Maine Public Utilities Commission

Maine Distributed Solar Valuation Study

Revised April 14, 2015

Maine Public Utilities Commission

Mark A. Vannoy, Chairman

David P. Littell, Commissioner

Carlisle J.T. McLean, Commissioner

Project Staff

Mitchell M. Tannenbaum, Acting General Counsel

Dr. Jason N. Rauch, Utility Analyst

Stuart G. O'Brien, Staff Attorney

Prepared by

Benjamin L. Norris and Philip M. Gruenhagen
Clean Power Research, LLC

Robert C. Grace and Po-Yu Yuen
Sustainable Energy Advantage, LLC

Dr. Richard Perez

Karl R. Rábago
Pace Law School Energy and Climate Center

Note on Edition

This edition is an updated and revised version of the March 1, 2015 report delivered to the Maine Legislature and incorporates changes and clarifications further described in the March 25, 2015 addendum.

Legal Notice from Clean Power Research

This report was prepared for the Maine Public Utilities Commission by Clean Power Research. This report should not be construed as an invitation or inducement to any party to engage or otherwise participate in any transaction, to provide any financing, or to make any investment.

Any information shared with Maine Public Utilities Commission prior to the release of the report is superseded by the Report. Clean Power Research owes no duty of care to any third party and none is created by this report. Use of this report, or any information contained therein, by a third party shall be at the risk of such party and constitutes a waiver and release of Clean Power Research, its directors, officers, partners, employees and agents by such third party from and against all claims and liability, including, but not limited to, claims for breach of contract, breach of warranty, strict liability, negligence, negligent misrepresentation, and/or otherwise, and liability for special, incidental, indirect, or consequential damages, in connection with such use.

Table of Contents

Maine Distributed Solar Valuation Study

Executive Summary

Background

During its 2014 session, the Maine Legislature enacted an Act to Support Solar Energy Development in Maine. P.L Chapter 562 (April 24, 2014) (codified at 35-A M.R.S. §§ 3471-3473) ("Act"). Section 1 of the Act contains the Legislative finding that it is in the public interest is to develop renewable energy resources, including solar energy, in a manner that protects and improves the health and well-being of the citizens and natural environment of the State while also providing economic benefits to communities, ratepayers and the overall economy of the State.

Section 2 of the Act requires the Public Utilities Commission (Commission) to determine the value of distributed solar energy generation in the State, evaluate implementation options, and to deliver a report to the Legislature. To support this work, the Commission engaged a project team comprising Clean Power Research (Napa, California), Sustainable Energy Advantage (Framingham, Massachusetts), Pace Energy and Climate Center at the Pace Law School (White Plains, New York), and Dr. Richard Perez (Albany, New York).

Under the project, the team developed the methodology under a Commission-run stakeholder review process, conducted a valuation on distributed solar for three utility territories, and developed a summary of implementation options for increasing deployment of distributed solar generation in the State.

The report includes three volumes which accompany this Executive Summary:

Volume I	Methodology
Volume II	Valuation Results
Volume III	Implementation Options

Volume I – Methodology

The methodology developed in Volume I was designed to quantify the benefits and costs of the gross energy produced by a photovoltaic (PV) system, as if it were delivered to the grid through its own meter, i.e., prior to serving any local load. Variants of this methodology could be used to determine the value of energy exported to the grid after netting local load (or even generation technologies other than solar), but these would require the development of generation/load profiles that are not included in this methodology.

Guided by the Act and a stakeholder-driven process, the methodology provides for the calculation of the costs and benefits of distributed solar generation for each of the selected components shown in Table ES- 1. The basis for the cost calculations is also shown.

Table ES- 1. Benefit/Cost Bases

Component	Benefit/Cost Basis
Avoided Energy Cost	Hourly avoided wholesale market procurements, based on ISO New England day ahead locational marginal prices for the Maine Load Zone.
Avoided Generation Capacity and Reserve Capacity Costs	ISO New England Forward Capacity Market (FCM) auction clearing prices, followed by forecasted capacity prices by the ISO's consultant. For reserves, the ISO's reserve planning margin is applied.
Avoided NG Pipeline Costs	Not included, but left as a future placeholder if the cost of building future pipeline capacity is built into electricity prices.
Solar Integration Costs	Operating reserves required to handle fluctuations in solar output, based on the New England Wind Integration Study (NEWIS) results.
Avoided Transmission Capacity Cost	ISO New England Regional Network Service (RNS) cost reductions caused by coincident solar peak load reduction.
Avoided Distribution Capacity Cost	Not included, but left as a future placeholder if the peak distribution loads begin to grow (requiring new capacity).
Voltage Regulation	Not included, but left as a future placeholder if

	new interconnections standards come into existence allowing inverters to control voltage and provide voltage ride-through to support the grid.
Net Social Cost of Carbon, SO2, and NOx	EPA estimates of social costs, reduced by compliance costs embedded in wholesale electricity prices.
Market Price Response	The temporary reduction in electricity and capacity prices resulting from reduced demand, based on the Avoided Energy Supply Costs in New England (AESC) study.
Avoided Fuel Price Uncertainty	The cost to eliminate long term price uncertainty in natural gas fuel displaced by solar.

Volume II - Valuation Results

First Year Value

Figure ES- 1 presents the overall value results from Volume II for the Central Maine Power (CMP) Base Case in the first year using the stakeholder reviewed methodology of Volume I. Avoided market costs—including Energy Supply, Transmission Delivery, and Distribution Delivery—are $0.09 per kWh. Additional societal benefits are estimated to be $0.092 per kWh. Avoided NG Pipeline Cost, Avoided Distribution Capacity Cost, and Voltage Regulation are included as placeholders for future evaluations should conditions change that would warrant inclusion.

Avoided market costs represent the benefits and costs associated with capital and operating expenses normally recovered from ratepayers, such as wholesale energy purchases and capacity. Societal benefits are those which accrue to society but are not typically included in setting rates. For example, the social cost of carbon is based on an estimate of costs that will be incurred to mitigate future impacts of carbon emissions, but those costs are not collected from Maine electric customers.

Figure ES- 1. CMP Distributed Value – First Year ($ per kWh)

First Year		Distributed Value ($/kWh)	
Energy Supply	Avoided Energy Cost	$0.061	Avoided Market Costs $0.090
	Avoided Gen. Capacity Cost	$0.015	
	Avoided Res. Gen. Capacity Cost	$0.002	
	Avoided NG Pipeline Cost		
	Solar Integration Cost	-$0.002	
Transmission Delivery	Avoided Trans. Capacity Cost	$0.014	
Distribution Delivery	Avoided Dist. Capacity Cost		
	Voltage Regulation		
Environmental	Net Social Cost of Carbon	$0.021	Societal Benefits $0.092
	Net Social Cost of SO_2	$0.051	
	Net Social Cost of NO_x	$0.011	
Other	Market Price Response	$0.009	
	Avoided Fuel Price Uncertainty	$0.000	
		$0.182	

Environmental Results

The above results indicate a very high environmental value relative to other solar valuation studies. In particular, the Net Social Cost of SO2 is 28% of the total value (market plus societal benefits). The study methodology was based on a three year historical calculation of marginal emissions rates. However, emissions of SO2 and NOx rates are expected to decline in the coming years. If the fuel type were assumed to be only oil and natural gas (FTA marginal emissions rates as described in the Displaced Pollutants section), the displaced emissions and the net social costs shown above would be reduced to 8% and 20% of the values calculated here for SO2 and NOx, respectively.

Long Term Value

Figure ES- 2 provides additional details in the benefit and cost calculations, including load match factors and loss savings factors, and the costs and benefits are shown as 25 year levelized values. The selection 25 years is based on the assumed useful service life of a typical solar PV system.

It is important to note that Figure ES-2 does not identify who the benefits and costs accrue to. For example, avoided energy cost is calculated based on avoided wholesale energy purchases, but this value may involve a series of transactions between the solar customer, the distribution utility, and the energy market participants.

The value shown in Table ES-2 represents a longer term projection of the levelized value of a solar PV system over a 25 year horizon. It is meant to be illustrative and not as a standalone value apart from First Year Value descriptions.

The societal benefits, such as the net Social Cost of SO_2, are external to what present market mechanics monetize; as such they do not monetarily accrue to any market participants (distribution utility, transmission provider, third party generators, etc.). It is left as a policy decision to determine whether these values are relevant and whether to include them in tariff design, incentives, and other structures.

Figure ES- 2. CMP Distributed Value – 25 Year Levelized ($ per kWh)

25 Year Levelized		Gross Value A ($/kWh)	×	Load Match Factor B (%)	×	Loss Savings Factor (1+C) (%)	=	Distr. PV Value D ($/kWh)	
Energy Supply	Avoided Energy Cost	$0.076				6.2%		$0.081	Avoided Market Costs $0.138
	Avoided Gen. Capacity Cost	$0.068		54.4%		9.3%		$0.040	
	Avoided Res. Gen. Capacity Cost	$0.009		54.4%		9.3%		$0.005	
	Avoided NG Pipeline Cost								
	Solar Integration Cost	($0.005)				6.2%		($0.005)	
Transmission Delivery Service	Avoided Trans. Capacity Cost	$0.063		23.9%		9.3%		$0.016	
Distribution Delivery Service	Avoided Dist. Capacity Cost								
	Voltage Regulation								
Environmental	Net Social Cost of Carbon	$0.020				6.2%		$0.021	Societal Benefits $0.199
	Net Social Cost of SO_2	$0.058				6.2%		$0.062	
	Net Social Cost of NO_x	$0.012				6.2%		$0.013	
Other	Market Price Response	$0.062				6.2%		$0.066	
	Avoided Fuel Price Uncertainty	$0.035				6.2%		$0.037	
								$0.337	

Gross Values represent the value of perfectly dispatchable, centralized resources. These are adjusted using

- Load Match Factors to account for the non-dispatchability of solar; and
- Loss Savings Factors to account for the benefit of avoiding energy losses in the transmission and distribution systems.

The load match factor for generation capacity (54%) is based on the output of solar during the top 100 load hours per year. The load match factor for Avoided Transmission Capacity Cost (23.9%) is derived from average monthly reductions in peak transmission demand.

The Distributed PV value is calculated for each benefit and cost category, and these are summed. The result is the 25-year levelized value, meaning the equivalent constant value that could be applied over

25 years that would be equivalent to the combined benefits of avoided market costs and societal benefits.

First Year results for all three utility service territories, including Emera Maine's Bangor Hydro District (BHD) and Maine Public District (MPD), are shown in Figure ES- 3. The results are the same for the first year results except for the avoided transmission cost component which reflects hourly load profiles. RNS rates do not apply to MPD so there is no avoided transmission cost included. Avoided energy is the same because the solar profile was assumed to be the same state-wide, and the LMPs are taken for the Maine zone. Avoided generation capacity costs are based on the same solar profiles and the same ISO-NE loads, so there are no differences in this category. There are differences in long term value due to differences in utility discount rate (not shown).

Figure ES- 3. Base Case Results for CMP, BHD, and MPD – First Year

First Year		CMP $/kWh	BHD $/kWh	MPD $/kWh
Energy Supply	Avoided Energy Cost	0.061	0.061	0.061
	Avoided Gen. Capacity Cost	0.015	0.015	0.015
	Avoided Res. Gen. Capacity Cost	0.002	0.002	0.002
	Avoided NG Pipeline Cost			
	Solar Integration Cost	(0.002)	(0.002)	(0.002)
Transmission Delivery Service	Avoided Trans. Capacity Cost	0.014	0.017	0.000
Distribution Delivery	Avoided Dist. Capacity Cost			
	Voltage Regulation			
Environmental	Net Social Cost of Carbon	0.021	0.021	0.021
	Net Social Cost of SO_2	0.051	0.051	0.051
	Net Social Cost of NO_x	0.011	0.011	0.011
Other	Market Price Response	0.009	0.009	0.009
	Avoided Fuel Price Uncertainty	0.000	0.000	0.000
		0.182	0.184	0.168

Volume III - Implementation Options

Objective

The Act sought information on options for distributed solar energy implementation. Volume III of this report provides an analysis of options for increasing investment in or deployment of distributed solar generation, with an emphasis on those options used in ten states with similarities to Maine in market structure (deregulated) and economic opportunity (driven by insolation, land use, electricity prices, etc.). It also provides general guidance to help the Legislature consider which options, approaches or models may be appropriate for Maine, considering the State's utility market structures.

Solar Implementation Options

Volume III includes a thorough list of solar implementation options in widespread use. The range of implementation options are organized into four major categories:

- **Instruments Used to Incentivize Solar -** Incentives commonly used as vehicles to incentivize distributed solar PV include a suite of implementation options aimed at changing market or economic decision making by (i) creating market demand, (ii) removing financing barriers, and/or (iii) lowering installation costs for solar PV.
- **Financing Enabling Policies -** Financing enabling policies enhance the accessibility of financing, lower financing transactions costs, open up access to lower-cost forms of financing, and otherwise lower the entry barrier to solar investment and enable a broader range of players to participate in the solar market.
- **Rules, Regulations and Rate Design –** Rules, regulations and rate design at all levels of government ensure legal access to the solar market, regulate the economics of solar PV and provide technical support to solar PV deployment.
- **Industry Support -** Industry support approaches are often paired with other implementation strategies to accelerate solar deployment. By incentivizing in-state solar investment, many industry support approaches are also designed to stimulate local job creation and foster state economic growth.

Table ES- 2Table ES- 5 provide an overview of implementation options. Options in shaded rows are commonly-used implementation options but of less potential interest for legislative consideration, and are only discussed briefly in Section 0 of Volume III. The other implementation options are more fully characterized and evaluated. Where applicable, Volume III highlights implementation examples in the five New England States (Connecticut, Massachusetts New Hampshire, Rhode Island and Vermont), New York, and four states (Delaware, Maryland, New Jersey, and Pennsylvania) within the PJM territory. The authors underscore important observations from implementation experiences in these states, as well as notable variations. Volume III also includes a summary of the identified solar implementation options that have been adopted in each state.

Table ES- 2. Summary of Solar Implementation Option: “Instruments Used to Incentivize Solar”

Subcategory	Implementation Examples	Description
Direct Financial, Up-front Incentives	Grants, Rebates, or Buy-Downs	Capacity-denominated (i.e., $/kW) incentives designed to reduce up-front cost of PV installations; typically targeted to small- and medium-scale customers
Direct Financial, Performance-Based Incentives (PBIs)	Feed-In-Tariffs, Standard Offer PBI Contracts or Tariffs, or PBIs	Pre-determined, fixed energy-denominated (i.e., $/kWh) incentives for solar energy production designed to provide predictable revenue stream; typically targeted to small- and medium-scale customers
	Competitive Long-Term PPAs	Long-term (10 – 25 years) PPAs for RECs, energy and/or capacity solicited through a competitive process; typically targeted to larger, more sophisticated players
	Long-Term Value of Solar Tariffs	Mechanism crediting solar generation at a rate determined by a value of solar analysis
	Technology-Specific “Avoided Costs”	Incentive rates set at the avoided-costs of a technology
Indirect Financial Incentives	Emissions Markets	Market-based emission cap-and-trade programs; usually regional scale
Expenditure-Based Tax Incentives	Investment Tax Credits	Capacity-denominated tax incentives (i.e., $/kW); Federal ITC is the most common form
Production Tax Incentives	Production Tax Credits	Electricity-production-based tax incentives (i.e., $/kWh)
Demand-Pull/Solar Minimum Purchase Mandates	Renewable Portfolio Standards (RPS)	Mandate requiring certain % of electric utilities’ annual retail sales be met with renewable generation
	Solar Set-Asides in RPS (SREC Market)	Mandate creating a separate tier or requiring certain portion of RPS to be met with solar
Net Metering	Net Metering Crediting Mechanism	Mechanism used for utilities to credit customers for excess on-site generation
	Virtual NM Crediting Mechanism	Subset of net metering that enables the aggregation of net metering accounts/facilities
	Community-Shared Solar	Subset of virtual net metering allowing multiple customers to share ownership interest in a single remote net metered facility

Table ES- 3. Summary of Solar Implementation Option: "Finance Enabling Policies"

Implementation Examples	Description
Solar Loan Programs	A broad spectrum of loan products supported by private sector financing or utilities
On-Bill Financing	Long-term, low interest loans where repayments are made through utility bills
PACE Financing	Long-term, low interest loans where payments are made through property taxes and are tied to hosting sites instead of system owners
Green Bank – Institutions and Suite of Other Programs	State-chartered institution offering a suite of programs and financing products; leverages and recycles public funding to stimulate growth of private financing markets for solar
Utility Ownership	Policies enabling T&D utilities to own generation assets in deregulated markets
Solar Lease and/or Third-Party Ownership Enabling Policies or Eligibility in Other Policies	Policies allowing a private developer to (i) install and own a PV system hosted by a property owner, then selling the power to the property owner through PPA; or (ii) lease PV panels to customers

Table ES- 4. Summary of Solar Implementation Option: "Rules, Regulations and Rate Design"

Subcategory	Implementation Examples	Description
Removing Institutional Barriers	Interconnection Standards	Regulations standardizing the requirements of integrating solar PV to the grid
	Solar Access Laws	Rules protecting customers' access to sunlight and solar development rights
	Business Formation/Financing Laws	Policies authorizing certain types of business models or market structures designed to lower the entry barrier and expand access to the solar market
	Permitting Simplification, Other "Soft-Cost Reduction" Strategies	A suite of strategies designed to reduce the non-equipment costs associated with various stages of solar PV development
Building Codes	Solar-Ready Building Standards, Zero-	Various building standards that (i) regulate orientation, shading, and other siting- and

	Energy Capable Home Standards	construction-related criteria; or (ii) support "plug-and-play" PV system configurations
Tax	Property Tax Exemption or Special Rate	Property tax relief to property owners installing solar PV
	Sales Tax Exemption	Tax relief exempting system owners from paying sales taxes for PV system equipment
	Property Tax/Payment in lieu of taxes (PILOT) Standardization or Simplification	State policies designed to limit community-by-community variations in property tax and PILOT rules; designed primarily to remove uncertainty
Grid Modernization	Policies Enabling Microgrids, Smart-Grid and Other DG-Friendly Grid Architecture	Policies designed to promote installations of DG-friendly technologies and grid architecture; aim to ease interconnection and advance implementation of solar PV
Rate Design	Time-Varying Rates, Rate Design, Fixed Charges and Minimum Bills	Cost-based utility rate design or rate structures designed to provide a correct or supportive price signal for the installation and operation of solar generation facilities

Table ES- 5. Summary of Solar Implementation Option: "Industry Support"

Implementation Examples	Description
Incentives for Companies, Technology Development, or Economic Development	Funding mechanisms designed to provide incentives for in-state solar businesses; allocated from the state budget, RPS alternative compliance payments, RGGI proceeds and/or public good funds
Local Content Bonus Or Mandate	Incentives or requirements that give preference to projects supporting in-state investment
Customer Acquisition Cost Reduction	Strategies leveraging scale economies or other measures to increase solar participation at a lower cost
Outreach/Education/Public Information/Voluntary Market Encouragement	Strategies designed to increase customer awareness of solar technology, voluntary and compliance solar markets, and solar funding and financing options
Public Sector Leadership and Demonstration	State or local initiatives, such as demo projects on public properties or statewide PV goals
Creation of Public Good Funds to Support Solar Programs/Policies	Policies establishing funds collected from ratepayers through utility bill surcharges; designed to provide long-term funding for solar incentive programs
Installer/Inspector Training and Certification	Training and certification programs designed to build a qualified local solar workforce

Solar Implementation in Maine

Section 2 of Volume III summarizes the current suite of implementation mechanisms applicable to solar PV in Maine. Maine's solar implementation mechanisms include a range of approaches that are broadly applicable to various renewable resources and not specific to solar. Implementation mechanisms currently used to support renewable energy implementation in Maine include net metering, shared ownership net metering, Renewable Portfolio Standard, community-based renewable incentives, long-term contracts, time-of-use rates, and interconnection standards.

Solar Implementation in Other States: Key Themes and Lessons Learned

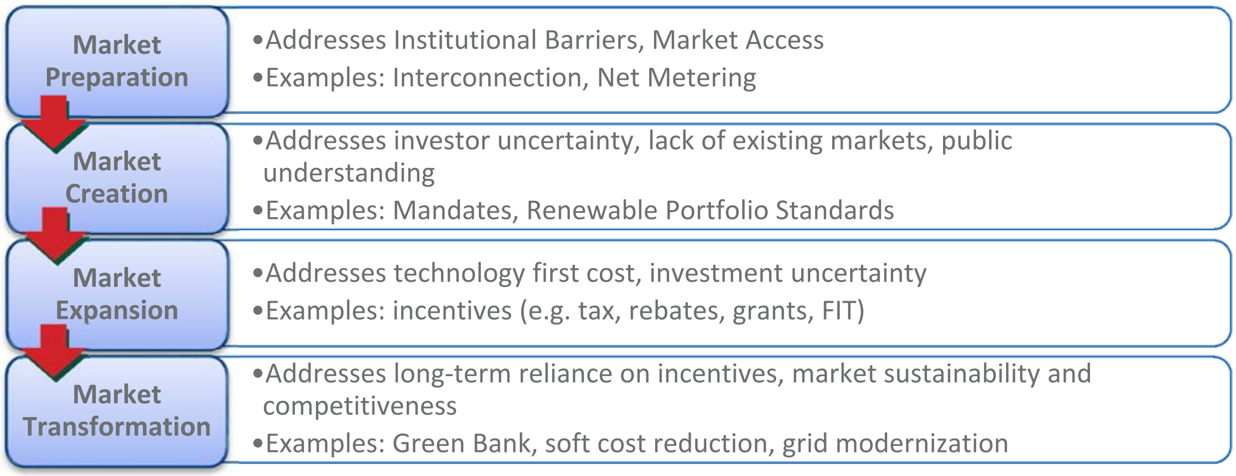
Section 3 of Volume III identifies and describes solar implementation options used in other states, with particular emphasis on the ten northeastern states identified above. The other states studied in Volume III have established a variety ofsolar-specific implementation options specifically targeted to grow solar penetration. Based on our analysis and evaluation of solar implementation experiences in these states, we identify four key themes or lessons learned from these other states that may be considered appropriate within Maine's context.

- A comprehensive strategy to support solar PV has proven effective at increasing solar PV penetration. In all ten states studied here, state policymakers implemented a combination of implementation options simultaneously to maximize the support available for, and reduce barriers to, diverse solar deployment. The Legislature may wish to consider combining various policies, programs, rules, regulations, incentives and industry support strategies to achieve multiple implementation objectives (e.g., develop scale economies, reduce costs, reduce risk and create an attractive investment climate, etc.).

- Low- or no-cost implementation options - options to enhance distributed solar adoption with minimal financial outlay relative to direct incentive programs - are available, and may be considered either alongside direct incentives, prior to adoption of incentives, or when there is limited appetite for costlier measures. Certain financing enabling policies and changes to rules and regulations such as revising building codes and implementing targeted tax measures; along with other industry support initiatives can be implemented in various market stages with minimal cost. Specific options are discussed in more detail in Section 4.3.2 in Volume III.

- Sequencing implementation options in a particular order enhances the cost-effectiveness of solar deployment. Figure 1 shows a path of implementation ordering commonly adopted by other states.

Figure 1 – Sequencing Solar Implementation



- Adopting synergetic implementation options can advance support for increased solar penetration, while over-stimulation and duplicative implementation objectives may impede or disrupt healthy market growth.

Other Considerations for Solar PV Implementation

In addition to the key themes and lessons learned, the authors identify a list of considerations that the Legislature may wish to take into account when developing a comprehensive implementation approach:

- Implementation options selected (if any) should align as best possible with the Legislature’s definition of priorities and objectives. Table 7 in Volume III identifies a list of objectives organized under 6 implementation priorities: market growth, equity, feasibility, compatibility with Maine’s energy market, economic and environmental goals that the Legislature may wish to consider. Because policy objectives like those delineated in Table 7 can conflict - specific implementation options can maximize one objective while working counter to another - it is important that the legislature understand the tradeoffs among these options.

- The Legislature may wish to create leverage with polices and initiatives already in place in other states in the region to finance local projects and support solar PV deployment in Maine. For example, the Maine Legislature may choose to adopt implementation options that leverage net metering benefits with RPS demand in other New England states.

- Implementation objectives and options are subject to constraints. Examples of implementation constraints include federal preemption via the supremacy clause of the US constitution, siting feasibility, and grid interconnection constraints.