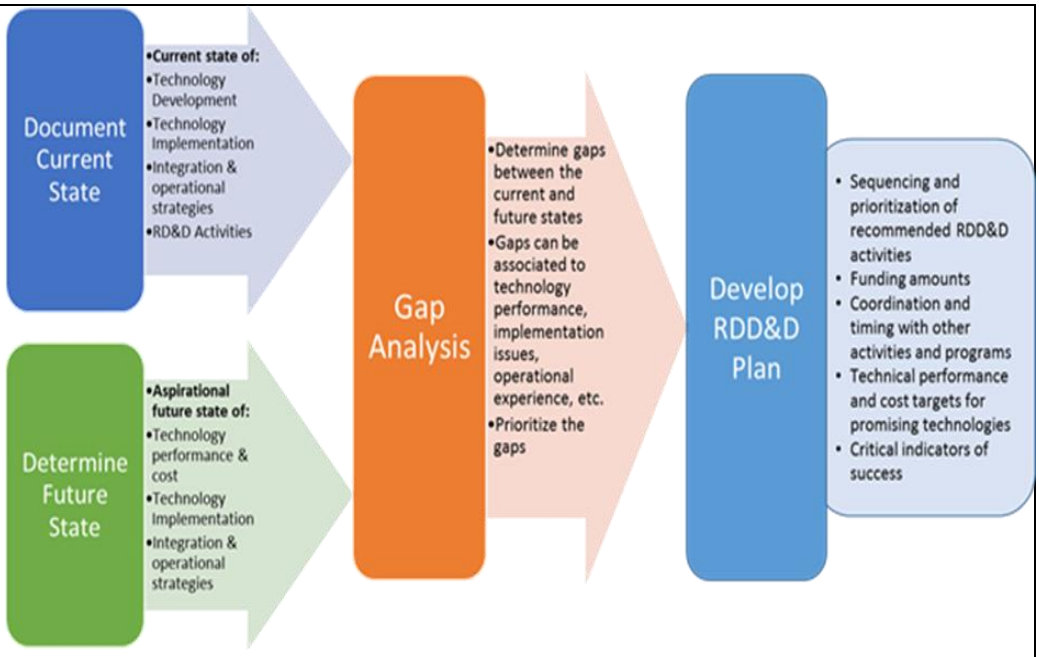
9.2.3 Stakeholder/Market Engagement

Stakeholder/Market Engagement	• Program focus and research activities included within this initiative have been, and will continue to be informed by REV proceedings and participating stakeholder viewpoints. Routine engagement with the New York State Department of Public Service (DPS) will continue to align program focus with current public policy goals. • NYSERDA will participate on working groups and advisory groups organized under the REV proceeding, as necessary, use subject matter experts and consultants to gain insights on gaps in grid innovation and build program offerings that are sharply focused on high priority research. • NYSERDA conducted interviews with utilities and academia in late 2015 and completed a market characterization assessment of it Grid Modernization program in early 2016 using industry expert panelists that provided insight into developing program priorities contained in this plan. NYSERDA has commenced outreach to grid-technology companies to gather intelligence on priority research and will gather additional intelligence on research priorities via direct participation in the formal utility-led Distribution System Implementation Planning (DSIP) stakeholder engagement process, including the Road Mapping project (see Activities below). • NYSERDA will continue to refine an approach for collaboration between NYSERDA, the New York Power Authority (NYPA), DPS, New York utilities, NYISO, and grid tech companies to ensure the Grid Modernization work is compatible with and complimentary to the development of DSIPs, consistent with New York State Public Service Commission (PSC) rules, and focused on needs specific to New York utilities. Collaboration will continue to build mechanisms ensuring various REV (REV Connects), NY Prize and CEF initiatives are integrated/aligned to make optimal use of time and resources.

9.2.4 Theory of Change

Technology Opportunities and Barriers Addressed	• Achievement of public policy goals for distributed resources including microgrids (e.g., NY SUN, combined heat and power, energy storage), and for improving overall electric grid system investment and operating efficiencies is constrained by the lack of real-time intelligence on system conditions, device and integrated system control functions, power quality concerns, and limitations in physical properties of existing system equipment. Validation of technology performance is critical to obtain acceptance by an engineering and standards-based utility culture focused on safety and reliability. These challenges will be addressed by exploring technology development in areas such as, but not limited to, the following:

	○ Research, development, and demonstration of lower cost sensors, higher-speed, lower cost processing of condition monitoring data to facilitate accurate power system state estimation, optimized power flow management, and real-time verification and control functions that are essential to multi-party transactions envisioned under REV. ○ Advancement of high-resolution aerial imaging technologies and advanced diagnostics of weather and other data relevant to outage prediction and recovery operations to accelerate outage predictions, damage assessments and restoration and improve vegetation management practices. ○ Enhancing the physical properties of materials and advanced engineering of equipment and component systems such as through scaling of superconducting technologies to distribution system applications and developing conductor coatings that mitigate environmental degradation to cable performance to develop more resilient, energy-efficient and higher-performing system components.
Testable Hypotheses	• If real-time data acquisition and computational capacities become commonplace, and DER control technologies meet performance goals, then: ○ distribution systems could be designed and operated more intelligently and less conservatively, delivering energy more efficiently while maintaining high levels of reliability and increasing resiliency ○ the capability of determining the optimal locations for, and usable magnitude of DER on the distribution system will no longer be an impediment to increased clean DER and improvements in utilization of the power system. • If research and product development can focus on problems common to all electric utilities, then adoption of innovation can be accelerated. • If capabilities of DOE and federal laboratories (and possibly complimentary in-state laboratory capability currently under development) can be leveraged, then development and adoption of promising grid modernization technologies/practices will be accelerated. • If validation and performance testing is completed, then acceptance of new technology and methods can be accelerated within the engineering and standards-based utility culture focused on safety and reliability.
Activities	***Apply Results of Grid Modernization Roadmap*** – Apply the results of the Grid Modernization Roadmap work, expected to be completed mid-2017 through Phase I of the Grid Modernization Investment Plan (DER Interconnection Investment Plan), to the design of program funding opportunities aimed at developing an advanced, integrated, high-performing grid as follows: • Use gaps assessment to guide program research (priorities/work streams/use cases, budget, and schedule) necessary to accelerate pace of development of technologies, applications and utility capabilities. • Using the assessment, collaborate with NYPA and the utilities, as necessary, on the development of the Advanced Grid Innovation Laboratory for Energy(AGILe) in New York to support grid modernization research that compliments plans and capabilities of the DOE's Grid Modernization Laboratory Consortium Testing Network.



Source (Electric Power Research Institute)

Technology Innovation Funding Opportunities - Provide funding opportunities in support of New York utilities and technology companies to leverage existing capabilities, validate distribution system technologies and practices, create innovative products and applications and otherwise facilitate the development of an advanced high performing integrated electric grid. Begin work as early as 3rd quarter 2016 or as guided by outcomes from the road mapping exercise, voice of customer research, and the DSIP process. This work will compliment, and not be duplicative of, the funding opportunities provided under the Phase I DER Interconnection Investment Plan which focus specifically on facilitating DER interconnection.

- Issue broad competitive solicitations for project proposals across the continuum of technology development (early stage research/ proof of concept, product engineering and testing, and product demonstration).
- Issue requests for proposals (RFPs) or other targeted calls for proposals, potentially in collaboration with New York utilities and DPS, to addresses challenges common across the system (e.g., large smart grid system/REV pilots).
- Specific tech-to-market support will be provided to technology developers to help drive the commercialization of new innovations. Support will be tailored specifically to help early-stage companies navigate the typical channels to market. As applicable, projects will be required to involve no less than one utility; in most cases, multiple utility involvement will be incentivized.

Securing Technical Services Assistance- Issue a solicitation to a field of subject matter experts and/or consultants covering areas of key interest to the program; or leverage applicable expertise acquired through other NYSERDA procurement processes for securing technical assistance to support program activities.

Technology Transfer Mechanisms- Develop more formalized mechanisms (e.g., platforms, periodic workshops, symposia) to transfer best practices/lesson learned from technology development activities. Technology transfer activities will be two-way conduits for information flow thereby providing ongoing “voice of customer” information

	back to the Program. Communicate these use cases to influence policy makers/regulators/utilities on the technical merits of such innovation and the business models such innovation can enable while pushing adoption/uptake by other utilities. Showcase the benefits of advanced grid management systems in managing and enabling increased DER integration using "best-in-class" utility smart grid applications. Begin work in 3rd quarter 2016.
Key Milestones	Milestone 1 (2017) • Issue broad competitive solicitation #1 guided by utility DSIP baseline filings and completed stakeholder market research (e.g., demonstrations, product development, engineering analyses and studies) in technology, tools and methods aimed at dynamic management of the electric grid. Milestone 2 (2017) • Enter into contracts for projects awarded under the broad competitive solicitation #1. Milestone 3 (2017) • Identify near-term opportunities for applied research that are aligned with utility supplemental DSIPs and the NY Grid Modernization Roadmap. Milestone 4 (2017) • Issue targeted competitive solicitation #2 guided by utility supplemental DSIPs and the NY Grid Modernization Roadmap. Milestone 5 (2017) • Enter into contracts for projects awarded under the targeted competitive solicitation #2. Milestone 6 (2018) • Identify technology gaps necessary to support community grid operation based on completed NY Prize Stage 1 evaluations. Milestone 7 (2018) • Issue broad competitive solicitation #3. Milestone 8 (2018) • Enter into contracts for projects awarded under the broad competitive solicitation #3. Milestone 9 (2018) • Issue targeted competitive solicitation #4. Milestone 10 (2019) • Enter into contracts for projects awarded under the targeted competitive solicitation #4. Milestone 11 (2019) • Issue broad competitive solicitation #5. Milestone 12 (2019) • Enter into contracts for projects awarded under the broad competitive solicitation #5.

	Milestone 13 (2020) • Issue targeted competitive solicitation #6. Milestone 14 (2020) • Enter into contracts for projects awarded under the targeted competitive solicitation #6. Milestone 15 (2020) • Issue broad competitive solicitation #7. Milestone 16 (2021) • Enter into contracts for projects awarded under the broad competitive solicitation #7. Milestone 17 (2021) • Issue targeted competitive solicitation #8. Milestone 18 (2021) • Enter into contracts for projects awarded under the targeted competitive solicitation #8. Milestone 19 (2022) • Issue broad competitive solicitation #9. Milestone 20 (202621) • Enter into contracts for projects awarded under the broad competitive solicitation #9.
Goals Prior to Exit	• Due to the nature of this work, the long lead time associated with adoption, and society's fundamental need for an efficient and reliable electric grid, NYSERDA envisions continuing to pursue innovation this space for many years. Research priorities will shift as various High Performing Grid functionality are realized and new or improved grid functionalities are identified. • By accomplishing the following, NYSERDA aims to accelerate the realization of customer benefits: o Demonstrated capability of advanced technologies, materials, tools and methods to dynamically manage the electric grid through several larger-scale pilot projects and/or through coordinated but disaggregated innovation pilots across the incumbent utilities. o Product development and demonstration projects linked to technology gaps impeding realization of the REV future state and advancing industry standard setting processes to facilitate regulator and industry acceptance, promote support for utility research, development, and demonstration (RD&D) investment and accelerate adoption/application. • NYSERDA will exit or cease funding specific areas of technology development and shift focus once scalability is confirmed and a value proposition to customers, regulators and policy makers can be validated/demonstrated.

9.2.5 Relationship to Utility/REV

Utility Role/Coordination Points	• NYSERDA will participate on working groups and advisory groups organized under the REV proceeding, as necessary, use subject matter experts and

	consultants to gain insights on gaps in grid innovation, and build program offerings that are sharply focused on utility-centric, high priority research. • Most program offerings require the engagement/support by at least one utility; NYSERDA funding for product field demonstration or pilot projects almost always require the formal engagement by at least one utility and preferably more. NYSERDA has solid working relationships with each utility, meet regularly with their utility RD&D counterparts and will continue to use this discovery process to design program offerings and technology transfer mechanisms that are of most value to this customer base. NYSERDA expects to develop and implement more effective technology transfer processes collaboratively with the utilities to accelerate technology innovation/adoption (see Activities/Resources). • Program activities will be designed and executed to compliment REV development activities. NYSERDA will continue to regularly engage with counterparties at DPS for the purposes of program planning and execution with the regulated utilities (see Activities/Resources). DPS will be able to review draft competitive offerings, and participate directly in the evaluation and ranking of proposals for funding to support project investment recommendations that are reasonably aligned with REV and State Energy Plan objectives. • NYSERDA will leverage its activities with those under REV (e.g., REVConnect), NY Prize and other Innovation program activity (e.g., Building Innovations) to preclude duplication of services making effective use of resources.
Utility Interventions in Target Market	• New York utilities do not have offerings to the market in this area. Furthermore, utilities are a key direct customer of this initiative and therefore are considered part of the target market. • New York utilities currently have modest internally funded research and development activities related to grid modernization. • New York utilities are routinely solicited by vendors looking to test and/or deploy new technology. Much of this new technology is not sufficiently field tested or de-risked to allow for widespread application on the utility grid. • New York utilities participate to varying degrees in broader grid modernization research programs with the DOE (Grid Modernization Lab Consortium) and the EPRI that often are designed to serve a multitude of utility interests across differing jurisdictions and markets; so unique interests of concern to New York may not be entirely addressed.

9.2.6 Budgets & Expenditures

An annual commitment budget for all activities included in this chapter is shown in Table 6. The annual expenditure projection is included in Table 7. Budgets and expenditures do not include Administration, Evaluation, or Cost Recovery Fee; these elements are addressed in the Budget Accounting and Benefits chapter filing. The budget as presented in the Budget Accounting and Benefits Chapter will serve as the basis for any subsequent reallocation request. The additional level of detail presented within the table below is intended for informational purposes only.

The budget presented below cannot be viewed in isolation from planning and regulatory actions that will be undertaken by the utilities and other market actors as the industry transformation called on by REV proceeds. Research priorities are expected to evolve with and be supportive of utility grid modernization plans as such become defined more formally via the REV proceeding. The

budget shown below is representative of a long-term view of needed investment in grid modernization that is characterized by long-lead times to develop, test and deploy REV enabling technologies. Specific research initiatives and associated costs will be identified and informed by the Roadmap; by needs outlined in the initial DSIPs and biennial updates to the DSIPs; and by progress in rolling out REV-enabling technology. Decisions on research priorities, types of investments, and timing and funding levels will be subject to revision accordingly.

Table 6: Annual Innovation & Research Budget Allocation – Commitment Basis

Commitment Budget	2016	2017	2018	2019	2020	2021	2022	Total
Research and Technology Studies/Development/ Demos	$5,000,000	$18,350,000	$20,350,000	$16,700,000	$16,700,000	$16,700,000	$16,700,000	$110,500,000
Total	$5,000,000	$18,350,000	$20,350,000	$16,700,000	$16,700,000	$16,700,000	$16,700,000	$110,500,000

Table 7: Annual Expenditures Projection

Expenditures	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Total	1%	6%	11%	14%	16%	16%	16%	11%	6%	2%	100%

9.2.7 Progress and Performance Metrics

Table 8 provides program Activity/Output indicators representing measurable, quantifiable direct results of activities undertaken in the initiative. Outputs are a key way of regularly tracking progress, especially in the early stages of an initiative, before broader market changes are measurable. Outcome indicators can encompass near-term through longer-term changes in market conditions expected to result from the activities/outputs of an intervention. Outcome indicators will have a baseline value and progress will be measured periodically through Market Evaluation.

Table 8. Initiative Specific Metrics

Indicators[11]		Baseline	2019[12] (Cumulative)	2022 (Cumulative)
Activity/ Outputs	# of studies, demonstrations, and product development projects initiated	0	52	109
	# of studies, demonstrations, and product development projects completed	0	19	67
	# of companies supported, # utility touchpoints/ partnerships, other partnerships with established manufacturers or grid technology companies[13]	0	31	64
Outcomes	Increased system (enterprise level) intelligence used to predict failures, disruptions and support self-healing (reduced outages).	Partial application of model centric-advanced distribution management system (ADMS) controls at two NY utilities.	Complete/nearly complete use of model centric-ADMS controls at one NY utility.	Use of model centric-ADMS controls at two or more NY utilities.
	Number of technologies/systems that enable system condition prediction and restoration being tested	Early stage products available; no noteworthy pilots underway in NY.	One new condition monitoring technology and restoration process management product/service being piloted or in use at a utility.	Multiple condition monitoring and restoration process services in use.
	Data collected through advanced sensing devices used to dynamically manage power flow and other system elements.	Partial functionality in existing / planned near-term pilot.	Full functionality power flow optimization pilot at one utility.	Full functionality power flow optimization in use at one or more NY utilities.
	Advanced control/integration of DER in the electric grid	Few research projects of modest scope in NY.	One full functionality pilot project with integration of multiple DER sources.	Integration of DER as standard practice at one or more NY utilities.

[11] A 0 (zero) denotes that the actual value is currently believed to be zero for baseline/market metrics.

[12] Number of expected projects supported is based on historical mix of project type and cost sharing requirements. Should it be decided to fund one or more large demonstration projects with higher NYSERDA cost sharing, the mix of project types supported would likely change materially reducing the number of projects.

[13] Participants are duplicative (utilities and academia participate concurrently on different projects) so number attempts to identify the number of unique project participants.

The benefits shown in Table 9 and Table 10 are direct, near term benefits associated with this initiative's projects. These benefits will be quantified and reported on a quarterly basis and will be validated through later evaluation. Due to the nature of these activities, estimating energy savings impacts at this stage is difficult because the specific technologies that will be support are not known. However, energy savings for projects supported by this initiative will be tracked and reported.

Table 9. Direct Impacts

Primary Metrics[14]		**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**TOTAL**
Energy Efficiency	MWh Annual								
	MWh Lifetime								
	MMBtu Annual								
	MMBtu Lifetime								
	MW								
Renewable Energy	MWh Annual								
	MWh Lifetime								
	MW								
CO2e Emission Reduction (metric tons) Annual									
CO2e Emission Reduction (metric tons) Lifetime									
Customer Bill Savings Annual ($ million)									
Customer Bill Savings Lifetime ($ million)									
Private Investment ($ million)[15,16]		$3.95	$11.5	$13.6	$11.4	$14.6	$14.6	$14.6	$84.25

Table 10. Annual Projected Initiative Participation

	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Participants[17]	6	9	9	7	11	11	11	64

[15] This reflects direct project co-funding and does not reflect private investments associated with full deployment of new solutions by the utility industry. Such private investment could be substantial.

[16] Historically, this area of investment has had several successful product development-to-commercialization ventures resulting in leveraging private sector funding at 4 or 5 times public sector funding. While it is possible for this to continue into the future, predicting such leverage is speculative; particularly in a capital intensive industry like the electric utility industry. Companies that can effectively participate in product development in this capital intensive, engineering and standards driven market space are typically well capitalized and have internally developed intellectual property needing only demonstration to the utilities. The leveraging depicted in Table 4 reflects recent trends in funding a greater share of engineering studies and demonstration projects and less product development projects, biasing the private leverage expectations lower. This mix of projects can change and a single large product development project success could result in greater private sector leverage.

[17] Participants are duplicative (utilities and academia participate concurrently on different projects) so number attempts to identify the number of unique project participants

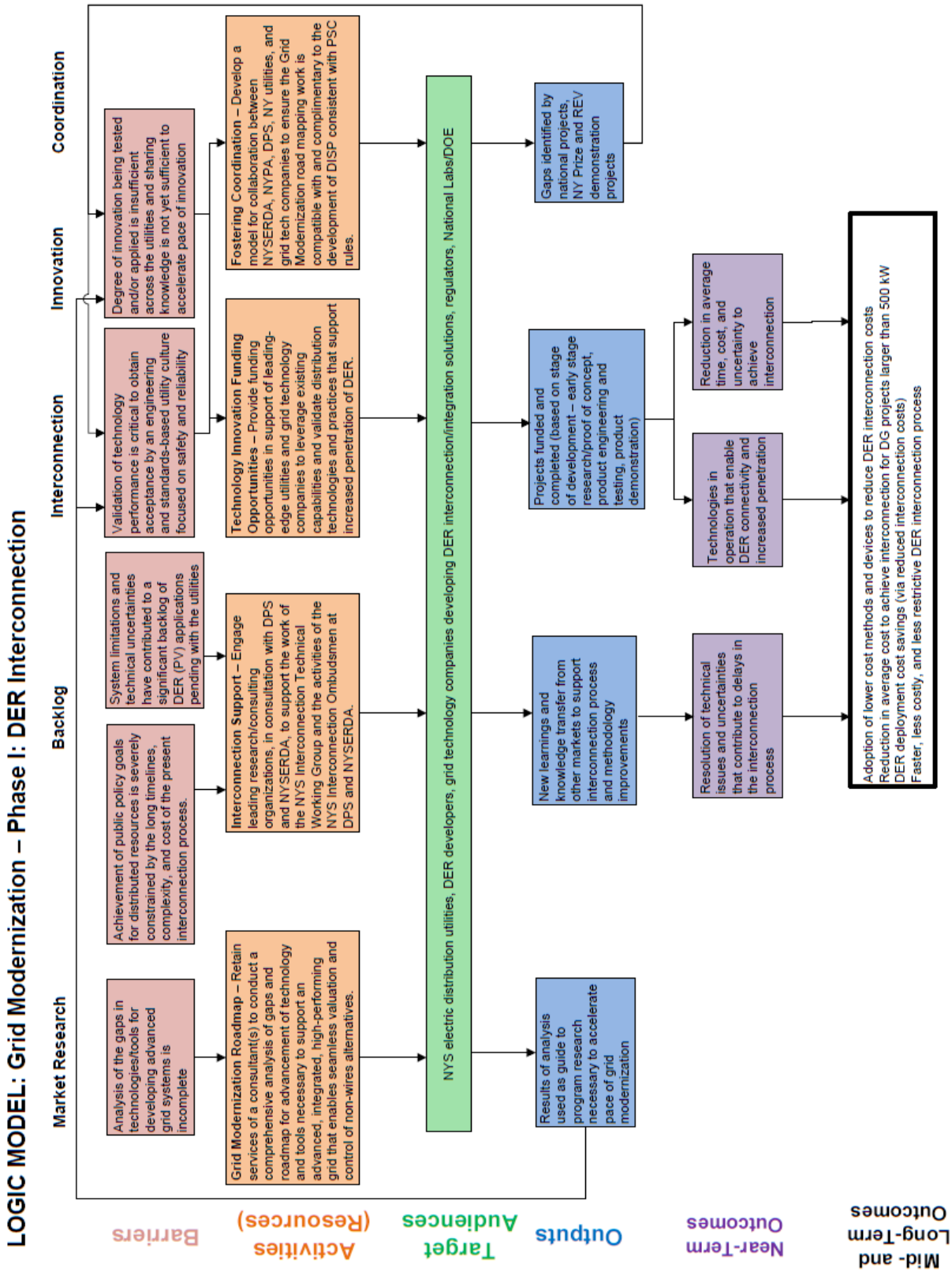
9.2.8 Fuel Neutrality

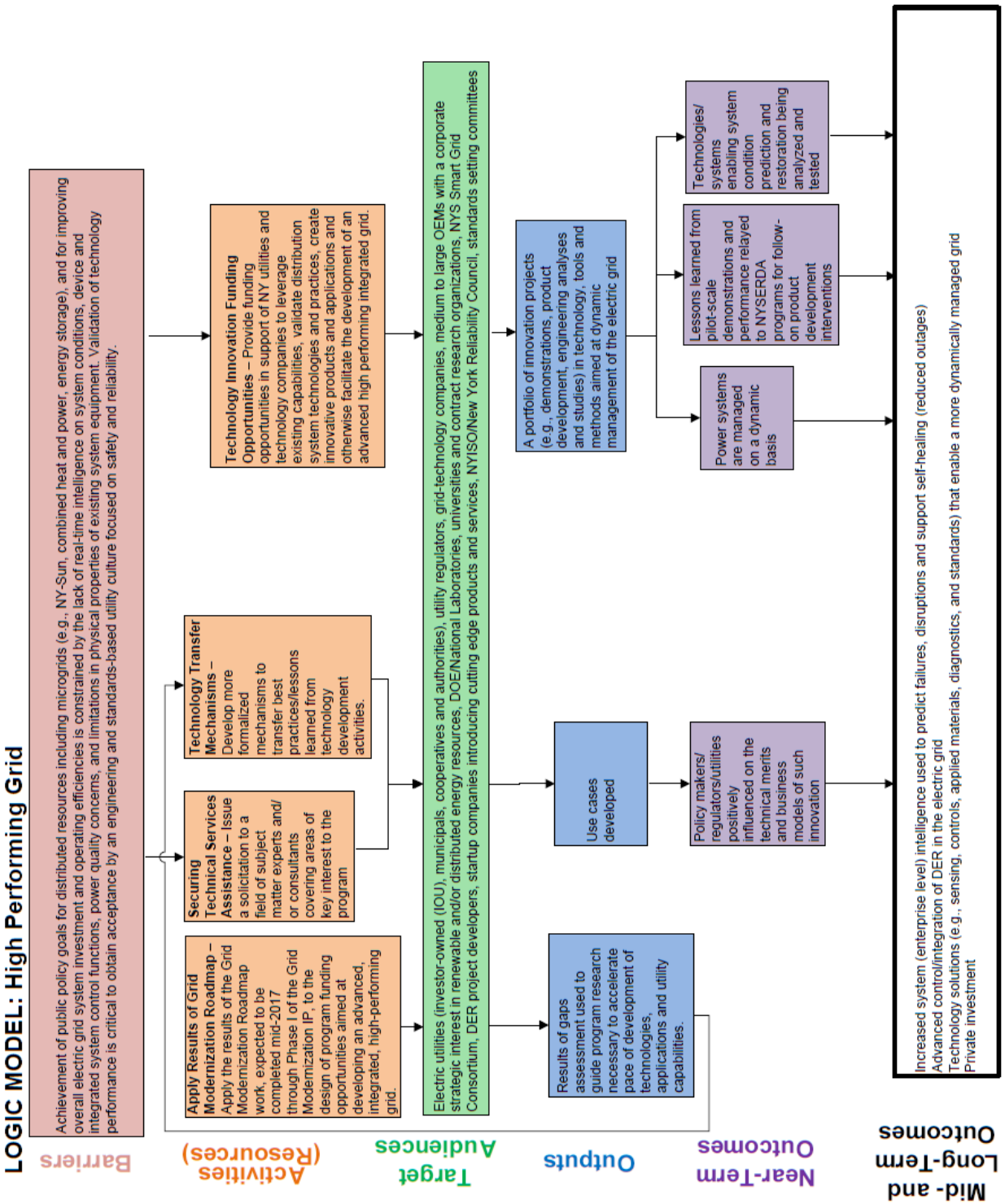
Fuel Neutrality	• This initiative is not being delivered on a fuel neutral basis.

9.2.9 Performance Monitoring and Evaluation Plans

Performance Monitoring & Evaluation Plan	NYSERDA's approach to monitoring and assessing the effectiveness of the initiative and overall market development is described below. **<u>Test-Measure-Adjust Strategy</u>** • NYSERDA will monitor standard activity/output metrics including number of projects initiated and completed by type, private investment, etc. • For any new technology developments launched under the program, on a yearly basis, NYSERDA staff and contractors will reassess the Technology and Commercialization Readiness Levels for each project in the portfolio. • NYSERDA will conduct peer reviews of certain projects based on need. Examples – technical impasse, pivot point, critical milestone. • NYSERDA will assess the portfolio of projects annually with an advisory panel and with senior NYSERDA management with regard to goals, metrics, outputs and outcomes. **<u>Market Evaluation/Impact Evaluation</u>** • Market Evaluation will draw on the logic model and will include baseline and longitudinal measurement of key indicators of market success. • Baseline measurements of key performance indicators will occur within one year of initiative approval and will address key progress indicators such as the technologies/systems available that enable system condition prediction and restoration. In these areas, NYSERDA will first utilize existing information and will fill gaps in information as needed for appropriate baselining. • Regular (e.g., annual or biennial) updates to key performance indicators and measurement of market change will occur once the initiative is underway. Sources of data include public and commercially available data, and primary data collection through surveys of key market actors. • NYSERDA will also examine benefits and impacts of product development and demonstration projects.

Appendix A – Logic Models




LOGIC MODEL: High Performing Grid
Barriers
Achievement of public policy goals for distributed resources including microgrids (e.g., NY-Sun, combined heat and power, energy storage), and for improving overall electric grid system investment and operating efficiencies is constrained by the lack of real-time intelligence on system conditions, device and integrated system control functions, power quality concerns, and limitations in physical properties of existing system equipment. Validation of technology performance is critical to obtain acceptance by an engineering and standards-based utility culture focused on safety and reliability.
Activities (Resources)
Apply Results of Grid Modernization Roadmap – Apply the results of the Grid Modernization Roadmap work, expected to be completed mid-2017 through Phase I of the Grid Modernization IP, to the design of program funding opportunities aimed at developing an advanced, integrated, high-performing grid.
Securing Technical Services Assistance – Issue a solicitation to a field of subject matter experts and/ or consultants covering areas of key interest to the program
Technology Transfer Mechanisms – Develop more formalized mechanisms to transfer best practices/lessons learned from technology development activities.
Technology Innovation Funding Opportunities – Provide funding opportunities in support of NY utilities and technology companies to leverage existing capabilities, validate distribution system technologies and practices, create innovative products and applications and otherwise facilitate the development of an advanced high performing integrated grid.
Target Audiences
Electric utilities (investor-owned (IOU), municipals, cooperatives and authorities), utility regulators, grid-technology companies, medium to large OEMs with a corporate strategic interest in renewable and/or distributed energy resources, DOE/National Laboratories, universities and contract research organizations, NYS Smart Grid Consortium, DER project developers, startup companies introducing cutting edge products and services, NYISO/New York Reliability Council, standards setting committees
Outputs
Results of gaps assessment used to guide program research necessary to accelerate pace of development of technologies, applications and utility capabilities.
Use cases developed
A portfolio of innovation projects (e.g., demonstrations, product development, engineering analyses and studies) in technology, tools and methods aimed at dynamic management of the electric grid
Near-Term Outcomes
Policy makers/ regulators/utilities positively influenced on the technical merits and business models of such innovation
Power systems are managed on a dynamic basis
Lessons learned from pilot-scale demonstrations and performance relayed to NYSERDA programs for follow-on product development interventions
Technologies/ systems enabling system condition prediction and restoration being analyzed and tested
Mid- and Long-Term Outcomes
Increased system (enterprise level) intelligence used to predict failures, disruptions and support self-healing (reduced outages)
Advanced control/integration of DER in the electric grid
Technology solutions (e.g., sensing, controls, applied materials, diagnostics, and standards) that enable a more dynamically managed grid
Private investment