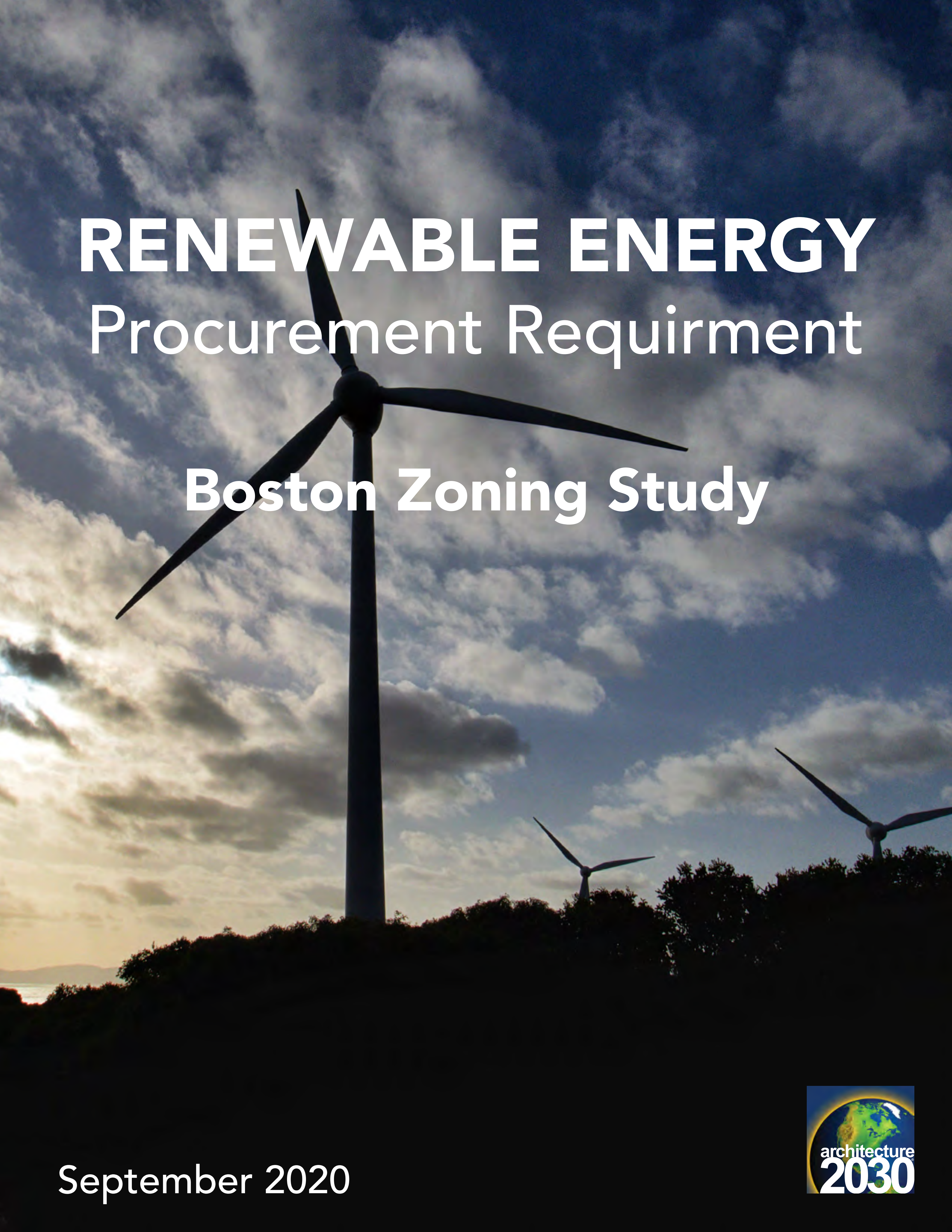
RENEWABLE ENERGY
Procurement Requirment

Boston Zoning Study



September 2020

architecture 2030

Renewable Energy Procurement Requirement

Boston Zoning Study (Revision 4)

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The City of Boston is considering renewable energy procurement as a requirement for the City. Buildings proposed to be constructed would be required to install on-site renewable energy and procure off-site renewable energy. The requirement is intended to offset building energy use and achieve zero-net carbon.

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Intent of the Renewable Energy Procurement Requirement

Residential and commercial buildings are responsible for about 39% of carbon emissions in the United States. About 12% results from the direct use of natural gas and other fossil fuels for heating while 28% results from electricity consumption.[1] In New England, each MWh of electricity generation results in 1,024 lb of carbon dioxide equivalent (CO_2e) emissions and each therm of gas combustion results in 19.97 lb of CO_2e emissions.[2] Building energy use and carbon emissions are tightly linked.

New buildings place an additional electric load on the grid and the renewable energy procurement requirement would requires that renewable energy be installed on-site and procured off-site to make up for this additional load. If new renewable energy production matches the additional load from a building, the carbon impact is close to zero. In effect, the renewable energy procurement requirement accelerates progress toward a clean electric grid by requiring or encouraging new renewable energy generating capacity over and above what the electric utilities or electric distribution companies are already required to do by their renewable portfolio standards (RPS).[3]

The amount of renewable energy required depends on the energy efficiency of the building, the more energy efficient the building, the less renewable energy is needed and the lower the renewable energy procurement requirement compliance cost. In the Boston zoning districts, all buildings must use the performance approach to achieve compliance with the locally enforced energy efficiency standards. Therefore, the renewable energy procurement requirement is determined from energy simulations. While less renewable energy is required when buildings are more energy efficient, all buildings must comply with the minimum energy efficiency standards adopted by Boston and the State of Massachusetts.[4] A building can never be less energy efficient than code minimum. No matter how much renewable energy is installed or procured, the building has to meet the minimum energy efficiency requirements.

The goal of the renewable energy procurement requirement is that renewable energy generators be installed to avoid the carbon emissions from conventional power plants. Additional renewable energy capacity is irrefutable when a PV system is installed on the building roof or building site along with construction of the building. However, this is not always the case with off-site procurement of renewable energy. The renewable energy procurement requirement sets minimum requirements for all off-site procurement options to address the type of off-site renewable energy generator, the length and durability of the contract and to assure that the RECs are retired on behalf of the building.

The concept of procurement factors is used to quantify other issues and risks associated with off-site procurement. On-site photovoltaic systems are assumed to have a procurement factor of one. Off-site procurement options are evaluated relative to on-site and assigned a procurement factor less than one to account for reduced impact, durability and other considerations. If 100 MWh of renewable energy production is procured and the procurement factor is 0.75, then only 75 MWh is counted toward compliance with the renewable energy procurement requirement.

Since buildings account for 39% of carbon dioxide emissions in the United States, the renewable energy procurement requirement can have a big impact on carbon emissions by requiring or encouraging new renewable energy generation when new buildings add electric load to the grid. This will avoid the emissions that would otherwise occur from conventional power generation. This is one of the most effective policy options available to local governments that want to move toward zero carbon emissions.

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1 These data are based on data from Lawrence Livermore National Laboratory, https://flowcharts.llnl.gov/commodities/carbon. Residential and commercial buildings are responsible for 75% of electricity use in the United States.

2 Carbon dioxide equivalent emissions include both methane and nitrous oxide based on their global warming potential over a 20-year time horizon. Calculations are by the author.

3 In states that do not yet have RPS requirements, the renewable energy procurement requirement adds renewable energy generators to avoid the source energy and carbon emissions from conventional generators.

4 The stretch code adopted for Boston requires that buildings larger than 100,000 ft^2 and shopping centers, laboratories and conditioned warehouses larger than 40,000 ft2 use the performance approach and show that the energy efficiency of the building is 10% better than Standard 90.1-2013, using the performance rating method from Appendix G. Residential buildings must be “solar ready” and include a dedicated space on the roof for collectors, pathways for plumbing or electrical lines and reserved space on the electric service.

Residual Electricity in New England

Massachusetts is part of ISO New England which also includes Connecticut, Maine, New Hampshire, Rhode Island, and Vermont. ISO New England acts as the balancing authority for the region. 2016 eGRID data from the United States EPA indicates that about half of electricity in New England was generated by natural gas with nuclear providing another 32% or so. These data are displayed in Figure 1. The average source energy conversion factor is 2.87[5] and the average emissions rate is 1,024 lb of CO_2e per MWh of electricity generated.[6]

Generation Source	
Coal	2.4%
Petroleum	0.6%
Natural Gas	49.8%
Nuclear	30.4%
Hydro	5.3%
Biomass	8.2%
Wind	2.5%
Solar	0.7%
Geothermal	0.0%
Other Fossil	0.1%
Unknown	0.1%

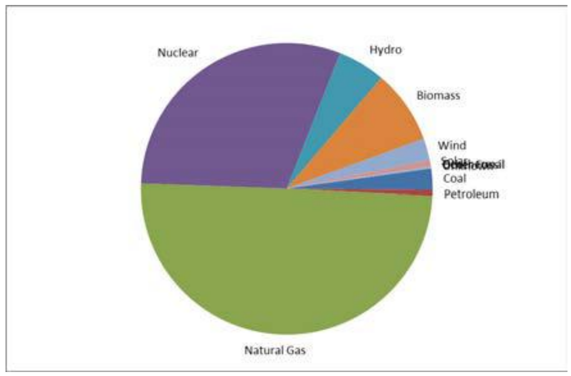

Figure 1 – Mix of Electricity Generation for the New England eGRID Subregion

Source: 2016 eGRID data for the NPCC New England subregion

Similar data is presented by ISO New England in Figure 2, which illustrates the change that occurred between 2008 and 2017. During this period, coal was practically eliminated as a fuel source for making electricity. Most of the decline in coal was made up with increases in natural gas, although wind grew to 3% of the electricity mix in 2017.

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5 The source energy conversion factor is the ratio of primary energy used to generate electricity to the electric energy delivered to customers. The 2.87 reported value is taken from work by the author on ASHRAE Standard 189.1 and assumes that the heat rate for non-combustible renewables is zero.

6 The CO_2e emission rates are taken from work by the author on ASHRAE Standard 189.1. These vary from the EPA figures for a several reasons: (1) They include all greenhouse gases, not just CO_2. (2) They include upstream emissions related to extraction, processing and delivery of fuels to the power plants, including methane leaks from gas pipes and distribution systems. (3) The data is based on a 20-year time horizon for global warming potential.

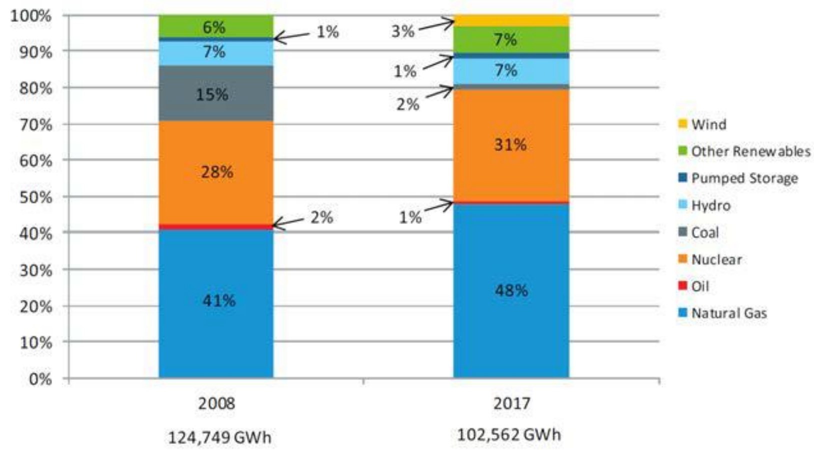

Figure 2 – ISO-NE Percentage energy generation by fuel type, 2008 compared with 2017

Source: 2017 ISO New England Electric Generator Air Emissions Report, ISO New England Inc., System Planning, April 2019, Figure 1-1

The mix of generation fuels is not constant. Figure 3 shows the monthly variation in 2017. While oil and coal use are minor on an annual basis, they are still used to some extent during the winter months. Hydro is also variable on an annual basis, with peak generation occurring in April and May and minimal generation in August and September. In 2017, the data indicate that one or more nuclear facilities were shut down for part of April and the difference was made up with additional natural gas use. Solar represents less than 1% of annual electric generation and this too is highly variable. Monthly production is strong April through October, but weak in the winter months. In regions with significant solar on the grid, there is more significant hourly variation especially on sunny days that coincide with mild temperatures.[7]

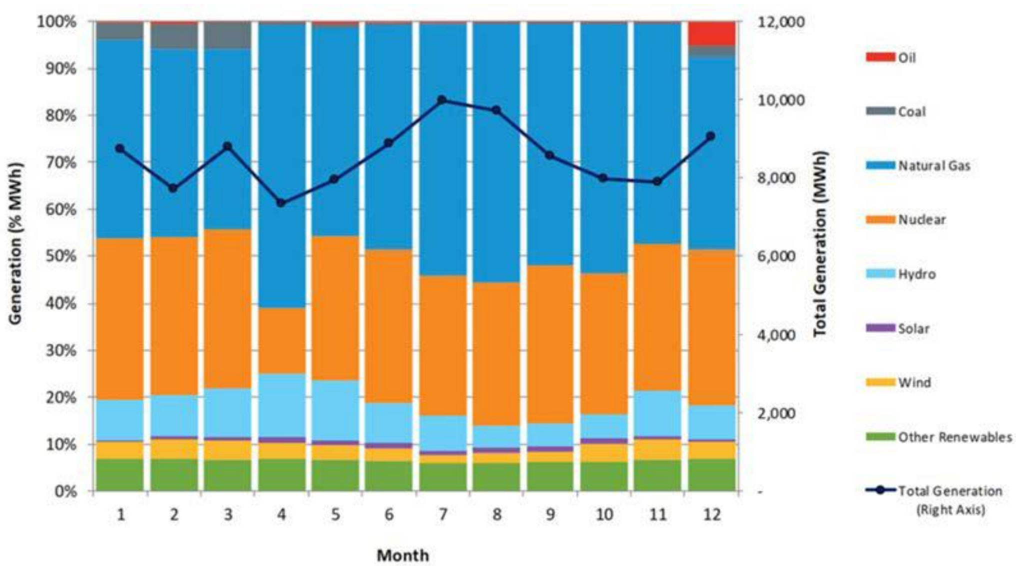

Figure 3 – ISO-NE Monthly Generation by Fuel Type – 2017

Source: 2017 ISO New England Electric Generator Air Emissions Report, ISO New England Inc., System Planning, April 2019, Figure 4-4.

7 California is a good example. Net load (that which must be met by dispatchable generators and excluding wind and solar) is very low in the middle of the day when the PV systems are producing and then ramps up steeply in the late afternoon and early evening. This change in hourly demand from year to year forms the infamous “duck curve”.

Massachusetts Policies and Programs

NEPOOL Generation Information System (GIS)

Generators feed electrons into the New England power grid. Residential, commercial and industrial customers draw electrons from the grid. The generators can be powered by coal, natural gas or oil which results in carbon emissions. Alternatively, the electricity generators can be powered by wind, water, solar, or other sources of renewable energy with zero or at least very small emissions. Once electrons enter the grid, they move according to the laws of physics following the path of least resistance, usually to the closest customer. Electrons generated by coal and solar are indistinguishable; electrons do not arrive with a label saying "I was created by solar".

Renewable energy certificates or RECs are used to keep track of the electricity produced by wind, solar and other renewable energy generators. A REC is created for each MWh of electricity generated by renewable energy. RECs can be bundled with the renewable energy (electricity) and sold as a package, or they can be sold separately (unbundled RECs). There are as many types of RECs as there are renewable energy generators, e.g. wind RECs, solar RECs, hydro RECs, etc. If a customer wants to make a claim that they use 100% renewable energy and they consume 100 MWh of electricity, they must purchase 100 RECs. If they want to be 100% solar, they would purchase 100 solar RECs or sRECs. Once a REC has been used to offset electricity consumption, it is retired. "Retirement means that the REC has been used and can no longer be sold.

If a building owner has solar on their roof and they sell the RECs, they can't claim the renewable energy benefits for themselves. The buyer of the RECs has that privilege. This is a common issue with most direct power purchase agreements (PPA). With a direct PPA, a solar system is installed on the customer's roof or parking lot, but it is owned by a third party who typically sells the RECs to the electric distribution company to improve the economic viability of the deal. In a case like this, the building owner is helping the electric distribution company meet its RPS requirement, but cannot claim that the building is using renewable energy. The Federal Trade Commission has advised that such a claim would be deceptive.[8]

NEPOOL GIS keeps track of RECs in New England as well as imported renewable energy from adjacent control areas. It makes sure that RECs are generated by eligible renewable energy generators and are used only once. For each REC, the GIS keeps track of the renewable energy generator that produced it, when the MWh of electricity was generated, who owns the REC, and whether it is active or retired. Other REC tracking organizations work in other parts of the country and provide a similar service.[9] REC tracking systems were first created to manage compliance with mandatory renewable portfolio standards (RPS) requirements, but they are also used to keep track of the sale and purchase of voluntary RECs.

Massachusetts and other New England states, require that electricity providers provide their customers with a disclosure statement that identifies how the electricity they are consuming is generated, e.g. how much came from natural gas, nuclear, solar, wind, etc. The NEPOOL GIS tracks all generation in New England, not just renewable energy and provides data to electricity providers to enable them to disclose this information to their customers.

REC Prices

RECs are a financial instrument and like other commodities, the price is a function of available supply and demand. Massachusetts Class I RECs must be produced by Class I generators. See Table 1. This limits the supply. Electric distribution companies must comply with the state RPS requirements by purchasing Class I RECs and a certain amount of these RECs (the solar carveout) must be from Class I solar

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8 The Federal Trade Commision (FTC) Part 260– Guides for the Use of Environmental Marketing Claims, Example 5, page 34.. See https://www.ftc.gov/sites/default/files/attachments/press-releases/ftc-issues-revised-green-guides/greenguides.pdf.

9 See for instance, Renewable Energy Certificate (REC) Tracking Systems: Costs & Verification Issues, Jenny Heeter, NREL, October 11, 2103, https://www.nrel.gov/docs/fy14osti/60640.pdf.

generators. The RPS requirement creates demand. For these reasons, the price of Massachusetts Class I RECs is significantly higher than non-Class I RECs. Figure 4 shows how the price has changed for the last decade. The price of Massachusetts RECs tracks very closely with those of Rhode Island, New Hampshire and Connecticut. Prices were $50/MWh and above between 2012 and 2016. Between 2016 and 2017, prices declined to about $20/MWh where they have remained after a low of about $5/MWh in late 2018.

The supply of solar RECs is more limited and Massachusetts and other New England bolsters demand through the requirement for a solar carveout. Figure 5 shows prices for the last decade. Since 2015, Class I solar RECs in Massachusetts have been selling between $300 and $400/MWh, many multiples higher than Class I RECs that are not limited to solar.

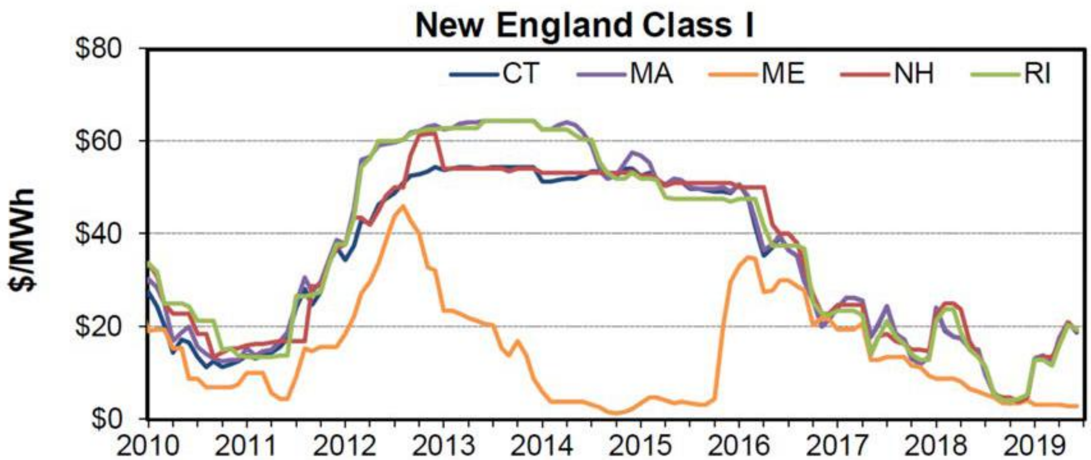


Figure 4 – Price of New England Class I RECs

Source: Galen Barbose, 2019 Annual Status Report, U.S. Renewables Portfolio Standards, July 2019, Berkeley Lab
Class I (Solar) consists of the SREC I, SREC II, and SMART programs; the targets for those programs are denominated in MW and translated here to the equivalent percentage of retail electricity sales.

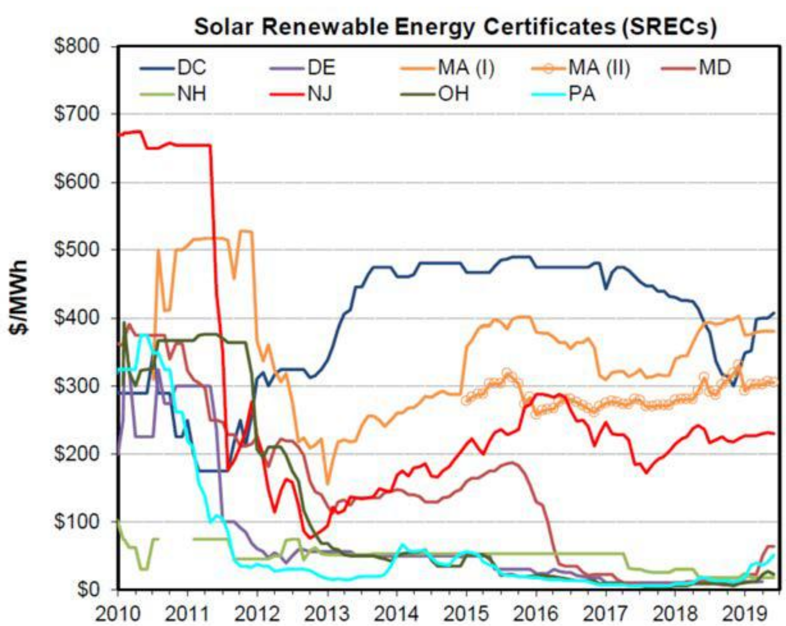


Figure 5 – Price of Solar RECs

Source: Galen Barbose, 2019 Annual Status Report, U.S. Renewables Portfolio Standards, July 2019, Berkeley Lab
Class I (Solar) consists of the SREC I, SREC II, and SMART programs; the targets for those programs are denominated in MW and translated here to the equivalent percentage of retail electricity sales.

Many states, including Massachusetts, have alternative compliance payments, which are penalties that regulated entities must pay if they fail to buy enough RECs to meet their mandated RPS target. Alternative compliance payments set a ceiling price on what eligible RECs would be able to command in compliance markets. In compliance markets, REC prices often hover just below the alternative compliance penalty. See Table 2 for the Massachusetts alternative compliance payments.

When RECs can be produced by any renewable energy generator anywhere in the United States, the price is significantly lower (see Figure 6). In late 2018, prices were around $0.70/MWh, almost 30 times cheaper than Massachusetts Class I RECs. Non-Class I or Class II RECs are commonly used by Massachusetts electricity providers when they offer 100% clean energy (see Table 4). Again, the price of unrestricted national RECs is low because of supply and demand. Wind farms in Texas and the Great Plains are cost effective without the additional revenue from selling RECs. This provides a plentiful supply of non-Class I or non-Class II RECs. More liquidity and supply allow for lower prices relative to current demand.[10]

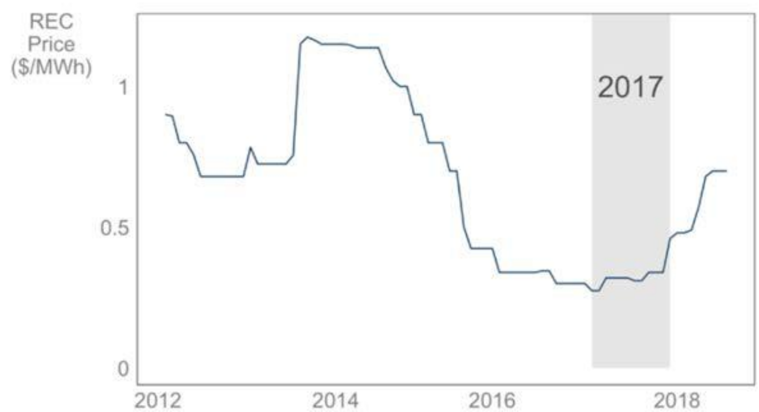


Figure 6 – Voluntary National REC prices, January 2012–August 2018

Source: Status and Trends in the U.S. Voluntary Green Power Market (2017 Data), Eric O'Shaughnessy, et. al. October 2018, NREL/TP-6A-72204

Massachusetts Renewable Portfolio Standards (RPS)

ISO New England serves as the balancing authority for the region and is responsible for assuring that the supply of electricity matches the demand for electricity on a near instantaneous basis. However, the Massachusetts renewable portfolio standards (RPS) require that electric distribution companies in the state purchase a minimum amount of renewable energy as a percent of sales. This energy is fed into the ISO New England grid and tracked through renewable energy certificates (RECs). For 2019, the Massachusetts renewable energy portfolio standards (RPS) require that electric distribution companies acquire renewable energy credits (RECs) to represent 14% of their electricity sales. The RECs must qualify as "Massachusetts Class I Compliance RECs"[11], but a carve-out also requires that about 6.2% of electric sales be offset by solar RECs. Table 1 summarizes the number and types of renewable energy generators that qualify for Massachusetts Class I RECs.

[10] A blog by Katy Kidwell of the Green Energy Consumers Alliance makes a strong case that not all RECs have the same impact. See https://blog.greenenergyconsumers.org/blog/class-i-recs.

[11] The requirements for Class I Generators are laid out in the Code of Massachusetts Regulations (225 CMR 14) and specify the type of generator, its location, when it was constructed and other requirements. It is worth noting that renewable energy generators that ISO New England counts as renewable energy may not qualify as Class I generators. In particular, biomass generators must document that the feedstock comes from forest thinnings, forest residues and other specifically defined sources. Also, legacy hydroelectric plants don't count toward the RPS requirements since the intent of the requirements is to encourage the construction of new renewable energy genrators. See also Synapse and Sustainable Energy Advantage, An Analysis of the Massachusetts Renewable Portfolio Standard, Prepared for the NECEC in Partnership with Mass Energy, May 2017.

Table 1 – RPS Class I Renewable Energy Generators

Source: RPS Class I Renewable Generation Units, Updated April 29, 2019. See file "Eligible Class I Renewable Units 091319.xlsx"

Row Labels	*Number of Generators*	*Nameplate Capacity (MW)*	*Average Size (MW)*
Anaerobic Digester	28	55	1.95
Biomass	6	2	0.32
Hydroelectric	43	367	8.53
Hydrokinetic	1	0	0.09
Landfill Gas	61	258	4.23
Photovoltaic	7,570	638	0.08
Tidal	1	1	0.90
Wind	123	4,188	34.05
Total	7,833	5,508	0.70

If a utility is short on renewable energy acquisition at the end of each RPS compliance period, the company makes an Alternative Compliance Payment (ACP) for the difference. The ACP moneys are invested by the Massachusetts Department of Energy Resources (DOER) in a combination of renewable energy and energy efficiency projects. These payments are shown in Table 2 and are approaching $70/MWh which is significantly more than the cost of non-solar Class I RECs. However, the cost of Class I solar RECs is just below the ACP.

Table 2 – Alternative Compliance Payment (ACP) Amounts

	2017 Rates ($/MWh)	*2018 Rates ($/MWh)*
RPS Class I	$67.70	$68.95
RPS Class I Solar Carve-Out	$448.00	$426.00
RPS Class I Solar Carve-Out II	$350.00	$350.00
RPS Class II Renewable Energy	$27.79	$28.30
RPS Class II Waste Energy	$11.12	$11.32
APS	$22.23	$22.64
Source: https://www.nepoolgis.com/2017/02/01/2017-acp-rates-for-massachusetts-rps-and-aps/		

The RPS requirement for various categories of renewable energy is shown in Figure 7 along with the total which will reach about 60% by 2050 if the goals are achieved. Eversource, the distribution company for Boston, acquires RECs through open solicitations.[12] The Massachusetts Department of Public Utilities requires that customers be provided with information on the source of electricity generation through a Disclosure Label.

[12] The following website is a typical RFP for the acquisition of RECs. See https://www.energysage.com/p/eversource/.

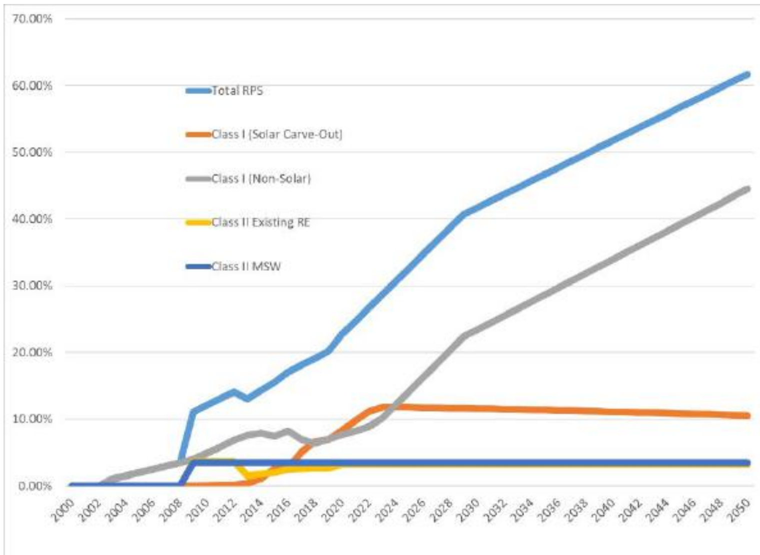


Figure 7 – Massachusetts RPS Percentage Targets

Source: Galen Barbose, 2019 Annual Status Report, U.S. Renewables Portfolio Standards, July 2019, Berkeley Lab
Class I (Solar) consists of the SREC I, SREC II, and SMART programs; the targets for those programs are denominated in MW and translated here to the equivalent percentage of retail electricity sales.

Massachusetts also has a Global Warming Solutions Act (GWSA) that works in combination with the RPS requirements. The requirement is for 16% clean electric power in 2018 but increases 2% annually to 80% in 2050. The Act sets a sector-wide, annually declining limit on aggregate CO_2 emissions from 21 large fossil fuel-fired power plants in Massachusetts, from 9.15 million metric tons of CO_2 in 2018 down to 1.8 million metric tons in 2050.[13]

Net Metering

A flexible net-metering program is available for building owners and developers in Massachusetts. With the program, customers are compensated for excess electric power that they generate.[14] However, there are restrictions on renewable energy construction: (1) some areas are not eligible for distributed generating facilities because of interconnection issues,[15] (2) systems must meet minimum requirements set by the distribution company (Eversource),[16] and (3) the total capacity of net-metering accounts is capped at a percentage of the "highest historical peak load, which is the most electricity consumed by the electric company's customers at any one time".[17] However, smaller projects are exempt from the cap. These include single-phase systems less than 10 kW (residential and small building scale) and three-

[13] See https://www.mass.gov/guides/clean-energy-standard-310-cmr-775. See also https://www.mass.gov/files/documents/2018/09/26/3dfs-electricity.pdf for a more detailed explanation.

[14] https://www.mass.gov/guides/net-metering-guide is an excellent summary. The Schedule Z is filed with the distribution company (Eversource).

[15] Problem areas within the service territory are called the "Area Network", where interconnections are not permitted because of "challenges for interconnection to a solar PV system". The Area Network includes portions of Boston, Cambridge and New Bedford and the neighborhoods of Beacon Hill, Back Bay, Chinatown, Downtown, Fenway area (certain areas), Financial District, North End, South End (certain areas), Theater District, and the West End. See https://www.eversource.com/content/docs/default-source/builders-contractors/boston-area-solar.pdf for more information. There are no maps or detailed descriptions of the "Area Network" for security reasons, but Eversource will provide information to individual property owners when asked.

[16] See "Standards for Interconnection of Distributed Generation", https://www.eversource.com/Content/docs/default-source/rates-tariffs/162.pdf?sfvrsn=6. Sometimes there may be a charge for upgrading the grid when this is needed to accommodate a PV system.

[17] See http://www.massaca.org/general-net-metering.asp.

phase systems less than 25 kW. Larger systems must file an Application for a Cap Allocation (ACA) with the System of Assurance of Net Metering Eligibility, which is part of the Massachusetts Department of Public Utilities (DPU). Exported energy for exempt systems is credited at retail rates, however larger systems that need a cap allowance are credited at 60% of the retail rate.

As of December 2019, the NStar (Eversource) net-metering cap is 348,460 kW; 243,273 kW is already interconnected; 24,087 kW has been allocated but not yet interconnected; and 651 kW is pending. The remaining capacity available under the cap is 80,449 kW or about 23%. National Grid, WMECO and Unitil have a waiting list for interconnections.[18] These allocations apply to private systems. Separate allowances apply to public systems and capacity if available except for the areas served by National Grid.

Solar Massachusetts Renewable Target (SMART) Program

Massachusetts recently introduced the SMART Program, which is a feed-in tariff program to encourage the construction of solar systems. The program compensates renewable energy developers for energy that they feed into the grid at a rate higher than retail rates. The program is structured in declining tiers. As more solar is installed, the compensation rate declines. However, *the RECs do not accrue to the owner of the system*. Renewable energy developers must sign an agreement that assigns the RECs to Eversource (in the case of Boston). The SMART program helps Eversource and the other distribution companies in Massachusetts achieve their RPS requirements, but it *does not result in the construction of additional renewable energy over what the RPS program is already requiring*.

Retail Competition

Massachusetts along with 18 other states (see Table 3) has retail competition for electricity. In these states, deregulation has made the electric transmission and distribution systems open to suppliers other than the distribution company. Electricity customers in Massachusetts can choose their own electricity provider, instead of using the default rate of their local distribution company, Eversource in the case of Boston. As of December 2019, 23 companies were offering electricity to retail customers (see Table 4). Many of these companies offer 100% renewable energy. Virtually all of these companies make this offer through the purchase of wind RECs from out of the region, as opposed to Class I RECs that are needed for compliance with the Massachusetts RPS requirements.

Table 3 – States with Electricity Retail Competition

Source: Electric Choice, https://www.electricchoice.com/map-deregulated-energy-markets/

State	*Year*	*State*	*Year*	*State*	*Year*
California[1]	N/A	**Massachusetts**	1998	Oregon	1997
Connecticut	1998	Michigan	1998	Pennsylvania	1996
Delaware	1999	New Hampshire	1998	Rhode Island	1996
Illinois	1997	New Jersey	1999	Texas[2]	2002
Maine	2000	New York	1997	Virginia[3]	2007
Maryland	1999	Ohio	1996	Washington DC	2001

Notes:
1 California's electric choice works on a very limited lottery system called DirectAccess.
2 Electricity deregulation is available to 85% of Texans.
3 Electricity choice programs are limited for residential consumers.

[18] See https://app.massaca.org/allocationreport/report.aspx? for more detail.

Table 4 – Electricity Providers in Eversource Distribution Network

Source: Energy Switch Massachusetts Website, December 10, 2019, Residential Customer Class

	Estimated Monthly Cost (Residential)			
Provider	*100% Renewables*	*Standard Offering*	*Difference*	*Cost ($/kWh)*
Ambit Energy	87.00	81.75	5.25	0.009
CleanChoice Energy	76.80			
Constellation New Energy	77.34	70.74	6.60	0.011
Direct Energy Services	74.64			
Discount Power	77.73			
Eligo Energy MA	84.24	83.04	1.20	0.002
Energy Rewards		71.34		
Green Mountain Energy	82.20			
IGS Energy[1]	76.74	77.34	(0.60)	(0.001)
Indra Energy MA	97.40	96.00	1.40	0.002
Just Energy Massachusetts		74.64		
Liberty Power Holdings	67.73	64.73	3.00	0.005
Massachusetts Gas & Electric		76.74		
NRG Home		85.20		
NSTAR d/b/a Eversource Energy		73.57		
Residents Energy		66.18		
SFE Energy Massachusetts		87.85		
SmartEnergy	83.40			
Starion Energy	66.24	64.44	1.80	0.003
Sunwave Gas & Power		79.08		
Think Energy	75.00			
Town Square Energy	83.82	65.52	18.30	0.031
Verde Energy USA	80.94			
Average from Above	77.80	75.79	4.62	0.008

Notes

1 The 100% renewable rate for IGS Energy requires a 36-month contract term while the standard offering has a 12-month contract term.

2. GreenEnergyConsumers.org is not listed on the Energy Switch website. This organization offers green electricity backed by Massachusetts Class I wind RECs. The cost premium reported on the website is $0.038/kWh ($38/MWh or REC). See http://greenenergyconsumers.org/greenpowered/howswitchingworks#mix.

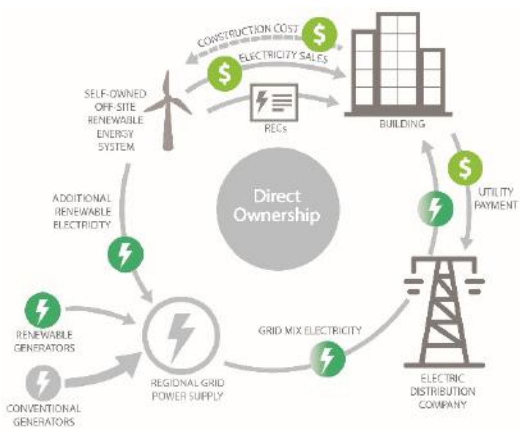
Off-Site Procurement Options

The renewable energy procurement requirement can recognize several methods for off-site procurement of renewable energy. Information from the ZERO Code technical support document[19] is included here along with information specific to Boston and Massachusetts. A listing of these options and their applicability in Boston is reviewed in the following table. More detail is provided in the sections that follow.

Table 5 – Boston Off-site Renewable Energy Procurement Options

Procurement Option	*Application to Boston*
Self-Owned Off-site	The Massachusetts net-metering rules support this option. An Eversource customer (host) can allocate excess power generation to other electric accounts (beneficiaries) and the credit shows up on the electric bill of the beneficiary. However, for non-exempt systems, the monetary compensation to utility bills is 60% of the retail rate. However, 100% of the RECs can be assigned.
Community Solar	Limited community solar or community renewable programs are available in Boston
Virtual Power Purchase Agreement	This option is available to large, credit-worthy building owners. The minimum virtual PPA deal is generally 5 MW for solar and 10 MW for wind. No known contracts exist with Boston companies.
Unbundled RECs	RECs may be purchased by building owners in the open market. Massachusetts Class I Compliance RECs come with a premium while unrestricted national RECs are available at a much lower price.
Green Pricing	Massachusetts has retail competition and many electricity providers offer 100% renewable energy which is generally achieved through the purchase of non-Class I or non-Class II RECs. See Table 4.
Utility Renewable Energy Contracts	Large customers are able to negotiate with the electric distribution company to supply them with renewable energy through special tariffs or bilateral contracts. No known contracts exist with Boston companies.
Renewable Energy Investment Fund	No REIF program exists at the present time, but the City of Boston is considering such a program with a parallel structure to its low-income housing program.

Self-Owned Off-Site



Graphics © EskewDumezRipple. Adapted by Architecture 2030.

With self-owned off-site or direct ownership, the complying building developer/owner installs a renewable energy system on a *separate parcel of land* from the complying building. The complying building would draw power from the grid while the off-site renewable energy system would deliver power to the grid. The Massachusetts virtual net-metering program allows some or all of the electricity and RECs to be assigned to the electricity account of the complying building.[20] Renewable energy production is credited to the electricity account(s) as if the renewable energy system were located on-site. Larger renewable energy systems might serve portfolios of buildings or campuses.

Virtual net-metering may also be used in Massachusetts for *on-site* renewable energy systems. An example is an apartment or condominium building where each dwelling unit has a separate electricity account. A shopping center with a common renewable energy system serving multiple stores is another example. The Standard 189.1 definition of on-site renewable energy

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[19] ZERO Code Off-Site Procurement of Renewable Energy, Technical Support Document, April 2018. The document can be downloaded from www.zero-code.org.

[20] The Massachusetts net metering program allows production from an off-site system to be assigned to one or more electricity accounts through the filing of a Schedule Z with the distribution company. California has a much more limited program available only to local governments and school districts which is called the renewable energy self-generation bill credit transfer (RES-BCT).

systems is used for the purpose of defining an on-site renewable energy system.[21] "On-site" means that the system is located on any of the following:

- the building,
- the property upon which the building is located,
- a property that shares a boundary with and is under the same ownership or control as the property on which the building is located, or
- a property that is under the same ownership or control as the property on which the building is located and is separated only by a public right-of-way on which the building is located.

In states like Massachusetts with virtual net-metering programs, keeping track of electricity production and assigning it to specific buildings can handled by the local distribution company. The credit shows up on the bill of the beneficiary account as if the renewable energy system were on-site and behind the meter. The cost credit is 100% for exempt systems but 60% of retail rates for large non-exempt systems. While cost is credited at 60% for non-exempt systems, RECs may be credited at 100%. The owner/operator of the renewable energy system files a Schedule Z with the distribution company (Eversource) which names the electric accounts that are to receive a share of the production. The Schedule Z can be filed twice a year.

A forward contract[22] can be used to assure that electricity and RECs are assigned to the building for a minimum period of time (15 years). This is needed in the event that the off-site renewable energy system is sold separately from the complying building and to assure that the RECs are assigned to the complying building for a minimum of 15 years.

Since owning and operating a renewable energy plant is generally not a core competency of most businesses or institutions, many organizations will delegate responsibility for construction and operation to others, especially for large systems.[23]

Cost Considerations

The initial (or overnight costs) for utility scale solar PV systems is estimated to be $1,060/kW of installed capacity.[24] The cost estimate for smaller building scale systems is higher at $1,800/kW of capacity.[25] An investment in solar PV buys the owner both electricity which can be sold into the market or used to reduce the electric bill of a particular building and the environmental benefits or RECs which are needed for renewable energy procurement requirement compliance. The electricity that arrives at a building is valued the same whether it was generated by solar or a conventional fossil fuel generator. The difference is the environmental benefits. The cost differential between solar PV system and a conventional generator is a reasonable estimate of the cost to the building owner of installing solar, either on-site or off-site.

Complying buildings are new construction which results in additional load on the grid. The cost differential can be estimated by comparing the total cost of generating a unit amount of electricity from solar PV, which is the most likely renewable energy system to be used for renewable energy procurement compliance to the total cost of generating the same amount of electricity with a conventional gas generator. The cost difference represents the premium that a building owner would pay and also is a reasonable estimate for the value of the associated environmental benefits.

Different types of electric generators can be compared in terms of their levelized cost of electricity (LCOE). LCOE accounts for all costs, including the capital cost or initial cost of building the generator,

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[21] See Addendum AM to Standard 189.1-2017 (to be published in Standard 189.1-2020).

[22] A forward contract is an agreement to buy specified assets at a given price in the future.

[23] For example, Stanford University contracts with a solar services provider to construct and manage an off-site renewable energy system that offsets power used at the Palo Alto campus.

[24] The cost estimate is for non-tracking (fixed) systems. See https://www.nrel.gov/docs/fy19osti/72399.pdf..

[25] The cost estimate is for non-tracking (fixed) systems. See "Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2019" (PDF). U.S. Energy Information Administration. 2019. Retrieved 2019-05-10.

maintenance and operation costs that occur over the life of the generator, the cost of upgrading the transmission system, annual fuel costs (for fossil fuel generators) and more. These costs which occur in increments over the life of the system are translated into equivalent annualized costs using appropriate fuel prices, fuel escalation rates, discount rate, and system life.

These annualized costs are then divided by the annualized electricity production which accounts for the peak generating capacity and the capacity factor, which is the percent of the time that the generator is expected to operate at full load. The capacity factor for solar is low, on the order of 30%. Wind is 40% to 45%. Combined cycle gas generators are 87% as they are used primarily for baseload while conventional gas combustion turbines are 30% since they are used mostly for reserve and peak loads. The U.S. Energy Information Agency and others have developed procedures for calculating the LCOE of various types of electric generators. The latest data from the EIA are shown in Table 6.

An advanced combined-cycle gas plant (Advanced CC) has the lowest LCOE among conventional dispatchable generators with a cost of $41.2/MWh. More than 75% of the LCOE is fuel. The LCOE of solar PV is $60.0/MWh, but this is reduced to $45.70/MWh when tax credits are factored in. Most of the LCOE for solar PV is capital cost with fuel being zero. The incremental cost of solar PV over advanced combined-cycle gas is in the range of $4.5/MWh to $18.8/MWh, depending on whether or not tax credits are considered. Without tax credits, the $18.8/MWh estimate is in the same range as the current price for Massachusetts Class I RECs which are currently selling for about $20/MWh.

The LCOE data in Table 6 are based on large utility-scale solar PV systems which cost less to build than smaller building-level systems. Based on the initial cost figures cited earlier, the capital cost increase for small systems is in the range of 70%.[26] EIA publishes the range in LCOE, which is presented in Table 7. From Table 7, the maximum LCOE for solar PV is 78% higher than the simple average without tax credits and 74% with tax credits. However, the LCOE maximum for advanced combined-cycle gas is only 17% higher. Working with the maximum LCOE values for solar PV and combined-cycle gas plants from Table 7, the LCOE increment is $58.8/MWh with no tax credits and $31.4/MWh when tax credits are considered. These values are more reasonable for building level systems where the initial construction costs are higher.

The LCOE analysis does not factor in the impact of net metering and virtual net metering. These programs compensate building owners at retail rates, or in the case of non-exempt systems 60% of the retail rate.

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[26] This is based on $1,800/kW for small systems and $1,060/kW for utility-scale systems.

Table 6 – Simple Average LCOE for New Generation Plants Entering Service in 2023 ($/MWh)

Source: U.S. Energy Information Agency, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2019, February 2019, Table 1b.

Plant type	*Capacity factor (%)*	*Levelized capital cost*	*Levelized fixed O&M*	*Levelized variable O&M (Fuel)*	*Levelized transmission on cost*	*Total system LCOE*	*Levelized tax credit*[1]	*Total LCOE including tax credit*
Dispatchable technologies								
Coal with 30% CCS[2]	85	61.3	9.7	32.2	1.1	104.3	NA	104.3
Coal with 90% CCS[2]	85	50.2	11.2	36.0	1.1	98.6	NA	98.6
Conventional CC	87	9.3	1.5	34.4	1.1	46.3	NA	46.3
Advanced CC	87	7.3	1.4	31.5	1.1	41.2	NA	41.2
Advanced CC with CCS	87	19.4	4.5	42.5	1.1	67.5	NA	67.5
Conventional CT	30	28.7	6.9	50.5	3.2	89.3	NA	89.3
Advanced CT	30	17.6	2.7	54.2	3.2	77.7	NA	77.7
Advanced nuclear	90	53.8	13.1	9.5	1.0	77.5	NA	77.5
Geothermal	90	26.7	12.9	0.0	1.4	41.0	-2.7	38.3
Biomass	83	36.3	15.7	39.0	1.2	92.2	NA	92.2
Non-dispatchable								
Wind, onshore	41	39.8	13.7	0.0	2.5	55.9	-6.1	49.8
Wind, offshore	45	107.7	20.3	0.0	2.3	130.4	-12.9	117.5
Solar PV[3]	29	47.8	8.9	0.0	3.4	60.0	-14.3	45.7
Solar thermal	25	119.6	33.3	0.0	4.2	157.1	-35.9	121.2
Hydroelectric[4]	75	29.9	6.2	1.4	1.6	39.1	NA	39.1

1 The tax credit component is based on targeted federal tax credits such as the PTC or ITC available for some technologies. It reflects tax credits available only for plants entering service in 2023 and the substantial phase out of both the PTC and ITC as scheduled under current law. Technologies not eligible for PTC or ITC are indicated as NA or not available. The results are based on a regional model, and state or local incentives are not included in LCOE calculations. See text box on page 2 for details on how the tax credits are represented in the model.

2 Because the New Source Performance Standard (NSPS) under Section 111(b) of the Clean Air Act requires conventional coal plants to be built with CCS to meet specific CO2 emission standards, EIA modeled two levels of CCS removal: 30%, which meets the NSPS, and 90%, which exceeds the NSPS but may be seen as a build option in some scenarios. The coal plant with 30% CCS is assumed to incur a three-percentage-point increase to its cost of capital to represent the risk associated with higher emissions.

3 Costs are expressed in terms of net AC power available to the grid for the installed capacity.

4 As modeled, EIA assumes that hydroelectric generation has seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.

CCS=carbon capture and sequestration. CC=combined-cycle (natural gas). CT=combustion turbine. PV=photovoltaic.

Table 7 – Range in LCOE for New Generation Plants Entering Service in 2023

Source: U.S. Energy Information Agency, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2019, February 2019, Table 2.

	Without tax credits				*With tax credits*[1]			
Plant Type	*Minimum*	*Simple Average*	*Capacity-Weighted Average*[2]	*Maximum*	*Minimum*	*Simple Average*	*Capacity-Weighted Average*[2]	*Maximum*
Dispatchable technologies								
Coal with 30% CCS[3]	93.7	104.3	NB	124.7	93.7	104.3	NB	124.7
Coal with 90% CCS[3]	89.0	98.6	NB	109.8	89.0	98.6	NB	109.8
Conventional CC	42.4	46.3	42.8	55.0	42.4	46.3	42.8	55.0
Advanced CC	37.8	41.2	40.2	48.1	37.8	41.2	40.2	48.1
Advanced CC with CCS	55.6	67.5	NB	75.7	55.6	67.5	NB	75.7
Conventional CT	84.1	89.3	NB	100.1	84.1	89.3	NB	100.1
Advanced CT	71.1	77.7	77.5	86.7	71.1	77.7	77.5	86.7
Advanced nuclear	75.1	77.5	NB	81.2	75.1	77.5	NB	81.2
Geothermal	38.2	41.0	39.4	46.5	35.9	38.3	36.9	43.1
Biomass	83.1	92.2	92.1	114.1	83.1	92.2	92.1	114.1
Non-dispatchable technologies								
Wind, onshore	38.9	55.9	42.8	72.9	32.8	49.8	36.6	66.8
Wind, offshore	115.5	130.4	117.9	158.8	104.0	117.5	106.5	142.6
Solar PV[4]	40.3	60.0	48.8	106.9	31.5	45.7	37.6	79.5
Solar thermal	138.2	157.1	NB	178.7	107.3	121.2	NB	138.2
Hydroelectric[5]	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1

1 Levelized cost with tax credits reflects tax credits available for plants entering service in 2023. See note 1 in Tables 1a and 1b.

2 The capacity-weighted average is the average levelized cost per technology, weighted by the new capacity coming online in each region. The capacity additions for each region are based on additions from 2021–2023. Technologies for which capacity additions are not expected do not have a capacity-weighted average and are marked as NB or not built.

3 Because the New Source Performance Standard (NSPS) under Section 111(b) of the Clean Air Act requires conventional coal plants to be built with CCS to meet specific CO2 emission standards, EIA modeled two levels of CCS removal: 30%, which meets the NSPS, and 90%, which exceeds the NSPS but may be seen as a build option in some scenarios. The coal plant with 30% CCS is assumed to incur a three-percentage-point increase to its cost of capital to represent the risk associated with higher emissions.

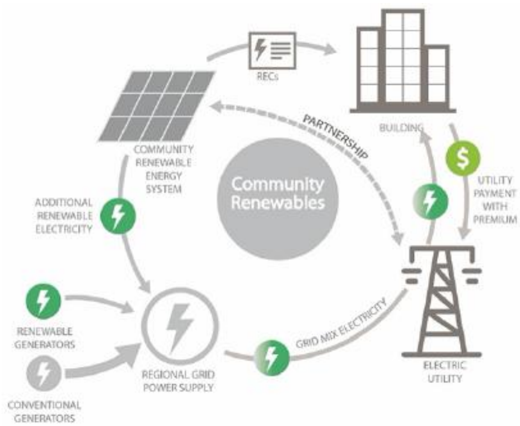
4 Costs are expressed in terms of net AC power available to the grid for the installed capacity.

5 As modeled, EIA assumes that hydroelectric generation has seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.

CCS=carbon capture and sequestration. CC=combined-cycle (natural gas). CT=combustion turbine. PV=photovoltaic.

Note: EIA calculated the levelized costs for non-dispatchable technologies based on the capacity factor for the marginal site modeled in each region, which can vary significantly by region. The capacity factor ranges for these technologies are 37%–46% for onshore wind, 41%–50% for offshore wind, 22%–34% for solar PV, 21%–26% for solar thermal, 76% for hydroelectric. The levelized costs are also affected by regional variations in construction labor rates and capital costs as well as resource availability.

Community Solar



Graphics © EskewDumezRipple. Adapted by Architecture 2030.

With community solar (or wind), a renewable energy developer constructs a renewable energy system and offers capacity to individual building owners or energy users. It works similar to virtual net-metering in that electricity production is credited to the complying building's electric account. When available, community solar is an attractive option for small businesses and residential customers that have a moderate load, but can't install on-site renewable energy because of shading or other limitations. The local utility is often a partner with the renewable energy developer, but in Massachusetts, the virtual net-metering rules make this less of a necessity.

There are two participation models for community solar: long-term and short-term. With the long-term model, the building owner/developer purchases or leases enough capacity to offset building energy. The short-term participation model is much more akin to a green pricing program and typically allows the complying building manager to opt out of the agreement on short notice.[27]

While "community solar" or "solar gardens" are the common terms used to describe these programs, most enabling legislation allows other sources of renewable energy, in particular, wind. An advantage of solar is its scalability, in that a portion of the capacity can be easily assigned to each program participant by allocating a number of panels to a particular property. Similar accounting can still be done with wind, but the process is less transparent since most turbines are very large and an individual building would only need a portion of its capacity.

To qualify for renewable energy procurement requirement, the RECs and other environmental attributes associated with the renewable energy capacity must be assigned to the complying building. However, this essential requirement is not satisfied by most community solar systems since most programs keep the RECs and sell them in order to improve the financial viability of the program.[28] Without the RECs, someone else owns the rights to the environmental benefits.

According to the Solar Energy Industries Association (SEIA), 40 states have at least one community solar program on-line, 19 states and D.C. have programs and policies to encourage community solar, and the market is expected to increase by 3.5 gigawatts in the next five years.[29] According to EnergySage, the top states are Minnesota with 120 MW of installed capacity, Colorado with 30 MW, and Massachusetts with 70 MW.[30] Some of the community solar programs operating in Massachusetts are listed in Table 8 along with links to their website.

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[27] Since solar production is seasonal, most programs require at least a year of participation to include both the cloudy and sunny months.

[28] The United States Department of Energy published "A Guide to Community Solar: Utility, Private, and Non-profit Project Development", November 2010. The guide was developed for the National Renewable Energy Lab by Northwest Sustainable Energy for Economic Development, Keyes and Fox, Stoel Rives, and the Bonneville Environmental Foundation. See NREL document 49930. This document provides guidance to organizations what want to set up community solar systems and has examples of programs circa 2010. *Virtually all of the programs cited as examples do not transfer the RECs to the program participants.*

[29] See https://seia.org/initiatives/community-solar.

[30] See https://news.energysage.com/comparing-top-community-solar-states-minnesota-california-massachusetts-colorado/.

Table 8 – Community Solar Programs in Massachusetts

Source: https://www.solar-estimate.org/news/community-solar-massachusetts

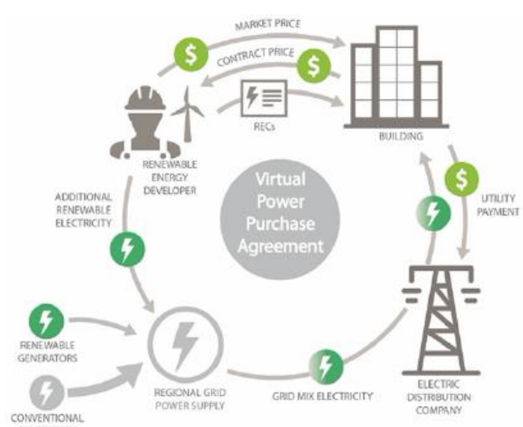
Energy Company	*Community Solar Program*
Clearway Energy Group	Clearway Community Solar (formerly NRG Community Solar)
CleanChoice Energy	CleanChoice Energy Community Solar
Clean Energy Collective	Roofless Solar
CVE North America	Halo Solar
BlueWave Solar	BlueWave Community Solar

Community solar in Massachusetts is made available through the virtual net-metering rules, discussed above. In part because of these rules, there is some confusion as to what constitutes a community solar system. A database developed by NREL, lists 206 community solar programs in Massachusetts with a total capacity of 254 MW.[31] Many of these seem to be private systems that use virtual net metering to assign electricity production and possibly RECs to separate properties, in many cases condominiums.

As noted earlier, most community solar programs don't quality for the renewable energy procurement requirement, because the RECs are typically retained by the electric distribution company or sold to the electric distribution company as a means to comply with state-mandated RPS requirements. Sometimes the RECs are sold separately in the open market. However, there are a few instances when community solar RECs are transferred to the customer. The SolarShare program by Sacramento Municipal Utility District (SMUD) was revised recently so that RECs are provided to the customer. Xcel Energy's Community Solar Garden program in Minnesota allows third party solar project operators to either retire the RECs on behalf of their customers or sell them to the utility for $20 to $30 per MWh.[32]

Community solar is similar in many ways to self-owned off-site systems. In both cases, a single renewable energy system can serve multiple buildings or customers and there is a direct credit to the electricity account. The difference is that self-owned off-site systems are *private* while community solar systems are open to the *public* and generally owned by a third party or in some cases the utility.

Virtual Power Purchase Agreements (vPPA)



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Direct (or physical) power purchase agreements are a common way to finance and install on-site photovoltaic (PV) systems. Energy service providers install, own and operate the PV system which is located on a building owner's property. The building owner agrees to purchase power from the system for the term of the contract, usually 15 to 20 years according to a schedule of prices agreed to in the contract. The PV developer (or energy service provider) bears the cost and risks associated with construction and operation. The building owner agrees to buy the renewable power for the contract term, but often does not get to claim the environmental benefits since many contracts assign RECs to the seller.

Virtual (or financial) power purchase agreements (PPAs) are a similar arrangement, except that the renewable energy system is not located on the building owner's property. Instead it is located in farm land, pastures, or rural land owned or leased by the renewable energy developer. While direct PPAs are almost exclusively PV systems, virtual PPAs often include wind or even geothermal energy. Virtual PPAs are the financial

[31] A publicly available community solar project list is available at https://data.nrel.gov/submissions/114.

[32] The Role of Renewable Energy Certificates in Community Solar, Andrea Romano, January 12, 2016, See https://www.navigantresearch.com/news-and-views/the-role-of-renewable-energy-certificates-in-community-solar.

instrument most commonly used by Google, Amazon and other large companies to acquire renewable energy to offset their operations. The buyer (customer) agrees to buy power from the system at a specified price schedule and period of time. In this way, they hedge price fluctuations of the energy market and assume more predictable utility expenses. If prices go up, they benefit; however, if prices go down, they end up paying more. These agreements are often called a “contract of differences”.

With virtual PPAs, the RECs and environmental benefits are always assigned to the buyer, so they qualify for the renewable energy procurement requirement. The Rocky Mountain Institute Business Renewables Center developed a Term Sheet for negotiating virtual PPAs and this document makes it clear that the RECs and environmental benefits are assigned to the buyer, in contrast to the typical direct PPA. Since one of the motivations for companies like Google to enter into virtual PPAs is to claim the environmental benefits, having the RECs assigned to them is essential.

Scalability is a challenge with virtual PPAs. The minimum size for solar virtual PPAs is about 5 MW and the minimum size for wind PPAs is about 10 MW.[33] A 5 MW solar system would power approximately one million ft² of office space. Also, the counterparty to the renewable energy developer must have an excellent credit rating. The minimum renewable energy system sizes and need for credit worthiness make virtual PPAs an unlikely option for small developers or building owners. However, governmental entities or utilities could serve as the counterparty and sell or allocate shares to individual building owners, a process known as aggregation. In 2018, there were only about 275 virtual PPAs negotiated in the United States for a total of 23.5 million MWh. The average size of the deal was about 85,000 MWh.[34]

Proximity is a potential issue with virtual PPAs. Sometimes the location of the renewable energy system is located in a separate electric grid thousands of miles from the electric load it is offsetting. Many buyers of virtual PPAs prefer to enter agreements with renewable energy systems located close to their facilities or at least in the same electric grid or market.

Another issue is that virtual PPAs are an agreement between an organization (often a corporation) and a renewable energy developer. They are not associated with a particular complying building. This creates an accounting and record keeping challenge. Transparent documentation is needed to assure that an adequate portion of the environmental benefits from the vPPA are assigned to the complying building for a minimum period of time and are not double counted. Tying the PPA to a particular building could be a challenge for virtual PPAs, since the renewable energy developer is making a deal with a creditworthy counterparty for the duration of the contract. Developers would be leery of a deal where the counterparty might change when the building is sold.

In traditional (vertically organized) electricity markets where the utility owns generation, transmission and distribution, the utility will sometimes serve as the broker for virtual PPAs between renewable energy developers and their large customers.[35] This option is discussed below under utility renewable energy contracts.

Cost Considerations

The cost of the vPPA to the buyer depends on the terms of the contract and the future sales prices for renewable electricity in the market where the renewable energy system is located. With a virtual PPA, the buyer guarantees the renewable energy developer a minimum wholesale price for the electricity they sell into the market. This is the strike price. If the developer is able to sell at a price higher than the strike, the buyer benefits and receives the difference from the developer. If the developer sells at a price lower than the strike price, the vPPA buyer makes up the difference through a payment to the developer. Because of this feature, vPPAs are often called a “contract of differences”. The actual electricity that the buyer

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33 Per Blaine Collinson.

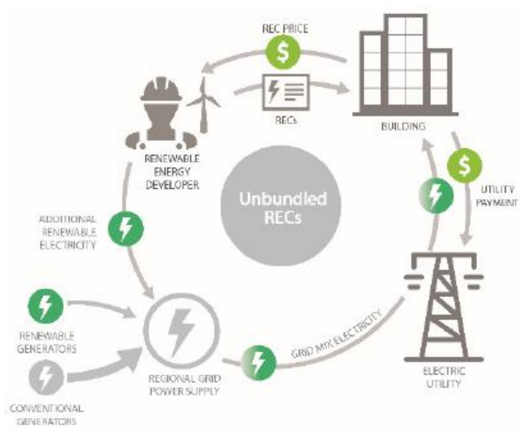
34 Status and Trends in the Voluntary Market (2018 data), Jenny Heeter, slides presented in September 2019 at the Renewable Energy Markets Conference in San Diego. NREL Document 74862.pdf.

35 See Lori Bird, et. al., Policies for Enabling Corporate Sourcing of Renewable Energy Internationally, A 21st Century Power Partnership Report, NREL/TP-6A50-68149, May 2017

receives at the facility is disconnected from the electricity generated by the counterparty in the vPPA, although it is usually the goal of the buyer to match the two.[36]

Cost data is not known for vPPAs, but in this case, program participants would still need to buy their electricity through a competitive supplier or EverSource. It is probably reasonable to assume a cost similar to green pricing programs which are in the range of $33 to $38 per MWh.

Unbundled RECs



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Renewable energy certificates (RECs) represent the environmental attributes or benefits associated with renewable energy. With vPPAs and some community solar programs, RECs are used for tracking and verification of the renewable energy purchased, however, RECs can be separated from the underlying renewable energy they are associated with and sold into the open market, typically in increments of one MWh.

The concept of RECs is international, but the term used varies in other countries. REC is used in the United States, Australia, India and other places. A variation is called an I-REC (the "I" standing for international). Europe uses the term Guarantees of Origin (GOs), Mexico uses the term Certificados de Energia Limpia (CELs), and the term Tradable Instruments for Global Renewables (TIGRs) is used in other areas. In some countries more than one designation is used.

RECs can be categorized in a number of ways according to the source of renewable energy (*type*), when the renewable energy was generated (*vintage*), where it was generated (*geography*), and when the generator was constructed (*age*). To approximate the benefit of on-site renewable energy, the source of the renewable energy should be new wind, solar or geothermal generators; production should occur in the same period of time of the building energy that is being offset, and the generator should be new and located in the same geographic area and electric grid of the complying building. As noted earlier, Massachusetts Class I RECs are for wind, solar and other specific generators built since 1998 and located in the New England area. The market sets a higher price for RECs when more conditions or restrictions apply.

The purchase of unbundled RECs is perhaps the most flexible method of procuring off-site renewable energy. This option is discussed in the Massachusetts context in the July 11, 2018 report by BR+A Engineers. BR+A recommends the use of "Class 1 Compliance RECs", as defined by the Massachusetts RPS rules or equivalent RECs from other states in the ISO New England area, which includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.[37] The report estimates $9/MWh as the "reasonable REC cost assumption" but Class I RECs are now selling closer to $20 (see Figure 4). This price is significantly higher than RECs with no geographic or generation source restrictions (see Figure 6).

Unbundled RECs represent the largest share of renewable energy procurement in the United States. In 2018, 63.2 million RECs were sold representing 47% of all voluntary renewable energy procurement.[38]

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[36] This structure causes some organizations, in particular financial institutions, to consider virtual PPAs in the same category as financial derivatives and require that they to be treated as speculative investments.

[37] BR+A, Using RECs to Achieve Class D Zero Net Energy Carbon Neutral Buildings, July 11, 2018. See BRplusA.com/co2-neutral.

[38] Status and Trends in the Voluntary Market (2018 data), Jenny Heeter, slides presented in September 2019 at the Renewable Energy Markets Conference in San Diego. NREL Document 74862.pdf.

About 33 million of the 51 million unbundled RECs in 2017 (about two thirds) were generated in just three states: Texas, Oklahoma and Kansas. These were mostly generated by wind turbines

For durability, forward purchase contracts must be structured so that the owner(s) of the complying building are required to purchase an adequate number of RECs for a minimum period of time (15 years).

Unbundled RECs may represent some or all of the renewable energy claims for green pricing and/or utility renewable energy contracts. In this case, the issues discussed here for RECs trickle down to other green products based on REC purchases.

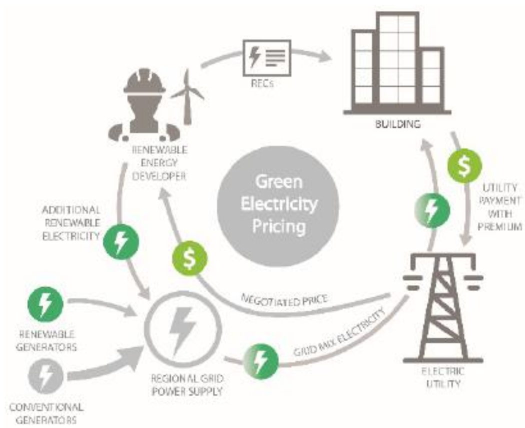
Cost Considerations

The price of unbundled RECs depends on whether they are Massachusetts Class I RECs or national unrestricted RECs. The price trend for Class I RECs is shown in Figure 4. This has been as high as $50/MWh between 2013 and 2015. The price dropped to around $5 for a brief time in late 2018, but the price is now about 20 $/MWh. The five-year running average is in the range of $30/MWh. However, Class I solar RECs are selling for more than 10 times general Class I RECs (see Figure 5).

Unrestricted national RECs which are mostly from wind in Texas and the Great Plains are currently selling at about $0.70/MWh. The price was as high as about $1.10/MWh in 2015 and as low as $0.40/MWh in 2016. The five-year running average is about equal to the current price of $0.70.

A broker fee or sales commission may result in slightly higher prices that those quoted above.

Green Pricing



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Electric distribution companies, community choice aggregators, and competitive electricity suppliers often offer their customers 100% renewable energy from the grid. There are no community choice aggregators serving Boston, but there are a number of competitive electricity suppliers (see Table 4).

Durability is the principal issue with retail green tariffs. Most of the programs only require a 12-month commitment and 36 months is about the longest commitment required by any of the existing programs. Green tariffs are generally voluntary and the customer (buyer) can opt out of the program on short notice and revert back to the standard offering. Without a long-term commitment, there is a loophole that prevents the typical green tariff from qualifying as a means to acquire off-site renewable energy, at least in the context of the renewable energy procurement requirement. If you can opt out on a moment's notice, it is not equivalent to the long-term commitment and additionality that comes with the construction of on-site PV.

The green tariff obligation needs to be passed on to future owners in the event the property is sold. Some retail providers are evaluating methods whereby customers can pre-pay the premium at the time of building construction.[39] This could possibly enable the premium to be financed from the capital improvement budget. Future building owners and/or tenants would receive 100% renewable energy, but pay according to the standard (default) tariff. Deed notations and/or covenants are other possible means of structuring a long-term commitment.[40] Committing to a single competitive supplier for the long-term may not be attractive to some building owners.

[39] Sonoma Clean Power, a community choice aggregator serving Sonoma County, is exploring this option as a way to expedite the reconstruction of homes destroyed by the Tubbs fire in Santa Rosa and surrounding areas.

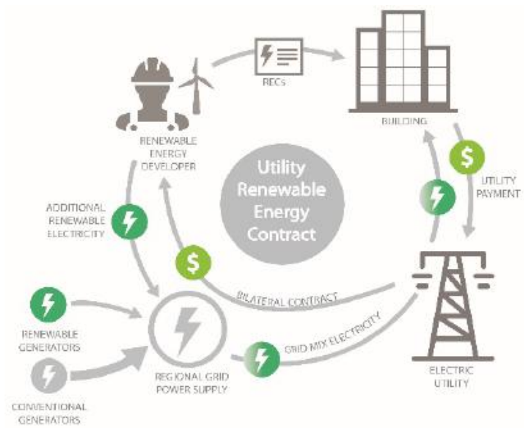
[40] The SMUD SolarShares program is technically a community solar program and it provides durability through a deed restriction.

Cost Considerations

In Massachusetts, the incremental price for green power depends on whether the electricity is backed by Massachusetts Class I RECs or national unrestricted RECs. One competitive supplier in Massachusetts, Green Energy Consumers, backs their green tariff with Massachusetts Class I wind RECs and they report a premium of $0.038/kWh ($38/MWh).[41] NREL reports that the the typical premium for 100% green power is about $0.033/kWh ($33/MWh) which is in the same range as that reported by Green Energy Consumers.[42]

As noted earlier, most competitive energy suppliers in Massachusetts back their green products with wind RECs from Texas and the Great Plains and these are far less expensive (see Figure 6). As result, the average premium is about $8/MWh ($0.008/kWh). For some suppliers, the premium is zero and the highest is about 11 $/MWh.

Utility Renewable Energy Contracts



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Some utilities offer to procure renewable energy on behalf of large nonresidential customers through a one-off bilateral contract or other arrangement. In these cases, the utility moves the customer to a custom rate structure to reflect the costs of the renewable energy project and retires RECs on behalf of the customer in proportion to their electricity consumption. A key difference between utility renewable energy contracts and retail green tariffs is that customers may negotiate for a particular class of renewable energy generators, e.g. solar. Also, the long-term price predictability of utility renewable contracts may yield economic benefits that do not accrue through utility green pricing programs.

These contracts are sometimes offered as an incentive for large companies to locate a data center or manufacturing plant to the area. In 2017, the NREL database on off-site renewable energy procurement lists just 15 customers for such contracts and the total renewable energy purchased was 2.78 million MWh or an average of 185,000 MWh per customer. NREL reported no utility renewable energy contracts in Massachusetts in 2017. These contracts are geographically concentrated: 60% of total sales were in Iowa with the other 40% scattered between just seven states: Virginia, Nevada, North Carolina, Oklahoma, Nebraska, Georgia and Tennessee.

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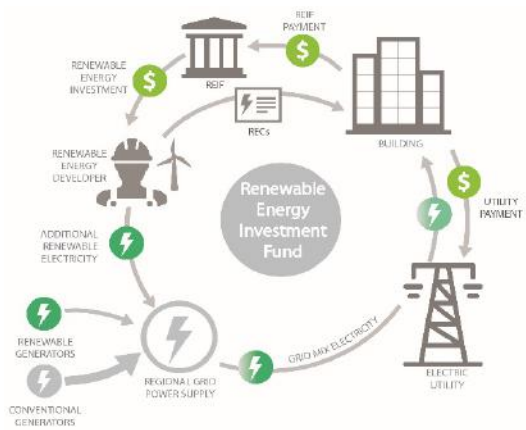
41 See See http://greenenergyconsumers.org/greenpowered/howswitchingworks#mix.

42 Status and Trends in the U.S. Voluntary Green Power Market (2017 Data), Eric O'Shaughnessy, Jenny Heeter, and Jenny Sauer, National Renewable Energy Laboratory, NREL/TP-6A20-72204, October 2018, Figure 9.

Renewable Energy Investment Fund



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A Renewable Energy Investment Fund (REIF) is a monetary account set up to accept payment from building owners or developers who are unable or don't want to install on-site systems. Management of the fund can vary, but would likely be a local or provincial governmental entity, although utilities may also have a role, depending on local circumstances.

Low-income housing programs provide a precedent for REIFs. In communities with requirements for low-income housing, developers often have the option to either provide a certain percentage of low-income housing as part of their project or alternatively, they may contribute to a fund and the local housing authority would use to the money to build or contract for low-income housing on another site. Appendix A has examples of low-income housing programs that could provide a precident for a REIF. Another parallel is the alternative compliance payment that utilities and competitive suppliers pay in the event that they fail to meet their RPS requirements for a certain period (see Table 2).

The managing entity for the REIF could use the money in a number of ways:

1. The most direct use of the funds would be to construct or expand a PV system on behalf of the building owner and assign RECs (and perhaps electricity as well through the Massachusett's virtual net metering program) to the complying building. In this case, the REIF would own, manage and operate the system(s).[43] Additionality would be achieved and if the system is located in the Boston area, it could provide educational and inspirational value. With this option (and with virtual net metering), the REIF program could function much like a community solar program where participants pay in advance through a REIF contribution for enough capacity to offset the complying building's energy use. System sizes would likely be larger than the 10-kW single-phase or 25 kW three-phase thresholds and the REIF would have to make an *Application for a Cap Allowance* in order to use virtual net-metering. At present there is about 80 MW of capacity remaining under the cap.

2. Rather than directly owning the renewable energy system, a second alternative is for the REIF to contract with a third-party for the construction, operation and management of the renewable energy system. The third-party renewable energy developer would sell power into the grid through ISO New England, but the environmental attributes associated with the renewable energy, including RECs and/or carbon credits, would be assigned to REIF participants for a minimum of 15 years. They would also transfer to the new property owner in the event of a sale.

   The contract with the third-party renewable energy developer could be structured in many ways, but one option would be through a vPPA (see earlier discussion). With this option, the REIF management could set special requirements, e.g. that the renewable energy generator be located in the ISO New England area, that it be newly constructed, and the type of generator could also be specified, e.g. solar. The REIF would enable the vPPA option to work for small customers who may not qualify for a vPPA contract themselves because of the minimum purchase quantity or the need for an excellent credit rating. The REIF would basically serve as an aggregator and distribute the RECs and other benefits of the vPPA to each of the program participants. The REIF would likely need to be backed by the City, since the renewable energy developer would require a counterparty with excellent credit.

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[43] The benefits of the federal investment tax credit would not apply to the city since it pays no federal taxes, but the system could be installed on city property thorugh a direct power purchase agreement. However since many contracts assign the RECs to the seller (renewable energy developer) in direct PPAs, special terms would need to be negotiated.

3. A third option is to use the REIF to purchase unbundled RECs (preferably Massachusetts Class I RECs) on behalf of program participants. Small businesses may find it difficult to locate a broker and directly buy unbundled RECs, and the REIF could make the process seamless for building owners and developers. Again, the program could be structured with a single upfront payment to cover the purchase of RECs for the minimum 15-year period. REIF management could enter a forward contract to buy the RECs on behalf of all the program participants for the minimum duration.

If an up-front payment is made to the REIF before building occupancy, the investment might be booked to the capital improvement budget and financed through the mortgage or other long-term financial instruments. The payment would be proportional to the amount of renewable energy needed to achieve compliance with the renewable energy procurement requirement. The renewable energy capacity for each program participant would be determined through energy performance modeling.

If the program is set up properly and effectively managed, it should provide near equivalency to the installation of on-site renewable energy systems in terms of impact and additionality. Contributions to the REIF would result in new renewable energy generation being added to the grid and operated for the long-term. The DOER guidelines for managing alternative compliance payments provide a precident and the payment itself (see Table 2) could be a reference point for setting the REIF amount.

Cost Considerations

The amount of money to be paid to the REIF should be adequate to cover the hard and soft costs of building new renewable energy systems (option 1), negotiating and buying a virtual PPA (option 2), or buying RECs (option 3). If option 1 is managed like a community solar program, then participants would have two benefits: an electricity credit to their utility bill as well the RECs and other renewable energy attributes. In essence, participants would be paying in advance for 15 years of electricity along with the RECs. If the REIF can install a PV system for $1,430/kW[44] and if the system produces 1,425 kWh each year for each kW of capacity[45], the system would produce both electricity and RECs at an annualized cost of $0.092/kWh ($92/MWh) for a 15-year period (or longer).[46] Soft costs would likely increase the cost. These costs include both the electric energy and RECs.

Template for the Renewable Energy Investment Fund (REIF) and Administrative Body

Model Language: The City of Boston shall establish a Renewable Energy Investment Fund (REIF) to act as a repository for fees generated through the Renewable Energy Procurement Requirement and appoint a commission to oversee the administration and impact of the fund. The commission shall include members with expertise in renewable energy, urban development, socioeconomic equity/environmental justice, and investment. The commission shall meet annually to review the impact of current and prior investments, quantify the renewable energy added to the grid through REIF funds, review and revise if necessary the payment requirements, and set funding priorities for the next year.

Boston's Inclusionary Development Policy (see Appendix A) provides a precedent for the authorization, by executive order or inclusion as a zoning article, for:

- Land use policy with long-term impact on ownership and operations
- Terms that are set during the land use permitting and are recorded with the deed to ensure future compliance
- City management of private development mitigation measures

Funds administered as part of a REIF must be managed effectively for long-term additionality and must ultimately contribute significantly to the proportional reduction of greenhouse gas emissions. Key

[44] This is the average of utility scale systems at $1,040/kW and building scale systems at $1,800/kW.

[45] This is the expected production of a solar PV system in the Boston area with a fixed azimuth and tilt (not tracking).

[46] This is based on a discount rate of 4.2% and a 15-year time horizon. Electricity production after the 15-year period is not considered but has value. However, for simplicity, maintenance and operation costs are not factored in.

considerations in the structure and administration of a REIF include clarity in purpose, oversight and accountability, and measurement of impact. The administrative authority responsible for the management of REIF funds would:

- Record allotment of funds,
- Quantify the impact from the investments with regard to additional renewable energy systems and reductions in greenhouse gas emissions,
- Periodically review and adjust the investments to ensure that REIF contributions are resulting in new renewable energy generation being added to the grid and operated for the long-term, and
- Verify that RECs are being retired on behalf of the complying buildings that have contributed to the REIF.

Procurement Option Variations

There are impartial variations in each of the procurement options depending on the type of renewable energy generator, whether the RECs are bundled with the energy or unbundled, and whether there is a direct credit to the customer's electricity account.

1. **Class of Generator**. When the procurement option is tied to Massachusetts Class I generators or RECs, the Massachusetts DOER verifies that the renewable energy generator meets the minimum requirements, confirms that the generator is located within the ISO New England grid and that the generator is relatively new. As result, the impact of procurement methods that rely on Class I generators is likely to have greater impact.
2. **Unbundled RECs**. Procurement methods are more transparency when the electricity produced and the associated RECs are not separated. In these cases, a specific renewable energy system, one that the building owner and tenants can look at or even visit, is providing both electricity and RECs to the complying building. While the generator is not located on the building property, the relationship is clear. RECs are confusing to people and most of this confusion goes away when RECs are bundled with a particular renewable energy generator.
3. **Electricity Credit**. Off-site procurement of renewable energy is also more transparent when the building owner can directly see the renewable energy production or credit on the utility bill from the electric distribution company. In Massachusetts, this can be achieved through virtual net-metering.

Table 9 shows the most common and possible variations for each procurement option. For example, green pricing in Massachusetts is typically backed by out-of-state wind RECs, but some offerings are backed by Massachusetts Class I RECs. Self-owned and on-site systems will almost always be PV systems, which qualify as Class I generators, and the complying building's electricity account will be directly credited through virtual net-metering. However, other situations are possible.

Based on the objective considerations noted above, many of the compliance options have significant variations that affect how well they compare to on-site renewable energy systems. These variations are shown in Table 10.

Table 9 – Classification of Off-site Renewable Energy Procurement Options in Massachusetts

			Off-Site Procurement Option						
Generator	*RECs*	*Electricity Credit*	*Self-Owned On-Site*[1]	*Community Solar*[2]	*Virtual PPA*[3]	*Purchase of RECs*[4]	*Green Pricing*[5]	*Utility Contracts*[6]	*REIF*[7]
Class I	Bundled with Energy	Yes	▯	▯				▯	▯
		No			▯				▯
	Unbundled	Yes		▯			▯		
		No	▯			▯			▯
	No RECs	Yes		▯					
		No	▯						
Other	Bundled with Energy	Yes	▯	▯				▯	
		No			▯				▯
	Unbundled	Yes		▯			▯		
		No	▯			▯			▯
	No RECs	Yes	▯	▯					
		No							

▯ Most Common ▯ Possible

Notes:

1. Directly owned off-site systems will typically be locally sited photovoltaic systems and electricity production can be directly credited to one or more buildings through Massachusett's virtual net-metering program.
2. Community solar systems are typically located within the "community". The problem is that most community solar systems do not retire the RECs on behalf of the customer.
3. Most vPPAs are backed by wind farms in Texas or the Great Plains. There are no known vPPAs in Massachusetts.
4. REC purchases can be for Massachusetts Class I RECs or national voluntary RECs. The latter is more common
5. The vast majority of green tariffs from competitive suppliers are backed by national voluntary RECs. However, some are backed by Massachusetts Class I RECs.
6. There are no known utility renewable energy contracts in Massachusetts. Most are in Iowa and the Great Plains states.
7. REIFs can be structured in a number of ways. The most transparent method would be to construct a local PV system, whereby the electricity and RECs can be directly credited to complying buildings. This is considered "most common" although there are no precedents. The REIF could also buy RECs or enter into a vPPA.

Table 10 – Procurement Options and Variations for Boston

Procurement Method	*Variation*	*Notes*
On-Site	n.a.	Basis of comparison
Self-Owned	n.a.	Located in community with electricity and RECs
Community Solar	Up-Front Payment	Cost of participation is paid in advance
	Subscription	Risk of loss of durability
Virtual PPA	MA Class I Generator	DOER approved generator in ISO New England region
	Out of Region	Probably wind from Texas or Great Plains
Unbundled RECs	MA Class I	DOER approved generator in ISO New England region
	Other	Probably wind from Texas or Great Plains
Green Pricing (RECs)	MA Class I	Backed by Massachusetts Class I RECs
	Other	Typically backed by wind RECs from Texas or Great Plains
Utility Contract	Bilateral Agreement	Custom long-term contract
	Special Green Tariff	Standard long-term contract
REIF	Local PV System	PV system is constructed in community
	vPPA Investment	Third-parties add capacity through a vPPA or other financial instruments
	Unbundled RECs	Money is used to buy unbundled RECs on behalf of program participants

Compliance Cost Summary

The cost of achieving compliance with each of the procurement methods depends on a number of factors. The cost of some options is fairly straightforward to assess, as the market has set a price, e.g. green pricing and unbundled RECs. The costs of on-site and self-owned off-site systems are a bit more complicated and depend on tax credits and the counterfactual. No data is available for utility contracts or virtual PPAs since these are not common in Massachusetts. Table 11 summarizes the range of costs that can be expected. The assumptions and procedures for developing these costs are discussed earlier.

Table 11 – Cost Comparisons for Procurement Options and Variations for Boston

Procurement Method	*Variation*	*Cost Range ($/MWh)*
On-Site and Self-Owned Off-Site	n.a.	$58.8 small systems with no tax credits, $31.4 small with tax credits $18.8 large systems with no tax credits, $4.5 large systems with tax credits
Community Solar	Up-Front Payment	Not available in Boston but probably similar to green pricing
	Subscription	Not available in Boston but probably similar to green pricing
Virtual PPA	MA Class I Generator	No data available but probably similar to green pricing
	Out of Region	No data available but probably similar to green pricing
Unbundled RECs	MA Class I	$20 current, $30 five-year running average, $50 high, $5 low
	Other	$0.70 current, $0.70 five-year running average, $1.10 high, $0.40 low
Green Pricing (RECs)	MA Class I	$33 to $38 based on current offerings and NREL estimates
	Other[47]	$8 average, $0 minimum, $11 maximum
Utility Contract	Bilateral Agreement	No data available
	Special Green Tariff	No data available
REIF	Local PV System	See self-owned and on-site systems.
	vPPA Investment	See vPPA
	Unbundled RECs	See unbundled RECs above

47 Town Square Energy is $31/MWh and this is assumed to be backed by Class I RECs.

Evaluation of Off-Site Renewable Energy Procurement Options

Minimum Requirements

All off-site renewable energy procurement must satisfy three minimum requirements.[48] These criteria are listed below and Table 12 evaluates each of the procurement options identified above relative to these minimum criteria.

1. **Generation Source**. The renewable energy generating source shall be photovoltaic systems, solar thermal power plants, geothermal power plants, wind turbines, or other Class I renewable energy generators approved by the Massachusetts DOER.[49]
2. **Durability**. The building owner shall sign a legally binding contract to procure qualifying off-site renewable energy for a period of 15 years and the contract shall be structured to survive a partial or full transfer of ownership of the property.
3. **Renewable Energy Certificates**. RECs and other environmental attributes associated with the renewable energy shall be assigned to the building project for the duration of the contract.

Table 12 – Minimum Requirements for Off-Site Procurement Options

	Minimum Requirements		
Procurement Option	*Generation Source*	*Durability*	*Renewable Energy Certificates*
On-Site (Off-site options are compared to this)	Will be solar in almost all cases.	The system is on-site but can be self-owned or installed through a solar lease or direct PPA.	Yes. But some owners have been known to sell the RECs and direct PPA contracts often assign the RECs to the seller.
Self-Owned (viable for Boston and supported by virtual net-metering)	Will typically be wind or solar.	Forward contract for RECs can provide durability in the event that the system is sold separately from the complying building.	Yes. Should not be a problem.
Community Solar (no known programs in Boston)	Usually solar but could be another type of generator.	It's easy to opt out of most programs.	No. Most community solar programs usually do not provide RECs to the participant
Virtual PPA (limited to large credit-worthy organizations)	Wind and solar are the most common, but other generator types are possible.	Not a problem. The renewable energy developer requires a long-term commitment.	Yes. This is the essence of the deal.
Unbundled RECs (Massachusetts Class I RECs are preferred)	Can be anything, but mostly wind with some solar.	Forward contracts can be used to establish a long-term commitment.	Yes. RECs are the asset being purchased.
Green Tariffs (includes competitive suppliers and CCAs)	Most are backed by wind RECs from Texas or the Great Plains.	The longest typical contract is 36 months – it's easy to opt out.	Yes. Most green tariffs in Massachusetts are REC buying programs.
Utility Renewable Contracts (none in Massachusetts)	Wind and solar are most typical.	Contracts are for the long-term.	Yes. Customers contract for RECs and energy.
Renewable Energy Investment Fund (REIF) (three investment options)	REIF management establishes criteria	Contribution can be an up-front payment or a subscription	Yes. Should not be a problem, but there are no precedents.

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[48] This is a shortened and consolidated list from that in the document titled "National and International ZERO Code" (See www.zero-code.org).

[49] See 225 CMR 14.00: Renewable Energy Portfolio Standard – Class I. These regulations allow new run-of-the-river hydro plants and certain biomass electricity generators as long as the fuel is certified to come from forest thinning, forest residues, or other residues. Biomass plants must also have a 60% overall efficiency in order to receive full credit. Electricity generators currently approved as Class I by DOER are listed in "Eligible Class I Renewable Units 091319.xlsx", dated April 29, 2019.

Additional Evaluation Criteria

In addition to the three minimum requirements, Architecture 2030 has identified additional factors to consider in evaluating off-site procurement methods relative to on-site construction.

- **Impact**. Additional renewable energy generating capacity will likely be added to the grid in proportion to the additional electricity demand created by the complying building and this generating capacity is over and above that required for RPS compliance.
- **Durability**. A 15-year commitment is a minimum requirement, but it is difficult to provide this durability with some procurement methods, e.g. green tariffs, and to assure that the commitment will survive a sale of the property.
- **Locality**. The generation source is located where the energy can more easily be delivered to the complying building site. In order of priority: Boston, Massachusetts, New England, Eastern Connection, United States.
- **Assignment to Building**. The renewable energy installed or procured can easily and directly be assigned to the complying building and RECs retired on behalf of the complying building.
- **Electricity Credit**. Electricity production from the renewable energy system is directly credited to the complying building.
- **Incremental Acquisition**. Renewable energy can be procured or installed in increments to match the exact loads of the complying building (some procurement options require a minimum contract that may exceed the needs of the building).
- **Grid Management**: The renewable energy system can be managed to supply the grid when power is needed but to avoid over-generation for low-load conditions.
- **Environmental Impact**. The renewable energy system has minimal impact on natural resources and habitat.
- **Inspiration/Education**. The renewable energy system is visible asset. As such it has the ability to inspire and educate building developers, designers and the public on the benefits of renewable energy.
- **Permanent Financing**. The cost of the renewable energy system or procurement can be booked to the capital improvement budget and can be included in the permanent financing for the project.

Calculating the Procurement Factors

The procurement factor is a discount that is applied to off-site procurement options when they fail to be equal to the construction of on-site renewable energy systems. Each procurement option and variation are compared to on-site PV construction in terms of the evaluation criteria listed above. It is expected that all off-site procurement options will have a procurement factor less than one. If the procurement factor is 0.70 and 100 MWh of renewable energy is purchased, only 70 MWh is counted toward renewable energy procurement requirement compliance. It is worth noting that with some procurement options like green pricing, the amount procured cannot exceed the electricity use of the building. In these cases, the procurement option would need to be supplemented with the purchase of unbundled RECs or another procurement option.

Not all of the evaluation criteria are given the same weight in the evaluation process. The weights assigned to each of the evaluation criteria are shown in Table 13. These weights represent subjective judgement and can be modified for local conditions and program emphasis. In the table, “Impact” is considered the most important and given a value of 100. Durability and Locality are considered half as important and are given a value of 50. Other values are assigned accordingly. The percentage weight for each criterion is the assigned value divided by the sum of the values for all the criteria.

Each procurement option and variation are judged for each evaluation criterion using the scales in Table 13. For example, “Impact” is judged to be High, Medium, Low or Zero. High gets a 3, Medium a 2, Low a

1 and Zero a zero. The sumproduct for each procurement option and variation is the sum of each numeric value (from the scale) times the percentage weight from Table 13. Onsite renewable energy is the basis of comparison and has a sumproduct of 2.92. The calculated procurement factor for each procurement option is its sumproduct divided by the baseline or on-site PV sumproduct. See Table 14, Table 15, and Table 16. Because of the subjective process, these are rounded to the nearest 0.05 and grouped. The groupings are shown in Table 17 and represent the recommended procurement factors for Boston.

Table 13 – Evaluation Scales and Weights for Each Evaluation Criterion

Criteria	*Evaluation Scale*				*Value*	*Weight (%)*
Impact	High	Medium	Low	Zero	100	28%
Durability	Yes	Possible	Difficult	No	50	14%
Locality	Local	Bal. Auth.	U.S.	Intern'l	50	14%
Assignment to Building	Yes	Possible	Difficult	No	30	8%
Electricity Credit	Yes	Possible	Unlikely	No	30	8%
Incremental Acquisition	Yes	Possible	Difficult	No	30	8%
Grid Management	Yes	Possible	Difficult	No	20	6%
Environmental Impact	Low	Depends	High		20	6%
Inspiration/Education	High	Medium	Low	Zero	20	6%
Permanent Financing	Yes	Possible	Unlikely	No	10	3%
Weight/Sum	3	2	1	0	360	100%

Table 14 – Evaluation of Procurement Options (Part 1)

			Community Solar		*Virtual PPA*	
Criteria	*On-Site (Basis of Comparison)*	*Self-Owned Off-Site*	*Up-Front Payment*	*Subscription*	*Class I Generator*	*Out of Region*
Impact	High	High	High	Medium	High	Low
Durability	Yes	Yes	Yes	Difficult	Yes	Yes
Locality	Local	Local	Local	Local	Bal. Auth.	U.S.
Assignment to Building	Yes	Yes	Yes	Yes	Difficult	Difficult
Electricity Credit	Yes	Yes	Yes	Yes	No	No
Incremental Acquisition	Yes	Yes	Yes	Yes	Difficult	Difficult
Grid Management	Possible	Possible	Possible	Possible	Possible	Possible
Environmental Impact	Low	Depends	Depends	Depends	Depends	Depends
Inspiration/Education	High	Medium	Medium	Medium	Low	Low
Permanent Financing	Possible	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
Sumproduct	2.92	2.78	2.78	2.22	2.00	1.31
Calculated Procurement Factor	1.00	0.95	0.95	0.76	0.69	0.45
Round to Nearest 0.05	1.00	0.95	0.95	0.75	0.70	0.45
Procurement Limited to Electricity Use	No	No	Yes	Yes	No	No

Table 15 – Evaluation of Procurement Options (Part 2)

	Unbundled RECs		*Green Pricing (RECs)*	
Criteria	*MA Class I*	*Other*	*MA Class I*	*Other*
Impact	Medium	Zero	Medium	Zero
Durability	Difficult	Difficult	Difficult	Difficult
Locality	Bal. Auth.	U.S.	Bal. Auth.	U.S.
Assignment to Building	Yes	Yes	Yes	Yes
Electricity Credit	No	No	No	No
Incremental Acquisition	Yes	Yes	Yes	Yes
Grid Management	Possible	Possible	Possible	Possible
Environmental Impact	Depends	Depends	Low	Depends
Inspiration/Education	Low	Low	Low	Low
Permanent Financing	No	No	No	No
Sumproduct	1.75	1.06	1.81	1.06
Calculated Procurement Factor	0.60	0.36	0.62	0.36
Round to Nearest 0.05	0.60	0.35	0.60	0.35
Procurement Limited to Electricity Use	No	No	Yes	Yes

Table 16 – Evaluation of Procurement Options (Part 3)

	Utility Contract		REIF		
Criteria	Bilateral Agreement	Special Green Tariff	Local PV System	vPPA Investment	Unbundled RECs
Impact	Medium	Medium	High	High	Medium
Durability	Yes	Yes	Yes	Yes	Difficult
Locality	Bal. Auth.	Bal. Auth.	Local	Bal. Auth.	Bal. Auth.
Assignment to Building	Yes	Yes	Yes	Difficult	Yes
Electricity Credit	No	No	Yes	No	No
Incremental Acquisition	Yes	Yes	Yes	Difficult	Yes
Grid Management	Possible	Possible	Possible	Possible	Possible
Environmental Impact	Depends	Depends	Depends	Depends	Low
Inspiration/Education	Low	Low	Medium	Low	Low
Permanent Financing	No	No	Possible	Unlikely	No
Sumproduct	2.03	2.03	2.81	2.00	1.81
Calculated Procurement Factor	0.70	0.70	0.96	0.69	0.62
Round to Nearest 0.05	0.70	0.70	0.95	0.70	0.60
Procurement Limited to Electricity Use	Yes	Yes	Yes	No	No

Table 17 – Recommended Procurement Factors

Group	*Procurement Option*	*Variation*	*Procurement Factor*
Basis	On-Site	n.a.	1.00
One	Self-Owned Off-Site	n.a.	0.95
	Community Solar	Up-Front Payment	
	REIF	Local PV System	
Two	Community Solar	Subscription	0.70
	Virtual PPA	MA Class I Generator	
	Utility Contract	Bilateral Agreement	
	Utility Contract	Special Green Tariff	
	REIF	vPPA Investment	
Three	Unbundled RECs	MA Class I	0.60
	Green Pricing (RECs)	MA Class I	
	REIF	Unbundled RECs	
Four	Virtual PPA	Out of Region	0.45
Five	Unbundled RECs	Other	0.35
	Green Pricing (RECs)	Other	

Cost Examples for Typical Buildings

There are many different ways for complying buildings to comply with the renewable energy procurement requirements. Various renewable energy procurement methods and combinations are available. Table 18 gives an estimated range in dollars per square foot for offices, retail stores and multii-family residential. The more energy efficient the building, the lower the compliance cost since less renewable energy needs to be installed or purchased. Estimates are provided for code-minimum buildings and beyond-code energy efficiency. The estimates represent the premium for renewable energy and do not include the base cost for electricity.

Table 18 – Compliance Costs for Typical Buildings

Building Type	*Approximate EUI (kBtu/ft2-y)*	*Cost Premium ($/ft²)* Average	Minimum	Maximum
Office (Code Minimum)	40	3.93	2.43	6.28
Office (Beyond Code)	25	2.46	1.52	3.92
Retail (Code Minimum)	50	4.92	3.04	7.85
Retail (Beyond Code)	30	2.95	1.82	4.71
Multi-Family (Code Minimum)	40	3.93	2.43	6.28
Multi-Family (Beyond Code)	25	2.46	1.52	3.92

The range of estimates in Table 18 are based on a variety of ways to comply with the renewable energy procurement requirement as shown in Table 19. Ten scenarios were developed but more are possible. Each scenario represents a choice between one or more renewable energy procurement options. The fractional purchases represent what is required to achieve compliance with consideration of the procurement factors.

Table 19 – Renewable Energy Procurement Requirement Compliance Scenarios

		Fractional Purchases per MWh of Building Energy									
		On-Site PV	*Self-owned off-site PV*	*REIF local PV system*	*REIF vPPA investment*	*Unbundled Class I RECs*	*Green pricing Class I RECs*	*REIF unbundled Class I RECs*	*Unbundled other RECs*	*Green pricing other RECs*	*Total Cost ($/MWh)*
	Procurement Factor	*1.00*	*0.95*	*0.95*	*0.70*	*0.60*	*0.60*	*0.60*	*0.35*	*0.35*	
	Cost ($/MWh)	*31.40*	*17.95*	*17.95*	*17.95*	*20.00*	*35.50*	*20.00*	*8.00*	*8.00*	
1	On-site PV	1.00									31.40
2	Half on-site, rest direct-owned offsite	0.50	0.53								25.15
3	REIF investment in local PV system			1.05							18.89
4	REIF investment in vPPA				1.43						25.64
5	Class I unbundled RECs					1.67					33.33
6	wind unbundled RECs								2.86		22.86
7	Green pricing (class I RECs)					0.67	1.00				48.83
8	Green pricing (other RECs)								1.86	1.00	22.86
9	30% on-site, green pricing and RECs	0.30				0.47	0.70				43.60
10	REIF unbundled Class I RECs							1.67			33.33

The cost for self-owned off-site PV, REIF local PV system and REIF vPPA investment are an average of utility-scale and building-scale PV systems with consideration of the investment tax credit. See Table 11 for the source of other data.

The building type and the level of energy efficiency shown in Table 18 and the compliance scenarios shown in Table 19 can be combined into a single graph that shows compliance costs in dollars per unit area as a function of the building EUI. A larger renewable energy systems is needed with greater EUIs. This provides a significant motivation to design buidlngs to be more energy efficiency. The relationship is shown in Figure 8

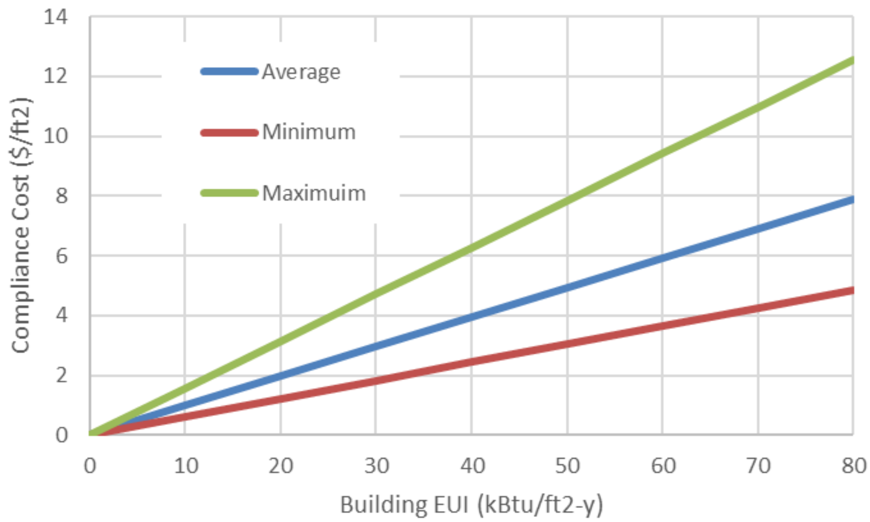

Figure 8 – Renewable Energy Procurement Requirement Compliance Costs vs. Energy Utilization Intensity

Appendix A – Affordable Housing Precidents

Affordable housing programs provide a precident for the Renewable Energy Investment Fund. The following are examples. Other non-profit and non-governmental precedents also exist for renewable energy investment funds, and these could be further explored as models for developing investment selection and review processes.

Boston's Inclusionary Development Policy Fund

The administration of REIF funds could be modeled after Boston's existing Inclusionary Development Policy Fund, which collects contributions from market-rate housing developments with ten or more units and in need of zoning relief to support the creation of income-restricted housing. Inclusionary Development Policy Funds are used by the City of Boston Department of Neighborhood Development ("DND") to fund the creation of affordable/income restricted housing across Boston. The DND makes funds available to support affordable housing through Requests for Proposals. Proposals that meet the DND's underwriting policies and standards for accessibility, sustainability, good design, and community support are eligible to receive funding from the DND. The DND supports developers who receive funding throughout their projects and can help find eligible tenants for buildings.

Santa Fe's Affordable Housing Trust Fund:

"The Affordable Housing Trust Fund was set up by the City to act as a repository for development fees generated through the affordable housing program, as well as for program income funds that are paid back to the City. Another source of funding is revenue from land sales by the city. To supplement Community Development Block Grant (CDBG) funding, the trust fund was set up so that at least 51% of funds must be used for downpayment assistance. Other prioritized activities include rental assistance for very low income renters and real estate/infrastructure funding to support nonprofit development.

Every year, the City's Community Development Commission sets funding priorities and an Request for Proposals (RFP) is released that is commensurate with the CDBG funding schedule as described in the preceding section. In order to achieve efficiency, the CDC will consider the applications for funding from the Affordable Housing Trust Fund at the same time as CDBG funding requests."

Arlington's Affordable Housing Investment Fund:

Since its creation in 1988, the Affordable Housing Investment Fund has been Arlington County's main financing program for the development of affordable housing. The program has enabled the majority of the approximately 7,500 rental units approved throughout the County to help provide homes for low- and moderate-income households, including specialized housing for the elderly, the homeless, or persons with disabilities.

The Fund supports affordable housing development and preservation in Arlington by:

- Providing low-interest, subordinate loans for developers of affordable housing.
- Subsidizing renovations and upgrades to keep existing affordable housing safe and sustainable.
- Alleviating the dramatic loss of affordable housing units in multifamily properties.

Austin's Affordable Housing Density Bonus Programs

In Austin, affordable housing density bonus programs are neighborhood-specific, and some allow a fee-in-lieu option, wherein developers pay a fee per square foot of bonus area. The funds gathered from fees may be allocated toward creating affordable housing in the city or investing in the neighborhood of the development: funds gathered through Austin's Downtown Density Bonus feed Permanent Supportive Housing; funds gathered through the North Burnet Gateway density bonus program are invested within two miles of North Burnet Gateway boundaries; funds from the East Riverside Corridor density bonus program are paid into the Transit Area Housing Assistance Fund. Although no examples of a fee-in-lieu option for density bonus programs incentivizing energy efficiency or building electrification have been identified, these could be effectively modeled after the fee-in-lieu option. Using this model, Boston could allow neighborhoods a degree of self-determination in their use of REIF money.

Victoria, British Columbia

Victoria, B.C.'s policy takes a similar but slightly different approach to quantifying the value of increased density and requiring correlated financial contributions: "the City has identified a fixed rate target which will be sought for certain rezonings which result in bonus density. For all other rezonings resulting in bonus density, the City will seek an amenity contribution equivalent to 75% of the additional land value created by the rezoning, based on an economic analysis." This structure could be adapted to require developments that undergo rezoning resulting in bonus density to contribute to a fund supporting energy upgrades in the neighborhood or city.