APPENDIX D

RENEWABLE ENERGY

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OVERVIEW

This Appendix discusses Connecticut's and New England's supply and demand outlook for renewable energy and how those resources may help fulfill the Connecticut renewable portfolio standards ("RPS"). Connecticut's RPS requires electric suppliers to procure increasing shares of their sales from qualifying renewable resources, as demonstrated by the submission to the electric distribution company ("EDC") of Renewable Energy Certificates ("RECs").[1]

This Appendix provides background on renewable requirements in the state and region and the analytical support for the main IRP report. To conduct the analysis, the Department constructed a **"Base Case"** future renewable supply resource scenario. The Department has adjusted its approach from past IRPs in setting the Base Case due to the increasing reliance in New England on long-term contracts for renewable energy resource development and compliance with the increasing RPS requirements. The Base Case includes the renewable capacity that is currently qualified in New England states, imports at their recent historical average, and the incremental capacity that has been contracted by Connecticut and Massachusetts at the time of this report. The Base Case renewable resource assumptions do not represent DEEP's *projection* of how the renewable projects *will* develop in New England over time. Instead, it simply represents a *snapshot* in which only existing resources and incremental renewable resources procured under the state programs are included as future REC supply for the study horizon.

DEEP also developed an alternate renewable energy scenario that assumes **"Additional Class I Renewables"** above the Base Case are added. This additional amount equals five percent of Connecticut's load and is based on future procurements of new renewable resources by DEEP pursuant to Connecticut Public Act ("PA") 13-303. (Additional discussion of the legislation is below.) The additional renewable resources under the "Additional Class I Renewables" case are assumed to be 535 MW of onshore wind and 56 MW of solar, similar to the mix of resources recently procured through PA 13-303 Section 6.

As with evaluating the potential impacts associated with the other resource strategies in the IRP, several important metrics are used to evaluate the effects of the two renewable energy-related scenarios: (1) Connecticut's customer costs, (2) resource costs, (3) Connecticut and regional emissions, and (4) employment and other macroeconomic indicators. DEEP's general conclusions and recommendations regarding how Connecticut can best meet its energy and environmental goals through renewable energy strategies are derived from these metrics.

[1] Connecticut has two EDCs: The Connecticut Light and Power Company ("CL&P") and The United Illuminating Company ("UI"). A small subset of Connecticut's population is served by municipal electric companies, which are not subject to the RPS. Because the vast majority of Connecticut citizens are served by EDCs, it is nevertheless appropriate to review Connecticut's renewable energy needs with a focus on the RPS.

CONNECTICUT'S RENEWABLE ENERGY REGULATIONS

Renewable Portfolio Standard

Connecticut's RPS requires electric suppliers to procure increasing shares of their sales from qualifying renewable resources.[2]

The RPS has a tiered structure with three classes.[3]

- **Class I** resources include electricity derived from solar, wind, fuel cells, methane gas from landfills, biogas such as that from anaerobic digestion, thermal electric direct energy conversion from another Class I source, low emission advanced renewable energy conversion technologies, ocean thermal, wave, tidal, certain run-of-river hydropower (<30MW, began operation after July 1, 2003, not based on a new dam or a dam that is a candidate for removal), and certain biomass facilities (using sustainable biomass fuel with nitrogen oxide (NOx) emission <0.075 lbs/MMBtu of heat input, or <500 kW, began operation after July 1, 2003). In addition distributed generation from a source that would otherwise qualify as Class I can now qualify as Class I renewable energy.

- **Class II** resources include biomass (NOx emission <0.2 lbs/MMBtu of heat input, began operation before July 1, 1998), small run-of-river hydroelectric (<5MW, began operation before July 1, 2003), and trash-to-energy facilities.

- **Class III** resources include customer-sited combined heat and power (with operating efficiency >50%, facilities installed after January 1, 2006), waste heat recovery systems (installed on or after April 1, 2007), and electricity savings from conservation. Beginning in 2014, energy saved through ratepayer-funded efficiency programs is no longer considered to be Class III energy except for the period of a pre-existing demand side contract under Conn. Gen. Stat. § 16-243m.

Figure 1 shows the Class I, II, and III requirements as a percent of Connecticut's retail electricity demand.

[2] The RPS program is defined in Conn. Gen. Stat. Sec. 16-245a

[3] The definitions of the resources that are included in each class are contained in Conn. Gen. Stat. Sec. 16-1, as amended by Public Act 13-303, An Act Concerning Connecticut's Clean Energy Goals ("2013 Act").

Figure 1
Connecticut RPS Requirement

Year	Class I	Class II or Class I (add'l)	Class III	Total
2013	10.0%	3.0%	4.0%	17.0%
2014	11.0%	3.0%	4.0%	18.0%
2015	12.5%	3.0%	4.0%	19.5%
2016	14.0%	3.0%	4.0%	21.0%
2017	15.5%	3.0%	4.0%	22.5%
2018	17.0%	3.0%	4.0%	24.0%
2019	19.5%	3.0%	4.0%	26.5%
2020	20.0%	3.0%	4.0%	27.0%

Source: Conn. Gen. Stat § 16-245a et seq. and Public Act No. 07-242, § 40-44.

While the market for Class I renewable generation is regional in nature, the Connecticut's RPS supply qualifications are somewhat different from those of the other New England states in that some resources that qualify as Class I resource in Connecticut may not qualify as such in other states. Specifically, Connecticut's Class I requirement is more inclusive in the following ways:

- Aside from small hydro and small biomass facilities, the definition of Class I renewable resources in Connecticut does not specify a "vintage" requirement, whereas Class I renewables in other New England states must have entered into service after a certain date to be eligible to meet RPS requirements.[4] As a result, existing resources that were built before 1998, such as some existing landfill gas, wind, and low-emission biomass plants, qualify as Class I resources only in Connecticut.

- Natural-gas powered fuel cells qualify as Class I resources in Connecticut, but do not in other New England states.

- Connecticut allows the generation of Class I RECs by natural gas fired generators that import landfill gas from outside of the state via interstate natural gas pipelines.

In addition, Connecticut's Class I RPS includes a lower Alternative Compliance Payment (ACP) than all other New England states, other than New Hampshire. The ACP effectively acts as a price ceiling on the REC prices by allowing required entities to pay the ACP as a substitute for meeting the required amount of Renewable Energy Credits (RECs). Connecticut's ACP for Class

[4] Massachusetts and Rhode Island's vintage requirement is December 31, 1997. Maine's vintage requirement is September 1, 2015 and New Hampshire's vintage requirement is January 1, 2006.

I and II requirements is fixed at $55/MWh, and for Class III at $31/MWh.[5] The 2015 ACPs for Massachusetts, Rhode Island and Maine are at approximately $67/MWh, escalating annually based on the consumer price index.[6] Due to the difference in ACPs across states, the EDCs or other load-serving entities in the New England states with higher ACPs than Connecticut's would be willing to pay higher REC prices than those serving load in Connecticut. This also means that when the region as a whole is short of Class I resources, REC suppliers tend to prefer to sell to load-serving entities in other New England states before Connecticut (and New Hampshire), leaving less available resources to meet the Connecticut Class I RPS requirements. Given these circumstances, Connecticut has a greater likelihood of a REC shortage than other New England states.

Connecticut's Renewable Energy Procurement Programs

Over the past several years, the Connecticut Legislature has created several programs to encourage the development of renewable energy resources through long-term contracting.

- **Project 150:** Project 150[7] seeks the development of 150 megawatts of installed renewable energy capacity in Connecticut through long-term contracting. Project 150 is currently anticipated to lead to the development of 63 MW of installed capacity with 30 MW of biomass capacity and 33 MW of fuel cell projects. The first projects were in service in December 2013.

- **ZREC/LREC:** The Legislature authorized the EDCs to enter into 15-year contracts for renewable energy credits from "zero-emission" generation projects, known as the "ZREC" program,[8]and "low-emission" generation projects, known as the "LREC" program[9]. The ZREC program allows for $720 million to be spent over six years of procurement and the LREC program allows for $300 million in payments over five years of procurements. In the near term, the ZREC and LREC programs are projected to develop approximately 45 MW of installed renewable resource capacity to be in service in 2014, with 38 MW from solar through the ZREC program and 7 MW from fuel cells through the LREC program. The second round of ZREC/LREC procurements resulted in an additional 66 MW of solar capacity and 13 MW of fuel cells, with average REC prices 23% lower than the previous procurement.

- **Section 127 of PA 11-80:** The Legislature authorized long-term contracting or EDC ownership of up to an aggregate of 30 MW of Class I renewable energy sources in Connecticut, with each EDC authorized for up to 10 MW.[10] It is anticipated that the 30

[5] Conn. Gen. Stat. §§ 16-243q and 16-244c(j)(1). The former DPUC set the Class III ACP level at $31/MWh, below the statutory cap of $55/MWh, in its February 16, 2006 Decision in Docket No. 05-07-19, *DPUC Proceeding to Develop a New Distributed Resources Portfolio Standard (Class III)*, at p. 16, available at http://www.ct.gov/pura/docketsearch.

[6] Massachusetts and Rhode Island's ACPs are $65.27/MWh in 2013.

[7] Conn. Gen. Stat. 16-244c(j)(2).

[8] Conn. Gen. Stat. §§ 16-244r and 16-244s.

[9] Conn. Gen. Stat. § 16-244t.

[10] Conn. Gen. Stat. § 16-244v.

MW will be constructed and be in service in 2015, including 15 MW of solar, 5 MW of wind, and 10 MW of fuel cells.

- **Residential Solar:** The Connecticut Clean Energy Finance and Investment Authority supported the installation of 60 MW of residential rooftop solar facilities[11] and expects to support about 10 MW of solar PV per year going forward.[12]

The projects currently supported through these programs are listed in Figure 2 below. In addition to the above programs, the Legislature increased DEEP's authority to procure additional Class I renewable resources. Below is a description of the authority provided under Public Act 13-303.

11 See CEFIA Market Watch Report for February 6, 2015. Available at: http://www.energizect.com/sites/default/files/uploads/Residential_Solar_Investment_Program_Market_Watch_Report_February_6_2015.pdf.

12 Conn. Gen. Stat. § 16-245m.

Figure 2
Summary of Current Class I Programs in Connecticut[13]

Program	Technology	Capacity (MW)	Plant	Location	Status	Online Date
Project 150						
	Biomass	30	Plainfield Renewable Energy	Plainfield, CT	Operating	Dec-13
	Fuel Cell	15	Bridgeport Fuel Cell Park	Bridgeport, CT	Operating	Dec-13
	Fuel Cell	18	---	CT	Approved	2015
Section 127						
Eversource/UI	Solar	5	East Lyme Solar Park	East Lyme, CT	Operating	2014
Eversource/UI	Solar	5	Somers Solar Center	Somers, CT	Operating	2013
Eversource	Wind	5	Wind Colebrook South	Colebrook, CT	Approved	2015
Eversource	Fuel Cell	5	CTS Energy	South Windsor, CT	Approved	2015
UI	Solar	2.2	Bridgeport Green Energy Park	Bridgeport, CT	Approved	2015
UI	Solar	2.2	---	CT	Approved	2015
UI	Fuel Cell	2.8	Bridgeport Green Energy Park	Bridgeport, CT	Approved	2015
UI	Fuel Cell	2.8	East Shore	New Haven, CT	Approved	2015
ZREC/LREC						
Eversource	Solar (Large)	10	---	CT	Approved	2014
Eversource	Solar (Med)	13.8	---	CT	Approved	2014
Eversource	Solar (Small)	6.5	---	CT	Approved	2014
Eversource	Fuel Cell	5.9	---	CT	Approved	2014
Eversource	*Solar (Large)*	*27.6*	---	*CT*	*Approved*	*2015*
Eversource	*Solar (Med)*	*17.8*	---	*CT*	*Approved*	*2015*
Eversource	*Solar (Small)*	*11.6*	---	*CT*	*Approved*	*2015*
Eversource	*Fuel Cell*	*5.3*	---	*CT*	*Approved*	*2015*
UI	Solar (Large)	2.6	---	CT	Approved	2014
UI	Solar (Med)	2.5	---	CT	Approved	2014
UI	Solar (Small)	2.4	---	CT	Approved	2014
UI	Fuel Cell	1.2	---	CT	Approved	2014
UI	*Solar (Large)*	*2.4*	---	*CT*	*Approved*	*2015*
UI	*Solar (Med)*	*4.4*	---	*CT*	*Approved*	*2015*
UI	*Solar (Small)*	*2.5*	---	*CT*	*Approved*	*2015*
UI	*Fuel Cell*	*8.0*	---	*CT*	*Approved*	*2015*
Section 106						
CEFIA	*Solar*	*55*	---	*CT*	*Operating*	*2015*
Section 103						
CEFIA	*Anaerobic Digester*	*1.6*	*City of Ansonia*	*Ansonia, CT*	*Approved*	
CEFIA	*Anaerobic Digester*	*1.0*	*Southington AD Facility*	*Southington, CT*	*Approved*	
CEFIA	*Anaerobic Digester*	*1.6*	*Bridgeport BioEnergy Facility*	*Bridgeport, CT*	*Approved*	
CEFIA	*Anaerobic Digester*	*1.6*	*Central CT AD Facility*	*Southington, CT*	*Approved*	
Section 6						
	Wind	250	Number Nine Wind Farm	Aroostook County, ME	Approved	2016
	Solar	20	Fusion Solar Center	Lisbon, CT and Sprague, CT	Approved	2016
Section 8						
	Biomass	21.5	Schiller Station Unit 5	Portsmouth, NH	Existing	2016
	Biomass	5	McNeil Station (Burlington Electric)	Burlington, VT	Existing	2015
	Biomass	2.7	McNeil Station (Green Mountain Power)	Burlington, VT	Existing	2015

[13] Capacity added through the 2015 ZREC/LREC program was estimated. The first two solar projects under Section 127 were procured by DEEP with contracts executed by the EDCs. All solar capacities are shown in terms of AC output. Plainfield is a 37.5 MW project, 30 MW of which is under contract.

Public Act 13-303: An Act Concerning Connecticut's Clean Energy Goals

On April 26, 2013, DEEP issued a study entitled "Restructuring Connecticut's Renewable Portfolio Standard," sometimes referred to as the "RPS Study."[14] That study recommended that the Connecticut legislature authorize the Connecticut EDCs to enter into long term contracts with renewable resources. Subsequently, the 2013 Legislative session enacted Public Act 13-303, which authorized the EDCs to enter into long-term contracts with renewable resources providers. The contracted resources in turn would assist Connecticut in meeting a substantial share of its Class I RPS requirement. The legislation also made several adjustments to the Connecticut RPS, based on recommendations in the RPS Study, including changes to class definitions. These adjustments are summarized below:

- **Section 1**: Run-of-the-river hydropower facilities up to 30MW now qualify as a Class I renewable energy source as long as they meet federal and state requirements and are not based on a new dam or a dam identified as a candidate for removal. Also, the law now explicitly precludes double-counting of RECs, stating that energy produced by any Class I resources that are used to meet RPS requirements in another state or province cannot be used in or be applied to Connecticut's RPS compliance.

- **Section 2**: Class III renewable energy has in the past included conservation and load management (C&LM) programs implemented in Connecticut. As of January 1, 2014, energy savings that resulted from utility sponsored conservation programs will no longer be considered a Class III source, except as required by the terms of a pre-existing contract with a demand-side management project pursuant to section 16-243m.

- **Section 3**: Defines "sustainable biomass fuel" as biomass that it is cultivated and harvested in a sustainable manner. Previously, the word "fuel" was not included as part of the defined term. This section also changed some of the conditions for being considered "sustainable."

- **Section 4**: Defines large hydropower as any hydropower facility that (a) began operation on or after January 1, 2003 (b) either is located in the New England or is to the north of New England and delivers power only into ISO-New England and (c) has generating capacity of more than 30 MW.

- **Section 5**: Requires DEEP to establish a schedule to gradually reduce the value of biomass and landfill methane gas RECs, commencing on January 1, 2015.

- **Section 6:** Section 6 allows the Commissioner of DEEP to solicit up to 4% of load served by the EDCs via Class I renewable energy resources. The resulting contracts from the

[14] Restructuring Connecticut's Renewable Portfolio Standard, Connecticut Department of Energy and Environmental Protection, April 26, 2013. Available at http://www.ct.gov/deep/lib/deep/energy/rps/rps_final.pdf.

solicitation were authorized to be as long as 20 years. The Section 6 procurement was initially offered and resulted with a 250 MW wind project in Maine and a 20 MW solar facility in eastern Connecticut were approved for long-term contracts. Each of these projects is new and will use the long-term contracts to secure financing.

- **Section 7:** Section 7 allows the Commissioner of DEEP to solicit up to 5% of load served by the EDCs (or the equivalent amount of RECs) via Class I renewable energy resources or large scale hydropower. The resulting terms of the Class I renewable energy contracts may be up to 20 years, or 15 years for large scale hydropower. This procurement has been initiated.

- **Section 8:** Section 8 allows the Commissioner of DEEP to solicit up to 4% of load served by the EDCs (or the equivalent amount of RECs) via Class I run-of-river hydropower, landfill methane gas or biomass facilities. The Section 8 procurement resulted in three contracts for RECs from existing biomass facilities, including 21.5 MW of Schiller Unit 5 in New Hampshire for 10 years, 5.4 MW of McNeil Generating Station in Vermont for 5 years, and an additional 2.7 MW of McNeil for 10 years.

- **Section 9:** Section 9 would allow DEEP to solicit additional proposals for Class I renewables and utilize large-scale hydropower procured under Section 7 to count toward the Connecticut RPS requirements if DEEP concludes that there is a shortage of Class I RECs and the shortage is expected to continue in future years.[15]

- **Section 10:** Section 10 requires that the Public Utilities Regulatory Authority (PURA) issue a decision on compliance with the RPS for calendar years up to and including 2012 by the end of 2013, for which a decision has not already been issued. Not later than December 31, 2014, and annually thereafter, the authority shall, following such an RPS compliance proceeding, issue a decision as to whether the electric distribution company's wholesale suppliers met the renewable portfolio standards during the preceding year. In

[15] Beginning in 2014, if in any calendar year a supplier makes alternative compliance payments ("ACPs") rather than submitting RECs to the electric distribution companies for RPS compliance, there would be a presumption that there is an insufficient supply of Class I renewable energy sources. The Commissioner of DEEP can overcome this presumption by determining that the ACP payments were made because of intentional or negligent action of a supplier, and not by a Class I REC shortage. If the presumption of a Class I REC shortage is affirmed by the Commissioner of DEEP, the Commissioner must determine whether the shortage will continue in future years. If it is determined by the Commissioner that the shortage will continue, the Commissioner shall solicit proposals from Class I renewable energy sources, in consultation with the Procurement Manager, OCC, and the Attorney General. If one or more proposals would benefit ratepayers and be consistent with state policies and strategies, the Commissioner may select such proposal(s) in consultation with the Procurement Manager to rectify the shortage. The EDCs would then, subject to review by PURA, enter into contracts with the winning proposal for not more than a ten-year contract term, with any RECs procured used for compliance with the Connecticut RPS. If the shortage cannot be rectified through the procurement from Class I sources, the Commissioner of DEEP may, beginning in 2016, allow not more than one percent of the Connecticut RPS to be met with large-scale hydropower procured pursuant to Section 7 instead of Class I RECs. The percentage from large-scale hydropower can then be ramped up by an additional 1% per year, but not more than 5% of the Connecticut RPS can be met with large-scale hydropower through 2020.

addition, the ACP funds will be used to offset the costs of contracts entered into through the ZREC and LREC programs, with any remaining funds applied first to reduce the costs of Project 150 and then to reduce non-by-passable federally mandated congestion charges.

- **Section 11:** The changes made in Section 10 are applied by Section 11 to licensed electric generation service suppliers.

NEW ENGLAND RENEWABLE PORTFOLIO STANDARDS

All six New England states have set explicit renewable energy targets through state legislative and regulatory processes. While each New England state has slightly different rules in its RPS or renewable development program, one common supply resource that meets the Class I REC definition in the five states with REC-based renewable programs is wind power. Wind power is the most abundant supply resource in the region and serves as the most common growth resource to meet the collective needs of the six states. The regional market for Class I RECs allows them to be traded across the six states.[16]

Figure 3 summarizes the renewable energy technologies that qualify for the RPS in each of the New England states.

[16] Vermont's renewable energy development program it is not a REC program. Utilities are expected to enter into long-term power purchase agreements, or develop renewable projects themselves. Renewable energy must be produced in Vermont but may be sold out-of-state. Vermont's renewable energy goals do not create additional demand for new Class I renewable resources in New England, but they can serve as a source of supply.

Figure 3
Technologies Designated in Renewable Portfolio Standards in New England, as of November 2013

Technology	CT Classes			MA Classes[a]			ME Classes		RI	NH Classes			
	I	II	III	I	IIa	IIb	I	II		I	II	III	IV
Solar thermal	✓			✓	✓		✓		✓	✓	✓		
Photovoltaic (PV)	✓			✓	✓		✓		✓	✓	✓		
Ocean thermal	✓			✓	✓				✓	✓			
Wave	✓			✓	✓				✓	✓			
Tidal	✓			✓	✓		✓		✓	✓			
Marine or hydrokinetic				✓	✓								
Hydro	**<30 MW**	<5 MW		<25 MW[a]	<5 MW[a]		✓[b]	✓	<30 MW	incremental			<5 MW
Wind	✓			✓	✓		✓		✓	✓			
Biomass, biofuels	Sustainable, advanced conversion, low NO_X emissions[c]	✓		Low-emission, advanced technology[d]	✓[d]		✓	✓[e]	✓ Includes cofiring with fossil fuels	Low NO_X, and PM emissions		<25 MW, low NO_X, and PM emissions	
Landfill gas	✓			✓	✓		✓		✓	✓[f]		✓[f]	
Anaerobic digester	✓			✓	✓				✓	✓		✓	
Fuel cells[g]	✓			w/ renewable fuels	✓		✓		w/ renewable resources				
Geothermal				✓	✓		✓		✓	✓			
Municipal solid waste		✓				✓		✓ w/ recycling					
Cogeneration, combined heat and power (CHP)			Customer sites, minimum 50% fuel efficiency	✓				✓[e]					
Energy efficiency			**Only existing projects for remainder of the contracts**										

Source: ISO-New England 2013 Regional System Plan, November 2, 2012, p. 136. Connecticut RPS revised per Public Act 13-298, Sections 1 and 2.

Figure 4(a) shows the Class I-equivalent targets for each New England state through 2024, which increases from a combined target of 8.7% of retail load in 2015 to 15.4% by 2024. Among the New England states, Connecticut has the most ambitious Class I RPS target in terms of percentage of load (20% in 2020) and is second only to Massachusetts in New England in annual renewable energy required in gigawatt-hours (GWh), as shown in Figure 4(b). (The Massachusetts Class I RPS target is 15% in 2020, but its retail load is approximately twice the magnitude of the retail load of Connecticut).

Figure 4
New England Class I-Equivalent RPS Requirements
(a) Percentage of Retail Load

State	Class	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CT	Class I	10.0%	11.0%	12.5%	14.0%	15.5%	17.0%	19.5%	20.0%	20.0%	20.0%	20.0%	20.0%
MA	Class I	8.0%	9.0%	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	16.0%	17.0%	18.0%	19.0%
ME	Class I	6.0%	7.0%	8.0%	9.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
NH	Class I+II	4.2%	5.3%	6.3%	7.2%	8.1%	9.0%	9.9%	10.8%	11.7%	12.6%	13.5%	14.4%
RI	New	5.5%	6.5%	8.0%	9.5%	11.0%	12.5%	14.0%	14.0%	14.0%	14.0%	14.0%	14.0%
VT	All	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL		**6.8%**	**7.7%**	**8.7%**	**9.7%**	**10.7%**	**11.7%**	**12.8%**	**13.4%**	**13.9%**	**14.4%**	**14.9%**	**15.4%**

(b) Annual GWh

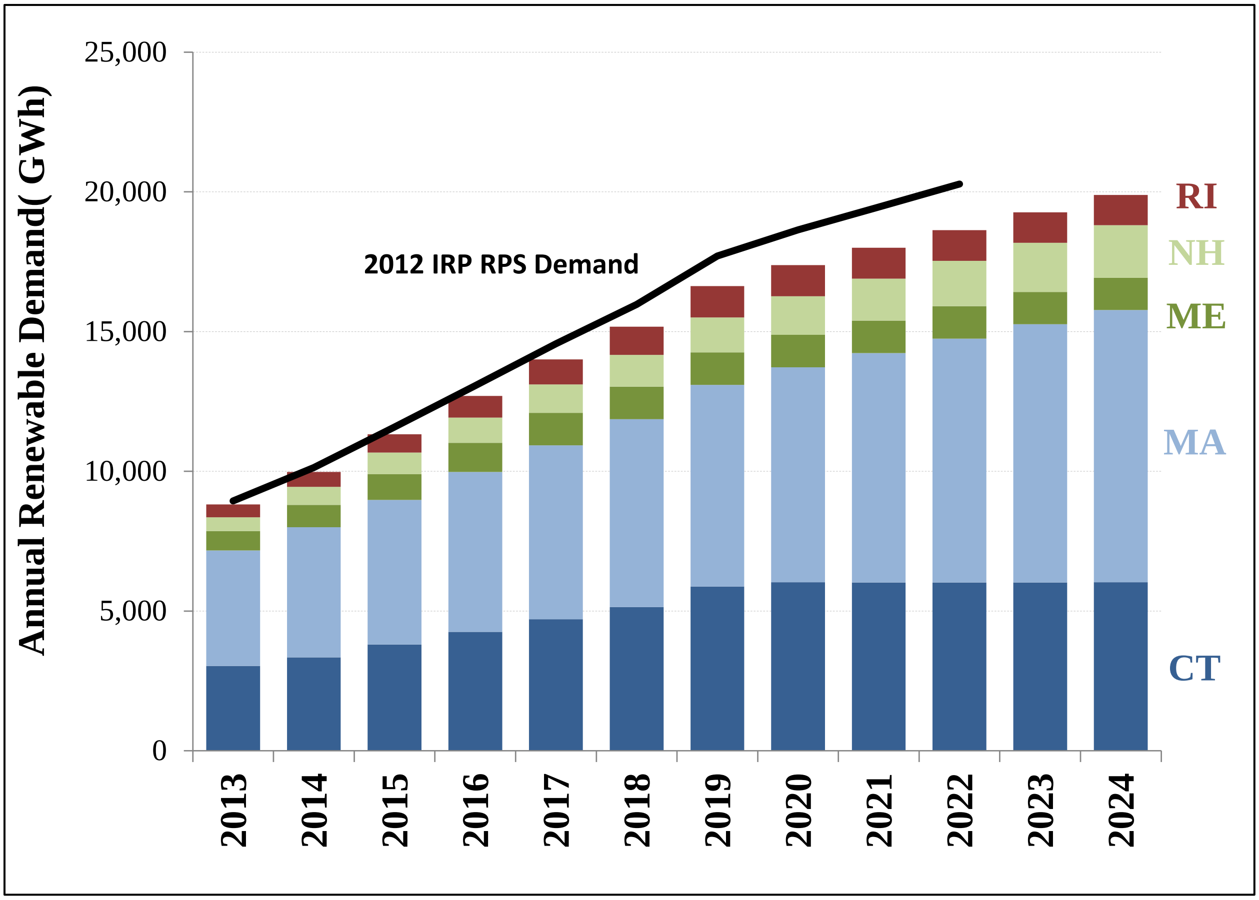


Figure 4 Sources and Notes:

[1] Percent requirements based on state RPS rules and regulations that are currently in place, and do not include renewable goals in Vermont. "Total" reflects the share of New England load that needs to be served by RPS qualified renewable resources.

[2] RPS demand is calculated based on CELT 2013 load forecast, net of Passive Demand Resources and any other incremental energy efficiency assumed in our "Base Case". Share of municipal-owned utilities in Connecticut, Massachusetts, and Rhode Island are excluded, as they are not required to meet the state RPS.

[3] Assumed that 90% of energy from installed solar is distributed and reduces the load forecast for each state.

In Figure 4(b), the line shows the total demand for renewable generation in New England presented in the 2012 RPS. In comparison, the forecast of demand for Class I RECs going forward has decreased since DEEP conducted the analysis for the 2012 IRP. There are two primary reasons for this change. First, New England's load growth has decreased due to an increased impact from energy efficiency programs. Second, the growth of distributed solar generation reduces the retail load served by load serving entities and thus their need for Class I RECs has also decreased.

Like Connecticut, several other New England states have unique features of their own. Specifically, Massachusetts has set several tiers of renewable energy goals, including an in-state solar "carve-out" with a target of 1,600 MW by 2020. Although the resulting solar resources help Massachusetts meet its Class I RPS requirements, they receive payments in the form of solar-

RECs (SRECs) in a separate Massachusetts-administered program. Thus, Massachusetts' solar program created a separate SREC market from New England Class I renewable. In contrast, Connecticut's ZREC supply arises from competitive bids rather than a single clearing price mechanism.

RENEWABLE ENERGY SUPPLY IN NEW ENGLAND

Although there is substantial technical potential for renewable energy sources in the region, slow economic growth has contributed to a modest peak load growth and relatively flat energy growth in New England and Connecticut.[17] These factors, together with continued low natural gas prices, have made project financing for new projects difficult to obtain. Legislative changes in Connecticut and Massachusetts, which affect the eligibility of biomass, landfill gas and large hydro projects, create additional uncertainties in the REC market. With the intent to reduce those uncertainties, statutory changes that allow the use of long-term contracts to fulfill a portion of Connecticut's and Massachusetts' Class I requirements will be the main driver for the development of new resources going forward.

Existing Class I Renewable Capacity in New England

Existing Class I renewable capacity in New England is approximately 2.1 GW (excluding qualified imports from neighboring regions). The existing renewable capacity is approximately 900 MW higher than reported in the 2012 Connecticut IRP. Figure 5 presents the current renewable capacity of Class I resources in New England, primarily based on the renewable capacity qualified for RPS compliance in each of the New England states.

Below, we highlight the most significant changes in the renewable capacity since the 2012 IRP.

- Installed onshore wind grew from 320 MW in 2012 to 806 MW, such that onshore wind surpassed biomass as the resource with the most installed capacity in New England. Over half of the installed onshore wind capacity is located in Maine, with New Hampshire and Vermont each adding over 100 MW of capacity.

- Biomass capacity has increased by over 100 MW. Due to increases in other resources, its share of installed capacity has decreased from 50% to 33%.

- Solar PV capacity has increased from 129 MW to 847 MW with the majority of new development occurring in Massachusetts.

- Capacity of other sources such as landfill gas, fuel cells, and small hydro has remained low, with a few modest additions.

- Connecticut has 177 MW installed renewable capacity (about 6.4% of total installed renewable capacity in New England).

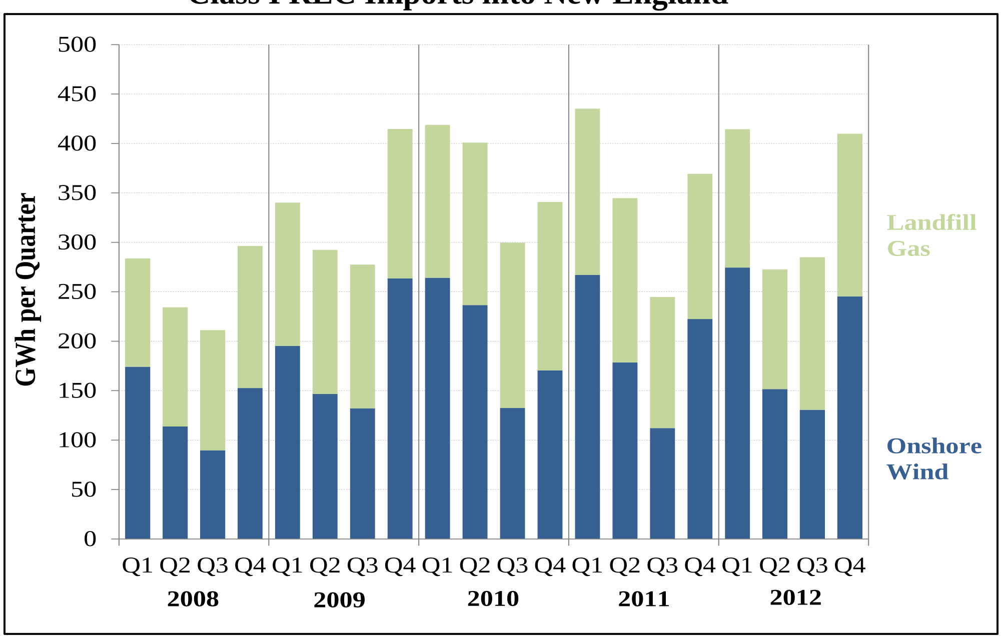
[17] 2013 CELT Report, 50/50 net peak and energy forecast.

Figure 5
Existing Class I Resources by State and Technology
(Nameplate Capacity in MW)

	Regional Supply by State						
Technology	*CT*	*MA*	*ME*	*NH*	*RI*	*VT*	***TOTAL***
Biomass/ Biofuels	0	46	516	185	50	2	**799**
Fuel Cells	26	0	0	0	0	0	**26**
Landfill Gas	13	39	8	24	63	20	**166**
Onshore Wind	5	84	431	171	10	113	**813**
Small Hydro	5	8	53	21	1	32	**121**
Solar PV	128	625	0	32	8	32	**824**
TOTAL	**177**	**802**	**1,008**	**433**	**131**	**199**	**2,750**

Imports of renewable power produced outside of and delivered to New England are an additional source of renewable energy supply. Figure 6 plots the quarterly imports for renewable energy, based on the data published by NEPOOL Generation Information System (GIS). Annual Class I REC imports into New England were about 1,500 GWh in 2011 and 2012. Almost all of the imports are from onshore wind and landfill gas resources in New York and Canada, approximately 1,500 GWh per year.

Figure 6
Class I REC Imports into New England



Source: Calculated based on data from NEPOOL Generation Information System (GIS).

Renewable Capacity Additions in New England

Approximately 3,600 MW of renewable generating capacity are in the ISO-New England (ISO-NE) generation interconnection queue, of which about 70% are proposed wind projects.[18] However, historical information shows that many of the projects in the queue are not likely to be built for a variety of reasons. In fact, 50% of all projects that have entered the queue since it began were withdrawn, including 56% of wind projects (68% of capacity).[19]

For this study, DEEP does not project or predict future capacity growth, as it has in past IRPs, based on information about proposed projects or projects in the ISO-NE interconnection queue. Instead, DEEP is relying on procurement targets that are likely to lead to renewable project development to set the supply portfolio in the Base Case and the Additional Class I Renewables cases. Thus, the analysis here is not a forecast, but instead is meant to provide a snapshot of the existing renewable resources and the renewable resources procured or already built based on specific state programs.

Below DEEP summarizes the assumptions in the Base Case and Figure 7 shows the resulting estimates for the renewable supply resources through 2024. The assumptions included:

- The currently contracted capacity of the Deepwater Block Island (30 MW) offshore wind project will be in-service by 2018. Cape Wind has not been included due to the withdrawal of its contracts.
- The Massachusetts RPS Solar Carve-Out II program will meet its goal of 1,600 MW by 2020.[20]
- The Connecticut Project 150 and Section 127 renewable procurement programs will result in capacity additions of 63 MW (Project 150) and 30 MW (Section 127).
- The LREC and ZREC programs will procure capacity based on their allocated funding and estimated costs of those resources, estimated to include about 428 MW of solar capacity (ZREC) and 46 MW of fuel cell capacity (LREC).
- The Section 106 Residential Solar program in Connecticut is funded at current levels through 2024, expecting to yield 159 MW (AC) of incremental installed capacity.

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18 ISO Generator Interconnection request queue as of November 11, 2013.
19 ISO Generator Interconnection request queue as of November 11, 2013.
20 For details on the Massachusetts RPS Solar Carve-Out Program see: http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out-2/about-solar-carve-out-ii.html.

The recently announced projects that remain in development from the Connecticut Section 6 (Number Nine Wind and Fusion Solar Center) and Massachusetts Section 83(a) (Oakfield Wind and Bingham Wind) procurements will be built.

Figure 7
Cumulative Existing and Contracted Class I Capacity in New England
(Nameplate Capacity in MW)

Technology	2014	2017	2019	2024
Biomass/ Biofuels	799	829	829	829
Fuel Cells	26	84	93	93
Landfill Gas	166	166	166	166
Onshore Wind	813	1,397	1,397	1,397
Offshore Wind	0	0	30	30
Small Hydro	121	121	121	121
Solar PV	824	1,673	2,265	2,521
Imports	414	414	414	414
TOTAL	**3,164**	**4,685**	**5,315**	**5,571**

New England RPS Supply and Demand

Based on the assumed capacity available through 2024, DEEP estimated the amount of energy generated by renewable technologies to meet the New England RPS requirements. The average capacity factors that we assumed for the entire capacity installed for each technology are shown in Figure 8.

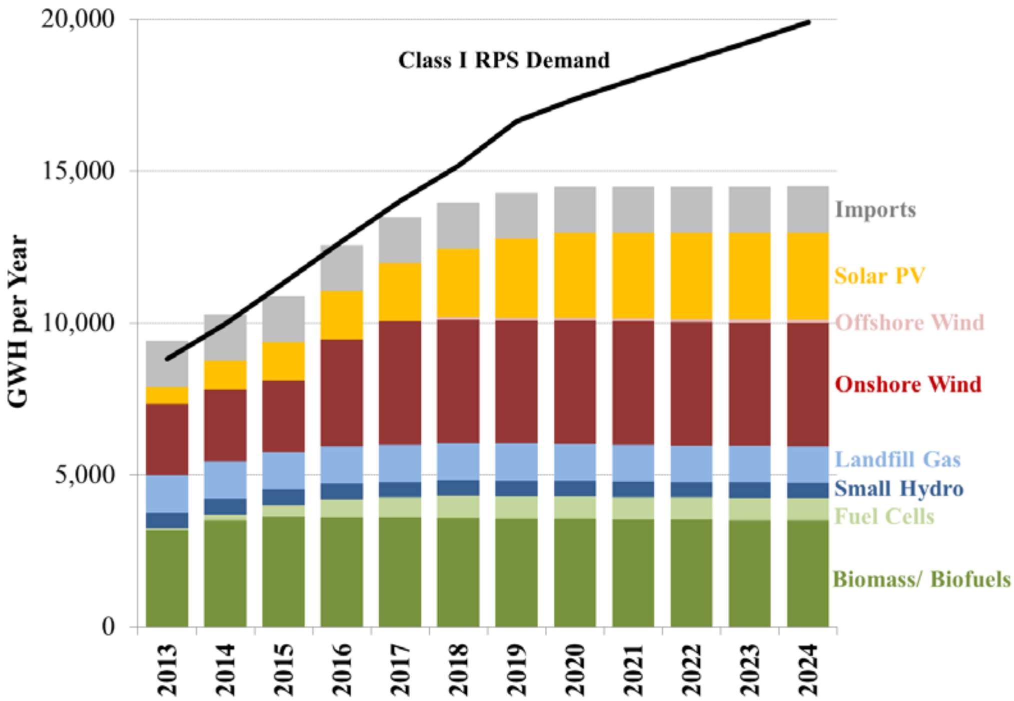
Figure 8
Capacity Factor Assumptions for Renewable Technologies

Technology	Capacity Factor
Biomass/ Biofuels	50.0%
Fuel Cells	90.0%
Hydro	48.4%
Landfill Gas	85.0%
Onshore Wind	
Connecticut (Utility-Scale)	27.9%
Connecticut (Behind-The-Meter)	20.0%
Massachusetts	32.0%
Maine	33.2%
New Hampshire	33.4%
Rhodes Island	23.8%
Vermont	34.7%
Offshore Wind	37.0%
Solar PV (DC) - Fixed Tilt	13.0%
Solar PV (AC) - Fixed Tilt	16.9%
Solar PV (AC) - Single Axis	20.8%
Solar PV (AC) - Dual Axis	22.1%

Figure 8 Sources and Notes: Capacity factor assumptions for onshore wind and solar PV are based on hourly generation profiles from National Renewable Energy Laboratory, and for other technologies based on "Massachusetts Renewable Energy Potential, Final Report," Prepared for Massachusetts Department of Energy Resources (DOER) and Massachusetts Technology Collaborative (MTC), August 6, 2008. Solar PV capacity factor is shown for a fixed-tilt installation in terms of both AC and DC capacity to account for the 77% efficiency of converting the panel DC output to AC output. We assume all solar capacity is fixed tilt in our analysis. Biomass capacity factor has been reduced due to recent changes in dispatch. The assumed value of 50% is similar to the capacity factor of existing biomass plants without a contract in the IRP modeling. Biomass plants with a contract would be expected to have a higher capacity factor.

The resulting supply and demand balance for renewable energy in New England is presented in Figure 9 below. As shown, the renewable supply in New England is expected to hover around the region's Class I RPS target levels through 2016 and then fall short of the target starting in 2017 (by approximately 5,400 GWh in 2024, or 27% of the demand for RECs).

Figure 9
New England Class I Renewable Resource Supply and Demand Balance in the Base Case



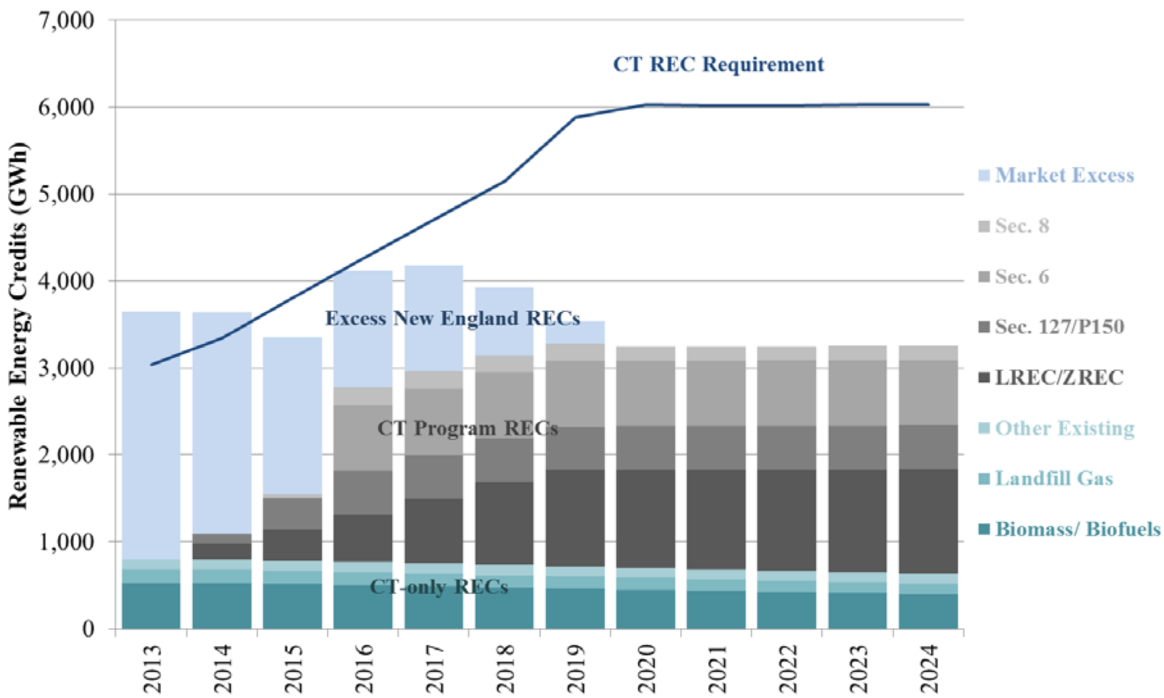
Biomass, which currently accounts for one-third of the region's REC supply, is expected to account for about 20% of the expected renewable generation by 2024 in the Base Case. The wind resources that have been built or procured (onshore and offshore) are assumed to significantly increase wind's share of the region's portfolio, contributing close to 33% of the total supply by 2024 in the Base Case. Solar PV is assumed to increase based on the incentives provided by the existing state programs such that its share of generation is expected to account for roughly 17% of the region's renewable generation by 2024.

Connecticut RPS Supply and Demand

Although the New England REC market often is considered a single regional market, the Class I REC market in New England has bifurcated with Massachusetts' short-term spot REC prices above the Connecticut ACP value and Connecticut's short-term REC prices just below the Connecticut ACP value. For this reason, current Class I REC prices in Connecticut are valued approximately $10 less than the rest of New England. (See Figure 13 the section on Class I REC prices below for more information.)

As renewable generators seek to sell their RECs at the highest price possible, a limited amount of RECs may be available for Connecticut's Class I RPS compliance. Figure 10 shows the supply and demand of RECs in Connecticut with the supply including RECs generated by landfill gas and biomass only qualified in Connecticut, RECs generated through state-sponsored procurement programs, and the expected quantity of RECs in excess of demand in other the New England markets.

Figure 10
Connecticut Class I Renewable Resource Supply and Demand Balance in the Base Case



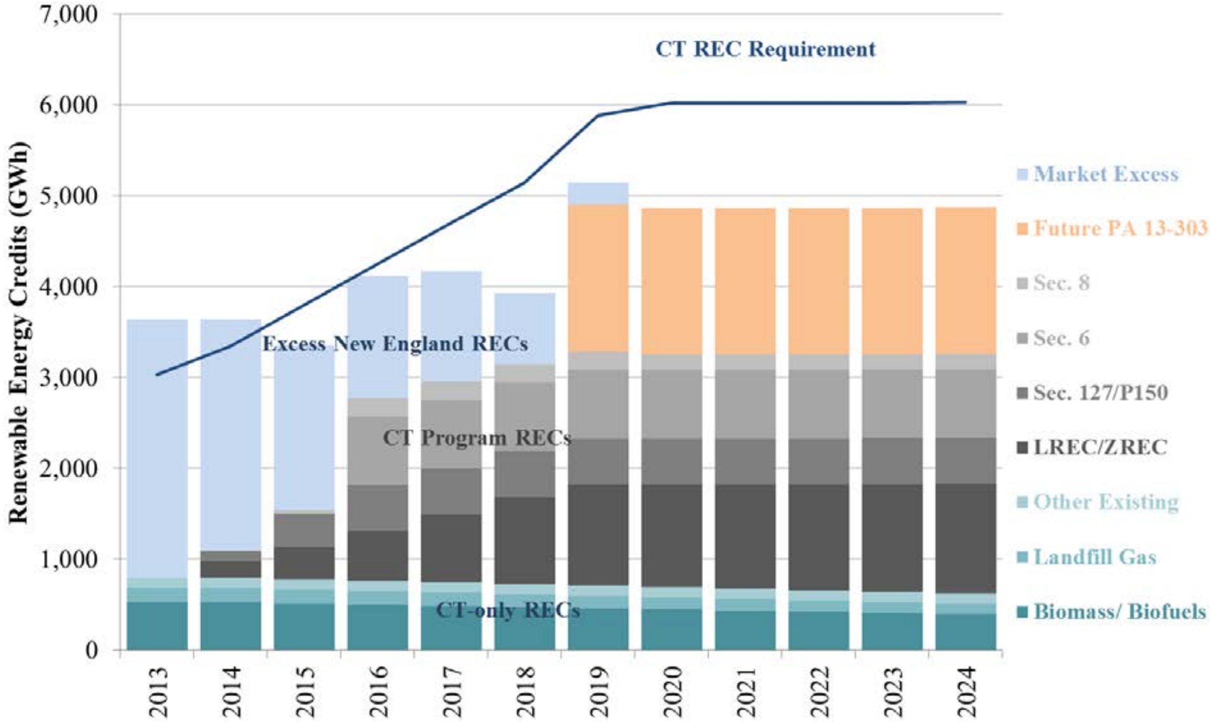
Under the Base Case assumptions, Connecticut is expected to experience a shortage of RECs starting in 2015. Banked RECs may be available to meet the 2015 demand in the Base Case, although no assumptions have been made by the Department about how entities will choose to bank RECs.

Alternate Scenario: Additional Class I Renewables

As DEEP has the authority to procure additional Class I renewable resources under Section 7 of PA 13-303, an alternative renewables scenario has been included in the IRP that is equivalent to 5% of Connecticut load in 2024. DEEP assumes that the additional procurement would yield approximately 535 MW of onshore wind and 56 MW of solar, similar to mix of resources recently procured through PA 13-303 Section 6.

Figure 11 below shows the approximate amount of additional procurement for the Additional Class I Renewables case. As indicated in the figure, if the additional renewables resources are in the supply mix by 2019, Connecticut the shortage is reduced but is still expected to begin in 2015 and continue through 2024. Additional Class I programs being considered by the legislature would further reduce and could eliminate the shortage if they are enacted.

Figure 11
Connecticut Class I Renewable Resource Supply and Demand Balance in the Additional Class I Renewables Case



The cumulative capacity and energy generated by resource type for the Base Case and Additional Class I Renewables resource strategies are shown in Figure 12.

Figure 12
Summary of Class I Renewable Resource Build-out in Connecticut and New England
(Nameplate Capacity MW, Base Case Futures)

	Base Case				Add'l Class I
Technology	2014 *(MW)*	2017 *(MW)*	2019 *(MW)*	2024 *(MW)*	2024 *(MW)*
Connecticut					
Biomass/ Biofuels	0	30	30	30	30
Fuel Cells	26	84	93	93	93
Landfill Gas	13	13	13	13	13
Onshore Wind	5	5	5	5	5
Offshore Wind	0	0	0	0	0
Small Hydro	5	5	5	5	5
Solar PV	128	476	734	820	875
Connecticut Total	**177**	**613**	**880**	**966**	**1,021**
ISO New England					
Biomass/ Biofuels	799	829	829	829	829
Fuel Cells	26	84	93	93	93
Landfill Gas	166	166	166	166	166
Onshore Wind	813	1,397	1,397	1,397	1,932
Offshore Wind	0	0	30	30	30
Small Hydro	121	121	121	121	121
Solar PV	824	1,673	2,265	2,521	2,576
Imports	414	414	414	414	414
ISO-NE Total	**3,164**	**4,685**	**5,315**	**5,571**	**6,162**

(Annual GWh, Base Case Futures)

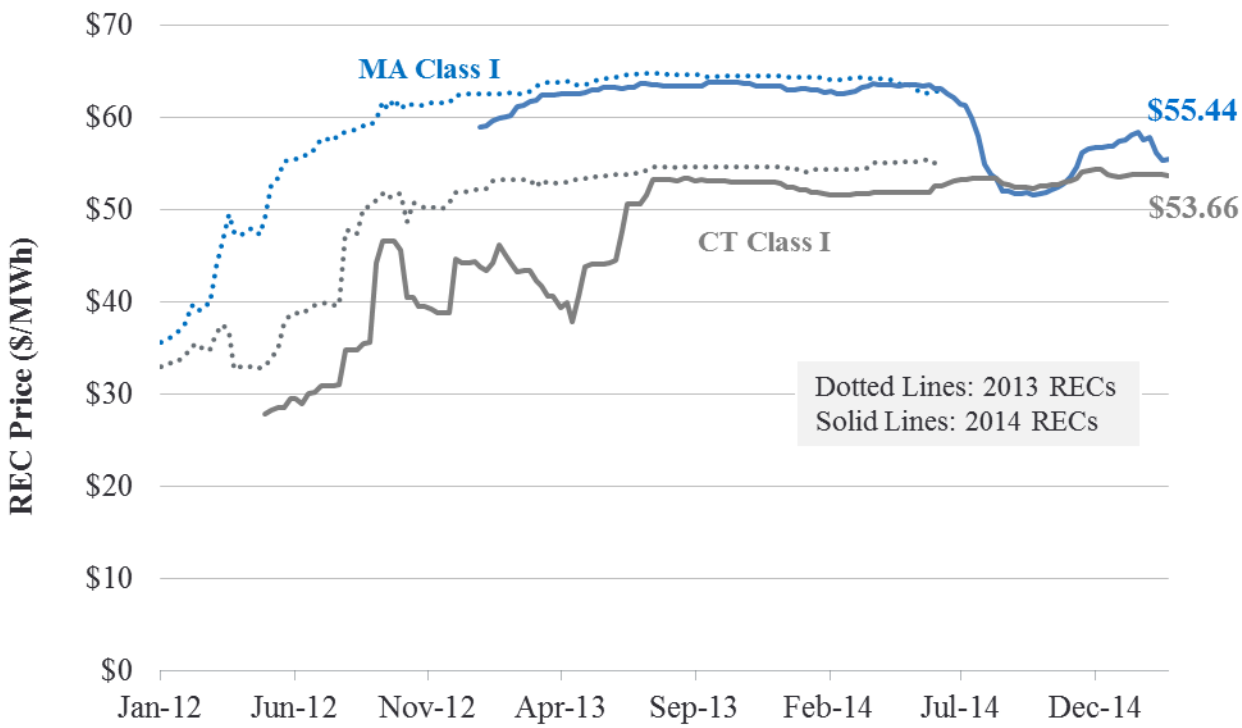
	Base Case				Add'l Class I
Technology	2014 *(GWh)*	2017 *(GWh)*	2019 *(GWh)*	2024 *(GWh)*	2024 *(GWh)*
Connecticut					
Biomass/ Biofuels	1	132	132	132	132
Fuel Cells	64	663	730	730	730
Landfill Gas	98	98	98	98	98
Onshore Wind	0	9	9	9	9
Offshore Wind	0	0	0	0	0
Small Hydro	21	21	21	21	21
Solar PV	43	542	836	933	997
Connecticut Total	**228**	**1,465**	**1,826**	**1,924**	**1,987**
ISO New England					
Biomass/ Biofuels	3,066	3,591	3,565	3,499	3,499
Fuel Cells	67	666	733	733	733
Landfill Gas	1,238	1,226	1,218	1,198	1,198
Onshore Wind	2,348	4,059	4,059	4,059	5,613
Offshore Wind	0	0	97	97	97
Small Hydro	513	513	513	513	513
Solar PV	287	1,905	2,579	2,871	2,934
Imports	1,520	1,520	1,520	1,520	1,520
ISO-NE Total	**9,038**	**13,479**	**14,283**	**14,489**	**16,107**

COSTS OF RENEWABLE RESOURCES

Class I REC Prices

Class I REC prices in New England have increased significantly in the past two years. Since January 2012, short-term REC prices have risen from about $35/MWh to $55/MWh, close to the ACP in Connecticut, as shown in Figure 13.

Figure 13
Massachusetts and Connecticut Class I REC Prices in 2012 and 2013



Source: SNL data as of February, 2015.

For this IRP, DEEP is using a snapshot of assumptions for the short-term Class I REC prices. DEEP has assumed in the Base Case that current Class I REC prices will remain near the ACP through 2024 due to the region's supply hovering around the demand levels when the procured resources identified above are expected to be built.

Given this assumption, load-serving entities may have the inclination to pay ACP rather than purchasing RECs. However, given that the goal of the RPS is to create incentives for actual build-out of renewable resources, DEEP has assumed that if RECs are available they will be purchased at close to the ACP value and used for compliance. If the region is short of RECs, then load-serving entities will pay the ACP for the amount it is short of demand.

For the long-term prices for Class I RECs, Connecticut's programs are expected to procure generation and RECs under long-term contracts. Below Figure 14 shows the estimated prices that have been paid for Class I resources under each program/procurement.

Figure 14
CT Procurement Program Average Class I Equivalent REC Prices

CT Program	**REC Price** (*2014$/MWh*)
ZREC	$134
LREC	$63
Residential Solar	$99
Section 6	$16
ACP	$55

Note: ZREC and LREC prices are from the first round. The Section 6 REC price has been estimated based on the bundled value of the long-term contracts and the projected energy prices for each project.

Prices for ZREC proposals were approximately 50% lower in the third round of procurement than in the first round. LREC prices have declined by approximately 10% from Round 1 to Round 3. Subsequent to 2014, DEEP assumes that the capital costs associated with solar PV resources would decline at a nominal rate of 3% per year for the remaining four years of the ZREC program. Conversely, a reduced Investment Tax Credit (ITC) level for solar resources post 2017, as currently stated in federal law, will increase the REC prices needed for new solar PV capacity.

In the long-term, DEEP assumes that the Class I REC prices will be driven by the long-term REC payments needed for onshore wind projects to be financially viable. Thus, for the Additional Class I Renewables case, DEEP estimated the capital and operation and maintenance (O&M) cost for onshore wind in New England. Similarly, DEEP also estimates the cost of solar PV for the purpose estimating the cost associated with ZREC and Residential Solar programs. These assumptions are shown in Figure 15.

Figure 15
Cost Assumptions for Renewable Technologies

Technology	**Overnight Cost**	**Fixed O&M Cost**	**Variable O&M Cost**
	(2014$/kW)	*(2014$/kW-yr)*	*(2014$/MWh)*
Onshore Wind	$2,749	$71.2	$0.0
Solar PV	$3,021	$53.3	$0.0

Figure 15 Sources and Notes: Based on costs for onshore wind and solar PV included in ISO-NE ORTP analysis (http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2013/oct892013/a06_iso_ortp_analysis_final_results_10_02_13.xlsx) Onshore wind overnight capital costs include $325/kW for interconnection costs.

The capital charge rate estimate for renewable technologies is shown in Figure 16.

Figure 16

Capital Charge Estimation Assumptions for Renewable Technologies

Operating Life (Years)	20
Tax Depreciation Schedule	5yr MACRS
Debt Rate	5.2%
Equity Rate	11.3%
Debt Fraction	50.0%
Tax Rate	40.6%
Inflation Rate	1.6%
ATWACC	7.2%
ATWACC Real	5.5%
Resulting Capital Charge Rate	**8.6%**

Based on the above cost assumptions, DEEP estimates the long-term REC prices based on the estimated requirements to keep onshore wind and solar PV investors financially viable. [21] The estimates represent the costs of procuring the additional renewables under the Additional Class I Renewables resource strategy. REC prices are shown in Figure 17 with and without the tax credits that are currently available for renewable generation – the Production Tax Credit (PTC) for wind generation and the Investment Tax Credit (ITC) for solar generation. DEEP has assumed that the PTC for onshore wind expired after 2013 and the ITC for solar PV will be reduced from 30% to 10% starting in 2017. The REC price needed for onshore wind in 2014 (without the PTC) is approximately $47/MWh and for solar (with the 30% ITC) is approximately $146/MWh.

[21] Solar is assumed to not clear in the ISO-NE Forward Capacity Market and thus receive no capacity revenue.

Figure 17
Estimated REC Price Needed for Renewables Resources in New England

Renewable Resource	Year	All-In Levelized Cost *(2014 $/MWh)*	Energy Revenue *(2014 $/MWh)*	Capacity Revenue *(2014 $/MWh)*	Total Revenue *(2014 $/MWh)*	Estimated REC Price Needed without Tax Credit *(2014 $/MWh)*	Levelized Tax Credit *(2014 $/MWh)*	Estimated REC Price Needed with Tax Credit *(2014 $/MWh)*
Onshore Wind								
Base	2014	$105.9	$55.7	$3.2	$58.9	$47.0	$22.4	24.6
Base	2017	$105.9	$58.5	$5.0	$63.5	$42.3	$22.4	19.9
Base	2019	$105.9	$61.0	$7.1	$68.1	$37.8	$22.4	15.4
Base	2024	$105.9	$67.3	$8.9	$76.2	$29.7	$22.4	7.3
Add. Class I Renewables	2024	$105.9	$66.3	$8.8	$75.1	$30.8	$22.4	8.4
Solar PV								
Base	2014	$305.2	$53.3	$0.0	$53.3	$251.9	$106.3	145.6
Base	2017	$271.6	$56.8	$0.0	$56.8	$214.8	$92.3	122.5
Base	2019	$251.6	$59.0	$0.0	$59.0	$192.7	$84.0	108.6
Base	2024	$209.3	$65.1	$0.0	$65.1	$144.2	$66.4	77.8
Add. Class I Renewables	2024	$209.3	$65.5	$0.0	$65.5	$143.8	$66.4	77.4

Figure 17 Notes: Values shown for onshore wind in Maine only since values are comparable in New Hampshire.

These REC payments are expected to decline in future years as energy and capacity revenues increase over time with fuel prices and inflation. Further, DEEP anticipates the capital cost of solar PV resources to continue to decline. Solar capacity can be expected to have a wide range of costs and the economics of new solar facilities will depend largely on the size of the installation and whether the facility is installed behind the meter.

Class II REC Prices

Pursuant to Conn. Gen. Stat. §16-1(a)(27) Class II renewable energy sources include energy derived from:

- Resource recovery facilities;
- Biomass facilities that began operation before July 1, 1998, provided the average emission rate for such facility not exceeding 0.2 pounds of NOx per million BTU of heat input for the previous calendar quarter; or
- Run-of-the-river hydropower generating facilities up to five MW that began operation prior to July 1, 2003.

Currently, there are 122 generating plants across New England that meet the Connecticut Class II requirement which have a total capacity of 670 MW. The 122 Class II sources include 94 hydropower facilities, 20 resource recovery facilities, 7 biomass plants and 1 wind plant.

If assumed that the average capacity for Class II generators is 80%, the 670 MW would equate to 4.7 million Connecticut Class II eligible RECs. Conn. Gen. Stat. § 16-245(a) requires that 3% of retail sales in Connecticut to be supplied by Class II energy sources. Given the state's electric demand in 2014, the Class II REC demand could be satisfied by 950,000 RECs. Although the generation from these sources may qualify for RECs in other New England states, this capacity creates the conditions for an over-supply in Connecticut Class II-eligible RECs.

Currently, Class II RECs trade in the $0.50/MWh range. DEEP estimates the total cost of Class II RPS compliance was approximately $500,000 in 2014.

Class III REC Prices

Under the existing Connecticut RPS, the Class III requirement is 4% of load, with a price floor of $10 per Class IIII REC. Figure 18 below shows the Class III requirements and the qualifying Class III RECs between 2009 and 2012. Because the supply of Class III resources was significantly greater than the requirements, average market prices for Class III RECs for 2012 and 2013 was $10.62/MWh.[22]

Figure 18
Summary of Historical Class III Requirement and Qualifying Resource Output

Year	**Class III Supply** CHP *(MWh)*	C&LM *(MWh)*	**TOTAL** ***(MWh)***	**Class III Demand** ***(MWh)***
2009	528,219	1,002,482	**1,530,701**	**953,925**
2010	645,978	1,236,626	**1,882,604**	**1,283,315**
2011	706,526	1,667,160	**2,373,686**	**1,268,577**
2012	866,576	1,989,840	**2,856,416**	**1,256,219**

Source: Class III supply as reported in NEPOOL Generation Information System (GIS). Class III demand calculated based on existing RPS targets increasing from 3% in 2009 and 4% in later years.

Section 2 of PA 13-303 changed the eligibility requirements of Class III RECs such that C&LM no longer qualify as a Class III resource. As can be seen above, eliminating the C&LM supply in previous years would have resulted in there being a shortage of Class III RECs, such that Class III REC prices would be expected to have reached the Class III ACP of $31/MWh. While CHP generation has grown significantly from 2009 to 2012, it is unknown how much new CHP generation will enter the market in future years and at what costs. For those reasons, we assume that future year Class III REC prices are at the ACP price of $31/MWh. DEEP estimates the total cost of Class III RPS compliance at $40 million in 2015 and beyond.

TRANSMISSION REQUIREMENTS FOR INTEGRATING WIND RESOURCES

The recent results in the long-term contracts signed by Connecticut and Massachusetts have shown that the greatest renewable energy resource potential in New England is from onshore wind. The majority of the onshore wind development is occurring in northern Maine where the transmission system is nearing export-constraint limits. Additional investment in transmission lines and substations will be required to allow the development of more onshore wind projects to

[22] SNL data as of October 25, 2013.

reach the regional market and ensure reliability and system stability in the areas local to the wind farms.

Part of the significant increase in wind build-out since the 2012 IRP has been the onshore wind capacity contracted by the states, most of which is located in northern New England. While it is not certain how much of the regional renewable targets can be met without significant transmission investments, recent experience has shown that the system is reaching a point where additional wind generation will start to create stability and congestion issues between northern Maine and New Hampshire. Resolving these issues will require new transmission lines to be constructed as well as upgrades to the existing system.

Based on prior analyses conducted by ISO-NE and prior IRPs, DEEP assumes that the ISO-NE system will need significant transmission upgrades for any incremental wind capacity in Maine above 571 MW.[23] The Department assumes that the transmission cost associated with accommodating the Base Case renewable build-out to be approximately $3,334 per kW (in 2014 dollars) of incremental wind capacity installed in Maine.[24]

Estimates of the transmission costs required for incremental wind capacity in export constrained regions vary widely. A 2011 report prepared for NESCOE evaluated the costs of connecting 3,000 MW of wind capacity in northern New Hampshire and western Maine to the transmission system. The report found that the transmission costs per kilowatt of wind capacity to be $905/kW (in 2014 dollars).[25] Based on this value, the total transmission costs in the Base Case would be $500 million and in the Additional Class I Renewable case would be $980 million.

Figure 19 below shows the estimated annual transmission costs for the Base Case and Additional Class I Renewables scenarios.

23 The value of 571 MW is based on the assumed capacity threshold in the 2012 IRP (446 MW) plus the additional export capacity estimated to be provided by the Maine Power Reliability Project (125 MW).

24 New England 2030 Power System Study, February 2010, pages 8, 21. The assumed $3,334 is the midpoint of the estimated transmission cost associated with 2,000 MW of onshore and 2,000 MW of offshore wind build-out case from the ISO-NE's Renewable Scenario Analysis (escalated to 2014 dollars).

25 RLC Engineering. Transmission Costs for Interconnecting 3,000 MW of Windfarm Capacity in Western Maine and Coos County New Hampshire. Prepared for NESCOE. October 18, 2011. Available at: http://nescoe.com/uploads/RLC_Final_Report___Appendices.pdf

Figure 19

Costs of Transmission for New Renewables in CT (2014 $m/yr)

Resource Strategy	**Year**	**Incremental Wind Capacity in Maine Above Transmission Threshold** *(MW)*	**Total Transmission Cost** *($m)*	**Total Annualized Transmission Cost** *($m/yr)*	**CT Load Ratio Share** *(%)*	**Transmission Cost Allocated to CT** *($m/yr)*
Base	2014	0	$0	$0	24%	$0
Base	2017	599	$1,996	$249	24%	$60
Base	2019	599	$1,996	$249	24%	$60
Base	2024	599	$1,996	$249	24%	$60
Add. Class I Renewables	2024	1,080	$3,600	$450	24%	$108

Figure 19 Notes: Unit transmission cost of $3,334 per kW of incremental wind capacity and capital charge rate 12.5% assumed. The transmission threshold for Maine has been estimated to be 571 MW.

Estimates of the transmission costs required for incremental wind capacity in export constrained regions vary widely, which demonstrates the on-going uncertainties. A 2011 report prepared for NESCOE evaluated the costs of connecting 3,000 MW of wind capacity in northern New Hampshire and western Maine to the transmission system. The report found that the transmission costs per kilowatt of wind capacity to be $905/kW (in 2014 dollars).[26] Based on this value, the total transmission costs in the Base Case would be $500 million and in the Additional Class I Renewable case would be $980 million.

As cost allocation of transmission built due to increasing wind capacity to meet state RPS requirements has recently become an area of greater focus in New England, various methods of cost allocation were proposed for calculating the transmission costs to be paid by Connecticut ratepayers. Currently, negotiations among state representatives are underway to resolve the cost allocation issue. The additional costs of transmission due to wind capacity procured by Connecticut and Massachusetts will depend on the outcome of negotiations among state representatives and/or the result of FERC decisions.

[26] RLC Engineering. Transmission Costs for Interconnecting 3,000 MW of Windfarm Capacity in Western Maine and Coos County New Hampshire. Prepared for NESCOE. October 18, 2011. Available at: http://nescoe.com/uploads/RLC_Final_Report___Appendices.pdf

CUSTOMER COSTS RELATED TO THE DEVELOPMENT OF RENEWABLES

The impact of RPS scenarios (and futures) on customer costs are calculated by adding the costs of complying with Class I, II, and II RPS requirements and the associated potential incremental transmission. Sections 10 and 11 of PA 13-303 have altered how the funds collected through the ACPs are allocated from the 2012 IRP. The ACP funds will now be used to offset the costs of contracts entered into through Project 150, the ZREC and LREC programs, or federally mandated congestion charges.

A summary of the estimated customer costs are provided below in Figure 20. The table shows the expected ACP funds on a separate line and included an equal value as a customer credit for offsetting the customer costs of the programs mentioned above and/or congestion charges.

Figure 20
Summary of Connecticut's Customer Costs Associated with Renewables
(in 2014 $million per year)

Market Scenarios	Resource Strategies					
	Base				Additional Class I Renewables	Change Relative to Base
	2014	2017	2019	2024	2024	2024
Base Case						
Class I RECs	$170	$148	$155	$37	$37	$0
Class I ACPs	$0	$0	$34	$139	$63	-$76
Class I CT Programs	$20	$90	$108	$118	$175	$57
Class II RECs	$0	$0	$0	$0	$0	$0
Class III RECs	$40	$38	$36	$33	$33	$0
Transmission for RPS	$0	$60	$60	$60	$108	$48
Customer Credits	$0	$0	-$34	-$139	-$63	$76
TOTAL RPS COST	**$229**	**$337**	**$359**	**$249**	**$355**	**$105**
Tight Supply						
Class I RECs	$166	$160	$109	$37	$37	$0
Class I ACPs	$9	$0	$97	$159	$84	-$76
Class I CT Programs	$20	$89	$108	$118	$172	$54
Class II RECs	$0	$1	$1	$1	$1	$0
Class III RECs	$41	$40	$38	$36	$36	$0
Transmission for RPS	$0	$60	$60	$60	$108	$48
Customer Credits	-$9	$0	-$97	-$159	-$84	$76
TOTAL RPS COST	**$227**	**$348**	**$316**	**$252**	**$354**	**$102**
Abundant Supply						
Class I RECs	$164	$137	$173	$85	$79	-$5
Class I ACPs	$0	$0	$0	$70	$0	-$70
Class I CT Programs	$20	$91	$109	$118	$177	$58
Class II RECs	$0	$0	$0	$0	$0	$0
Class III RECs	$39	$36	$34	$31	$31	$0
Transmission for RPS	$0	$60	$60	$60	$108	$48
Customer Credits	$0	$0	$0	-$70	$0	$70
TOTAL RPS COST	**$223**	**$325**	**$377**	**$294**	**$395**	**$101**
High Gas						
Class I RECs	$170	$148	$155	$37	$37	$0
Class I ACPs	$0	$0	$34	$139	$63	-$76
Class I CT Programs	$20	$86	$104	$118	$158	$40
Class II RECs	$0	$0	$0	$0	$0	$0
Class III RECs	$40	$38	$36	$33	$33	$0
Transmission for RPS	$0	$60	$60	$60	$108	$48
Customer Credits	$0	$0	-$34	-$139	-$63	$76
TOTAL RPS COST	**$229**	**$333**	**$356**	**$249**	**$338**	**$88**
Low Gas						
Class I RECs	$170	$148	$155	$37	$37	$0
Class I ACPs	$0	$0	$34	$139	$63	-$76
Class I CT Programs	$20	$95	$115	$124	$205	$80
Class II RECs	$0	$0	$0	$0	$0	$0
Class III RECs	$40	$38	$36	$33	$33	$0
Transmission for RPS	$0	$60	$60	$60	$108	$48
Customer Credits	$0	$0	-$34	-$139	-$63	$76
TOTAL RPS COST	**$229**	**$342**	**$367**	**$255**	**$384**	**$128**

Figure 20 Notes:

[1] "Transmission for RPS" is calculated based on the incremental wind capacity built after 2015, and assume $3,334 per kW of new wind capacity added. See previous section for the details.

[2] "Class I CT Programs." reflect the annual payments needed to support in-state Class I programs (Project 150, residential solar PV, ZREC, LREC, and other Class I projects) net of energy, capacity and Class I market revenues.

Due to the credits that the ACP provides to customers, the Additional Class I Renewables resource strategy appears to be significantly more costly to customers because less ACP is made under this strategy. However, recycling the ACP back to the ratepayers fails to accomplish the overall policy goal of using more renewable energy for the state. Thus, from a policy perspective, the customer cost metric must be combined with the environmental benefits metric and achievement of the goals set out in the RPS to measure the desirability of using long-term contracts to procure more renewables. As shown in Figure 21, procuring renewables under long-term contracts is estimated to decrease the cost to customers by about $6/MWh in the Base Case in terms of the cost per MWh of renewable energy generated.

Figure 21
Summary of RPS Costs Per MWh of Renewable Energy Generation

Market Scenarios	**Resource Strategies**					
	Base				Additional Class I Renewables	Change Relative to Base
	2014	2017	2019	2024	2024	2024
Total RPS Cost (2014 $m)						
Base Case	229	337	359	249	355	105
Tight Supply	227	348	316	252	354	102
Abundant Supply	223	325	377	294	395	101
High Gas	229	333	356	249	338	88
Low Gas	229	342	367	255	384	128
Total Renewable Generation (GWh)						
Base Case	3,345	4,705	5,208	3,061	4,684	1,622
Tight Supply	3,285	4,920	4,301	3,061	4,684	1,622
Abundant Supply	3,248	4,490	5,560	4,079	5,584	1,505
High Gas	3,345	4,705	5,208	3,061	4,684	1,622
Low Gas	3,345	4,705	5,208	3,061	4,684	1,622
Cost per MWh of Generation (2014 $/MWh)						
Base Case	68.56	71.54	69.01	81.49	75.71	-5.78
Tight Supply	69.17	70.79	73.38	82.32	75.59	-6.72
Abundant Supply	68.61	72.31	67.77	72.18	70.83	-1.36
High Gas	68.56	70.79	68.33	81.49	72.06	-9.44
Low Gas	68.56	72.69	70.38	83.40	81.92	-1.48

It is possible that Class I REC market prices will remain at the ACP throughout the period of this analysis in the Base Case. However, if the region is slightly long with Class I REC supply in some of the intermediate years the short-term REC prices could be set by the REC payment needed for onshore wind projects to stay financially viable. In that case, DEEP expects that the Base Case would incur lower costs to the customer in 2014 - 2017, the years in which there is assumed to be just enough supply to meet the regional demand. Such a change would result in customer costs that are $24 million lower in 2014 and $29 million lower in 2017.

RENEWABLE ENERGY AND ECONOMIC DEVELOPMENT

One of the important policy drivers for renewable energy development is its potential impact on the economic development of the state. DEEP estimated the potential employment and macroeconomic impacts of the Additional Class I Renewable Case, taking into consideration the incremental changes in customer bill and the uses of the ACP payments from the Base Case.

The employment and macroeconomic effects associated with the various scenarios are estimated based on the following assumptions:

- Customers pay for RECs, ACPs, and transmission costs through their electricity bills; these costs increase customers' spending on electricity and thereby reduce their spending on other activities. The indirect effects associated with such reduced spending on other activities are simulated to slightly reduce the downstream employment and economic activities in the state.
- ACP and some of the REC payments go to pay for investments in Connecticut-based renewable projects, such as the installation of solar PVs and manufacturing for fuel cell technology. Those payments can directly and indirectly affect employment levels in the relevant sectors of Connecticut's economy.
- Over the long term, the use of renewable energy can help reduce volatility in customers' electricity costs. While that is a benefit to consumers, we have not quantified those effects in this study.

Figure 22 below shows the incremental impact on employment and macroeconomic activities in Connecticut under the Additional Class I Renewable Case.

Figure 22
Incremental Impact on Employment and Macroeconomic Activities
(Relative to Base Case Scenario)

Resource Strategies in 2024	**Change in All Jobs (FTEs)** (*count*)	**Change in State GDP** (*$m/yr*)	**Change in Industry Sales Output** (*$m/yr*)	**Change in Net State Revenue** (*$m/yr*)
<u>Incremental Add'l Class I Renewables</u>				
Solar PV Maintenance and Repair	64	8	13	0
Electricity Cost Related	-268	-64	-$111	-$3
Total	**-204**	**-55**	**-98**	**-2**

ENVIRONMENTAL BENEFITS OF RENEWABLE ENERGY

The development of renewable energy generation is largely driven by concern for the environment. The use of renewable energy can help reduce the overall air pollution resulting from the burning of fossil fuels and thereby reduce adverse environmental impacts.

Figure 23 summarizes the annual CO_2 emissions in Connecticut and New England under each renewable resource scenario, and alternative futures.

Figure 23
Summary of CO_2 Emissions Across Renewable Resource Scenarios and Futures
(in million tons per year)

Resource Strategy	Year	Market Scenarios				
		Base	Tight	Abundant	HiGas	LoGas
Connecticut						
Base	2014	8.7	-	-	-	-
Base	2017	9.0	9.7	8.3	9.2	8.9
Base	2019	9.3	9.0	8.3	9.4	9.0
Base	2024	8.8	8.9	8.1	9.2	8.4
Add'l Class I Renewables	2024	8.6	8.7	8.0	9.1	8.3
New England						
Base	2014	38.9	-	-	-	-
Base	2017	37.1	40.7	33.5	38.1	35.7
Base	2019	36.4	40.3	32.1	37.5	34.7
Base	2024	36.9	42.4	31.2	38.6	34.5
Add'l Class I Renewables	2024	36.1	41.7	30.5	37.9	33.8