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Clean Energy Fund Investment Plan: Agriculture

Portfolio: Market Development

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14 Agriculture

NYSERDA seeks to address energy efficiency opportunities in the agricultural sector that focus on providing trusted information and build on strengthening relationships with farm partners. To overcome barriers that are impeding progress, the initiatives will seek to address the risk aversion experienced by the owners and operators that energy efficiency could interrupt their agricultural business and processes, lack of trust in the energy efficiency technology to deliver the intended benefits, lack of in-house expertise or time to dedicate to energy improvements, and cost and finance sensitivity.

The first initiative described in this Chapter is Greenhouse Lighting and Systems Engineering, which aims to target energy-related improvements in greenhouse system operations by optimizing energy efficiency, crop yield and quality. The goal will be to establish a Consortium that will become financially self-sufficient by bringing together academia and marketplace knowledge and experience to develop new control systems, lighting products and technical services to increase the adoption of the new technologies in the greenhouse industry.

Potential additional initiatives under consideration include: Best Practices in Farm Management which aims to provide proven best practice information to educate the agriculture marketplace on the benefits and costs of energy related improvements, Advanced Technology Pilots to illustrate and document the value proposition of technologies for targeted energy use on farms, and addressing the Controlled Environment Agriculture marketplace through benchmarking and technical assistance.

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

14.1 2030 Greenhouse Lighting and Systems Engineering

14.1.1 Overview

Present Situation	• Overall interest from consumers in locally-grown food is increasing, and to support this demand in New York, with its relatively short growing season, greenhouses are growing rapidly. The United States Department of Agriculture (USDA) census data[1] shows lettuce and tomato, two profitable crops that are well-suited for greenhouse production, growing in New York 10.6% per year from 2007 to 2012. Since 2012, continued rapid growth in greenhouse product value, acreage, year-round usage and control techniques has been observed, leading to newer greenhouses producing more than twice the yields per acre of low-tech greenhouses. • Greenhouses are more electricity-intensive (electricity use per square foot) overall than other buildings, including food service buildings and hospitals. Much of this is due to lighting. A typical lighting power density for commercial

[1] Based on New York State-specific data from USDA NAFF Census data 2007-2012, published in 2014

	buildings is 1 watt per square foot, but a lettuce greenhouse in the New York climate uses more than ten times that number. A conservative estimate of the electricity used just for lighting in existing New York State greenhouses producing lettuce and tomatoes in 2015 is 313 GWH per year, which equates to 164,662 metric tons of CO_2 annually based on New York's power generation mix. • Light-emitting diodes (LEDs), unlike traditional high-pressure sodium lighting, could be manufactured to emit a variety of light spectra to meet the needs of specific crops. With the right control systems, even current LEDs marketed to greenhouses can be dimmed, pulsed, and controlled, allowing an unprecedented level of optimization and integration of greenhouse management systems, leading to large energy savings. • More advanced control systems for greenhouses also regulate ventilation, lighting, and CO_2 supplementation. Electricity savings of 70 to 86% (depending on New York State climate zone) are possible through synergistic control of these parameters. • Though potential energy savings are very high, a market gap exists because the market players do not understand the potential opportunity. Growers do not have the expertise to design specialized control systems, nor can the lighting industry do it alone because they do not have the deep and specialized understanding in plant physiology and overall greenhouse systems that is needed to optimize crop production and energy usage. This is why packaged solutions for greenhouse production and energy-use optimization do not exist, system-wide demonstrations have not yet occurred at scale, and teams with cross-cutting expertise have not formed on their own. • The Consortium will develop progressively more advanced control systems that treat greenhouse operations as systems, make market players aware of these systems, develop cross-cutting expertise, and provide training for teams of service providers so that market adoption can occur.
Intervention Strategy	• To facilitate realization of the energy savings potential and address market barriers, NYSERDA will support formation of a Greenhouse Lighting and Systems Engineering (GLASE) Consortium that will synergistically target energy-related improvements to greenhouse system operations (e.g. integrated control of ventilation, lighting, humidity and CO_2 supplementation). • Funding will be provided to Cornell University and Rensselaer Polytechnic Institute (RPI) as core members to advance the Consortium, which will include further membership with the full range of required expertise, including plant biologists, agricultural engineers, computer software control engineers, and lighting engineers, who together represent world-class expertise on greenhouse operation. Past work performed by core members in this area (including a portfolio of existing patents and proprietary data) forms an in-depth body of knowledge and experience. • The Consortium will develop new control systems, lighting products, and technical services, and conduct iterative field testing to demonstrate and refine the systems and products in real-world settings. • Deployment of new lighting products will be pursued through manufacturers in the Consortium, working closely with plant biologists in the Consortium. Manufacturers will also work closely with other Consortium members versed in systems integration and greenhouse-specific engineering, who will deploy control systems and provide ongoing technical services to greenhouses. • The Consortium will achieve the best possible uptake and deployment of solutions by using the core members' strong industry connections across the LED lighting and greenhouse supply chain with manufacturers, technical service providers, researchers, and through collaboration with specific

	adoption-ready growers. • NYSERDA will also coordinate with the Consortium to provide NYSERDA-based technical service assistance to growers, and work with NYSERDA outreach contractors to assist in information dissemination. • Successful integration of synergistic greenhouse operations will decrease operating expenses and optimize production, and in so doing increase revenues for New York growers. • For a visual representation of this strategy, please reference the flow chart entitled "Logic Model: Agriculture - GLASE," which can be found in Appendix A.
Goals	• The goal of this initiative is to establish a financially self-sufficient GLASE Consortium to develop new control systems and lighting technologies for greenhouses, and through an aggressive and targeted outreach campaign involving Consortium and industry partners, facilitate the uptake of the new technologies so the benefits may be realized. The GLASE Consortium aims to transform lighting and systems management in the rapidly-growing greenhouse industry by optimizing energy efficiency, crop yield and quality.
State Energy Plan/Clean Energy Standard Link	This strategy contributes to the goals of the New York State Energy Plan and Clean Energy Standard (CES), including greenhouse gas emission reductions, statewide energy efficiency improvements and growth in the clean energy economy. By making greenhouses more efficient, the initiative will mitigate the increase in electricity demand resulting from New York's growing greenhouse industry. Through use of better control systems, seasonal greenhouses may also extend their growing season in the spring and fall, or even extend their operations to year-round, which contributes positively to local load factors. These attributes of the program support Renewable Energy Vision (REV) concepts regarding electricity demand and load factors.

14.1.2 Target Market Characterization

Target Market Segment(s)	The target market for this initiative is greenhouses and vertical farms[2], with an initial focus on the fastest growing vegetable and other food crop markets in New York State.
Market Participants	Market participants include: • Botanists with demonstrated expertise in greenhouse and vertical farm crop production, particularly hydroponic production of vegetables • Engineers with demonstrated success in technologies that integrate greenhouse operating systems, sensors and software, including design and modulation • Lighting designing and manufacturing companies • Potential manufacturers of improved greenhouse control and lighting products • Greenhouse growers • Supermarket produce buyers • Agriculture and lighting engineers • Controlled Environment Agriculture researchers • New York State Department of Agriculture and Markets • Cooperative Extension agents • Small lighting sales companies • Horticulture suppliers • Energy Auditors

[2] A vertical farm is a greenhouse system where trays of crops are stacked vertically to maximize production per square foot. Unlike greenhouses, all lighting is artificial; there is no sunlight.

	• Academic and research organizations • Trade associations
Market Readiness	• The Consortium concept was an outgrowth of prior work sponsored by NYSERDA. In one prior project using commercially-available lighting in an operational greenhouse, the traditional LED luminaires performed below the industry standard: high-pressure sodium luminaires. The LEDs did not meet general manufacturer claims for light intensities or energy efficiencies, nor were their spectra optimized for plant growth. Other NYSERDA work led to development of a lighting software management system and a "virtual grower" greenhouse simulator. In still other work, significant energy savings were achieved by sensing the physiological state of the plant and controlling light delivery. This led to the concept of the need for a consortium that could be used to help specify, develop, demonstrate, and tailor systems to individual plant species, which vary widely in their specific needs. • This would allow LEDs to provide added value to the grower by not only meeting basic grower expectations for energy efficiency and light intensity, but also by providing improved plant responses, including yield and morphology. • The type and level of control of greenhouse operations has only recently been made possible by the unique attributes of LED lighting. However, to fully take advantage of the opportunity for energy savings, improved LEDs must be paired with improved control systems. Advanced greenhouse controls have the potential to lead to vast savings in greenhouse electricity usage. The potential for electricity reduction is conservatively estimated at 70-86% per greenhouse, (depending on the New York climate zone) leading to an estimated 1,915,000 metric tons of greenhouse gas savings by 2030. • If New York's greenhouse acreage for lettuce and tomatoes grew by a conservative 10.6% per year, it would reach an estimated $567 million by 2030 (in 2015 dollars). This would represent a 56.7% penetration of the $1 billion+ New York market for lettuce and tomatoes alone. There is realistic potential for expansion beyond 2030 as these wholesale market values do not include other vegetables and crops. • NYSERDA has spent multiple years investigating the technologies and opportunities unique to the greenhouse market sector, and has fostered relationships with key players to bring a consortium of plant scientists and lighting technology and control specialists together. NYSERDA will use its deep understanding of the issues to help market players understand the large potential benefits that greenhouse systems can provide, and to help develop improved systems that synergistically control electricity use. NYSERDA will also use its existing relationships with market players to bring disparate parties together to form teams of cross-cutting expertise.
Customer Value	• A successful effort would lead to an overall reduction of 10-16% in total greenhouse operating costs, including electricity and other energy costs (heating) as well as costs for labor, supplies, packaging, delivery, insurance, etc. Greenhouses operate in a highly competitive environment with tight profit margins, and they use more electricity per square foot than other applications (e.g., food service, hospitals, offices, hotels, or schools). One type of greenhouse, a plant factory, uses nearly as much electricity on a watt per square foot basis as data centers, which are among the highest users of electricity. Effective management of electricity expenditures is crucial to remaining profitable and competitive, particularly for this energy-intensive sector. Payback for improved systems ranges from one to three years. • It is anticipated benefits to growers will begin to accrue in the first year of the seven-year program with commercial sales of the first generation of control system products. Electricity reductions from lighting alone are targeted at 50% of a greenhouse's current electricity usage. Electricity reductions for overall systems that control not only lighting but also humidity, ventilation and CO_2 levels, are targeted at 70-86% less electricity usage per greenhouse by year seven.

	• The energy efficiency and crop productivity improvements (shorter growth cycles) resulting from advances in greenhouse systems management will be quantified as avoided production of greenhouse gases (metric tons of CO_2) and electricity consumption per unit of crop growth. • An additional benefit is expected through growth of new business opportunities in New York State for manufacturing the luminaires to a global greenhouse industry. • Benefits to the consumer that result from production system improvements include fresher, more local products with longer shelf life and improved nutritional value. • If the 10.6% annual growth in lettuce and tomato greenhouse space were to continue, lettuce and tomato crops produced in New York greenhouses would reach a wholesale market value of $567 million (in 2015 dollars) by 2030. The wholesale value of all lettuce and tomatoes consumed in New York is currently more than $1 billion. In addition to lettuce and tomatoes, there are many other crops (vegetables, flowers, herbs, berries, etc.) that could be grown in greenhouses, resulting in a total wholesale value for all crops much greater than $1 billion.

14.1.3 Stakeholder/Market Engagement

Stakeholder/Market Engagement and Customer Discovery	• For more than three years, NYSERDA has been collaborating with Cornell and RPI to develop and refine this Consortium concept. NYSERDA has vetted the approach, market assumptions, technology readiness levels, estimates of energy and GHG savings, financial model, and business plan to self-sufficiency. The analysis concluded that there is a high level of technical readiness for the concept. The product development is maturing; the time to market for each individual product has been estimated, and plans are developed so that different products roll out during the seven years that NYSERDA will support the Consortium. • Marketing to potential GLASE Consortium participants will begin with the more than 30 stakeholders, including many important major market players, who have already signed letters of intent expressing interest in joining the GLASE Consortium. • The market for greenhouse system control products manufactured in New York is international and includes many well-known traditional lighting companies. Expansion of the GLASE Consortium to future members will be part of Consortium activities. • Existing greenhouse suppliers have a large network of online and print trade publications which will also be used for marketing. The Consortium will coordinate with the Controlled Environment Agriculture (CEA) Advisory Board, New York's newly-formed greenhouse stakeholder group. • Manufacturing partners will hold an advisory capacity in the Consortium. • Greenhouse growers will also be fully engaged as advisors and as demonstration sites. • NYSERDA staff will also work with New York State Department of Agriculture & Markets and Cornell Cooperative Extension to connect to the in-state market. • NYSERDA will also utilize the Clean Energy Advisory Council (CEAC) as a way to engage with stakeholders, as appropriate.[3]

[3] The Clean Energy Advisory Council was established by the Public Service Commission through an Order in the Clean Energy Fund Proceeding (Case 14-M-0094. et al, Proceeding on Motion of the Commission to Consider a Clean Energy Fund, Order Authorizing the Clean Energy Fund Framework, filed January 21, 2016).

14.1.4 Theory of Change

Technology Opportunities and Barriers Addressed	• **Packaged solutions for greenhouse production and energy-use optimization do not exist.** While there are LED technologies that have the potential to improve the energy efficiency and therefore energy costs of greenhouses, they are not tailored to the necessary conditions for enhanced crop production. For example, lighting manufacturers do not specialize in plant physiology, but growers need to synergistically optimize not only lighting but also CO_2, humidity, and ventilation needs. The Consortium will address this by documenting potential and trending market size, disseminating information, and working with key players to implement solutions. • **The full potential of a system-wide approach to greenhouse control has not been fully demonstrated at scale**, and market players are not yet aware of the large potential for benefits that greenhouse systems can provide. A major goal of the Consortium is to promote a system-wide approach to greenhouse operation. • **The industry currently lacks cross-cutting expertise in greenhouse system solutions.** More service provider teams will be needed in the greenhouse industry who can integrate lighting with the other parameters to optimize plant health and energy use. The Consortium can help bring these partners together and train them in specialized applications.
Testable Hypotheses	• If greenhouse operators implement innovations that improve and customize their ability to control lighting, ventilation and CO_2 systems for their specific crops, then they will save 70 to 86% of their electricity costs, depending on their New York climate zone. • If influential manufacturers and end-users are involved in the Consortium, then they will participate as commercialization partners and demonstration sites that accelerate adoption of new innovations beyond the 18 acres of greenhouses targeted for 2019. • If the GLASE Consortium is successful in disseminating information, then paid memberships will occur, resulting in a financially self-sustaining Consortium that continues after the NYSERDA-funded milestones end. • If the GLASE Consortium is successful in forming and training teams with cross-cutting expertise in specialized applications of greenhouse control systems, then those teams will be able to assist growers in implementation of packaged solutions that optimize energy usage.
Activities	NYSERDA will contract with Cornell University and RPI to form and advance the GLASE Consortium. In doing so, NYSERDA will: • **Form and Grow Consortium.** Assist Consortium with the design and organizational structure, and draft documents. Monitor Consortium activities, including: formalizing relationships with those who have expressed interest in joining the Consortium and delineating specific activities and roles for each; recruiting new members; targeting influential large manufacturers of luminaires; in order to achieve financial sustainability, finalizing the business model and growing Consortium membership to balance costs and income to achieve financial self-sustainability after year seven; including mechanisms to support partnerships, membership fees, fee-based trainings and services, and royalties and licenses of patentable products. • **Establish Scientific Advisory Panel**. Establish a panel within the Consortium. Also work with existing advisory panels in New York's newly-formed Controlled Environment Agriculture trade group[4], as appropriate, to identify areas of

[4] The Controlled Environment Agriculture trade group is a voluntary information exchange organization with a broad mission of promoting opportunities in controlled environment agriculture.

	need/opportunity, vet potential solutions, offer guidance on optimal path to market, provide a source of technical and market intelligence, and serve as a pool of potential demonstration partners. • **Technical Activities.** Monitor work of the Consortium as it develops new lighting products as well as new control strategies and services for light, CO_2 and humidity. Work is anticipated to include: optimizing lighting by automating dimming, pulse-width modulation, and integrating combinations of appropriate wavelengths for optimal crop growth; use of CO_2 enhancement in greenhouses; investigation of LED use to alter plant physiology and morphology as appropriate to increase yield or the production of chemical compounds that increase crop value; design of novel prototype luminaires for greenhouses; and development of software that includes whole greenhouse systems management integrated with light and CO_2 regulation. New products will be tested in small and large pilot settings, and provisional patents will be filed. • **Deployment Support Activities.** Assist the Consortium with the continual education and outreach to growers and the lighting industry, specifically targeting companies within New York State to assemble and market novel luminaires. Fact sheets, case studies and social media products will publicize the results of the program to growers, lighting manufacturers and others, and highlight participation by various stakeholders. This information will help Consortium members and others better understand best practices and the economics of improved control systems, as well as assist with new member recruitment. Trade association meetings and industry conferences targeting the greenhouse industry will be used to network with key market constituents. Training will be provided to help service providers target the specialized needs of growers. NYSERDA will utilize its Environmental Research Program's Science Advisors for agriculture to provide guidance on market uptake. NYSERDA and the Consortium will work closely with Cornell Cooperative Extension, an experienced provider of assistance to farmers, to disseminate information. NYSERDA will also coordinate this effort with the existing NYSERDA Agricultural Energy Audit program, which performs energy audits for farms. The Consortium will develop and maintain a data warehouse to assist in data dissemination, as well as survey members and non-members to track market adoption rates, associated savings, and product lifespans.
Key Milestones	<u>Milestone 1 (2016)</u> • Contract with core Consortium members. <u>Milestone 2 (2016)</u> • Review and approve Scientific Advisory Panel structure. <u>Milestone 3 (2017)</u> • Review and approve Consortium business plan to attain financial self-sustainability in 2023. <u>Milestone 4 (2018)</u> • Monitor small (6,000 square feet) pilot demonstration of a basic light and shade control system. <u>Milestone 5 (2018)</u> • Publish case study of demonstration. <u>Milestone 6 (2019)</u> • Monitor small (6,000 square feet) pilot demonstration of CO_2 supplementation integrated with the light and shade control system.

	Milestone 7 (2019) • Monitor large (20,000 square feet) pilot demonstration of a basic light and shade control system. Milestone 8 (2019) • Publish case study of demonstrations. Milestone 9 (2020) • Monitor small (6,000 square feet) pilot demonstration of efficient LED lights integrated with the CO_2 supplementation and light and shade control system. Milestone 10 (2020) • Monitor large (20,000 square feet) pilot demonstration of CO_2 supplementation integrated with the light and shade control system. Milestone 11 (2020) • Publish case study of demonstrations. Milestone 12 (2021) • Monitor large (20,000 square feet) pilot demonstration of efficient LED lights integrated with the CO_2 supplementation and light and shade control system. Milestone 13 (2021) • Publish case study of demonstration. Milestone 14 (2021) • Formal training offered to service providers.
Goals Prior to Exit	• Availability of products in the marketplace that can reduce electricity costs (and concomitant carbon emissions). Savings in an individual greenhouse up to 70 to 86% (depending on New York climate zone) are targeted. • The Consortium is self-funding through partnerships, membership fees, fee-based trainings and services, and royalties and licenses of patentable products. • Demonstrated electricity savings are achieved through synergistic solutions for greenhouse systems. Up to four hardware and software products and up to three services will be commercialized at program's end. There are approximately eight provisional patents filed by the Consortium. • In addition to the direct savings from the pilots, there are indirect savings resulting from market penetration of improved control systems and lighting technologies in New York tomato and lettuce greenhouse acreage of at least 25%.

14.1.5 Relationship to Utility/REV

Utility Role/Coordination Points	• Utilities may be able to identify specific greenhouses with high energy bills or specific geographic areas with large loads and work collaboratively with the Consortium to address those needs. • NYSERDA will also take advantage of the CEAC Clean Energy Implementation and Coordination Working Group to coordinate planning and implementation with the New York State utilities.
Utility Interventions in Target Market	• Utilities currently do not have similar interventions specifically targeted at this market segment, however customers may be able to take advantage of utility incentive programs for energy efficiency improvements at commercial and industrial facilities.

14.1.6 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.

NYSERDA's commitment of funds in this case is to a Consortium who will distribute assistance and information to current and potential participants on NYSERDA's behalf. These activities will occur over a longer period of time than is evident from the committed budget and benefits shown here. NYSERDA will continually monitor performance and report actual progress.

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

Commitment Budget	2016	2017	2018	Total
Research and Technology Studies/Development/Demos	$4,250,000	-	-	$4,250,000
Implementation Support	$450,000	-	-	$450,000
Tools, Training, and Replication	$300,000	-	-	$300,000
Total	$5,000,000	-	-	$5,000,000

Table 2: Annual Expenditures Projection

Expenditures	2016	2017	2018	2019	2020	2021	2022	2023	Total
Total	5%	20%	20%	19%	17%	11%	6%	3%	100%

14.1.7 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[5]		Baseline (Before/Current)	2019 (Cumulative)	2022 (Cumulative)
Activity/ Outputs	Greenhouse area used for pilot testing	0	26,000 square feet	26,000 square feet
	Number of paid Consortium memberships	0	20	25
	Number of products developed	0	2	4
	Number of services developed	0	2	3
	Number of product variations tested in pilot systems	0	5	8
	Number of case studies developed	0	2	4
Outcomes	Average market penetration of improved technologies in New York greenhouse acreage in the lettuce and tomato sectors	0%	22%	25%
	Number of provisional patents filed	0	2	8
	Reduction in greenhouse electricity use in New York	0	Up to 50% reduced electricity usage per greenhouse, depending on NYS climate zone	Up to 70-86% reduced electricity usage per greenhouse, depending on NYS climate zone
	Number of acres of greenhouses in New York (beyond pilot participants) adopting the improved technologies	0	18	23
	Consortium remains viable after NYSERDA milestones are completed	n/a		Projections for Year 8 financials show positive cash flow. Consortium has 25-30 paying members.

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.

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

Table 4. Direct Impacts[6]

Primary Metrics[7]		2016	2017	2018	TOTAL
Energy Efficiency	MWh Annual	3,470	-	-	3,470
	MWh Lifetime	34,700	-	-	34,700
	MMBTu Annual	-	-	-	-
	MMBTU Lifetime	-	-	-	-
	MW	-	-	-	-
Renewable Energy	MWh Annual	-	-	-	-
	MWh Lifetime	-	-	-	-
	MW	-	-	-	-
CO2e Emission Reduction (metric tons) Annual		1,830	-	-	1,830
CO2e Emission Reduction (metric tons) Lifetime		18,300	-	-	18,300
Customer Bill Savings Annual ($ million)		$0.29	-	-	$0.29
Customer Bill Savings Lifetime ($ million)		$2.92	-	-	$2.92
Private Investment ($ million)		$9.46	-	-	$9.46

Table 5. Annual Projected Initiative Participation

	2016	2017	2018	2019	2020	Total
Participants (Paid Consortium members)	0	5	10	5	5	25

Benefits shown in Table 6 represent the estimated indirect market effects expected to accrue over the longer term as a result of this investment and follow on market activity. Many interrelated factors impacting indirect benefits (e.g., potential electricity reduction, growth in greenhouse acreage in NY, or market penetration of improved technologies) may vary from projected values. Thus, rather than claim the full and very significant amount of indirect benefits that NYSERDA believes may accrue from this investment, as discussed on other sections of this investment plan, NYSERDA has applied some additional conservativism to the indirect benefit targets in Table 6. Actual indirect benefits may exceed targets shown in Table 6. The indirect benefits that accrue from this investment will be quantified and reported based on periodic Market Evaluation studies to validate these forecasted values. Market Evaluation may occur within one year (-/+) of the years noted in the table and projected future indirect benefits and/or budgets necessary to achieve them may be updated based on the results of market evaluation. Indirect impact across NYSERDA initiatives may not be additive due to multiple initiatives operating within market sectors. The values presented below are not discounted, however NYSERDA has applied a discount of 50% to the overall portfolio values in the Budget Accounting and Benefits chapter.

[6] NYSERDA's commitment of funds in this case is to an implementor who will put the funds to use on NYSERDA's behalf over a longer period of time (seven years) than is evident from the committed budget and benefits shown in this plan (benefits will be acquired over a period of 10 years). NYSERDA will monitor performance and report actual progress.

[7] Impacts are expressed on a commitment-year basis, and are incremental additions in each year. Assumes a 10-year measure life. Benefits are rounded to three significant figures. Totals may not sum due to rounding. Customer bill savings are calculated as direct energy bill savings realized by customers participating in NYSERDA's programs.

Table 6. Estimated Indirect Market Impact

Indirect Impact		2020	2025	2030
Energy Efficiency	MWh Cumulative Annual	112,000	278,000	364,000
	MMBtu Cumulative Annual	-	-	-
Renewable Energy	MWh Cumulative Annual	-	-	-
	MW	-	-	-
CO2e Emission Reduction (metric tons) Cumulative Annual		59,000	146,000	191,000

14.1.8 Fuel Neutrality

Fuel Neutrality	• This initiative is not being delivered on a fuel neutral basis. The focus is electric lighting, ventilation and controls.

14.1.9 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>** • Routine reporting on energy savings to date, and progress against identified annual energy savings goals will be collected and reviewed. Private sector and federal funding leverage will be evaluated. • The Consortium operations and success, including its ongoing research, will be evaluated annually together with input from the advisory panel with regard to set goals, metrics, outputs and outcomes. Redirecting (as needed) will ensure continued progress against goals. • Annually assess mix of market participants in the Consortium and determine if outreach strategies have to be updated to attract more members from specific market sectors. • Survey growers and manufacturers on barriers, perceived benefits and their willingness to participate in the Consortium and/or adopt new products or technologies. • Annually gather market characterization data from Controlled Environment Agriculture trade association and USDA, as available. • Track over time the number of non-Consortium members participating in outreach activities. **<u>Agriculture – GLASE Strategy Measurement & Verification</u>** • As part of the implementation strategy, all pilot sites will undergo intense measurement and verification of electricity savings, which will be used to calculate CO_2 savings. Data will be analyzed to increase the understanding of product performance and iteratively improve greenhouse control systems. **<u>Market 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 strategy approval, including current market penetration of control systems in greenhouses, current product lifespans and current crop production yields.

	• Regular (e.g., annual) updates to key performance indicators and measurement of market change, including level of market adoption (replication into non-pilot facilities), and the associated benefits. • Sources of data will include pilot data, public and commercially available data, data from New York's Controlled Environment Agriculture trade association, and primary data collection through surveys of key market actors. **<u>Impact Evaluation/Field Verification</u>** • As noted above, the implementation of pilots will include intense measurement and verification of electricity savings, which will be used to calculate CO_2 savings. Independent impact evaluation/field verification will rely on measurement and verification conducted as part of the pilot activities and will verify the results of this analysis as needed. • Replication of improved technologies into other greenhouses in New York State, beyond pilot participants, and the resultant energy benefits will also be subject to independent impact evaluation review. Methodology will be determined, as appropriate, based on the level of adoption and technologies involved. • Data from Field Verification/Impact Evaluation can be used to help lend confidence in the market, especially among other end users.

Appendix A – Logic Model