New York State Energy Research and Development Authority

New York Solar Study:
Executive Summary

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Summary of Findings and Recommendations

The Power New York Act of 2011 directed NYSERDA to conduct a study to evaluate the costs and benefits of increasing the use of solar photovoltaics (PV) in New York State to 5,000 megawatts (MW) by 2025. As requested by the Act, the following represents NYSERDA's findings and recommendations that are based on the conclusions of the technical analysis completed in the Study.

NEW YORK'S RENEWABLE ENERGY CONTEXT

New York State is a national leader in the deployment and production of renewable energy. This leadership is attributable to New York's strategic pursuit of policies designed to develop a diverse portfolio of renewable energy resources, including solar, wind, hydropower and biomass. New York's diverse portfolio approach capitalizes on the State's many renewable resources – this diversity is New York's strength. The success of this approach is reflected by the fact that New York has developed more than 1,800 MW of renewable energy, exclusive of hydropower, more than any other state in the Northeast. Including hydropower, New York's renewable energy capacity is comparable to the entire renewable energy capacity of the other eight states in the Northeast.

In a recent U.S. Department of Energy (DOE) report, New York ranked 5th in the nation for the amount of installed renewable energy capacity providing electricity to the state. New York was the only state east of the Mississippi named in the top 5, and the only Northeast state placing in the top 10.

COST OF ACHIEVING A 5,000 MW PV GOAL

There is significant uncertainty in estimating the cost of PV out to 2025. Experts project that the installed cost of PV by 2025 could range from $1.4 to $4.3 million per installed MW. This range and various assumptions about the renewal of the federal tax credit, set to expire in 2016, formed the basis of the scenarios analyzed in the Solar Study.

The Low Cost scenario is based on the DOE SunShot goal for PV cost reduction and assumed extension of the federal tax credit through 2025. The High Cost scenario is based on long-term historical trends and assumed the federal tax credit would revert to a pre-federal stimulus level following expiration of the current credit in 2016. The most likely scenario, referred to as the Base Case, is based on a survey of experts by the DOE and assumed a moderate reduction of the federal tax credit beyond 2016. The Base Case estimates $2.5 million per installed MW for large-scale systems and $3.1 million per installed MW for small-scale systems.

- The cost of achieving a 5,000 MW goal exceeds the benefits using the Base Case scenario.

- The cost of PV and the availability of federal tax credits through 2025 are the driving factors of cost in a 5,000 MW goal.

- The Low Cost scenario had a net benefit while the High Cost scenario had a net cost four times as high as the Base Case.

- In the Base Case, achieving a 5,000 MW goal would have a ratepayer impact of $3 billion over the study period (2013 – 2049), which would equal on average a 1% impact on ratepayer electric bills. In any given year, this rate impact could be as much as 3%.

  Note: The study period goes beyond 2025 because PV installations in 2025 have a 25-year life-span, and ratepayers are assumed to pay for the power generated by these installations throughout the life of the systems.

- The ratepayer impact under the Low Cost scenario would be approximately $300 million, whereas the impact under the High Cost scenario would be $9 billion.

JOB IMPACT

Modeling of the Base Case scenario found that while direct PV jobs would be created, the impact on New York's economy as a whole would be a net negative primarily due to the ratepayer impact.

- Approximately 2,300 jobs associated directly with PV installation would be created for the installation period through 2025.

- Economy-wide jobs would be reduced by 750 through 2049 because of a loss of discretionary income that would have supported employment in other sectors in the economy.

- The Gross State Product (GSP) would be reduced by $3 billion through 2049, representing an annual decrease in GSP of less than 0.1%.

- The Low Cost scenario would lead to a creation of 700 jobs economy-wide through 2049, while the High Cost scenario would lead to a loss of 2,500 jobs.

ENVIRONMENTAL IMPACT

A 5,000 MW goal would yield the following environmental benefits through 2049:

- A 4% reduction in fossil fuel consumption equal to 1,100 trillion Btus.

- A 3% reduction in carbon dioxide (CO_2) emissions equal to 47 million tons.

- A reduction of nitrogen oxides (NO_x), which produces smog and acid rain, by 33,000 tons (4%); sulfur dioxide (SO_2), which also produces smog and acid rain, by 67,000 tons (10%); and mercury by 120 pounds (3%).

POLICY OPTIONS

The study reviewed numerous government policies and best practices used around the world to stimulate demand for PV systems. Four specific policy options were analyzed to determine their relative rate impact to New York.

- Solar Quantity Obligation Using Tradable Solar Renewable Energy Credits (SRECS) with a Price Floor Mechanism, similar to approaches adopted in neighboring states. Under this policy option, utilities (or other entities) are responsible for buying SRECS (tradable certificates that represent the production of one MWh of electricity generation from a PV system) from the spot market, but prices are supported by a long-term minimum price that provides a greater degree of revenue certainty to developers and investors.

- Auction for Long-Term Contracts by Electric Distribution Companies, similar to an approach adopted by California. Under this policy option, utilities manage a competitive procurement under which they award long-term contracts to purchase renewable energy.

- Hybrid Upfront Incentives for Residential and Small Commercial & Industrial (C&I) with a Central Procurement Approach to Large C&I and MW-Scale Installations, similar to New York's current Renewable Portfolio Standard (RPS) approach. Under this policy option, rebates are provided for small PV systems and incentives for larger PV systems are provided by a central procurement entity through some type of competitive bidding.

- Hybrid Standard Offer Performance-Based Incentives for Residential and Small C&I and Auctions for Long-Term Contracts for Large C&I and MW-Scale Installations, similar to proposals under consideration in the State Legislature. Under this policy option, utilities are responsible for providing incentives to larger projects through a competitive procurement and long-term contracts. Smaller projects receive performance-based incentives, typically a standard offer (in cents per kWh produced).

The results of the four specific policy options analyzed included:

- A quantity obligation with price floor is the most expensive policy option and is projected to cost 50% more than the least-cost policy option.

- The other three policy options have comparable costs, with hybrid upfront incentives for smaller customers and central procurement for larger customers being the least expensive policy option.

RECOMMENDATIONS

Given the major uncertainties in PV technology cost reductions and the continued availability of federal tax credits over this time period, there is a significant range in the potential cost estimates to ratepayers of meeting a 5,000 MW goal by 2025.

The magnitude and range of this cost uncertainty ($300 million – $9 billion) is substantial, and strongly suggests the need for a policy response and investment strategy that is both flexible and responsive.

Nevertheless, even with this range of cost uncertainty, given the many potential benefits that PV has to offer and the long-term potential for lower-cost PV technology, New York State should support continued investment in the steady and measured growth and deployment of PV as part of a sound and balanced renewable energy policy.

New York should strengthen such investment through continued development of policies such as net metering, sales tax exemptions and interconnection standards that could further reduce the cost of PV installation and remove barriers to reaching the targets.

This strategy should also be complemented by additional efforts to reduce the balance of system costs for PV, including more streamlined permitting processes, and continued financial support for targeted research and development, workforce training and business development.

Continued federal incentives will play a critical role in the magnitude and predictability of future PV prices. In addition, the SunShot goal articulated by the DOE is an aggressive and meritorious goal that, if achieved, would substantially reduce PV cost and change the benefit-cost equation. New York State should strongly support continued federal incentives and aggressive federal research efforts to reduce the cost of PV to consumers.

EXECUTIVE SUMMARY

1.   INTRODUCTION

Signed into law on August 4, 2011, the *Power New York Act of 2011* (the "Act") required the New York State Energy Research and Development Authority (NYSERDA), in consultation with the Department of Public Service (DPS), to develop a Study to Increase Generation from Photovoltaic Devices in New York (the "Solar Study"). While the current contribution of photovoltaic (PV) energy generation is small and the cost of the technology is at a premium compared with current electricity prices, the Act sought analysis of the benefits and costs of PV, acknowledging that costs are declining and noting the potential for PV energy generation to contribute to economic development and job creation in the State.

Specifically, the Act directed that the Solar Study should:

- Identify administrative and policy options that could be used to achieve goals of 2,500 Megawatts (MW) of PV installations operating by 2020 and 5,000 MW operating by 2025 (the "Goals");

- Estimate the per MW cost of achieving increased generation from PV devices and the costs of achieving the Goals using the options identified in the analysis;

- Analyze the net economic and job creation benefits of achieving the Goals using each of the options identified in the analysis; and

- Conduct an analysis of the environmental benefits of achieving the Goals using the options identified in the analysis.

1.1. PV Deployment Scenario and Study Approach

Key Finding:

- The pace of annual PV capacity additions drives the timing and magnitude of annual rate impacts, employment impacts, costs, and benefits. As such, the pace of PV development is a central component of any PV policy design. Policymakers should therefore consider the actual cost of annual development in establishing policy targets, so as to craft a flexible and responsive policy.

The Solar Study used a comprehensive suite of analytical tools and techniques to model the impacts of achieving the Goals. Case studies and secondary sources were also used to develop policy options, as well as to characterize the global and New York PV markets. A PV deployment scenario was developed that projected annual PV capacity additions needed in order to meet the 2,500 MW by 2020 and 5,000 MW by 2025 Goals, as shown in Figure ES-1. The pace of annual PV capacity additions drives the timing and magnitude of annual rate impact, employment impacts, costs, and benefits. As such, the pace of PV development is a central component of any PV policy design. Policymakers should therefore consider the actual cost of annual development in establishing policy targets, so as to

craft a flexible and responsive policy. This would more likely create a predictable investment environment while not burdening ratepayers with the impacts of extreme price volatility.

The PV deployment scenario assumed that the New York market would grow annually in response to state and federal incentives, the cost of PV technologies would decline, and the required installation labor per PV system would be reduced. This annual deployment path is shown in Figure ES-1 below. The PV deployment scenario also laid out specific geographic and PV system size distributions for PV capacity additions for the New York City, Upstate, Capital, Long Island and Hudson Valley regions.[1] A second deployment scenario, which projected the State's PV installations under existing program and polices, was also developed as a Reference Case to isolate the impacts of the Goals of the Act.
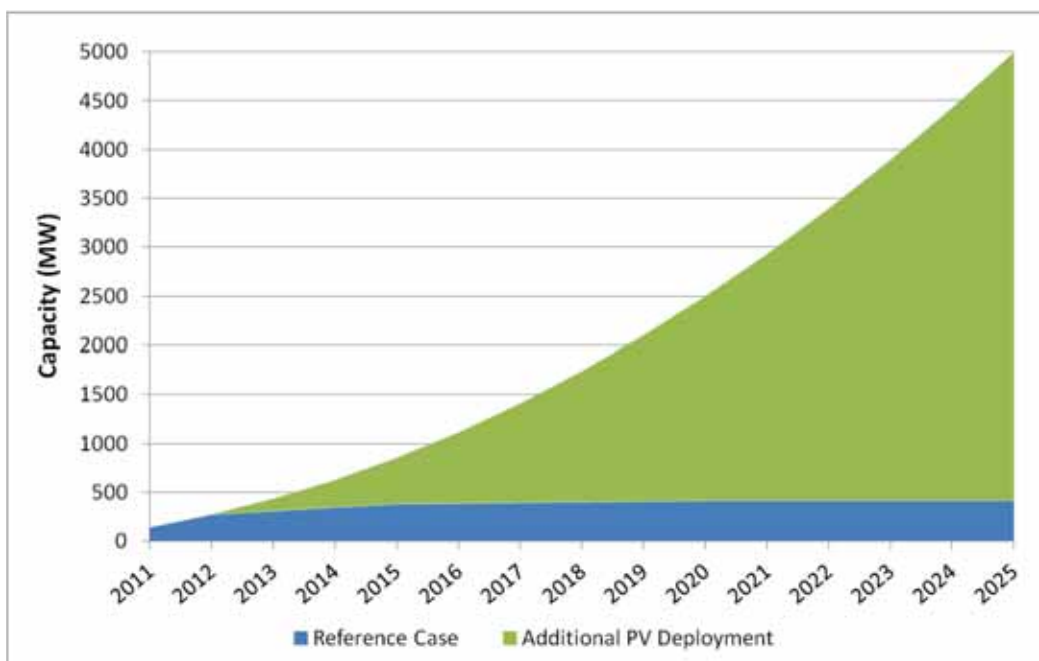

Figure ES-1. PV Capacity Target and Path

The total costs of meeting the Goals were developed using a cost-of-energy analysis, which examined a range of future costs and potential regional installation scenarios. To accurately estimate possible PV cost trajectories, the scenarios varied the future cost of PV equipment, level of federal incentives, location of installations, and system sizes. The energy cost analysis used the National Renewable Energy Laboratory's Cost of Renewable Energy Spreadsheet Tool (CREST) to estimate lifetime average energy costs for each of the modeled scenarios. A comparative cost analysis of non-PV renewable energy technologies was also completed, using the CREST model.

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[1]   The base PV deployment scenario geographic distribution was based on historical load distribution for New York and the projections of system size distributions were based on historical trends and data from other states that have seen large-scale PV deployment.

The benefits associated with meeting the Goals include: avoided electricity production costs, reduced air pollution, reduced use of fossil fuels, lowered wholesale electricity prices for all consumers (called price suppression), avoided distribution system upgrades, and avoided line losses. These benefits were estimated using the Integrated Planning Model (IPM), which determined how the electricity system would be impacted by achievement of the Goals. Benefits were calculated to 2049, the final year when PV systems installed under the program were assumed to be operating. To accurately estimate the range of possible benefits, different assumptions for the price of natural gas and the economic value of emissions were explored.

These costs and benefits were analyzed to assess the net impact on all New Yorkers, including analysis of ratepayer impacts.

The impacts of meeting the Goals on New York's economy (measured by changes in employment and gross state product) were developed using a Regional Economic Models Inc. Policy Insight (REMI PI+) model. The REMI PI+ model is an advanced macroeconomic model that combines an input-output model with a dynamic ability to forecast shifts in prices and competitiveness factors over time to determine impact to the whole economy. The economic impacts were analyzed for a range of future PV costs and natural gas prices.

The Solar Study also identifies a series of policy mechanisms that were incorporated into the modeling scenarios. These were identified through research of best practices of national and international PV incentive programs. This work included the development of comprehensive case studies of some of the largest global PV markets. Diverse incentive mechanisms are currently being implemented worldwide to drive PV demand, and many of these could be used to meet the Goals analyzed in this Solar Study. Each of the policy mechanisms identified as part of the Solar Study would be adequate, if properly implemented, to meet a 5,000 MW target. The Solar Study does not recommend a single policy or specify policy implementation details, rather it describes the strengths and limitations associated with the different policy mechanisms and recommends additional considerations should any mechanism be pursued.

To isolate the impact of a single policy, the Solar Study analyzes only the impact of achieving a 5,000 MW goal by 2025. This was necessary in order to isolate the impact of this policy for analysis purposes. The Solar Study does not measure the effects of transformation in the marketplace or demand for PV products outside the scope of a 5,000 MW target; thus, no PV systems were modeled as installed after 2025, no PV systems were modeled as being replaced at the end of their assumed economic life, and no PV systems were assumed to continue producing electricity (albeit at a reduced level) after the end of their economic life. Incorporating these issues would present a number of analytical challenges. There is considerable uncertainty in predicting market dynamics more than 15 years into the future. In addition, further study is necessary to determine the degree to which new PV installations beyond 2025 should be attributed to the policies being studied. Among other challenges would be the development of additional novel reference cases correlating to different costs and federal incentives in the future.

The Solar Study did not directly address the potential physical value of certain applications of PV on the New York power grid, including localized reliability impacts (such as supporting existing network conditions and/or affecting future grid planning and operating resources) and how such applications may be enabled by targeted PV deployments.

1.2. New York in the Global PV Market

Key Findings:

- The global PV market has recently seen dramatic declines in PV panel prices.

- These declines have benefited New York, with installed costs dropping significantly in the past three years.

- The existing global supply chain could adequately meet the needs of New York's market as it grows toward the 5,000 MW target.

The global PV market has grown substantially over the last decade, led by several European Union (EU) countries with well-funded PV incentive programs and aggressive PV targets. As the global PV market supply chain has expanded and PV technology has improved, the costs of PV has decreased significantly over the past few decades. Figure ES-2 shows the growth of the global PV market as well as the market prices for PV panels from 2000 to 2010. As the figure shows, within this general decrease, PV prices rose from 2004 to 2006. This was largely the result of a global shortage of polysilicon, one of the key raw materials in the silicon PV supply chain.
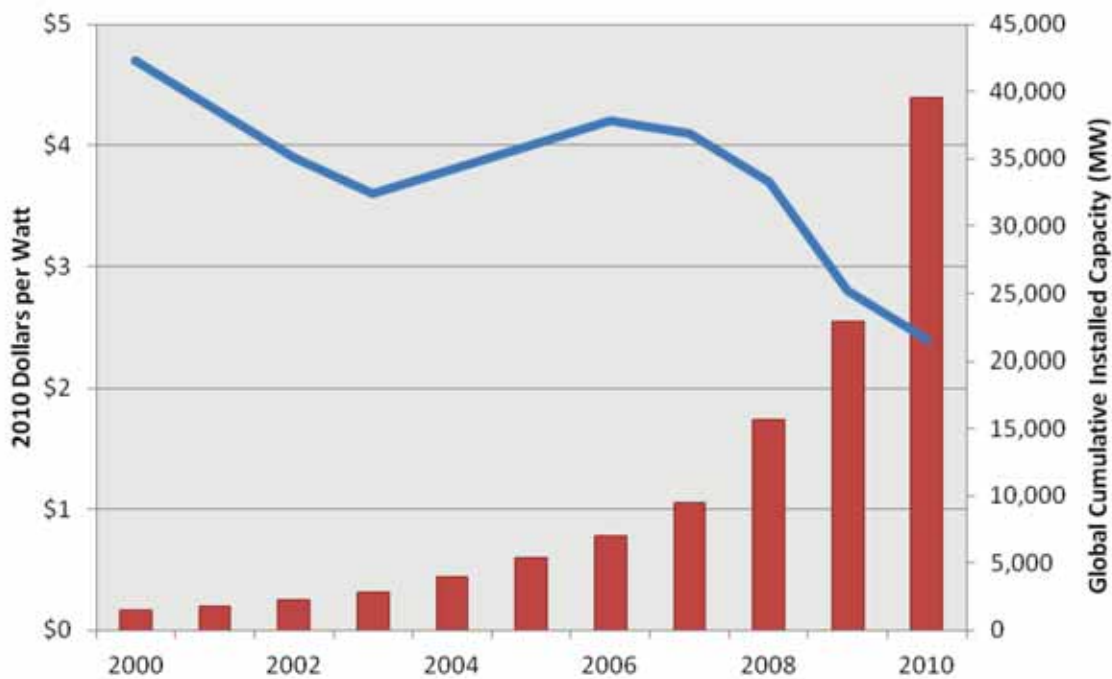

Figure ES-2. Global PV Module Price Index and Cumulative Installed Capacity

New York has benefited from this long-term global downward price trend. Supported by stable state-level incentives and comprehensive ancillary policies,[2] installed costs for PV systems in the NYSERDA incentive program have declined more than 20% since 2003. As seen in Figure ES-3, this decrease has been led by substantial decreases in PV module costs in the past two years. Balance of System (BOS) includes all of the PV hardware components other than the module and inverter.
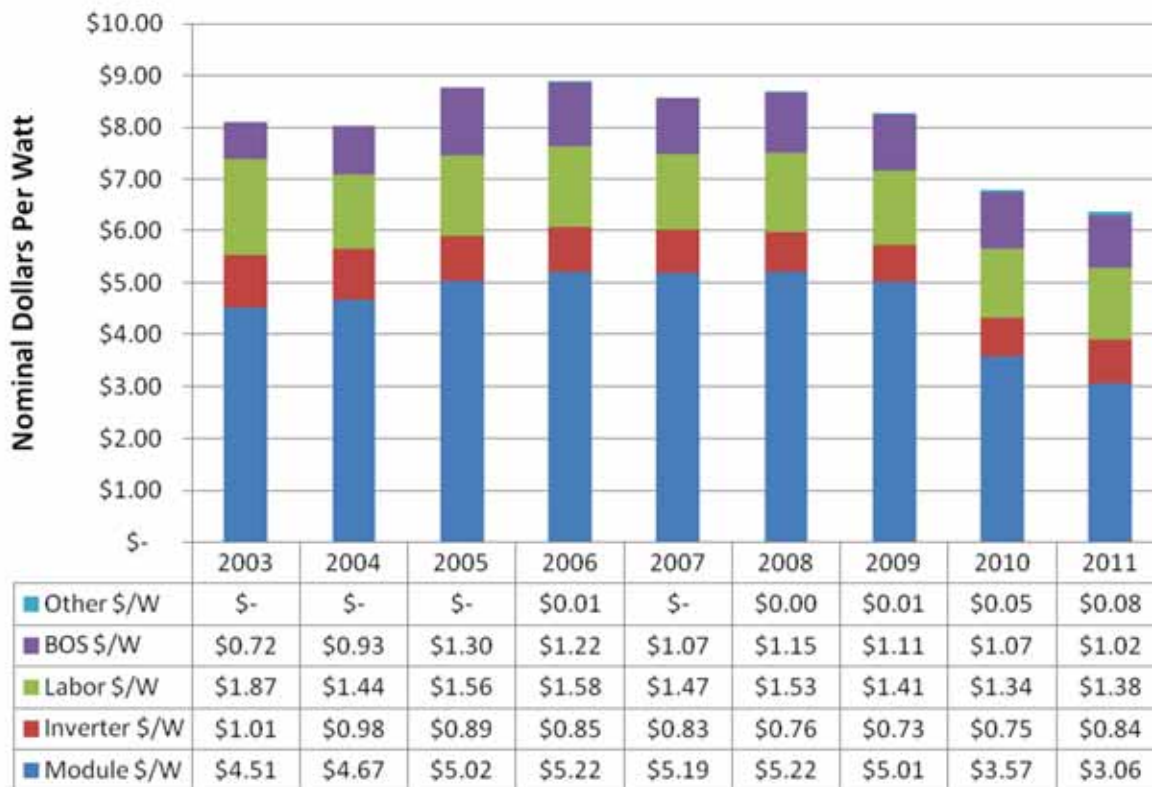

	2003	2004	2005	2006	2007	2008	2009	2010	2011
■ Other $/W	$-	$-	$-	$0.01	$-	$0.00	$0.01	$0.05	$0.08
■ BOS $/W	$0.72	$0.93	$1.30	$1.22	$1.07	$1.15	$1.11	$1.07	$1.02
■ Labor $/W	$1.87	$1.44	$1.56	$1.58	$1.47	$1.53	$1.41	$1.34	$1.38
■ Inverter $/W	$1.01	$0.98	$0.89	$0.85	$0.83	$0.76	$0.73	$0.75	$0.84
■ Module $/W	$4.51	$4.67	$5.02	$5.22	$5.19	$5.22	$5.01	$3.57	$3.06

Figure ES-3. **NYSERDA Database of Installed Cost 2003-2011**

The recent increase in demand from countries in the EU has led to a rapid expansion of the global PV supply chain. Global market demand was estimated to be 16.6 GW in 2010 and industry analysts estimate that there is currently significant manufacturing overcapacity in several key value chain components. Existing global manufacturing capacity would be sufficient to meet the needs of the New York market if it met a 5,000 MW by 2025 Goal. Under the modeling assumptions used for this study, PV panel demand for 2025 in New York would represent little more than 2.5% of current global PV panel capacity.

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[2] New York has a wide range of policies and programs that support the growing PV market. These include net-metering regulations, workforce development and technology and business development initiatives, outreach programs, and residential tax credits, as well as well-funded direct incentives.

1.3. Policy Objectives

A comprehensive list of policy objectives was not defined in the Act; however, identification of these objectives was necessary to evaluate and compare the scenarios and sensitivities studied. A broad set of potential objectives was identified based on an examination of current New York renewable energy policies and other industry experience with solar policies,[3] in order to shape the selection of policy options evaluated.

The policy objectives identified were organized into general categories, as shown in Table ES-1 below. Using the policy objectives, corresponding quantitative and qualitative metrics were developed to measure progress toward meeting the objectives in the various cases studied herein. An important observation is that some policy objectives conflict — maximizing one may take away from maximizing another. As such, different policy approaches may yield different tradeoffs among these objectives. For example, reducing installation costs will also reduce the number of jobs needed to install the systems.

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[3] The proposed policy objectives was based on a literature survey of potential policy objectives and constraints from a range of sources, including (i) the Act; (ii) previously introduced New York solar legislation, such as the NY Renewable Energy Sources Act, A00187A (2009); NY Solar Industry Development and Jobs Act, A11004 (2010); and NY Solar Jobs Act, A05713 (2011); (iii) existing NY renewable energy programs, particularly the RPS; (iv) solar policy goals from other states as summarized in *When Renewable Energy Policy Objectives Conflict: A Guide for Policy-Makers* (Grace, Donovan, & Melnick, 2011); (v) published studies by the National Renewable Energy Laboratory (NREL, 2011a), Deutsche Bank (DB Climate Change Advisors, 2009) and the California Energy Commission (KEMA, 2010).

Table ES-1. Policy Objectives

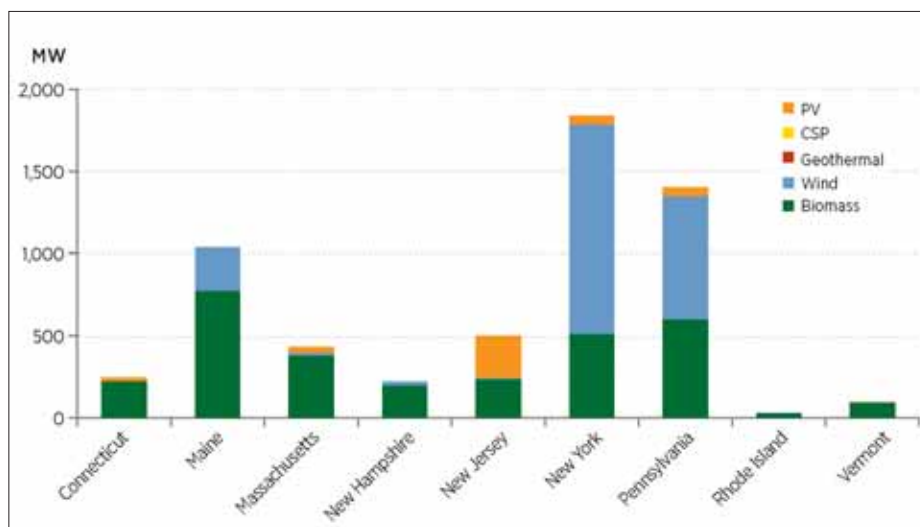| Category	Policy Objectives
Environmental	• Minimize greenhouse gas emissions • Minimize criteria pollutant, mercury and other air pollution emissions • Reduce impacts related to water use in thermal electric generation (thermal, quality, quantity) • Preserve land from fuel cycle impacts (mining, drilling, etc.) • Minimize use of land with higher value alternative uses • Reduce reliance on finite fossil fuels
Energy Security and Independence	• Increase fuel diversity • Increase energy security and supply reliability • Increase domestic energy production
Reliability	• Reduce electric delivery disruption risk • Minimize negative grid planning and operating reserve impacts • Minimize distribution system negative reliability impacts (avoiding degradation of system loss of load probability)
Economic Development	• Maximize net in-state job creation • Maximize gross state product (GSP) growth • Support existing clean technology industries • Minimize out-of-state capital flows • Create stable business planning environment (for supply chain investment)
Energy Cost	• Reduce distribution system upgrades and minimize additional upgrades caused by PV • Reduce wholesale prices (energy and capacity impacts) • Minimize direct cost of policy to ratepayers • Minimize total cost of policy (exclusive of monetizing environmental, public health or other impacts) • Integrate well with competitive retail market structure in NY • Integrate well with competitive wholesale market structure in NY
Technology Policy	• Create a self-sustaining solar market • Assist emerging technologies in becoming commercial technologies • Foster technology innovation and development
Societal	• Ensure geographic distributional equity/ effectiveness at aligning benefits with those who bear the costs • Maximize benefits to environmental justice communities

2. NYS RENEWABLE ENERGY POLICY CONTEXT

Key Findings:

- New York has aggressive renewable energy goals and robust policies that support those goals.

- Current New York policies support a range of renewable technologies including several high-cost early-stage generation sources, like PV, that have the potential to reach significant market penetration as costs decline.

- New York has taken a holistic approach to development of a robust renewable energy market, including PV, through workforce development, as well as technology and business development initiatives.

- Existing PV programs in New York have stimulated a stable and growing market, but this market is small in relation to other East Coast markets.

New York has approached renewable energy through the development of a diverse portfolio of resources. While two-thirds of New York's installed renewable capacity is from hydropower, it also has significant capacity from wind, biomass, and PV. A U.S. Department of Energy publication reports that as of 2010, New York has developed more than 1,800 MW of renewable energy, excluding hydropower — more than any other state in the Northeast, as shown in Figure ES-4. Additionally, when hydropower capacity is included, New York's renewable energy capacity is comparable to the entire renewable capacity of the other eight states in the Northeast.[4]

Sources: EIA, LBNL, GEA, SEIA/GTM, Larry Sherwood/IREC, U.S. Census[5]

Figure ES-4. Renewables 2010 Installed Capacity (Excluding Hydropower) in the Northeast

Much of the non-hydropower renewable energy development in New York State is a result of its renewable energy target – one of the most aggressive in the nation. First adopted in 2004, current New York policies require that 30% of the state's electricity come from renewable sources by 2015. New York meets its renewable energy targets through several programs, including a unique Renewable Portfolio Standard (RPS) mechanism that, unlike other states, includes a centralized procurement of renewable energy attributes, with the programs being administered by NYSERDA.

New York's RPS program is designed to support a diverse portfolio of energy generation technologies, from wind and PV, to biomass and hydropower. In order to ensure a diversity of energy sources, the New York RPS has both a

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[4] Overall, New York is ranked 5th in the nation for electric renewable energy installed capacity. New York was the only state east of the Mississippi named in the Top 5, and the only Northeast state placing in the Top 10.

[5] The figure was obtained from NREL's 2010 Renewable Energy Data Book. The report was produced by Rachel Gelman, edited by Scott Gossett, and designed by Stacy Buchanan of the National Renewable Energy Laboratory (NREL). The document can be found at www.nrel.gov/analysis/pdfs/51680.pdf.

Main Tier, which has supported large-scale generation projects, and a Customer-Sited Tier (CST), which is designed to support smaller, emerging energy generation technologies for use on customer sites. Figure ES-5 shows a breakdown of currently operating energy generation resources developed through the RPS program over the life of the initiative ("other" resources include anaerobic digester gas-to-electricity, small wind and fuel cells). Figure ES-5 does not include PV projects that have been awarded but not yet installed.
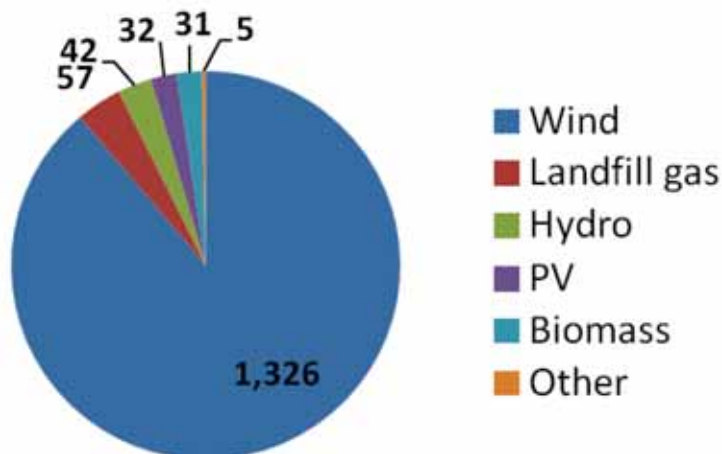

Figure ES-5. Cumulative Generation Project Types Supported Through the New York RPS in MW (2011)

The RPS CST has been the major driver of the New York PV market outside of Long Island over the course of the past decade, wherein NYSERDA has provided over $100 million in incentives for PV projects. These incentives have been provided in the form of upfront payments to project owners to help buy-down the cost of installing PV. Incentives have been designed to promote growth in both the residential and small commercial PV market.

More recently, the CST has also supported PV installations as part of an ongoing regional program. Funding totaling $30 million was released in the first two rounds of competitive bidding for the CST regional program (also known as the "geographic balance" program) in 2011, which resulted in awards to develop 26.6 MW of PV in the lower Hudson Valley and New York City regions. A total of $150 million is devoted to this program through 2015.[6] Through the CST, including the regional program, NYSERDA expects to develop more than 170 MW of PV capacity by 2015.

On Long Island, the Long Island Power Authority (LIPA) has been operating PV incentive programs since 2000. Historically, these programs have been well-funded and have led to the development of a robust PV market on Long Island. LIPA's current programs include an upfront incentive program for homeowners and small businesses, as well as a power purchase initiative that is developing several utility-scale PV systems for wholesale power generation.

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[6] The CST regional program supports both PV and biogas facilities; however it is anticipated that the majority of the funding from this initiative will support PV installations.

This initiative includes the development of the largest PV facility on the East Coast, a 32 MW system at Brookhaven National Laboratory, which was commissioned in November of 2011. To date, LIPA's initiatives have supported more than 70 MW of PV. It is expected that under current programs, more than 140 MW of PV will be developed on Long Island by 2020. Additionally, the New York Power Authority (NYPA) has developed nearly 2 MW of PV projects on public properties over the last 15 years.

While these incentive programs have been a key component driving the New York PV market, PV systems have also benefited from a number of other state and federal incentives. These include both a federal Investment Tax Credit (ITC) and a 5-year Modified Accelerated Cost Recovery System (MACRS) depreciation for commercial systems.[7] Residential PV systems also benefit from a 30% federal tax credit as well as a 25% state tax credit. A suite of other ancillary policies including net metering and local property tax exemptions are also available in New York and are critical to driving the New York market.

Figure ES-6 below shows the development of the New York PV market between 2002 and 2011 by funding source.
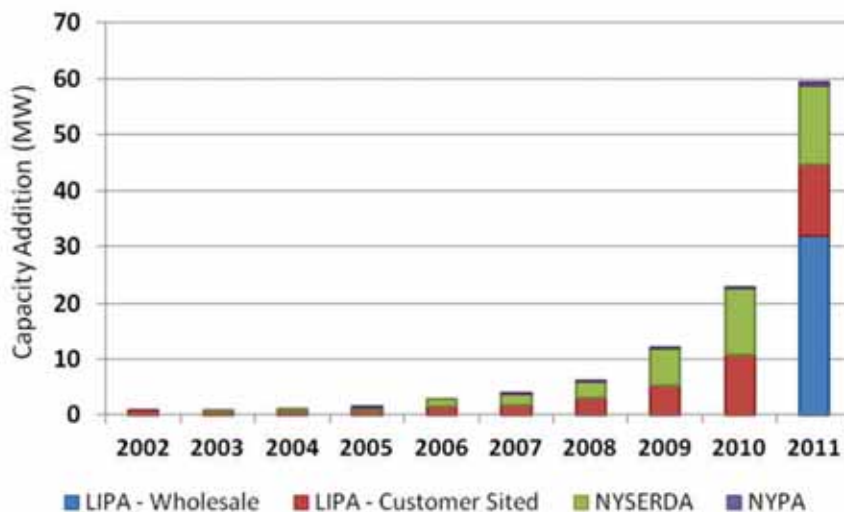

Figure ES-6. Annual PV Capacity Additions in New York (2002-2011)[8]

This diverse suite of PV incentive policies has created a stable and growing PV market in New York and has supported a growing PV installer base, with over 370 individuals eligible to serve as primary installers on NYSERDA-supported PV projects. By developing a comprehensive and steady PV incentive funding strategy, New York has avoided the boom and bust market cycles that have created uncertainty in a number of East Coast markets in recent years. These funding programs have also led a number of national PV development firms to enter the New York market. Additionally, New York has a history of using complementary policies and programs to support the industry, including those in the areas of workforce development and technology and business development.

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[7]   The 5-year MACRS expired on January 1, 2012.

[8]   The LIPA – Wholesale Scale bar consists of a single 32 MW installation at Brookhaven National Labs. The LIPA PV wholesale PV power purchase program is expected to install 17MW in 2012.

Compared with PV programs in other East Coast states, however, the New York PV market has been limited in size. In 2011, New Jersey installed 240 MW while Pennsylvania installed 91 MW. This compares to New York's 59 MW installed state-wide in 2011. Until recently, caps on the existing incentive programs in New York limited the development of large commercial and MW-scale PV systems, which is a substantial portion of the PV market in other East Coast states. Nevertheless, the recent implementation of the NYSERDA regional program, as well as LIPA's development of utility-scale PV projects, have led to greater diversity in the state's PV generation fleet.

3. PV COST PROJECTIONS

Key Findings:

- By 2025, the cost of PV is expected to significantly decline, where the Base Case installed cost will range from $2.50 per W for MW-scale systems to $3.10 per W for the residential-scale system, in nominal dollars. For the Low Cost Case, the range is $1.40 per W to $2.00 per W and for the High Cost Case the range is $2.90 per W to $4.30 per W.

- PV is not expected to achieve wholesale parity during the analysis period (2013 thru 2049) in any cost future.

- Retail parity may be achieved, and will occur sooner in New York City than in other regions of the state. This suggests a greater leverage of state PV incentive dollars in New York City. In a low-cost future there is parity in New York City by 2017.

- PV cost of energy is expected to be more expensive than large-scale onshore wind energy and will most likely be more expensive than offshore wind in 2025.

- PV cost of energy may be competitive with small-scale wind energy and greenfield biomass technologies by 2025.

- Due to the differences between what is measured by cost of electricity and by the value of the energy produced, it is recommended that a full study of the costs and benefits of other renewable energy technologies be conducted to better inform renewable energy policy development.

- Continued federal incentives will play a critical role in the magnitude and predictability of future PV prices. In addition, the SunShot goal articulated by the U.S. DOE is an aggressive and meritorious goal that, if achieved, would substantially reduce PV cost and change the benefit-cost equation. It is recommended that New York should strongly support continued federal incentives and aggressive federal research efforts to reduce the cost of PV to consumers.

As technologies have advanced and the size of the global market has grown, PV prices have declined significantly in the past decade. Supported by stable incentive programs and favorable ancillary policies, costs in New York have followed this trend with average prices in 2003 at $8.11 per W while systems installed in 2011 averaged $6.38 per

W. While the general price trend has been downward, market prices for system components have been volatile over the past several years, with a shortage of silicon driving up prices for PV panels between 2004 and 2006. Similarly, a global silicon and panel supply glut is currently affecting the market, with panel prices declining between 20 and 30% over the past 12 months.

As a result of this recent short-term volatility of the PV market, price forecasts for the Solar Study were developed based on long-term market trends and publicly-available price forecasts. Three PV cost cases were developed, representing potential High, Low and Base Case installed costs. The High Cost Case was derived based on the national average annual PV system price decline over the past decade. The Base Case was developed on the results of a 2009 U.S. Department of Energy PV expert survey, while the Low Cost Case was an adaptation of the U.S. Department of Energy's SunShot initiative. Figure ES-7 shows the cost trajectories for these and other PV price scenarios evaluated for the Solar Study.
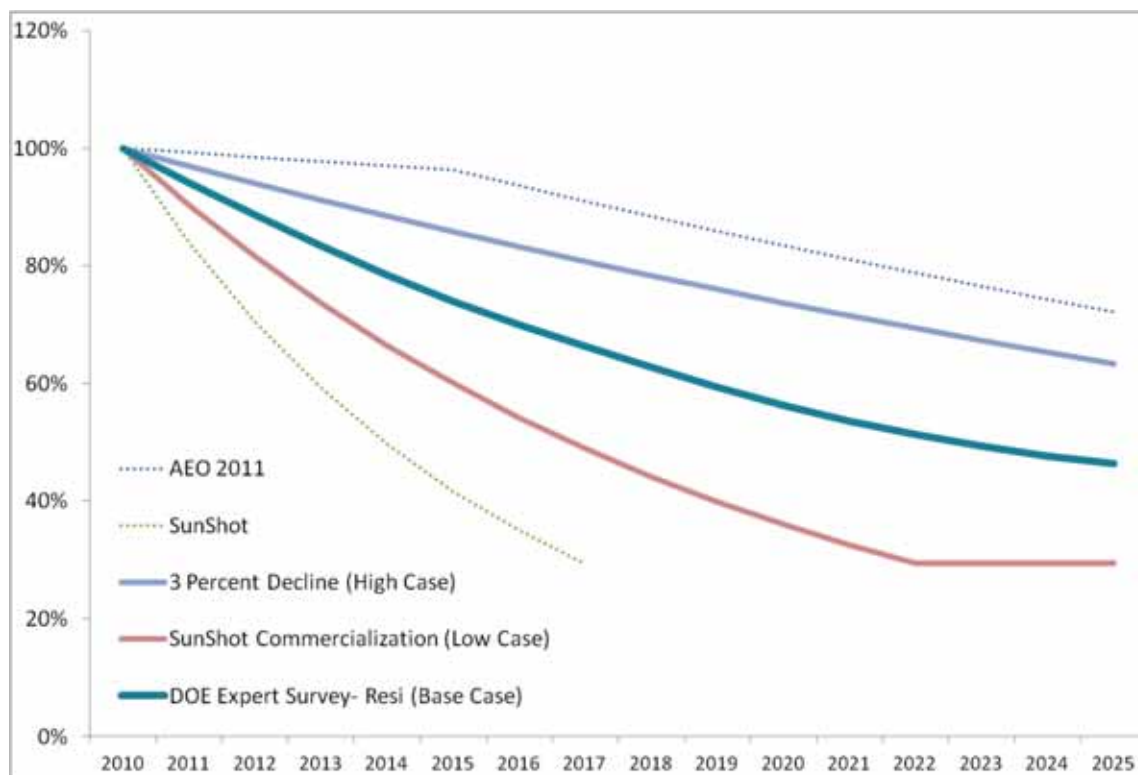

Figure ES-7. Forecast PV Installed Cost Trajectories (2010-2025)

Capital cost trajectories from the three selected cases were applied to New York PV market prices using 2010 as the starting point. The analysis estimated PV system installed costs for residential, small commercial, large commercial and MW-scale PV systems in the Upstate, New York City and LIPA-load zones. Projections were developed through the final 2025 installation year. Under the Base Case trajectory, residential systems for non-New York City sites declined from $6.70 per W to $3.10 per W in 2025, while costs for these systems under the Low Cost Case declined to $2.00 per W in 2025. Similarly, small commercial systems in Upstate New York declined from $6.30

per W in the 2010 analysis year to $3.00 per W in 2025. Under the Low Cost Case, installed costs for these systems declined to $2.00 per W in 2025. In comparison, MW-scale systems in the upstate region declined from $4.40 per W to $2.50 and $1.40 per W in the Base and Low Cost Cases respectively.

3.1. PV Cost of Energy Compared to Retail and Wholesale Electricity Prices

An often-stated PV strategy is to support the above-market technology until the cost of PV achieves "grid parity." A PV installation is said to reach "grid parity" when lifetime average energy costs equal the retail cost of power purchased from the grid. Although grid parity is frequently assumed to be the point when PV will be widely adopted, some policy intervention will likely still be necessary to increase market demand. This conclusion is supported by experiences from energy efficiency programs, where incentives are frequently necessary to drive demand for technologies that have average costs that are below retail electricity rates. In particular, the upfront cost of PV installations will likely continue to be a barrier to widespread adoption, even if average generation costs reach grid parity. Innovative ownership structures, such as third party leasing or power purchase agreements (PPAs) are increasingly used in the New York market to address this first-cost issue.

The Solar Study examined energy costs for a range of system types and installation load zones, considering installed cost trajectories, financing assumptions, and federal policy scenarios, throughout the 2011 to 2025 analysis period. Base Case modeling assumptions included:

- **Federal Incentives:** Federal ITC continues at 30% through 12/31/2016 and then phases down to 15% over a 5-year period, remaining at this reduced level indefinitely.[9]
- **Financing Structure:** 50/50 debt-to-equity ratio with 15-year debt at 6% and 12% cost of equity.

Energy production for each of the four installation types (residential, small commercial, large commercial and MW-scale) were developed using PVWatts, a PV production estimator developed by the National Renewable Energy Laboratory. The cost, financing and production assumptions were input into the CREST model to develop projected energy costs for each system type in each load zone for each cost and financing scenario.

The energy cost modeling was highly sensitive to federal incentives and PV cost assumptions. Modeling showed that retail grid parity will be reached in different regions of New York in different years, with areas of the state that have better PV resources and higher electricity prices reaching grid parity before areas with relatively poor PV resources and lower energy prices. Small commercial systems in New York City would reach retail grid parity in 2017 in the Low Cost Case with Upstate installations approaching retail grid parity by 2025. One potential policy focus to explore could target resources to areas of the state that are likely to reach grid parity sooner. This could

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[9] For the Low-Cost scenario, the federal tax credit was assumed to extend through 2025 at its current level. For the High-Cost scenario, the federal tax credit was assumed to revert to a pre-federal stimulus level following expiration of the current credit in 2016.

lower the costs of reaching the 5,000 MW Goal. None of the scenarios in this analysis showed PV cost competitive with wholesale electricity generation during the study period.

3.2. PV Cost of Energy vs. Other Renewable Technologies

The analysis compared expected PV energy costs with energy costs for other renewable energy technologies including biomass, onshore and offshore wind, hydropower and landfill gas. Figure ES-8 compares energy costs for large-scale systems, by technology, in 2025. As with the grid-parity analysis, PV costs were highly dependent on installed cost assumptions. Under the Base Case, MW-scale systems in the Capital Region are forecast to have a higher cost of energy than all other modeled resources, with the exception of small new hydroelectric resources. In the Low Cost Case, the PV costs are forecast to also have a lower cost than high-cost offshore wind, small onshore wind, and greenfield biomass. All other resources, including large onshore wind and the offshore wind low cost case, are forecast to have lower costs than the PV Low Cost Case.

The comparison of PV to wind energy may be more instructive than the comparison to other technologies, as wind is presently the only other technology with both a high installation growth rate and substantial additional resource potential. Wind energy is the resource that is likely to set the price for compliance with policies that require the development of new, large-scale renewable energy facilities. Other resources may represent lower cost supply in limited quantities. This quantity-oriented view is an important consideration in the policy-making process and is not adequately represented by looking at a comparison of energy costs alone.
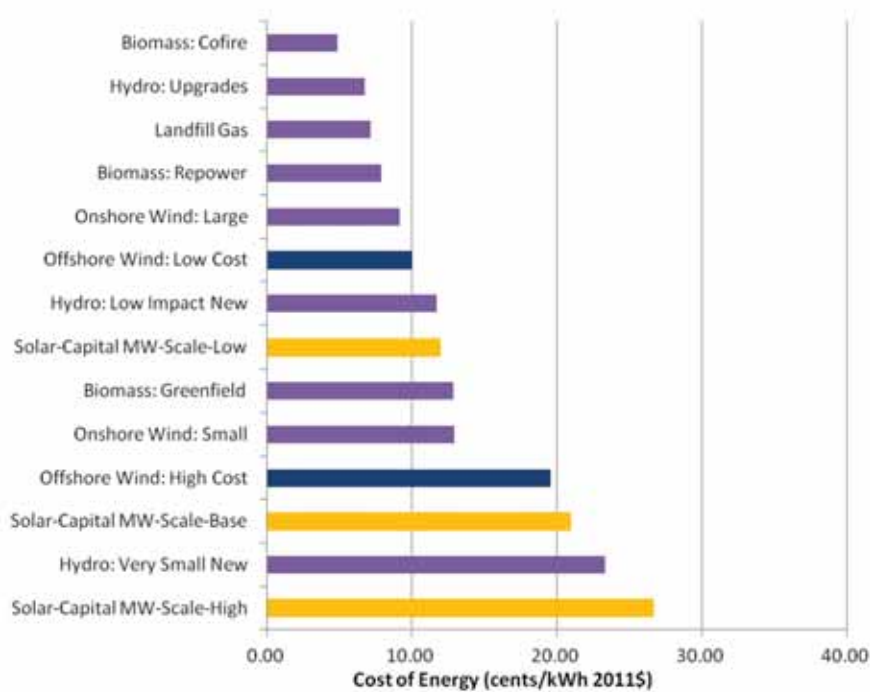

Figure ES-8. Renewable Energy Cost Comparisons in 2025

It should be noted that distributed technologies such as PV have value that is not fully accounted for in this analysis. Examples of other potential, but uncertain benefits that have been studied elsewhere, including PV's potential to mitigate or hedge ratepayer exposure to fuel cost variability and PV's ability to enhance grid security.

4. BENEFIT-COST ANALYSIS

Key Findings:

- Future cost of PV and the federal incentive level were the primary drivers of total cost of reaching the Goal, while the location of installations and system sizes were secondary cost drivers.

- Price suppression and avoided electricity production costs were the greatest drivers of benefits, while other factors, including reduction in air pollution, reduction in the use of fossil fuels, avoided distribution system upgrades, and avoided line losses showed smaller benefits.

- Under the Base Case scenario, reaching the 5,000 MW Goal had a net cost for New York of $2 billion.

- Under the Low Cost Case scenario, reaching the 5,000 MW Goal had a net benefit for New York of $2 billion.

- Under the High Cost Case scenario, reaching the 5,000 MW Goal had a net cost for New York of $8 billion.

- Increased deployment of PV downstate had a higher benefit-cost ratio, lowering the overall costs of meeting the Goal by nearly $1 billion, as electricity costs are higher in the New York City region.
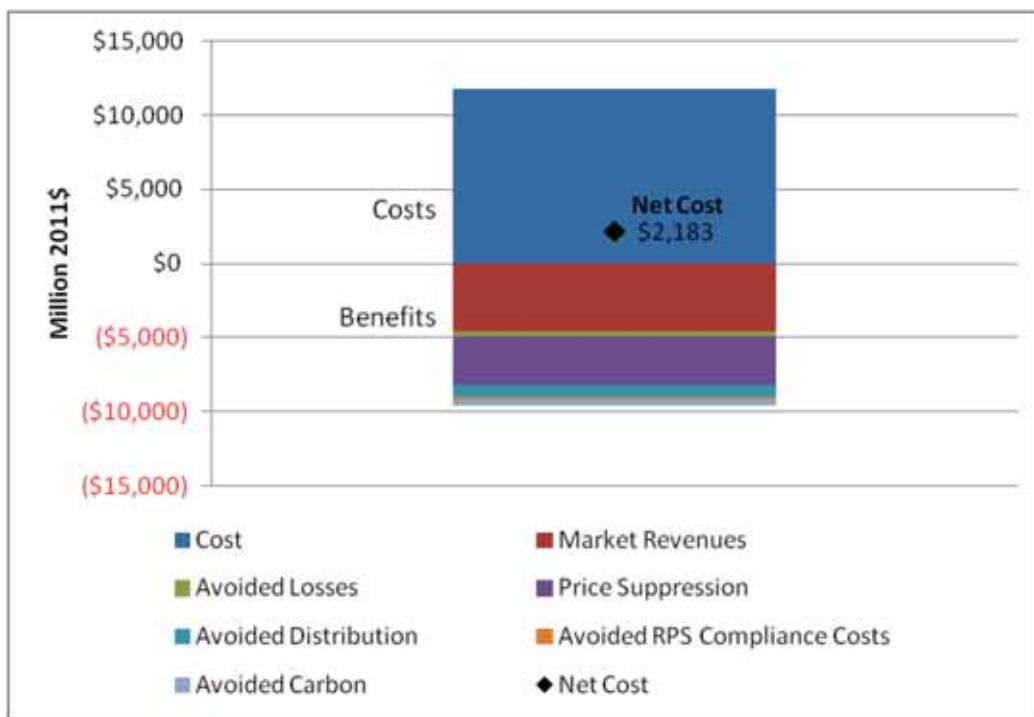
The benefits and costs of the implementation of the 5,000 MW by 2025 Goal were studied. A range of benefits were quantified for the Base Case deployment scenario from 2013 through 2049 — the final year when PV systems installed during the policy implementation period were expected to still be generating. These benefits included:

- **Wholesale Energy Market Value:** the estimated dollar value of the electricity exported to the grid

- **Wholesale Capacity Market Value:** the value of a PV system to the grid's generation capacity market

- **Avoided Losses:** this value reflects the benefits of generating power closer to its point of consumption, reflected as a reduction in energy lost to transmission and distribution inefficiencies

- **Price Suppression:** this is the value to electricity consumers of reducing electricity demand in the wholesale market, lowering electricity prices for all customers

- **Avoided Distribution Costs:** installation of distributed generation such as PV can reduce or defer the need to upgrade the utility distribution system

- **Avoided RPS Compliance Costs:** this is the benefit of displacing the purchase of renewable energy credits from other sources with PV to meet the requirements of the state's renewable portfolio standard

- **Monetized Carbon Values:** this is the monetized value of avoiding future carbon emissions (a carbon value of $15 per ton was used to develop the carbon benefit price)

Modeling showed that price suppression and avoided electricity production costs were the greatest drivers of benefits, while other factors, including reduction in air pollution, reduction in the use of fossil fuels, avoided distribution system upgrades, and avoided line losses showed smaller benefits.

The costs of the Base Case scenario were also quantified. These costs included the cost of installing PV generation assets and the administrative costs associated with developing and operating a PV incentive program. Modeling showed that future cost of PV and the federal incentive level were the primary drivers of total cost of reaching the Goal, while the location of installations and system sizes were secondary cost drivers.

The benefit cost analysis found that, for the Base Case implementation, the costs outweighed the benefits by $2.2 billion. Figure ES-9 shows the total lifetime benefits and costs of the PV deployment.

Note: Positive equates to costs while negative equates to savings

Figure ES-9. Lifetime Cost and Benefit of Base Case Scenario

A series of sensitivity analyses were performed to better understand the impacts of other deployment scenarios on the cost of reaching the PV deployment targets. This analysis found that a geographic PV deployment scenario that favored more downstate installations lowered the overall costs of meeting the targets by nearly $1 billion. This was because power generated in downstate regions had higher wholesale value and improved price suppression effects.

A second sensitivity analysis was completed to understand the potential effects of higher future natural gas costs on the overall cost of achieving the Goal. Under this scenario, the benefits of PV increased by more than $1 billion for a net policy cost of $1.1 billion. These benefits included increased wholesale value for PV generation as well as increased wholesale price suppression effects.

5.   JOBS AND MACROECONOMIC IMPACT

Key Findings:

- Analysis conducted looked at the overall impacts to the New York job market, taking into consideration the jobs gained in the solar industry and elsewhere, as well as the potential job loss due to the costs imposed on the economy by the Goal.

- In terms of the total impact of the Base Case PV deployment on the economy, there will be no economy-wide net job gain; in fact, modeling showed an economy-wide net loss of 750 jobs because of the impact of increased electricity rates needed to pay for the PV program. Gross State Product (GSP) would be reduced by $3 billion between 2013 and 2049, representing a small annual decrease in GSP of less than 0.1%.

- Deployment to a level of 5,000 MW will create approximately 2,300 direct PV jobs associated with PV installation for the installation period (2013–2025) and an average of approximately 240 direct jobs associated with Operations and Maintenance (O&M) from 2025–2049.

- There will also be 600 jobs lost for the study period primarily as a result of the reduced need to expand and upgrade the distribution grid, a reduced need for conventional power plants, and reductions in in-state biomass fuel production.

- The sensitivity analysis demonstrates that a Low Cost Case future would lead to economic growth, including the creation of 700 economy-wide net jobs and an additional $3 billion in GSP, while a High Cost Case future would lead to a reduction in GSP of $9 billion and on the order of 2,500 economy-wide net job losses.

- Subsidies at the scale required to achieve 5000 MW by 2025 would most likely have a small net-negative impact on the economy; however, continued support for PV is warranted given the promise of a low-cost PV future.

Although it is clear that the installation of 5,000 MW will create new PV industry jobs in New York, the broader implications for the New York economy are more complex and require more in-depth modeling to determine how the positive impacts of PV development balance against the negative impacts of the electricity rate increases needed to pay for the PV program. Furthermore, the creation of a 5,000 MW PV goal cannot be assumed to change the PV supply chain in New York State.

Three key jobs and economic indicators that were calculated for this Study include: direct PV jobs, economy-wide net jobs, and changes to GSP.

5.1. Direct PV Jobs

Direct PV jobs include jobs that are associated with PV system installation, operations, and maintenance. In New York, these jobs would be concentrated in the fields of construction, engineering, legal and financial services, and wholesale trade. Figure ES-10 below shows direct job creation for the Base Case, as well as for High Cost and Low

Cost Cases. The jobs for all three scenarios can be categorized according to whether they result from the initial PV investment or from O&M activities. As can be seen in Figure ES-10 below, PV installation activity creates jobs until 2025, after which point jobs are created only by O&M activity. The Base Case results in an average of 2,300 direct jobs during the installation phase from 2013 to 2025. The Low Cost Case results in 1,800 direct jobs, and the High Cost Case results in 2,800 direct jobs. The number of O&M jobs created during the O&M phase (2026 to 2049) for all three scenarios is approximately 240.
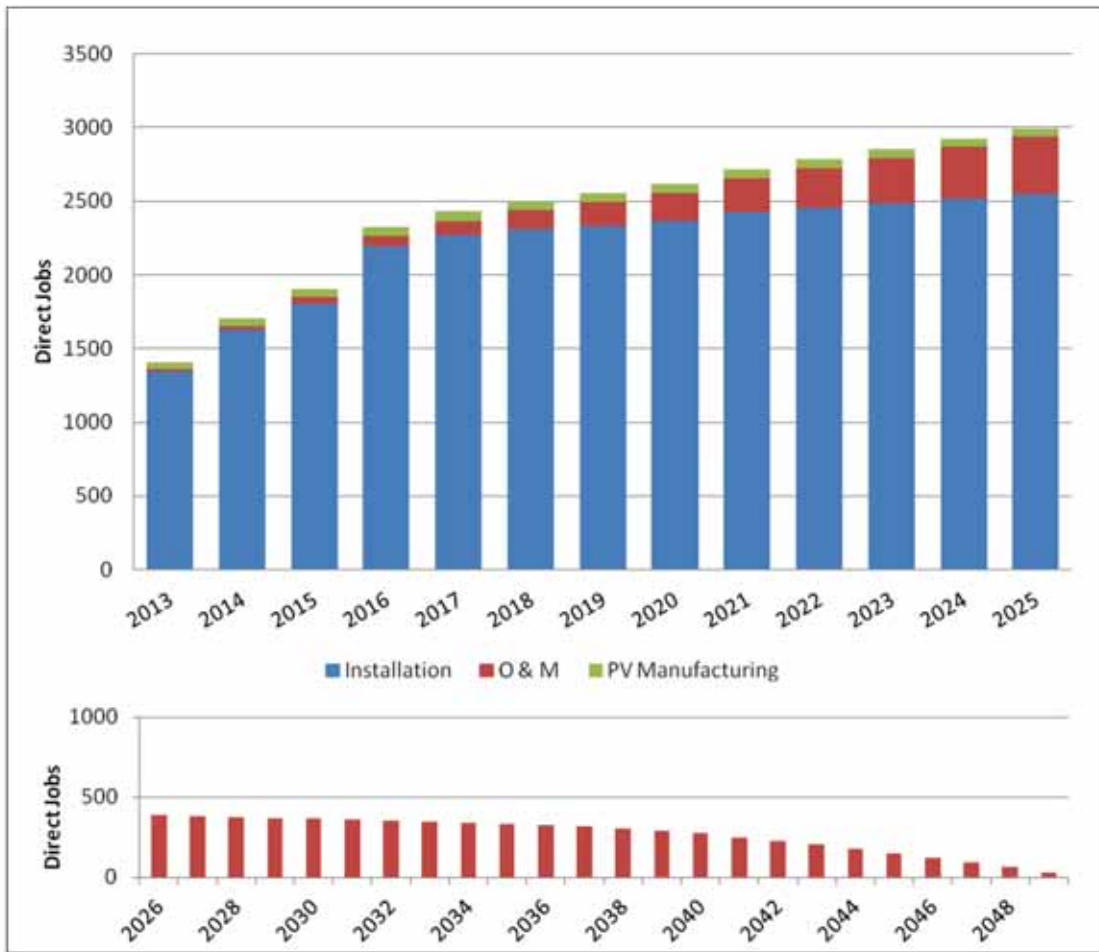

Figure ES-10. Source of Annual Direct PV-related Job Changes - Base Case

In addition to the direct PV jobs created, the installation of PV will also create direct job losses in some sectors as PV electricity reduces demand for electricity from other sources. Since PV is sited close to the loads it serves, there will be less need for expanding and upgrading the electric distribution system. As a result, labor and manufacturing jobs related to the distribution grid will decrease in the future. PV will also decrease demand for other types of fuel and power plants. Jobs will be lost from a diminished need for the construction of power plants that would otherwise be built. Although most fuels come from out of state, some biomass production occurs in New York and some jobs

in biomass fuel will also be lost as PV increases. In total, an annual average of 400 direct job losses will occur over the course of the study period.

5.2. Economy-Wide Net Jobs

Economy-wide net job calculations take the effect of PV investment on the entire New York State economy into account. This includes positive impacts such as the creation of new PV jobs and the savings to ratepayers when electricity prices are suppressed by PV output. Economy-wide net jobs also take into account job losses attributable to negative impacts on the economy, such as the cancellation of new power plants that are made unnecessary by the added PV capacity and the additional costs of PV incentives, which reduce the amount of capital consumers have to spend in the economy. Economy-wide net jobs are calculated using the REMI PI+ model, an advanced economic model that reflects New York's industry mix and considers the salient interconnections between multiple industries across the entire state. Economy-wide net jobs are calculated for the Base Case, Low Cost Case, and High Cost Case. As shown in Figure ES-11 below, the number of economy-wide net jobs created is highly sensitive to the cost of PV. The best outcome is delivered by the Low Cost Case, under which 700 economy-wide net jobs will be created.[10] The Base Case results in a loss of 750 economy-wide net jobs, whereas the High Cost Case results in a loss of 2,500 economy-wide net jobs. Economy-wide net jobs are created in each of the first 13 years of the program, stimulating the economy; but net jobs are lost in the last 23 years of the study period. It is important to note that this analysis assumes that the manufacturing sector in New York continues to supply 5% of components and that the remainder of PV system components is imported from out-of-state.
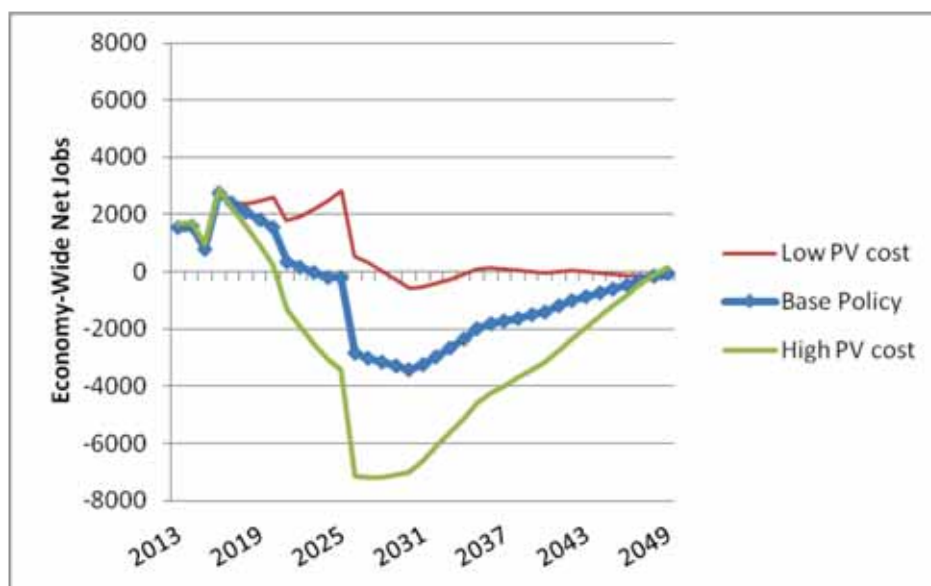

Figure ES-11. Economy-Wide Net Job Impacts across PV Cost Cases

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[10]   The job results represent a simple total of the annual job values over the 37-year span of the study. Other ways of totaling jobs across years could be used that give greater weight to near-term numbers than to out-year numbers.

The overall result of negative economy-wide net jobs is primarily because of the high relative cost of PV compared to other forms of traditional or renewable generation. This cost necessitates rate increases, which, in turn, create job losses that offset the direct jobs created in the New York PV industry. This result should not necessarily be assumed to apply generally to renewable energy policies. Other forms of renewable generation, especially those whose costs are substantially lower than PV's costs, can be expected to produce better macroeconomic results since they will not necessitate electric rate increases of the same magnitude as PV.

5.3. Gross State Product (GSP)

Gross State Product (GSP) represents the total amount of worker income and corporate profit that is generated across the New York economy as a result of the 5,000 MW PV program. GSP is calculated using the REMI PI+ model for the Base Case, as well as for Low Cost and High Cost Cases. As shown in Figure ES-12 below, the pattern of the impact for GSP is similar to that of economy-wide net jobs. Only the Low Cost Case results in a net gain to the State economy, at $2.7 billion in net present value (NPV). The Base Case results in a loss of $2.9 billion, whereas the High Cost Case represents a loss of GSP totaling $10 billion.
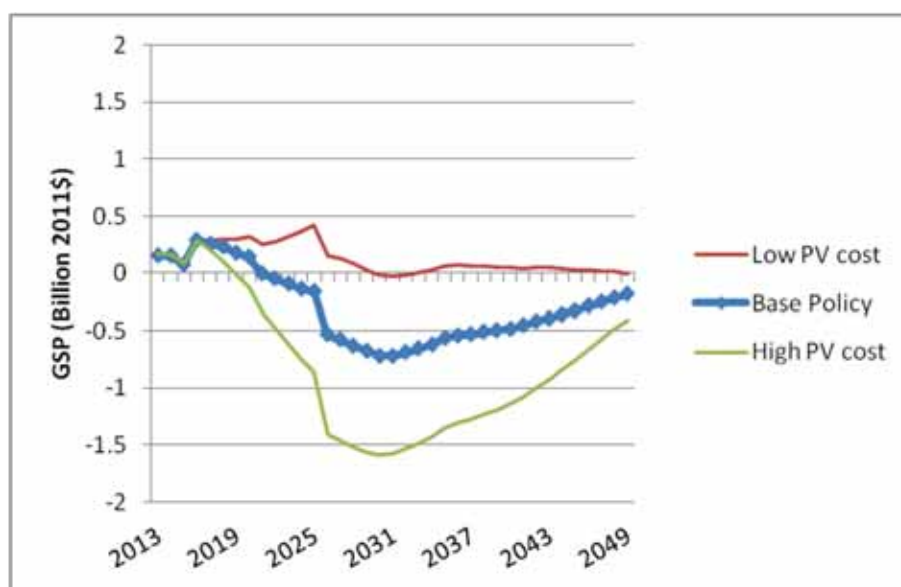

Figure ES-12. Total GSP Impacts across PV Cost Cases (Billion 2011$)

6. RETAIL RATE IMPACTS

Key Findings:

- The net impact of the PV deployment on electricity bills takes into account the above-market costs of PV, the costs of net metering, and the savings generated by the suppression of wholesale electricity prices.

- The net impact of these factors on retail electricity rates is $3 billion over the study period, or approximately 1% of total electricity bills. In any given year, this rate impact could be as much as 3% of total electricity bills.

- Analyses of Low Cost and High Cost scenarios were also conducted. The impact of the Low Cost scenario is approximately $300 million in additional ratepayer impacts or 0.1% of total bills (annually a maximum of 1%), whereas the impact under the High Cost scenario would be $9 billion or 2.4% of total bills (annually a maximum of 5%).

- An analysis was also conducted to determine the effect of higher natural gas prices on PV impacts. Higher natural gas prices would reduce the above-market cost of PV and lower the retail rate impact to 0.6% of total electricity bills (annually a maximum of 2%) instead of 1%.

- Since retail rates are higher in Southeast New York, PV is closest to grid parity downstate. Concentrating smaller-scale PV installations downstate would result in lower overall retail rate impacts.

It is assumed that any incentive costs needed for deploying 5,000 MW of PV would be recovered from New York State ratepayers through their electricity bills. As the total amount of PV installed increases, so, too, will the total impact on electricity rates.

The installation of 5,000 MW of PV will ultimately have an impact on the electricity bills that New Yorkers pay. These impacts include both the additional costs of PV incentives and savings from the wholesale electricity market price reductions that PV installations can achieve. The Study takes both costs and savings into account and calculates the net retail impact of PV incentives borne by ratepayers over time. The factors that are taken into account in this calculation include:

- **The direct rate impact of the above-market cost of PV.** The above-market cost of PV at the retail level is the difference between the cost of electricity generated from PV systems and the price at which customers purchase electricity from the grid. This calculation is done for each year of the study period. The above-market costs of PV decrease over time as the price of electricity from the grid rises, as the cost of PV systems declines, and as the more expensive PV systems that are assumed to be installed early in the study period are assumed to be retired later on.

- **The net metering impact.** Many PV generators will consume PV electricity on their own property and will get credit at the retail electricity rate for both the PV electricity that they consume and that they export to the grid under the state net metering law. The ability to net meter is a benefit to PV system owners. Still, net metering also represents a cost to the ratepayers who do not participate in the net metering program. The price of electricity from the grid reflects the cost to produce the electricity and the cost of building and maintaining the grid itself. Customers who use their PV electricity onsite avoid paying a portion of the transmission and distribution rates. These costs must then be recovered from other ratepayers via increases in retail rates. In calculating the impact of PV deployment on ratepayers, this "cross-subsidy" was taken into account.

- **The price suppression effect.** As more PV is installed on the grid, it increases the supply of electricity and reduces the wholesale market price for electricity from the grid. This price suppression impact lowers electricity prices for all customers and partially offsets the additional costs of PV incentives and net metering. The price suppression effect, however, is temporary and small compared to the additional cost impacts.

Figure ES-13 shows the net rate impact of the projected PV installations over the study period. The period of rate reduction in the early years of the study period reflects the electricity price suppression impact. Electricity price suppression also has the effect of delaying the maximum ratepayer impact from the initial deployment until several years after total installations peak in 2025. The total net present value of the impact under Base Case assumptions is $3.3 billion, or approximately 0.9% of total electricity bills over the study period. Retail rate impact is also highly sensitive to PV cost. Under the sensitivity analyses, the result of the Low Cost Case is $340 million in additional ratepayer impacts (0.1% of total bills), whereas it is $8.6 billion under the High Cost Case (2.4% of total bills).
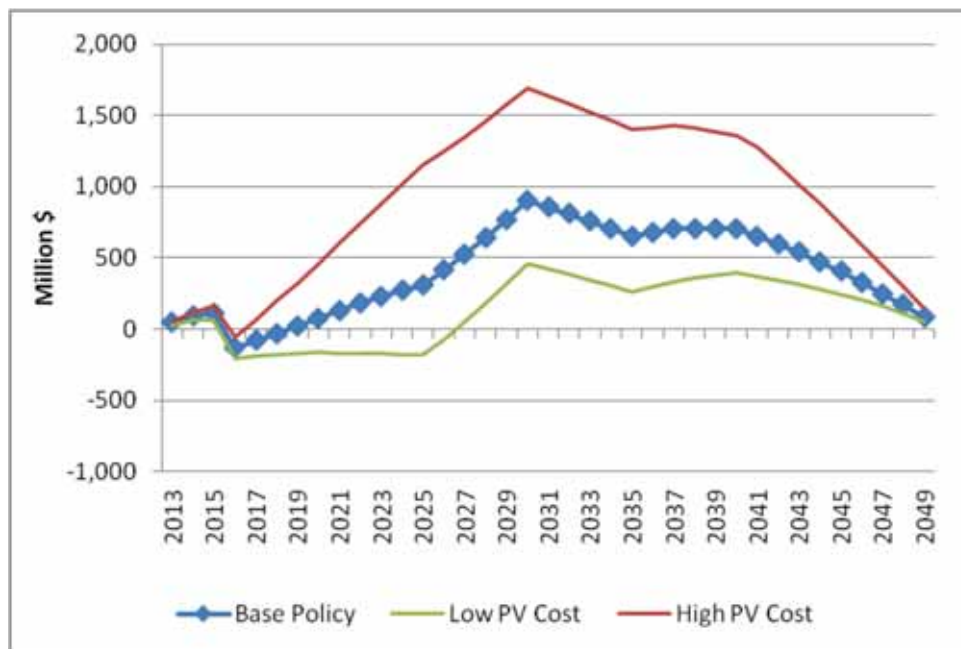

Figure ES-13. Annual Net Rate Impact, Base, Low and High PV Cost, 2013-2049 (nominal$)

Several additional analyses were performed in order to calculate the impact of different scenarios, including the impact of natural gas prices and the impact of concentrating PV in different regions of New York State. Specifically, the effect of higher natural gas prices on the rate impact was analyzed, as were the impacts of installing a greater amount of PV in downstate areas and the impacts of installing a greater amount PV in upstate New York. As can be seen in Table ES-2 below, higher natural gas prices would decrease the impact of PV on retail rates. Likewise, the concentration of a greater amount of PV downstate would decrease the total impact on retail rates, whereas a greater concentration upstate would increase the total impact on retail rates. This is because retail rates are higher in downstate areas and so the above-market costs are lower, whereas the opposite is true of upstate areas. Put another way, PV electricity prices are currently closer to parity with the price of electricity from the grid downstate than they

are in upstate New York. Concentrating PV downstate would minimize total electricity bill impact compared to other geographic distributions.

Table ES-2. Net Rate Impact as % of Total Bill, Base Policy and Sensitivities, NPV, 2011$

Scenario	Average (2013-2049)
Base	1%
High natural gas prices	0.6%
Greater downstate deployment (Alternative A)	0.7%
Greater upstate deployment (Alternative B)	1.4%

7.   ENVIRONMENTAL IMPACTS

Key Findings:

- Over the study period (2013–2049) PV will reduce fossil fuel consumption by 1,100 trillion Btus (TBtus). This includes a 7% reduction in the use of natural gas, a 4% reduction in the use of coal, and a 40% reduction in the use of oil in the electricity sector in 2025.

- This reduction will lower carbon dioxide (CO_2) emissions by 47 million tons, equivalent to taking an average of approximately 250,000 cars off the road for each year of the study period. The CO_2 emissions reduction is valued at $450 million for the Base Case.

- A high valuation for CO_2 emission reduction values the 47 million tons at $3.2 billion and has a significant enough benefit to make the Base Case net-beneficial to New York.

- The amount of CO_2 reduction remains small compared to the total reduction that was identified for the power generation sector in the New York State Climate Action Plan Interim Report. In 2025, PV will reduce emissions by 1.7 million metric tons, or 5% of the emissions from the electric generation sector in that year.

- The reduction in fossil fuel use will lower nitrogen oxides (NO_x) by 33,000 tons, sulfur dioxide (SO_2) by 67,000 tons and mercury by 120 pounds. The net present value of this combined reduction is $130 million over the study period. This valuation is based on health benefits only, and does not attempt to monetize ecosystem benefits (such as reduction in acidification of lakes, streams and forests, and eutrophication of estuaries and coastal waters).

- In 2025, PV will reduce total NO_x emissions by 4%, total SO_2 emissions by 17%, and total mercury emissions by 6%.

- PV could also require land for site systems. It is estimated that 5,000 MW of PV would require 23,000 acres of land if the entire amount were ground-mounted. Still, there is a significant amount of roof space available, as well as areas such as brownfield sites, existing power plant sites, and parking lots where PV could be deployed without using land that could have other productive uses. In total, it is estimated that PV would require from 2,600–6,000 acres of greenfield space total, which is less than 0.02% of total state land area.

The installation of 5,000 MW of PV in New York will positively impact the environment by reducing the use of fossil fuels for electricity generation. Fossil fuels create environmental burdens at every stage of their fuel cycle, from ecosystem and human health impacts associated with the extraction process, to air and water emissions from plant operation, to disposal issues associated with toxic waste products. By reducing the need for fossil fuel power plants, PV will reduce these negative impacts. In total, 5,000 MW of PV would reduce fossil fuel consumption in power plants by 1,100 TBtus. Table ES-3 below lists the total amount of coal, natural gas, and oil that is projected to be consumed in 2025 and as well as the projected reduction in consumption resulting from PV installations.

Table ES-3. Projected Reductions in Fossil Fuel Consumption from PV Generation in 2025

Fuel type	Amount consumed in 2025 (TBtus)	Fuel displaced by PV in 2025 (TBtus)	% reduction in fuel consumption in 2025
Coal	110	8	7%
Natural gas	460	20	4%
Oil	2	0.80	38%

7.1. Air Pollutants

The electricity generation sector is a major source of emissions of several air pollutants that impact the environment and public health. These include carbon dioxide (CO_2), which contributes to global climate change, sulfur dioxide (SO_2) that contributes to acid rain and fine particle concentrations in the atmosphere (causing asthma and other health problems), nitrogen oxides (NO_x) that contributes to both of these pollution problems and to ground-level ozone (a lung irritant that also damages trees and crops), and mercury, which is a toxic substance linked to neurological and other health problems. The Solar Study focused on the value of the reduced air pollutants achieved by a reduction in fossil fuel use.

7.1.1. Carbon Dioxide

Over the course of the study period, it is projected that PV would displace a total of 47 million tons of CO_2. To put these reduction numbers in context, the net present value of these reductions would be between $450 million and $3.2 billion. The two values for CO_2 reflect the fact that there is significant uncertainty in accurately monetizing the value of a ton of CO_2. The lower value is the same assumed in the benefit-cost analyses contained in Chapter 4, and reflects the assumption that CO_2 reductions are valued at $15/ton. This is the current value used by DPS as part of electricity generation sector benefit-cost tests. The higher value uses an assumption of $107/ton that was developed

for the UK government as part of the Stern Review on the Economics of Climate Change. If the higher value were used instead of the lower value, the impact of PV deployment on society would change in the Base Case from a loss of $2.2 billion to a gain of $590 million.

Based on the electricity system modeling conducted as part of the Solar Study, the total CO_2 emission from the New York electric generation sector will be approximately 34 million metric tons in 2025. The deployment modeled in the Solar Study will achieve 1.7 million metric tons of reductions in that year, or roughly 5% of the total projected emissions. The installation of 5,000 MW of PV will therefore contribute New York's overall climate action goals, but a broader portfolio of climate action strategies will be required if the state seeks to achieve the 80 by 50 greenhouse gas emission reduction goal[11].

7.1.2. Sulfur Dioxide, Nitrogen Oxides, and Mercury

The total amount of SO_2, NO_X and mercury emissions that PV would displace over the course of the study period is contained in Table ES-4 below. The table also contains the total value of each of the emissions reductions. SO_2, NO_X, and mercury were valued at $3,500/ton, 1,100/ton and $195 million / ton, respectively, based on health benefits only. These values do not monetize ecosystem benefits, such as reductions in acidification of lakes, streams and forests, or eutrophication of estuaries and coastal waters.

Table ES-4. Net Present Value of Emissions Reductions

Air Pollutant	Total amount	Net present value of emissions reductions (millions)
SO_2 (tons)	67,000	$24
NO_x (tons)	33,000	$97
Mercury (pounds)	120	$13

The total value of these emissions reductions over the study period is $130 million. Incorporating this value into the calculation of PV deployment's cost to society would reduce the total losses in the Base Case from $2.2 billion to $2.1 billion.

Table ES-5 below lists the total amount of NO_X, SO_2, and mercury emission projected for 2025 and as well as the corresponding emissions reductions associated with PV deployment. As can be seen in the Table, PV deployment will have the greatest impact on the total amount of SO_2 emissions.

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[11] Executive Order 24 in August 2009 formally established a New York State goal of reducing GHG emissions 80 percent below 1990 levels by 2050 (or 80 by 50), See the New York State Climate Action Plan Interim Report - November 9, 2010. http://nyclimatechange.us/

Table ES-5. Projected Emissions Reductions

Fuel type	Emissions in 2025 (tons)	Emissions reduced by PV in 2025 (tons)	% reduction in emissions in 2025
NO_X	24	0.9	4%
SO_2	15	2.5	16%
Mercury	0.04	0.002	6%

7.2. Land Use

Another important environmental consideration of PV is the land area used to install systems. Today nearly all PV installations in the Northeast are on roof tops or other structures. It is likely that the number of ground-mounted systems will increase, however, as New York scales up its PV market and looks to build systems that are too large for roof tops. Ground-mounted systems can be developed on land with little or no high-value alternative use ("brownfield sites"), such as capped landfills and contaminated sites. Other types of sites that may be attractive, and that have little or no competing value, include highway medians and inside-the-fence buffer zones (e.g. at substations, airports, power plants, transmission rights of way, etc.). It is likely that installations would also take place on sites with alternative uses ("greenfield sites") if New York were to scale up to meet a 5,000 MW target. The use of greenfield sites for PV installations has a potentially negative impact on the environment. The Solar Study assumes that, on average, one megawatt of PV requires five acres of space.[12]

There are approximately 30 million acres of land in New York State. If the entire 5,000 MW of PV were ground-mounted, it would require 23,000 acres, or approximately 0.08% of the total land available. Three land use scenarios were developed to test the likely impact of PV deployment on greenfield sites. The base PV scenario assumes that PV is installed in the state in a way that reflects current load distribution. The two other scenarios assume a greater number of systems installed in downstate areas (with a greater number of on-roof and brownfield installations) and a greater number of systems installed in upstate areas, where greenfield sites would be more prevalent. Table ES-6 below shows the estimated amount of greenfield space required under each scenario. The total impact is small, ranging from under 0.01% to 0.02% of New York land area.

Table ES-6. Land Use Impacts

Deployment	Acres of greenfield land used	% of state total land
Base deployment	3,000	0.01%
Greater downstate deployment (Alternative A)	2,600	0.009%
Greater upstate deployment (Alternative B)	6,000	0.02%

These scenarios illustrate that PV can be deployed in ways that have different implications for land use and open

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12 This figure is based on reports from secondary sources as well as interviews with and surveys of installers familiar with ground-mounted installations.

space. Land use impacts can be minimized by focusing development in downstate areas. A focus on development downstate is consistent with the finding that downstate areas (e.g. New York City) will experience grid parity first and will therefore create the most cost-effective opportunities for PV deployment. New York State, for example, has already begun to target downstate areas through programs such as the RPS regional competitive bidding program.

8. PV POLICIES

Key Findings:

- A comprehensive approach to PV deployment will likely include cash incentives as well as low-cost or no-cost complementary regulations such as streamlined permitting, interconnection standards, and building construction mandates that can reduce the installed cost of PV and drive demand.

- There is a range of policy incentive mechanisms that can be used for PV deployment, such as upfront payments, standard offer performance-based incentives, and quantity obligations. Although each of these mechanisms has different characteristics, the salient differences between policy types can be reduced through policy design. Even so, there are fundamental differences in terms of overall policy cost, investor security, and implementation.

- Renewable Energy Credits (RECs) are a policy tool that can be combined with most other policy mechanisms. RECs that are traded on spot markets and are not supported by long-term contracts or price floors, however, are challenging to finance and increase the investor risk, and therefore, the cost, of quantity obligations.

- The longer the term for a PV incentive, the lower the $/kWh payment needs to be. Therefore, longer-term payments create the opportunity for PV to reach parity faster.

- Incentive rates can be set administratively or through competitive processes. Competitive processes are consistent with New York's competitive electricity market, although they may create barriers to entry for smaller and less sophisticated market participants. Competitive processes can be used for larger projects, whereas administratively-determined incentives can be used to target smaller projects.

In exploring policies to achieve 5,000 MW of PV by 2025, New York has an opportunity to learn from its own experience and from the experience of other states and countries. Broadly, policy mechanisms can be categorized as incentives and regulations. Incentives include policies that address economic and financial barriers to PV, such as rebates and tax credits, whereas regulations are policies that address non-economic barriers, such as interconnection standards and streamlined permitting. Incentives are currently the primary driver of PV markets, but regulations can accelerate adoption and lower PV system costs. Streamlined permitting and best practice interconnection standards, for example, can lower PV development costs, whereas workforce training programs could lower the cost of

installations. Table ES-7 below provides examples of incentives and regulations, a number of which are used in concert to provide a comprehensive approach to support the deployment of PV.

Table ES-7. PV Incentives and Regulations

PV INCENTIVES	PV REGULATIONS
Performance-based incentives	Streamlined permitting
Rebates / grants	PV building requirements
State tax credits	Improved or uniform interconnection standards
State tax exemptions	Net metering[13]
Industry recruitment and support	PV access and PV rights laws
State PV loan programs	Community PV regulations
PACE[14] financing	
On-bill financing	
Loan guarantees	

Although PV currently requires incentives due to the technology's above-market cost, regulations such as mandates requiring PV in new construction may be sufficient to support market growth in the future when PV reaches price parity with electricity from the grid.

The analysis focuses initially on three categories of incentives: standard offer performance-based incentives, upfront payments, and renewable energy quantity obligations. The structure and design variations of these incentives is discussed in detail in the body of the Study and benchmarked against national and international experience. Each of these three policy types is also qualitatively assessed from the ratepayer, investor and policy maker perspectives. It is important to note that the Study does not recommend one policy type over another. Instead, the emphasis of the policy review is to identify lessons learned that can be expanded as New York contemplates the appropriate policies.

Standard offer performance-based incentives (PBIs) provide PV projects with a payment for each kWh generated for a set number of years. The PBIs are set ahead of time and available on a first come, first-served basis. Standard offer PBIs are one of the most prevalent forms of PV support around the world and have supported the majority of the world's PV systems. Examples of standard offer PBIs include California's incentives for PV systems larger than 30 kW, Vermont's SPEED standard offer program, and feed-in tariff policies in European countries such as Germany and Spain.

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[13] Depending on how defined net metering can have elements of both incentives and regulations.

[14] Property Assessed Clean Energy financing, or PACE, is a local government financing tool that allows municipal governments to lend funds to property owners and collect re-payments through property tax bills. PACE financing programs have been implemented in a number of municipalities; however, a 2010 decision by the Federal Housing Finance Administration (FHFA) has limited the expansion of PACE programs for residential property owners.

Standard offer PBIs can lower investor risk and the costs of financing by providing PV projects with a known payment stream. Standard offer PBIs can also encourage those with smaller projects to participate since there are few barriers to participate in the incentive program. While PBIs have their advantages, it can be challenging to set the right payment rate that is attractive for PV generators. Standard offer PBIs also do not encourage project-on-project competition. Moreover, the ability of standard offer PBIs to lower investment risk and attract a broad range of participants means that the market can grow rapidly. Rapid market growth can be a challenge if not anticipated and managed correctly. Table ES-8 below summarizes the strengths and limitations of standard offer PBIs from the perspective of ratepayer, investors, and policymakers.

Table ES-8. Strengths and Limitations of Standard Offer PBI

Ratepayer perspective	Investor perspective	Policymaker perspective
STRENGTHS • Low investor risk = low costs of capital and decreased policy costs • Payment based on performance • Long-term, fixed price contract can serve as a hedge against rising energy prices LIMITATIONS • Rates can be set "too high" • No automatic adjustment for changes in market prices	STRENGTHS • Revenue certainty and security • Standard offer lowers transaction cost and development risk • Allows smaller projects to participate LIMITATIONS • A large market response can limit policy durability if not adequately managed	STRENGTHS • Lower policy costs • Easily targeted for specific project types LIMITATIONS • Challenging to get the rate right • Purchase requirement on distribution utilities is new for NY • No project-on-project competition

Lessons learned: Standard offer PBIs can create the conditions for rapid market growth for a broad range of project types and sizes. In Germany, for example, over 7 GW of PV was installed in 2010 and again in 2011. The majority of these projects have been rooftop systems below one MW in size. Germany projects that it will reach over 51,000 MW by 2020. In order to contain the cost of market growth, Germany's PV PBI rate decreases annually, and the government has also intervened in the middle of last several years to introduce additional reductions. The German market has maintained momentum through 2010 despite rapid expansion. Spain, by contrast, unexpectedly installed 2,800 MW of PV under a generous standard offer PBI in 2008. In reaction to this growth, Spain capped its markets and dropped its rates in a way that curtailed market growth and shook investor confidence. A key lesson learned is that standard offer PBIs should have clear goals and volume management strategies established at the outset.

Standard offer upfront payments include both grants (payments at the time of purchase) and rebates (payments that are made once the installation is complete). They are similar to PBIs in that their levels are set and known in advance and they are available on a first-come, first-served basis. The primary difference from PBIs is that they are

paid at the outset of a project, rather than over time. Most upfront payments are also based on the installed capacity of the system (e.g. $/kW). Seventeen states, including New York, currently have programs that support PV through upfront payments. To date, approximately $2.942 billion has been spent across the United States through state rebate or grant programs, supporting over 1,300 MW of PV capacity.

The strengths and limitations of upfront payments are similar to those of PBIs: they lower investor risk by providing a known amount of revenue and enable smaller projects to participate if offered on a first-come, first-served basis, but, it can be challenging to set upfront payments at the right level.

A key difference is that upfront payments do not necessarily create incentives for performance, although they can be linked to the expected or initial performance of the system. It is also important to note that rebates may be more cost-effective for ratepayers than PBIs because they provide PV projects with their required return in a shorter period of time. Nevertheless, the rate impact of having the incentive payments front-loaded instead of spread out over time may be challenging for ratepayers. The strengths and limitations of upfront payments are summarized in Table ES-9 below.

Table ES-9. Strengths and Limitations of Standard Offer Upfront Payments

Ratepayer perspective	Investor perspective	Policymaker perspective
STRENGTHS ▪ Upfront payments can provide PV projects with the return they require more cost-effectively than PBIs LIMITATIONS ▪ The rate shock of initial payment for a large volume of installations can be high ▪ Rates can be set too high	STRENGTHS ▪ Revenue certainty and security ▪ Standard offer lowers transaction cost and development risk ▪ Allows smaller projects to participate LIMITATIONS ▪ A large market response can limit policy durability if not adequately managed	STRENGTHS • Can be useful for early adoption in order to persuade innovators to enter market LIMITATIONS • Challenging to get the rate right ▪ Typically requires source of funding (e.g. SBC) and a fund, which can be subject to political risk ▪ Not performance based

Lessons learned: Most U.S. states have used upfront payments to jump-start their PV markets and many states continue to use rebate programs as the primary mechanism for supporting PV growth. As PV markets have matured, however, an increasing number of states have transitioned to PV-specific renewable energy quantity obligations supported by REC markets (see below). A key argument for this transition in states such as New Jersey has been that the ratepayer impact of rebates would be unsustainable at the scales anticipated under the renewable energy quantity obligations. It has been acknowledged, however, that smaller-scale systems may not be well equipped to compete in REC markets. As a result, some states such as Massachusetts have continued to provide upfront payments to smaller-scale systems while requiring larger-scale systems to participate in the REC markets. A key lesson learned is

that upfront payments may not be well-suited to be the sole mechanism used to achieve 5,000 MW by 2025, but they could be used in tandem with other incentives to support smaller-scale projects that might otherwise "fall through the cracks."

Renewable energy quantity obligations set mandatory targets for PV. Utilities (or other entities) are responsible for purchasing RECs in order to demonstrate compliance with the quantity obligation targets. RECs are typically procured through a short-term or "spot" market or through a bidding process (e.g. auctions and RFPs) in which PV projects are awarded long-term purchase contracts.[15] Sixteen states, plus Washington D.C., have established targets to specifically support PV and/or distributed generation. Similarly, New York has specific policies to target PV under its RPS.

The strengths of quantity obligations are that they encourage competition between PV projects and favor least cost projects. The limitations of quantity obligations differ depending on whether the policy relies exclusively on short-term REC trading or whether long-term contracts are available. Short-term REC trading can lead to uncertain revenues from PV projects and can make them difficult and expensive to finance. Competitive bidding can eliminate the problem of uncertain payment streams by awarding PV projects long-term contracts. Still, not all PV projects have enough money and sophistication to effectively compete for long-term contracts. As a result, competitive bidding can serve as a barrier to smaller-scale projects. The strengths and limitations of quantity obligations are summarized in Table ES-10 below.

Table ES-10. Strengths and Limitations of Quantity Obligations

Ratepayer perspective	Investor perspective	Policymaker perspective
STRENGTHS ▪ Favors least cost projects ▪ Competition encourages lower costs LIMITATIONS ▪ Prices can be inflated by investor risk premiums (if no long-term contracts) ▪ Market prices can spike during REC shortage	STRENGTHS ▪ Creates demand and a market ▪ Supports financing (if long-term contracts, price floors, etc.) LIMITATIONS ▪ Price volatility hampers financing (if no long-term contracts) ▪ Policy changes can impact market prices and project revenue	STRENGTHS ▪ Low administrative burden for spot market trading ▪ Fits restructured markets ▪ Quantity of supply known in advance ▪ Competitively neutral LIMITATIONS ▪ Unknown cost ▪ Can create barriers for emerging technologies or smaller projects

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[15] New York's RPS policy is an example of a quantity obligation. New York's RPS Main Tier procurement is unique because its competitive procurement is organized by the state rather than by individual utilities and because renewable energy attributes are procured under contract instead of electricity and/or RECs.

Lessons learned: To date, the performance of PV quantity obligations has been mixed. REC prices in markets that rely on spot market trading have been volatile. This price volatility has negatively impacted existing projects and has made it challenging and expensive for new projects to secure financing. In order to alleviate concerns over REC price volatility, several states that rely on REC trading have introduced mechanisms such as price floors, loan programs, and competitive bidding for long-term contracts in order to provide security for the market. A key lesson learned is that quantity obligations for PV require some type of mechanism to reduce or eliminate REC market price volatility in order to support cost-effective financing.

The incentive types described above (standard offer PBIs, standard offer upfront payments, and renewable energy quantity obligations) are intended to serve as illustrative examples and benchmarks and they do not necessarily represent the full universe of possible policies that New York could implement. The policy mechanisms should also not be considered mutually exclusive. First, the limitations of each policy can be addressed using a variety of different policy designs that can effectively blur the salient difference between the policy mechanisms. Second, each of the policy mechanisms (and their variations) can be combined and implemented as hybrid policies, which are discussed in greater detail in the next section.

The New York regional competitive bidding PV incentive program illustrates how different incentive types can be combined in new or hybrid forms. The program has elements of upfront payments in that it is paid partially once the project is installed; however, the mechanism seeks to mitigate some of the limitations of upfront rebates by linking full payment to PV system performance over the first three years of operation. The program also awards the payments on a competitive basis, rather than as a standard offer.

9.   MODELING OF POLICY MECHANISMS

Key Findings:

- The difference in ratepayer impact among the three least expensive policy mechanisms is less than 17%, which is potentially smaller than the impact of specific design choices including targeting deployment to specific installation types and locations.

- An upfront payment incentive for smaller customers (and central procurement for larger customers) similar to the policy approach used in New York for the RPS is the least expensive mechanism analyzed as part of the Solar Study.

- A quantity obligation with price floor (similar to the policies in neighboring states) is projected to cost 50% more than the least cost policy mechanism.

- Many complementary policies could be implemented at low or no overall cost in parallel with the analyzed incentive polices, on either a local or state-wide basis, potentially reducing the cost of and removing barriers to reaching the targets, and should therefore be considered as New York refines its solar policies.

- Costs to compete for and potentially negotiate a contract could be prohibitive for smaller-scale generators.

- The choice of policy mechanisms that reduce investor risk and administrative and transaction costs will have lower peak and average direct and net impacts on ratepayers.

Based on the qualitative analysis of different policies conducted in the previous section, a subset of policies was selected for quantitative analysis in order to determine how changes in the policy might alter the impacts of the 5,000 MW Goal. Many of the impacts discussed in this Study, such as the environmental benefits and the electricity price suppression effect depend on the total amount of capacity installed and do not vary with policy types. Different policies can have different ratepayer impacts, however, depending on the policy mechanisms chosen and their designs.

For the purpose of the quantitative analysis, four policy mechanisms were selected from a broad suite of options for additional modeling. The criteria used to select these mechanisms included:

- **The level of investor security that they create**. As detailed in the comparison of PV policies, incentives that provide a stable, long-term revenue stream provide the highest level of investor security. Incentives with values that vary over time are perceived to be the most risky. Creating investor security is important because it lowers the costs of financing projects and therefore, overall policy costs. Quantity obligations that rely only on spot market REC trading were not selected for further analysis because they do not provide projects with certain revenues and they create a high degree of risk. This decision was reinforced by recent REC market price volatility in neighboring markets. Quantity obligations were only considered if they included a mechanism to create certain revenues, such as a price floor for tradable RECs or long-term contracts.

- **The cost of taking advantage of the incentive**. Some incentives, such as upfront payments and standard offer PBIs, are easy for PV projects to take advantage of because they are known in advance and available on a first-come, first-served basis. Other incentives, however, require a higher degree of sophistication and cost to access. Competitive procurements, for example, require PV projects to prepare and submit bids and applications without the guarantee of winning. Since not all projects can afford the costs of participation in these competitions (for example, due to transaction costs), they serve as a barrier, particularly for smaller-scale projects. In order to reflect the objective of supporting a diversity of system sizes in New York, it was determined that some of the modeled policies should have features which encouraged broad market participation.

- **The need for competitive pressure on PV system prices.** Encouraging project-on-project competition not only places downward pressure on PV prices, but is also consistent with the competitive and deregulated

electricity market environment in New York. Quantity obligations with tradable RECs or competitive bidding create competition between projects. As a result, some form of quantity obligation was incorporated into each of the four policy mechanisms selected for additional modeling.

The four policy mechanisms selected for additional modeling include:

- **A PV quantity obligation with a price floor** ("QO w/ price floor"). This option assumes that a QO is the primary policy mechanism that supports all system sizes under the 5,000 MW PV scenario. The QO uses REC spot market trading, but the prices are supported by a long-term price floor that provides a greater degree of revenue certainty to project developers and investors. This model is similar to the approaches adopted in neighboring states.

- **An auction for long-term contracts managed by the electric distribution companies (EDCs)** ("EDC LT Contract Auction"). This assumes that the state EDCs will manage a competitive procurement for all PV project sizes, under which they will award long-term contracts to purchase renewable energy from winning bidders. This approach is similar to the competitive auction for renewable energy that was recently adopted in California (e.g. the Reverse Auction Mechanism).

- **The current RPS approach with a PV carve-out for the Main Tier: rebates for small PV systems and the current RPS procurement approach for large projects** ("Hybrid A"). Since this option represents a hybrid of two different types of policy mechanism, it is referred to as "Hybrid A." Hybrid A assumes that the current New York RPS central procurement mechanism is expanded to specifically target large-scale PV systems. Since competitive bidding may serve as a barrier to smaller-scale projects, however, Hybrid A also assumes that rebates will be available on a first-come, first-served basis to smaller-scale projects. This approach is similar to the existing New York RPS policy since it combines elements of both the main tier procurement and the rebates available through the Customer-Sited Tier.

- **A policy that combines standard offer PBIs for small systems with auctions for long-term contracts for large systems** ("Hybrid B"). This option combines two distinct policy mechanisms and is therefore referred to as "Hybrid B". Similar to Hybrid A, Hybrid B assumes a competitive procurement for large projects and a standard offer incentive for smaller systems. Under Hybrid B, however, the standard offer incentive is a PBI, rather than an upfront payment. Also, the auctions for long-term contracts under Hybrid B are managed by the EDCs, instead of being managed centrally by the state. This is similar to approaches under consideration in the State Legislature.

The modeling results for the comparative ratepayer impacts of the different policies are contained in Figure ES-14 below. The quantity obligation with a price floor has the highest direct ratepayer impact at $4.5 billion (NPV) over the full policy period (2013 – 2049). The policy mechanism with the lowest ratepayer impact ($3 billion) is Hybrid A, which combines a rebate with competitive procurement. A primary driver for the quantitative differences between models is the cost of financing, which is assumed to be highest for the quantity obligations because the

price floor removes some, but not all, of the projects revenue risk. It is important to note, however, that although the comparison below focuses on rate impact, policy mechanisms should be judged and selected based on the consideration of multiple criteria beyond rate impact alone.
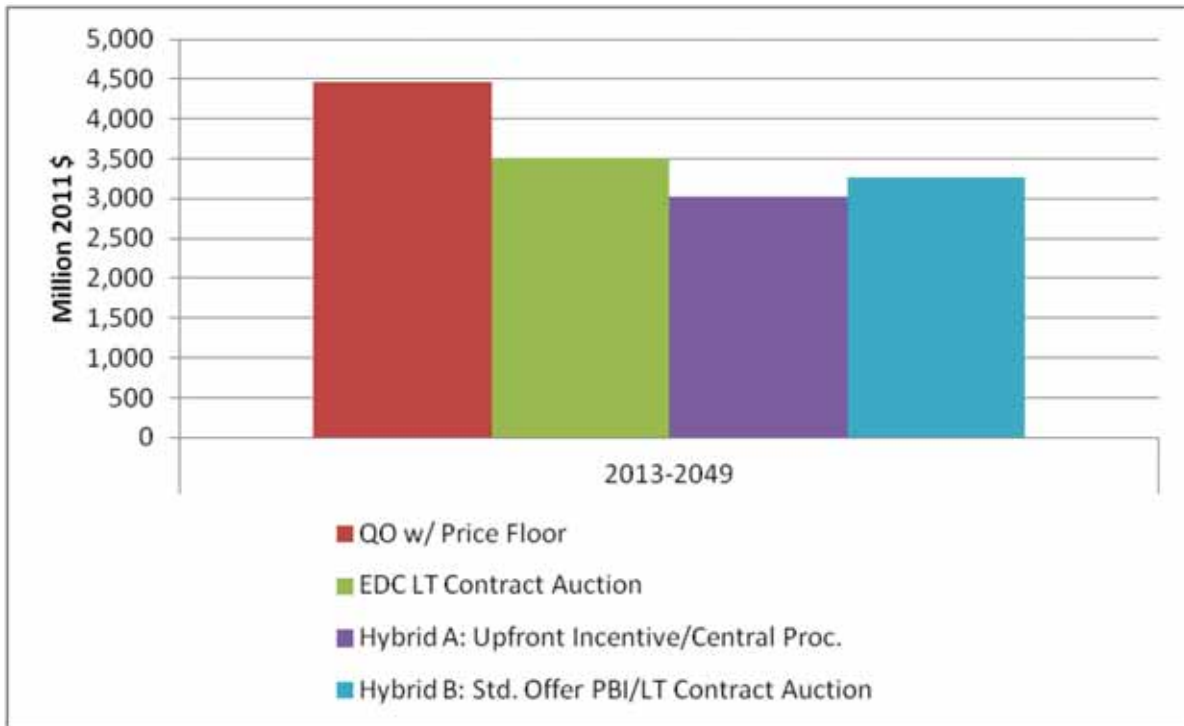

Figure ES-14. Net Ratepayer Impacts of Policy Options

A second important driver for the quantitative differences between the policies is the fact that Hybrid A uses rebates for a significant proportion of the policy. As can be seen in Figure ES-15 below, the use of rebates causes a higher initial ratepayer impact than the other policies. In 2013, for example, Hybrid A would account for 0.5% of total electricity bills, whereas the other three policy mechanisms would account for under 0.2%. By the time the last rebates are paid in 2025, however, the share of Hybrid A in state electricity bills drops off rapidly, as only the payments needed to cover the long-term contracts remain. Although their initial cost is lower, the other three policies would each account for a greater share of electricity bills in 2025. The ratepayer impact calculation includes consideration of both the cost of net metering to ratepayers that do not participate in the program as well as the electricity price reduction effect of PV. From 2016-2018, the electricity price reduction effect actually creates ratepayer savings, rather than ratepayer costs. This impact is temporary, however, and cannot fully offset the costs of PV deployment.
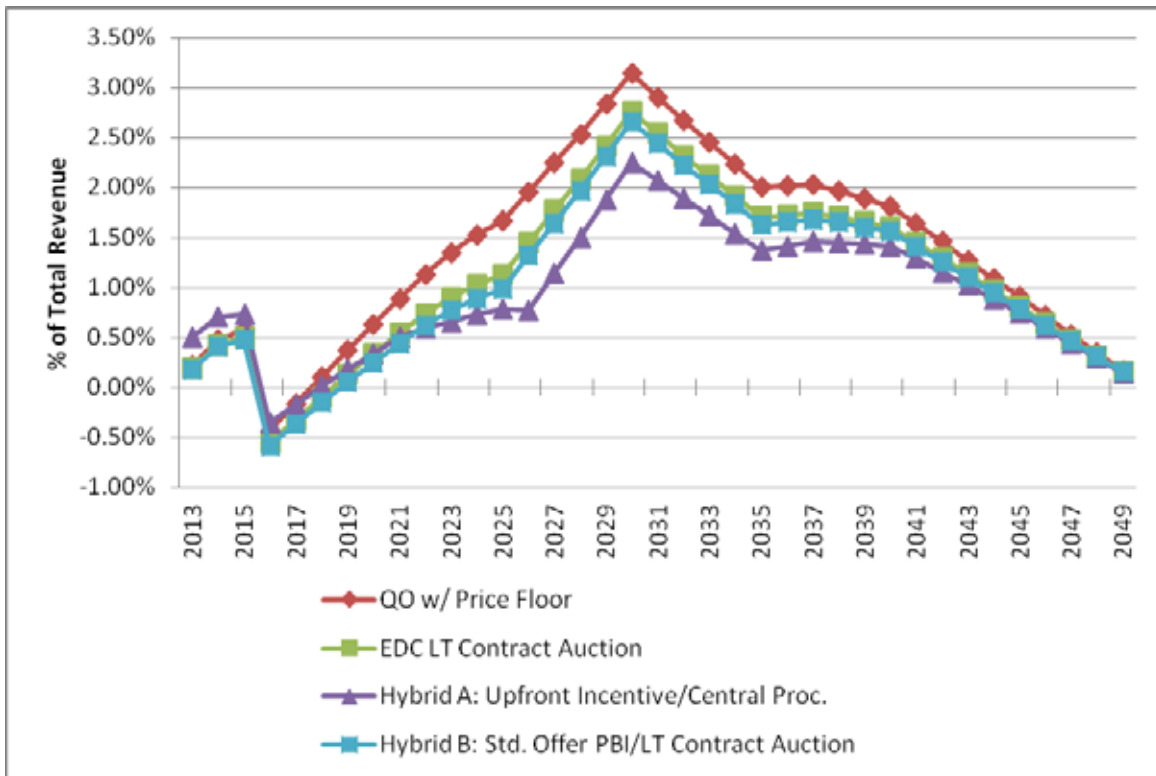
Figure ES-15. Net Annual Ratepayer Impacts of Policy Options as a Percent of Total Revenue

10. CONCLUSIONS

The Solar Study analyzed a broad range of benefits and costs in order to assess the impact of meeting a 5000 MW by 2025 Goal. The Solar Study also described strengths and limitations associated with policy mechanisms that could be used to reach such a target and provided recommendations should any mechanism be pursued. The following summarizes the key findings of the Solar Study:

- PV Deployment Scenario

  o The pace of annual PV capacity additions drives the timing and magnitude of annual rate impacts, employment impacts, costs, and benefits. As such, the pace of PV development is a central component of any PV policy design. Policymakers should therefore consider the actual cost of annual development in establishing policy targets, so as to craft a flexible and responsive policy.

- New York in the Global PV Market

  o The global PV market has recently seen dramatic declines in PV panel prices.

- These declines have benefited New York, with installed costs dropping significantly in the past three years.

- The existing global supply chain could adequately meet the needs of New York's market as it grows towards a 5,000 MW target.

- NYS Renewable Energy Policy Context

  - New York has aggressive renewable energy goals and robust policies that support those goals.

  - Current New York policies support a range of renewable technologies including several high-cost early-stage generation sources, like PV, that have the potential to reach significant market penetration as costs decline.

  - New York has taken a holistic approach to development of a robust renewable energy market, including PV, through workforce development as well as technology and business development initiatives.

  - Existing PV programs in New York have stimulated a stable and growing market, but this market is small in relation to other East Coast markets.

- PV Cost Projections

  - By 2025, the cost of PV is expected to decline significantly, where the Base Case installed cost will range from $2.50 per W for MW-scale systems to $3.10 per W for the residential-scale system, in nominal dollars. For the Low Cost Case, the range is $1.40 per W to $2.00 per W and for the High Cost Case the range is $2.90 per W to $4.30 per W.

  - PV is not expected to achieve wholesale parity during the analysis period (2013 thru 2049) in any cost future.

  - Retail parity may be achieved, and will occur sooner in New York City than in other regions of the state. This suggests a greater leverage of state PV incentive dollars in New York City. In a low-cost future there is parity in New York City by 2017.

  - PV cost of energy is expected to be more expensive than large-scale onshore wind energy and will most likely be more expensive than offshore wind in 2025.

  - PV cost of energy may be competitive with small-scale wind energy and greenfield biomass technologies by 2025.

  - Due to the differences between what is measured by cost of electricity and by the value of the energy produced, it is recommended that a full study of the costs and benefits of other renewable energy technologies be conducted to better inform renewable energy policy development.

  - Continued federal incentives will play a critical role in the magnitude and predictability of future PV prices. In addition, the SunShot goal articulated by the U.S. DOE is an aggressive and meritorious goal

that, if achieved, would substantially reduce PV cost and change the benefit-cost equation. It is recommended that New York should strongly support continued federal incentives and aggressive federal research efforts to reduce the cost of PV to consumers.

- Benefit-Cost Analysis

  o Future cost of PV and the federal incentive level were the primary drivers of total cost of reaching the Goal, while the location of installations and system sizes were secondary cost drivers.

  o Price suppression and avoided electricity production costs were the greatest drivers of benefits, while other factors, including reduction in air pollution, reduction in the use of fossil fuels, avoided distribution system upgrades, and avoided line losses showed smaller benefits.

  o Under the Base Case scenario, reaching the 5,000 MW Goal had a net cost for New York of $2 billion.

  o Under the Low Cost Case scenario, reaching the 5,000 MW Goal had a net benefit for New York of $2 billion.

  o Under the High Cost Case scenario, reaching the 5,000 MW Goal had a net cost for New York of $8 billion.

  o Increased deployment of PV downstate had a higher benefit-cost ratio, lowering the overall costs of meeting the Goal by nearly $1 billion, as electricity costs are higher in the New York City region.

- Jobs and Macroeconomic Impact

  o Analysis conducted looked at the overall impacts to the New York job market, taking into consideration the jobs gained in the solar industry and elsewhere, as well as the potential job loss due to the costs imposed on the economy by the Goal.

  o In terms of the total impact of the Base Case PV deployment on the economy, there will be no economy-wide net job gain; in fact, modeling showed an economy-wide net job loss of 750 jobs because of the impact of increased electricity rates needed to pay for the PV program. Gross State Product (GSP) would be reduced by $3 billion between 2013 and 2049, representing a small annual decrease in GSP of less than 0.1%.

  o Deployment to a level of 5,000 MW will create approximately 2,300 direct PV jobs associated with PV installation for the installation period (2013–2025) and an average of approximately 240 direct jobs associated with Operations and Maintenance (O&M) from 2025–2049.

  o There will also be 600 jobs lost for the study period primarily as a result of the reduced need to expand and upgrade the distribution grid, a reduced need for conventional power plants, and reductions in in-state biomass fuel production.

  o The sensitivity analysis demonstrates that a Low Cost Case future would lead to economic growth, including the creation of 700 economy-wide net jobs and an additional $3 billion in GSP, while a High Cost Case future would lead to a reduction in GSP of $9 billion and on the order of 2,500 economy-wide net job losses.

- o Subsidies at the scale required to achieve 5000 MW of PV by 2025 would most likely have a small net-negative impact on the economy; however, continued support for PV is warranted given the promise of a low-cost PV future.

- Retail Rate Impacts

  - o The net impact of the PV deployment on electricity bills takes into account the above-market costs of PV, the costs of net metering, and the savings generated by the suppression of wholesale electricity prices.

  - o The net impact of these factors on retail electricity rates is $3 billion over the study period, or approximately 1% of total electricity bills. In any given year, this rate impact could be as much as 3% of total electricity bills.

  - o Analyses of Low Cost and High Cost scenarios were also conducted. The impact of the Low Cost scenario is approximately $300 million in additional ratepayer impacts or 0.1% of total bills (annually a maximum of 1%), whereas the impact under the High Cost scenario would be $9 billion or 2.4% of total bills (annually a maximum of 5%).

  - o An analysis was also conducted to determine the effect of higher natural gas prices on PV deployment. Higher natural gas prices would reduce the above-market cost of PV and lower the retail rate impact to 0.6% of total electricity bills (annually a maximum of 2%) instead of 1%.

  - o Since retail rates are higher in Southeast New York, PV is closest to grid parity downstate. Concentrating smaller-scale PV installations downstate would result in lower overall retail rate impacts.

- Environmental Impacts

  - o Over the study period (2013–2049) PV will reduce fossil fuel consumption by 1,100 trillion Btus (TBtus). This includes a 7% reduction in the use of natural gas, a 4% reduction in the use of coal, and a 40% reduction in the use of oil in the electricity sector in 2025.

  - o This reduction will lower carbon dioxide (CO_2) emissions by 47 million tons, equivalent to taking an average of approximately 250,000 cars off the road for each year of the study period. The CO_2 emissions reduction is valued at $450 million for the Base Case.

  - o A high valuation for CO_2 emission reduction values the 47 million tons at $3.2 billion and has a significant enough benefit to make the Base Case net-beneficial to New York.

  - o The amount of CO_2 reduction remains small compared to the total reduction that was identified for the power generation sector in the New York State Climate Action Plan Interim Report. In 2025, PV will reduce emissions by 1.7 million metric tons, or 5% of the emissions from the electric generation sector in that year.

- o The reduction in fossil fuel use will lower nitrogen oxides (NO_x) by 33,000 tons, sulfur dioxide (SO_2) by 67,000 tons and mercury by 120 pounds. The net present value of this combined reduction is $130 million over the study period. This valuation is based on health benefits only, and does not attempt to monetize ecosystem benefits (such as reduction in acidification of lakes, streams and forests, and eutrophication of estuaries and coastal waters).

  - o In 2025, PV will reduce total NO_x emissions by 4%, total SO_2 emissions by 17%, and total mercury emissions by 6%.

  - o PV could also require land for site systems. It is estimated that 5,000 MW of PV would require 23,000 acres of land if the entire amount were ground-mounted. Still, there is a significant amount of roof space available, as well as areas such as brownfield sites, existing power plant sites, and parking lots where PV could be deployed without using land that could have other productive uses. In total, it is estimated that PV would require from 2,600–6,000 acres of greenfield space total, which is less than 0.02% of total state land area.

- PV Policies

  - o A comprehensive approach to PV deployment will likely include cash incentives as well as low-cost or no-cost complementary regulations such as streamlined permitting, interconnection standards, and building construction mandates that can reduce the installed cost of PV and drive demand.

  - o There is a range of policy incentive mechanisms that can be used for PV deployment, such as upfront payments, standard offer performance-based incentives, and quantity obligations. Although each of these mechanisms has different characteristics, the salient differences between policy types can be reduced through policy design. Even so, there are fundamental differences in terms of overall policy cost, investor security, and implementation.

  - o Renewable Energy Credits (RECs) are a policy tool that can be combined with most other policy mechanisms. RECs that are traded on spot markets and are not supported by long-term contracts or price floors, however, are challenging to finance and increase the investor risk, and therefore, the cost, of quantity obligations.

  - o The longer the term for a PV incentive, the lower the $/kWh payment needs to be. Therefore, longer-term payments create the opportunity for PV to reach parity faster.

  - o Incentive rates can be set administratively or through competitive processes. Competitive processes are consistent with New York's competitive electricity market, although they may create barriers to entry for smaller and less sophisticated market participants. Competitive processes can be used for larger projects, whereas administratively determined incentives can be used to target smaller projects.

- Modeling of Policy Mechanisms

  o The difference in ratepayer impact among the three least expensive policy mechanisms is less than 17%, which is potentially smaller than the impact of specific design choices including targeting deployment to specific installation types and locations.

  o An upfront payment incentive for smaller customers (and central procurement for larger customers) similar to the policy approach used in New York for the RPS is the least expensive mechanism analyzed as part of the Solar Study.

  o A quantity obligation with price floor (similar to the policies in neighboring states) is projected to cost 50% more than the least cost policy mechanism.

  o Many complementary policies could be implemented at low or no overall cost in parallel with the analyzed incentive polices, on either a local or state-wide basis, potentially reducing the cost of and removing barriers to reaching the targets, and should therefore be considered as New York refines its solar policies.

  o Costs to compete for and potentially negotiate a contract could be prohibitive for smaller-scale generators.

  o The choice of policy mechanisms that reduce investor risk and administrative and transaction costs will have lower peak and average direct and net impacts on ratepayers.

New York Solar Study:
Executive Summary

January 2012

State of New York
Andrew M. Cuomo, Governor

New York State Energy Research and Development Authority
Francis J. Murray, Jr., President and CEO