

Net-Zero Emissions With Renewable Energy Certificates: A Public Policy for a Massachusetts Municipal Light Plant

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Abstract

The promotion, desire and need for renewable energy generation and transmission to electric grids to provide clean, non-carbon-based power has increased in recent years with more focus on climate change mitigation in both the public and private sectors. Renewable Energy Certificates, also known as “RECs” are the established public policy mechanism for incentivizing, verifying, tracking and supporting renewable energy. REC markets are created and managed by state governments to allow selling, purchasing and trading of these “green commodities” to substantiate environmental attribute claims. A new legislation in Massachusetts requires all stakeholders, businesses and sectors to reduce emissions, which means electric utilities, both public and private, must participate in REC markets to green their power supply portfolios that they provide to consumers. This paper explores and analyzes the role of REC markets, monetary policy, trends, stakeholders, participants, and the current public policy debates in this area. A specific public policy making case is explored for this research, the Municipal Light Plant in Shrewsbury, MA, utilizing RECs to achieve a 100% non-carbon power supply or “net-zero” emissions. A financial analysis based on REC market research and debate is conducted to inform a rules-based and judgement-based fiscal Power Supply Policy and Greenhouse Gas Emissions Standard for SELCO (Shrewsbury Electric and Cable Operations), a public electricity utility.

Keywords: Renewable Energy Certificates (RECs), net-zero emissions, non-carbon electricity, greenhouse gas emissions standard, power supply policy, municipal light plant (MLP)

1. Introduction and Background Information

Renewable energy generation and distribution to end users through the electric grid is an essential action to address climate change. Historically, this has been more expensive compared to traditional fossil fuel energy generation, therefore, governments have stepped in to incentivize renewable energy generation by assigning it monetary value. As the Environmental Protection Agency explains, “because the physical electricity we receive through the utility grid says nothing of its origin or how it was generated, RECs play an important role in accounting, tracking, and assigning ownership to renewable electricity generation and use.” (n.d.) In many US states, each megawatt hour (MWh) of electricity generated by a certified renewable resource produces a Renewable Energy Certificate (REC) that has a dollar value. This “green commodity” can be sold, traded, bought and retired to claim ownership or credit of the environmental attributes, in REC markets.

This value that is assigned to renewable energy incentivizes clean, renewable energy development over fossil fuels that emit greenhouse gases. An analogy that can help one understand RECs is to think about it like a house and deed. The house is the electric energy and the deed is the REC, these are two separate components where one can live in the house without owning the deed. When you buy the power generated by a renewable source, but do not purchase and retire the REC, you do not own the right (deed) to claim that as a renewable resource in your power portfolio. Similarly, one can own the deed to a house you don’t live in. This is the equivalent to purchasing and retiring RECs to claim the renewable resource. The REC market is a unique form of monetary policy where state governments essentially act as central banks, setting up the foundation market and injecting targeted economic stimulus. The renewable generating sources act as commercial banks, accelerating the effect of the initial influence from the state by providing the REC assets. Electric utilities, large corporations and general consumers utilize these assets by buying them, confirming their

monetary value. The state can set price ceilings, floors, and inject stimulus with different rules, regulations and public policies. In Massachusetts, the Department of Energy Resources (DOER) is responsible for management and oversight of this market.

Electric utilities are one of the most important participants in REC markets, as they procure electric power from various generating sources and deliver it to consumers through distribution networks. The power supply portfolio of electric utilities vary depending on contracted power purchase agreements (PPAs). Governments have required these portfolios to have a minimum percentage of non-carbon emitting generation. Private, for-profit, investor-owned utility companies like National Grid, have historically been required to have minimum percentages, participating in compliance REC markets. Starting in 2021, Massachusetts public electric utilities, also known as Municipal Light Plants (MLPs) must also meet minimum requirements detailed in the recently passed climate action bill S.9, having “net-zero” emissions by 2050 at the latest, with 100% non-carbon portfolios. Governments are looking at the electricity sector as the foundation upon which to build completely net-zero communities. The plan is to have the electricity provided to consumers be 100% carbon free, so that consumers can “fuel shift” their currently fossil fueled assets, like heating/cooling systems, vehicles, and other equipment to electric equipment.

Reliance on the REC market is critical to reaching this goal, as the only way to claim non-carbon power supply credit is with RECs produced by renewable energy generation or emissions free energy certificates (EFECs) produced by nuclear generation. Failure to meet emissions reduction requirements outlined in S.9 will result in utilities having to make Alternative Compliance Payments (ACPs) to the Massachusetts Clean Energy Center (MassCEC), which aids the development of renewable energy projects. The stability, pricing, oversight and management of these markets by state governments will dictate feasibility of accomplishing net-zero emissions through the electricity sector. The future outlook of pricing for REC markets is uncertain, but growth and increase in participation is guaranteed (Heeter, J., & O'Shaughnessy, 2020). One of the primary objectives of this research paper is to investigate and describe the role, policies, trends and pros/cons of REC markets and green commodities with the scope of studying various REC markets around the world, but the main focus will be US markets, particularly the New England region. Another primary objective is to analyze this information and data to inform a power supply policy for Shrewsbury, Massachusetts' municipal light plant SELCO (Shrewsbury Electric and Cable Operations) that utilizes RECs to achieve net-zero carbon emissions. This has not been conducted extensively for a particular case with an academic approach, therefore this study brings new knowledge to the area of “green finance” and the economics of emissions reduction.

2. Literature Review

The role of RECs in engaging communities to lower their dependence on GHG emitting energy sources has seen huge growth in the late 1990s. Government-imposed use of RECs to meet green energy goals has boosted the use and led to an expansion in the green energy market. While investing in green energy has become more stable over time it's still viewed as volatile. This volatility makes investors wary about putting their money towards green energy projects without the reassurance that they will receive a return on their investment. RECs have sprung to larger popularity as state governments begin to mandate their use to lower the dependence on GHG emitting energy sources. The market is focused on electricity, as the grid is set up to allow for energy from all sources. Both voluntary and compliance REC markets have particular features that differentiate themselves from each other (Figure 1).

The main purpose for these differences is due to their target audiences which can be explained as consumers for voluntary markets and distributors for compliance markets. Both markets feature similar issues on different scales with voluntary markets being more stable as the growth in these markets is more natural in opposition to the rise in compliance policies in many states. As seen on Figure 1, there are a lot more actors and stakeholders involved in the voluntary markets in order to protect consumers and give them the best possible prices to encourage participation.

The RECs market growth has been rapid in the past few years and the expansion potential is great as individual states and communities begin to adopt carbon-free electricity timelines. For the energy sector in Massachusetts, RECs have been established as the way the state will reach its goal of reaching net-zero emissions by 2050. The growth in the market has seen a lean towards utility-market partnerships for residential areas (Holt and Bird, 2005).

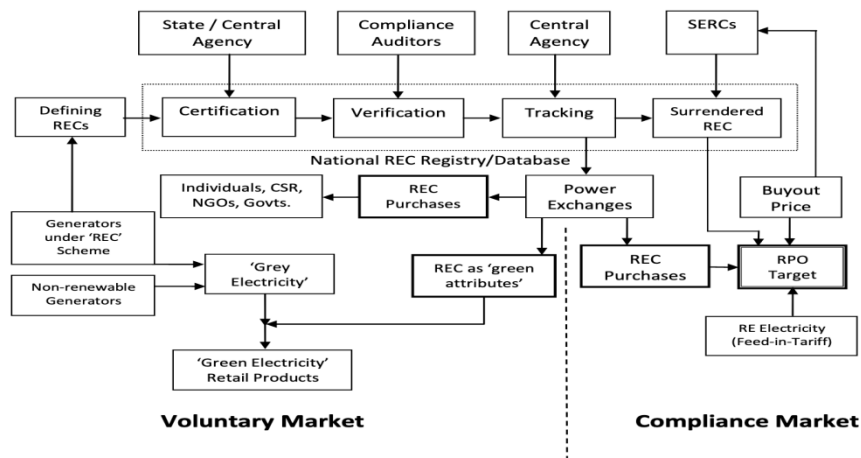


Figure 1. Participants and Actions in REC Markets

Source: Singh, 2011, pg. 3

These partnerships allow consumers to easily access green energy through their provider without having to do research on particular RECs. Data from the U.S. Energy Information administration supports that when energy suppliers offer green products as a standard option that their sales increase more than their competitors that don't have those options (Holt and Bird, 2005). The renewable energy industry is at the center of the REC market. While the REC market stimulates the development of renewable energy production the demand and supply have been unable to line up leading to inconsistent pricing of RECs. This is mainly caused by large upfront costs of building the power generating plants coupled with the past uncertainty of the market's success. Long-term contracts that bundle energy and RECs are utilized in the energy field to mitigate the risk for investors and encourage their financial support (Holt et al, 2011). The development of new projects will be key to maintain the expansion of RECs as the current trajectory shows the gap between supply and demand growing (Holt et al, 2011).

Prices differ between states, REC type, and voluntary and compliance markets (Figures 2 and 3). The voluntary market is for individuals or businesses who purchase RECs to offset carbon emissions created by their activity and operations, while the compliance market consists mostly of electricity companies that purchase large shares to distribute to their customers. Participants in compliance markets must purchase RECs to reach non-carbon energy goals set by the government. RECs in the compliance market are used to track the type of energy sources that electricity companies are using. Even in individual states, pricing can greatly fluctuate with Massachusetts seeing \$15 to \$50 per REC in 2011 (Holt et al, 2011) (Figure 3). Heeter (2020) has claimed that REC pricing correlates with electricity demand, as both are measured in MWhs, but this is likely only somewhat correlated at a generalized national level for unbundled RECs and ERCOT (Texas) electric pricing (Figure 4).

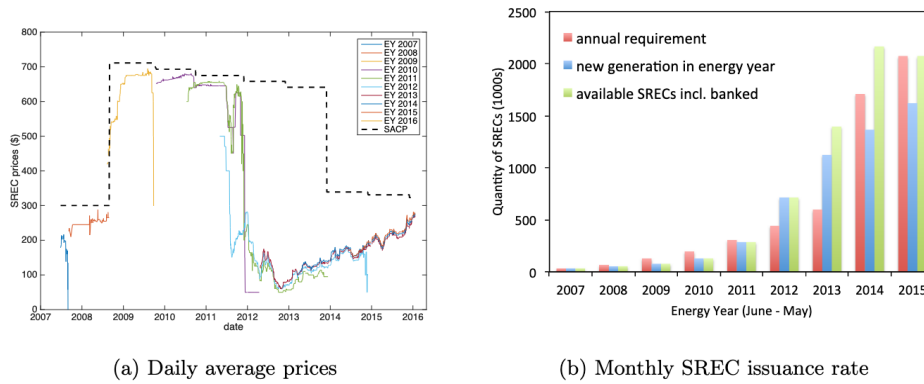
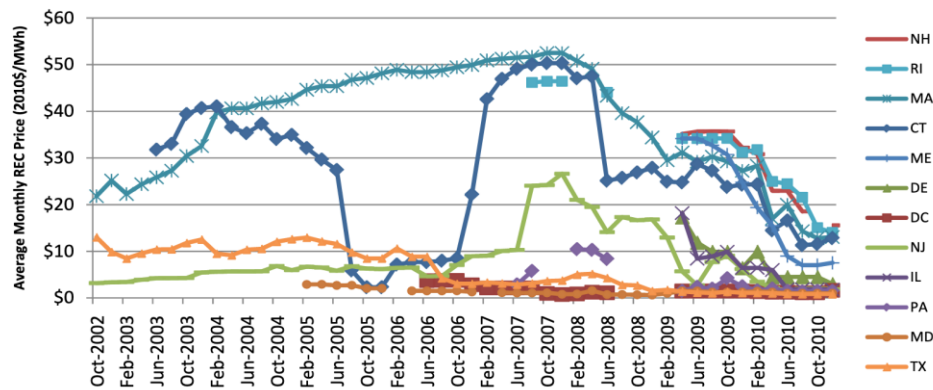


Figure 2. Historical NJ SREC prices and annual generation compared to requirement levels

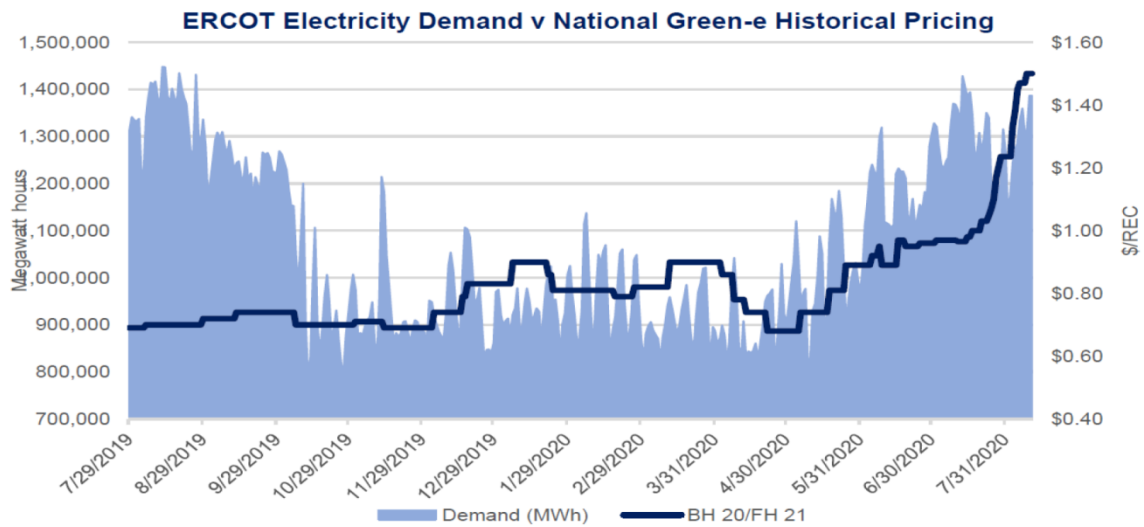
Source: http://energysystems.princeton.edu/Papers/Coulon%20Khazaei%20Powell_Mar2013.pdf. Pp. 5



Note: Plotted values are the last trade (if available) or the mid-point of bid and offer prices for the current or nearest compliance year. Source: Evolution Markets (2007) and Spectron Group (2011).

Figure 3. REC Pricing Trends Across US States, 2002-2010

Source: <https://www.nrel.gov/docs/fy11osti/51904.pdf> pp.11



Source: Karbone (2020)

Figure 4. REC Prices vs Electricity Demand in Texas, 2019-2020

Source: Karbone 2020

Compliance markets have the most room for expansion and the most potential for economic growth due to their higher prices (Figure 2). Overall, the increase in demand is great for the green energy sector, there have been some issues in project financing for new ventures. Long-term financing is important for these projects but seems to only be plausible through the support of “large institutions or corporate buyers” that are willing to hedge price risk (Holt and Bird, 2005). Tax benefits have also been used to encourage investors in certain markets (Singh, 2011). Khazaei et al (2016) even propose a policy to help stabilize the market through collective predictive market behavior modeling. As REC markets expand, comparisons may help guide changes regarding price and market volatility (Khazaei et al, 2016). The REC market has some benefits and some downfalls, but the market is still worth investing in. The benefits include the ability to provide cost-effective green energy to a larger demographic, the reduction of transmission costs, and the ability to enable consumers to direct their money towards renewable energy if they choose. Some of the downfalls include the difficulty in marketing RECs to consumers, the inconsistency of the definition of RECs, and limited market infrastructure to track and verify the validity of RECs (Holt et al, 2011). Another major issue that concerns the expansion of RECs is how to properly regulate this complex market. A great amount of public resources and time is required to create, maintain and regulate REC markets, from generation verification, REC minting, reporting, monitoring and implementing stabilization measures.

Hulshof et al have developed performance indicators to see if the European Union energy certificate market is functioning properly (Hulshof et al, 2019). Research has found that creating international standards has a positive impact on the markets. Privatization on the other hand, can lead to more fees and lower market volume. Concluding remarks from Hulshof et al show that the EU's certification market is currently not functioning efficiently due to a lack of transparency in pricing which is also a large issue in the US markets. Market comparisons from the EU, India, and the US show patterns in volatile pricing, regulation confusion, and marketing (Holt et al, 2011). The United States government has been creating fiscal policies that positively impact the renewable energy industry. Both state and federal renewable energy tax incentives have been “*the primary policy driver for the growth of wind, solar, and other renewables during the past decade*” (Bhattacharyya, 2020). Tax credits have been most influential in the solar industry through the use of investment tax credit (ITC). Like RECs there are stipulations to these tax credits that prefer newer renewable energy projects over older (Bhattacharyya, 2020).

Another tax credit referred to as a production tax credit has even stricter restrictions only supporting the production of new energy builds to help boost the sector's growth. Unfortunately, Covid-19 had a large and potentially lasting impact on the growth of the industry, setting back those looking to invest in such projects (Bhattacharyya, 2020). When the

economy is receding, tax credits are less effective as citizens and businesses do not have the extra cash to participate in voluntary programs. Economic prosperity is the best way to ensure the growth of the energy industry which can be done through strategic monetary policies. This will have a large impact on the supply of green energy and thus could push back benchmarks in areas lacking access.

On March 26th 2021, Massachusetts Gov. Charlie Baker signed a landmark climate change action bill, S.9 “*An Act creating a next-generation roadmap for Massachusetts climate policy*”. This comprehensive and relatively aggressive legislation (compared to other US states and past bills) was developed to mitigate the wide ranging negative impacts (environmental, social and financial costs) of climate change by progressively limiting greenhouse gas (GHG) emissions from all sectors of the economy, reaching “net-zero” emissions by 2050. Using 1990 as a base year, S.9 sets firm targets of at least a 50% reduction in emissions by 2030, 75% by 2040 and 85% by 2050, with the remaining 15% achieved by natural carbon capture and storage (sequestration) through increasing vegetation, achieving net-zero emissions (Fraser, 2021). These targets are to be revisited every 5 years. S.9 builds upon the 2017 MA DEP 310 CMR 7.75: Clean Energy Standard for electricity sellers (not including Municipal Light Plants (MLPs)) which specifies an increasing minimum percentage of clean energy power supply in their portfolios, also called the Renewable Portfolio Standard (RPS). This legislation was updated by S.9, so that for the first time in MA, MLPs like SELCO are included in emissions reduction requirements through a portfolio standard with carbon-free power supply sources meeting specified percentages at benchmark years up to 100% “net-zero” in 2050 as seen on the table on page 2 and 3 of SELCO Power Supply Policy & GGES (Attachment 1). To the researchers’ knowledge, this is the first financial analysis conducted for a specific organization that is beholden to this new legislation and therefore adds unique and specific knowledge to the public policy area of utilizing RECs to meet emissions reduction goals.

3. Methodological Approach and Discussion

The best approach to achieving net-zero emissions differs between communities. For example, in Shrewsbury, MA, the mantra of the municipal electric utility, SELCO, has always been “low cost and reliability” with its approach to power procurement and distribution operations. Times are changing, with increased focus on environmental sustainability, both mandated by the state and voluntary interest from the community. This desire, coupled with the uncertainty of the REC markets, makes reaching a net-zero power supply sooner rather than later a prudent action. MLPs like SELCO are now stakeholders and active participants in compliance REC markets. Utilizing data, information and insight from green commodity market experts at Massachusetts Municipal Wholesale Electric Company (MMWEC, 2021), a partner of SELCO’s, an economic analysis was performed on different pathways SELCO can achieve a 100% non-carbon power portfolio. This analysis was performed by Patrick Collins, using Excel. To summarize the analysis, SELCO’s contracted non-carbon and potentially non-carbon MWhs (if RECs are purchased and retired rather than sold) with different generating sources for each year from 2020 (Figure 5) onwards were summed to form a baseline total non-carbon sales position (Figure 6).

Existing Carbon Free Contracts - Purchased Generation by Year (MWh)						
All \$ Values based on estimated pricing (not locked)	2020	2021	2022	2023	2024	2025
NYPA						
Class II MWh	17,652	14,300	14,300	14,300	14,300	14,300
Millstone						
Non-Carbon MWh	20,964.00	25,499.00	23,473.00	23,473.00	25,569.00	23,473.00
Class II \$	\$ 19,231.80					
Unbundled ME Class II MWh Purchased & retired	5,061.00					
Seabrook						
Non-Carbon MWh	56,784	60,759	66,004	60,759	60,940	66,004
Solar Rebate Programs						
Solar MWh	166	175	180	185	188	190
Class I \$ (can't sell MLP, can sell SELCO)	\$ 6,723.00	\$ 6,650.00	\$ 6,480.00	\$ 6,105.00	\$ 5,828.00	\$ 5,700.00
Hydro Québec						
MWh	2930	17,520	17,520	17,520	17,568	14,590
Voluntary Renewable Program (Green Light)						
Class I MWh	176	178	179	180	181	182
Class I \$ (customer pays)	\$ 7,128.00	\$ 6,764.00	\$ 6,444.00	\$ 5,940.00	\$ 5,611.00	\$ 5,460.00
Potential Non-Carbon Contracts						
Berkshire						
Class I MWh	5,061.00	5,441.00	5,417.00	5,400.00	5,409.00	5,389
Class I \$	\$ 222,180.00	\$ 206,758.00	\$ 205,846.00	\$ 178,200.00	\$ 167,679.00	\$ 161,670.00
Solar Landfill						
Solar MWh	5,164	5,000	5,000	5,000	5,000	5,000
SREC II Discount Factor	0.65	0.65	0.65	0.65	0.65	0.65
Solar REC \$	\$ 989,430.00	\$ 859,462.50	\$ 816,562.50	\$ 775,450.00	\$ 735,800.00	\$ 699,400.00
Class I \$						
Hancock Wind						
Class I MWh	8,693	13,262	13,213	13,185	13,201	13,152
Class I \$ (can't sell)				\$ 355,995.00	\$ 356,427.00	\$ 355,104.00
MayFlower Wind, \$71.23 (bundled energy, MA CI I & Clean Peak Cert.), 2026-2045						
Firm Hydro power + ME Class II from Brookfield, ATC, 2024-2028 @ \$50.50						
	2020	2021	2022	2023	2024	2025
Total Non-Carbon Load (Business as Usual) (MWh)	103,733	118,431	121,656	116,417	118,746	118,739
Carbon Free Position (% of Retail Sales)	37.35%	43.04%	43.78%	41.48%	41.89%	41.47%
Remaining Carbon Sales (MWh)	173,987.00	156,703.00	156,229.34	164,247.19	164,724.84	167,566.54
Class I Load (MWh)	13,930.00	18,881.00	18,809.00	18,765.00	18,791.00	18,723.00
Class II Load (MWh)	17,652.00	14,300.00	14,300.00	14,300.00	14,300.00	14,300.00
SREC Load (MWh)	5,164.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Total Class I Value (\$)	\$ 222,180.00	\$ 206,758.00	\$ 205,846.00	\$ 178,200.00	\$ 167,679.00	\$ 161,670.00
Total Class II Value	\$ 19,231.80	\$ -	\$ -	\$ -	\$ -	\$ -
Total Solar REC Value	\$ 989,430.00	\$ 859,462.50	\$ 816,562.50	\$ 775,450.00	\$ 735,800.00	\$ 699,400.00
Total RECs Sold	\$ 1,211,610.00					
Total RECs Bought/Retired	\$ 25,954.80	\$ 6,650.00	\$ 6,480.00	\$ 6,105.00	\$ 5,828.00	\$ 5,700.00
Total RECs Market Value (\$)	\$ 1,230,841.80	\$ 1,066,220.50	\$ 1,022,408.50	\$ 953,650.00	\$ 903,479.00	\$ 861,070.00

Figure 5. SELCO Existing Power Portfolio Contracts, MWhs and RECs 2020-2032

Source: Authors own calculations based on collected secondary data.

	2020	2021	2022	2023	2024	2025
Total Non-Carbon Load (Business as Usual) (MWh)	103,733	118,431	121,656	116,417	118,746	118,739
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Class II Load (MWh)	17,652.00	14,300.00	14,300.00	14,300.00	14,300.00	14,300.00
SREC Load (MWh)	5,164.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Total Class I Value (\$)	\$ 222,180.00	\$ 206,758.00	\$ 205,846.00	\$ 178,200.00	\$ 167,679.00	\$ 161,670.00
Total Class II Value	\$ 19,231.80	\$ -	\$ -	\$ -	\$ -	\$ -
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Total RECs Sold	\$ 1,211,610.00					
Total RECs Bought/Retired	\$ 25,954.80	\$ 6,650.00	\$ 6,480.00	\$ 6,105.00	\$ 5,828.00	\$ 5,700.00
Total RECs Market Value (\$)	\$ 1,230,841.80	\$ 1,066,220.50	\$ 1,022,408.50	\$ 953,650.00	\$ 903,479.00	\$ 861,070.00

Figure 6. SELCO Existing Portfolio Summary, 2020-2032

Source: Authors own calculations based on collected secondary data.

The MWh difference between this baseline and the target non-carbon level (MWhs) based on target non-carbon portfolio percentages were multiplied with different REC prices depending on REC treatment approach, to calculate the total added cost in dollars per year (Figure 8). The revenue “lost”, or opportunity cost of purchasing and retiring

RECs rather than selling them, which SELCO has historically done, is part of this total added cost. This cost was then translated to \$/kWh sold, which can be applied to customer bills. The cost to reach a net-zero, 100% non-carbon portfolio was quite low in all outlined scenarios (Figures 8, 9, 10, and 11).

One of the most important components of this analysis is how owned RECs associated with SELCO’s generating assets are treated and this treatment depends on REC type or class. REC class is determined by which type of generation facility created the REC. MA Class I RECs are produced by the “cleanest” or least environmentally impactful facilities including solar and wind. These RECs have a higher value, set by the state, and are currently trading around \$40 (Figure 7). Although pricing of RECs is very difficult to predict, MMWEC experts anticipate a linear decrease to \$30 in 2025, with supply outpacing demand in initial years. This trend will likely reverse, with demand outpacing supply starting in 2026 onwards to 2032 rebounding the price back to ~\$40 (Figure 7). MA Class II RECs are produced by lower tier facilities that have larger environmental impacts but still produce clean power, like hydro. These RECs have a lower value, set by the state, and are currently trading around \$3.80. Prices for MA Class II RECs are expected to increase to about \$8 in 2032, with a 7% annual increase (Figure 7). Estimating REC prices has limitations and confidence in actual materialization of projections is not the best, as MMWEC experts reiterate difficulty, as the historical REC trends are volatile, do not correlate well with other indexes, markets and commodities, and are heavily influenced by public policy at the state level. For example, changes in the Alternative Compliance Payment rate set by the DOER, which acts as a price ceiling for RECs, will also likely change the expected price of RECs, as they can sometimes float just under the ACP ceiling, as seen in Figure 2a, NJ SREC prices from 2007-2011. This Figure provides an excellent example of how volatile, unpredictable and policy-influenced REC prices can be, as the prices float just under ACP for the first handful of years, then rapidly plummet in 2012, then slowly increase until 2016. The traditional economic logic of prices remaining stable with supply and demand increasing at equal rates may not apply to the REC market, with such heavy regulation. One would assume that over time, as more renewable energy projects are developed, generating more energy and RECs, increasing the clean percentage of the grid’s supply, that the REC market would saturate, devalue and die. But state governments will likely set price floors and ceilings to somewhat stabilize the market and keep a value assigned to renewable energy over fossil fuels.

REC Retirement Cost Analysis	Projected MWh Load	Projected Change from Previous Year (%)	Projected Retail Sales (MWh)	Estimated RECs Pricing- MA Class I	Estimated 1 year RECs Pricing- ME (Class II)	Locked 5-year RECs Pricing- ME (Class II)	Locked 10-year RECs Pricing- ME (Class II)	Locked 5 year RECs Pricing- Class I	SREC \$
2020	287,203		277,720.00	\$ 40.50	\$ 3.00				\$280.00
2021	289,135	-0.94%	275,134.00	\$ 38.00	\$ 3.80	\$5.00	\$7.60	\$52.65	\$264.45
2022	292,026	-1.00%	277,885.34	\$ 36.00	\$ 4.07	\$5.00	\$7.60	\$52.65	\$251.25
2023	294,947	-1.00%	280,664.19	\$ 33.00	\$ 4.35	\$5.00	\$7.60	\$52.65	\$238.60
2024	297,896	-1.00%	283,470.84	\$ 31.00	\$ 4.66	\$5.00	\$7.60	\$52.65	\$226.40
2025	300,875	0.99%	286,305.54	\$ 30.00	\$ 4.98	\$5.00	\$7.60	\$52.65	\$215.20
2026	303,884	0.99%	289,168.60	\$ 36.00	\$ 5.33	\$5.00	\$7.60	\$52.65	\$171.00
2027	306,923	0.99%	292,060.29	\$ 37.00	\$ 5.70		\$7.60		\$162.00
2028	309,992	0.99%	294,980.89	\$ 38.00	\$ 6.10		\$7.60		\$150.00
2029	313,092	0.99%	297,930.70	\$ 39.00	\$ 6.53		\$7.60		\$127.50
2030	316,223	0.99%	300,910.00	\$ 40.00	\$ 6.99		\$7.60		\$108.38
2031	319,385	0.99%	303,919.10	\$ 40.00	\$ 7.48		\$7.60		\$92.12
2032	322,579	0.99%	306,958.29	\$ 40.00	\$ 8.00				\$78.30
2033	325,805	0.99%	310,027.88						
2034	329,063	0.99%	313,128.16						
2035	330,708	0.50%	314,693.80						
2036	332,361	0.50%	316,267.27						
2037	334,023	0.50%	317,848.60						
2038	335,693	0.50%	319,437.85						
2039	337,372	0.50%	321,035.03						
2040	339,059	0.50%	322,640.21						
2041	340,754	0.50%	324,253.41						
2042	342,458	0.50%	325,874.68						
2043	344,170	0.50%	327,504.05						
2044	345,891	0.50%	329,141.57						
2045	347,620	0.50%	330,787.28						
2046	349,358	0.50%	332,441.22						
2047	351,105	0.50%	334,103.42						
2048	352,861	0.50%	335,773.94						
2049	354,625	0.50%	337,452.81						
2050	356,398	0.50%	339,140.07						

Figure 7. Data driving the SELCO REC Analysis, expected total electric sales and REC pricing

Source: Authors own calculations based on collected secondary data.

The most valuable RECs are produced by solar facilities (SRECs) that were constructed during the initial years of the creation of REC markets. In MA, SREC programs set very high price floors and ceilings. SELCO owns a large solar system located at the Shrewsbury landfill cap. The Solar RECs (SRECs) produced by this facility have been sold in the compliance REC markets to bring in revenue to offset the initial costs of the project. This is a common practice for most renewable energy projects and an example of the ultimate goal of RECs: to incentivize renewable energy

development, as this project would likely not have been financially feasible without REC revenue. MA SRECs are priced extremely high, around \$280 (Figure 7). As these SREC programs are phased out by the state government, these become less valuable each year, likely dipping to below \$100 at the last available year in 2027. Because of this inflated pricing, it is best to sell SRECs and use this revenue to purchase the same MWhs (or more) with other REC types of less monetary value, such as MA Class I. In 2028, solar facilities in the SREC II program like SELCO's will produce Class I RECs going forward, instead of SRECs. Because SREC Program II was ended a few years ago, the SRECs produced are discounted from the trading price by 35%, as the discount factor of 0.65 can be seen in Figure 7. It is important to note that although these different REC types have different monetary values, the contribution of MWhs to meet non-carbon power supply is the same; one SREC, one MA Class I and one MA Class II are all equal to one MWh of electric energy. The desire to purchase one over the other resides in the consumer that wants to claim certain credit for a certain environmental attribute. Locking in REC prices to reduce market fluctuation risk and exposure to volatility may also be a smart practice. 10 year and 5 year pricing is available for Class II RECs, at \$7.60 and \$5 respectively (MMWEC, 2021). The locked pricing informed the estimated 1 year pricing, as it closely matches in the last available year of each locked pricing scheme: \$5.33 vs. \$5 in 2026 and \$7.48 vs. \$7.60 in 2031 (Figure 7).

Total projected electricity retail sales (MWhs) were modelled from present day to 2050, informed by variables including historical sales, long term weather/climate forecasts and increased electrification. SELCO's sales are expected to remain stable for the next few years, around 280,000 MWhs, then increase by about 1% annually from 2024 to 2034, then 0.5% thereafter until 2050. The logic behind this is that the increased demand associated with fuel shifting the transportation sector with electric vehicles (EVs) will likely occur rapidly in the next decade or so, then plateau. Public policy and auto manufacturers are pushing towards nearly complete electrification within a decade.

SELCO's power supply portfolio was broken down between different generating sources and classified as carbon or non-carbon based on the definition set by MA legislation S.9 where RECs or EFECs must be used to count as non-carbon (Figure 5). The existing non-carbon contracts include inexpensive hydro from the New York Power Authority (NYPA) and Hydro Quebec that includes Class II REC equivalents. In 2020, hydro made up 6% of SELCO's total power portfolio, the highest contribution from renewable power. MWhs from nuclear sources including Millstone and Seabrook are non-carbon as EFECs are associated with the purchased energy. Nuclear currently makes up the majority of SELCO's non-carbon power portfolio. In 2020, nuclear energy made up 27% of the total power portfolio, therefore SELCO is quite reliant on nuclear power both for energy requirements and non-carbon requirements. A very small percentage of the portfolio is solar, as the SRECs from SELCO's landfill solar facility cannot be counted as non-carbon, as they are sold. The solar in the portfolio comes in the form of retirement of the MA Class I RECs produced by SELCO customers that participate in the solar rebate programs that require transfer of REC ownership to SELCO in return for a generous rebate. Another small source of MA Class I RECs in the portfolio is from SELCO's voluntary renewable program, called the Green Light Program, where SELCO customers can choose to pay a bit extra on their bills for local wind energy credit. All of these contracted MWhs add up to a baseline non-carbon position which was balanced against the total MWh sales, establishing a non-carbon percentage, which in 2020, was 37%. There are also potential non-carbon contracts, where SELCO currently procures energy from owned renewable sources like Berkshire Wind and the Landfill Solar, where SELCO has sold these RECs for revenue; and unowned renewable sources like Hancock Wind where SELCO has opted not to purchase RECs. Treating RECs associated with these contracts differently (buying/retiring rather than selling) increases non-carbon position without having to purchase unbundled RECs on the open market.

In 2021, SELCO General Manager Chris Roy decided to continue to sell the 2020 Berkshire Class I RECs absent an official power supply policy, even though the "right" thing to do given passage of the S.9 climate bill may have been to retire the RECs and claim environmental credit. To offset the sale of these RECs and clean MWhs, Mr. Roy had SELCO purchase unbundled MA Class II RECs, the least expensive RECs in MA. This judgement-based fiscal action with regards to REC treatment to achieve emissions goals is exactly the approach that was first modelled, seen in Figure 8, "*Sell all RECs, buy CII, w/ est. 1 yr prices*". In this scenario, the revenue from the sale of more valuable MA Class I RECs that SELCO can bring in is used to purchase less valuable Class II RECs but a greater number, therefore reaching 100% in 2030.

Another fiscal policy approach that was modelled is titled "*Buy REC in contracts, Buy CII for Solar, Buy CII, w/ est. 1 yr prices*" as seen in Figure 8, where all contractual RECs are bought and retired, rather than sold on the market, except for SRECs, which are always sold and replaced with Class I, and any remaining difference needed to reach a given year's target non-carbon percentage goal is made up with Class II RECs. This same REC treatment approach was modelled with locked pricing as well. The target year for 100% non-carbon was set at 2032, with 5% annual increase from 45% at 2021. The last approach that was modelled uses this same REC treatment, but reaches 100% at the last

possible year in 2050, with a 2% annual increase from 43% in 2021. Costs were not modelled past 2032 due to higher uncertainty about REC pricing and state policy. Things are changing so rapidly in this area that it could be a whole new world in the later years.

Limitations of this analysis include the difficulty of predictive REC market pricing, as mentioned several times, as well as the fact that new contracts are not considered. Without doubt, SELCO will enter into new long-term contracts that provide bundled non-carbon energy and environmental attributes such as Mayflower Wind and local hydro like Brookfield, both before 2030 and likely lasting decades. MMWEC has advised that off-shore wind like Mayflower should contribute at least 10% of SELCO's power supply, as it is relatively low cost Class I renewable energy and more reliable than on-shore wind and solar. It can also provide Clean Peak Certificates, which will be a new environmental attribute associated with large scale projects that can provide essential power during peak demand events. All inclusive, bundled long term contracts like this can substantially reduce the cost of meeting emissions reduction targets, therefore this analysis may overestimate costs to net-zero emissions.

4. Research Findings

Table with multiple columns representing years from 2020 to 2050 and rows detailing various financial metrics such as Target Non-Carbon Level, REC Equipment Needed, and Total Added Cost per kWh. The table is divided into three main sections: 'Buy REC in contracts, Buy CI for Solar, Buy CII, w/ 5 year locked pricing', 'Buy REC in contracts, Buy CI for Solar, Buy CII, w/ 5 year locked pricing', and 'A More Detailed Schedule/Scenario'.

Figure 8. Different approaches to 100% non-carbon power supply 'net-zero'

Source: Authors own calculations based on collected secondary data.

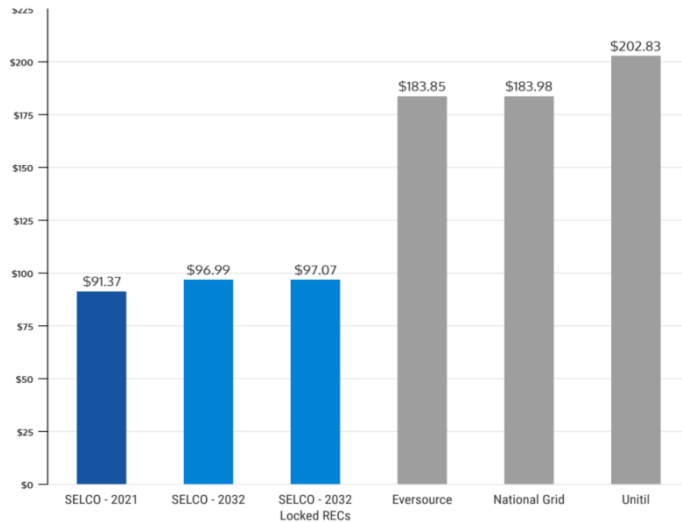
As seen in Figure 8, the financial cost to reach 100% non-carbon power supply utilizing RECs is quite low, making this endeavor affordable for public electric utilities like SELCO. Millions of dollars might seem like a lot of money, but spread over thousands of customers on a kWh basis, over a decade, the costs per bill is minimal; some would say unnoticeable. This aligns with the costs that other MA MLPs incurred that have power portfolios that are at or very close to 100% non-carbon, like Concord Light and Belmont Light. The modelled total cost to 100% net-zero emissions with the cheapest REC treatment approach "Sell all RECs, buy CI II" while hitting 100% early in 2030, is \$5,821,961.34 (Figure 8, row 129). The total added cost of purchasing unbundled Class II REC on the market increases each year, starting at \$19,764.94 in 2021 and \$1,373,000.38 in 2030. With estimated 1 year pricing, the total cost of the for the more balanced REC treatment approach, where contractual RECs are purchased and retired for credit, except for solar, and the needed difference to meet target non-carbon percentage is made up with Class II NEPOOL (New England Region) RECs, is \$14,759,506.24, hitting net-zero in 2032 (Figure 8, row 143). The total added cost of purchasing increases each year, starting at \$396,758.00 in 2021 due to the lost revenue from not selling the contracted Class I RECs and purchasing Class I RECs to offset SRECs selling. This REC treatment approach boosts SELCO's baseline non-carbon percentage because RECs from contracts including Berkshire, Hancock and the Landfill Solar are counted for credit. This hovers around and over 50% non-carbon between 2021 and 2025, then dips in later years due to contracted MWhs decreasing (Figure 8). This approach actually puts the portfolio ahead of targeted non-carbon levels in the first couple of years, seen in the negative "RECs Equivalent Needed (MWh)" in Figure 8. The added cost per kWh starts at around 1/10th of one cent (\$0.0014421) and increases to just over 7/10th of one cent (\$ 0.0074879) in 2032 (Figure 8). Translating this per kWh cost to the average residential customer that uses 750 kWh a month on average, it would cost around \$13 per year, or a bit over \$1 per month, in 2021. This cost increases to \$ 67.39 per year

in 2032, or a bit under \$6 per month (Figure 8). Adding the per kWh cost to the average 750 kWh customer’s bill, would lead to a total electric bill of \$ 96.99 in 2032 with a 100% non-carbon power supply, less than a \$6 difference from the current \$ 91.37 based on SELCO’s current residential rate of \$0.11516 per kWh (Figure 9).

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Carbon Free %	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Rate per kWh (2021 Baseline)	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516	\$0.11516
Added kWh Cost	\$0.00144	\$0.00139	\$0.00271	\$0.00285	\$0.00309	\$0.00400	\$0.00437	\$0.00478	\$0.00542	\$0.00595	\$0.00650	\$0.00749
Average Monthly kWh Usage	750	750	750	750	750	750	750	750	750	750	750	750
Customer Charge	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Monthly Cost (2021 Baseline)	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37	\$91.37
Added Monthly REC Cost	\$1.08	\$1.04	\$2.04	\$2.14	\$2.32	\$3.00	\$3.28	\$3.59	\$4.06	\$4.46	\$4.87	\$5.62
Total Monthly Bill	\$92.45	\$92.41	\$93.41	\$93.51	\$93.69	\$94.37	\$94.65	\$94.96	\$95.43	\$95.83	\$96.24	\$96.99
Added Yearly REC Cost	\$12.98	\$12.50	\$24.43	\$25.66	\$27.82	\$35.96	\$39.36	\$43.04	\$48.76	\$53.58	\$58.47	\$67.39
Total Annual Bill	\$1,062.40	\$1,061.43	\$1,085.29	\$1,087.76	\$1,092.08	\$1,108.36	\$1,115.17	\$1,122.52	\$1,133.97	\$1,143.59	\$1,153.39	\$1,171.22

Figure 9. Modelled costs for the recommended approach for the typical 750 kWh / month customer
 Source: Authors own calculations based on collected secondary data.

COST COMPARISON PER 750kWh AS OF JULY 1, 2021



SELCO's estimated 2032 100% Net-Zero rate would be approximately half as much as neighboring IOU Q1 2021 rates for 750kWh of residential use.

Tracking projected future REC market fluctuations, we estimate the 2032 cost per 750kWh will be \$96.99 per month.

If the Commimssion prefers to stabilize the impact of possible future REC market fluctuations, locked REC pricing is available. Under that model, the 2032 monthly cost for 750kWh will be \$97.07.

Figure 10. SELCO modelled costs vs Investor owned Utilities

AVERAGE COST PER 750kWh Q1 2021

DATA PROVIDED BY MMWEC

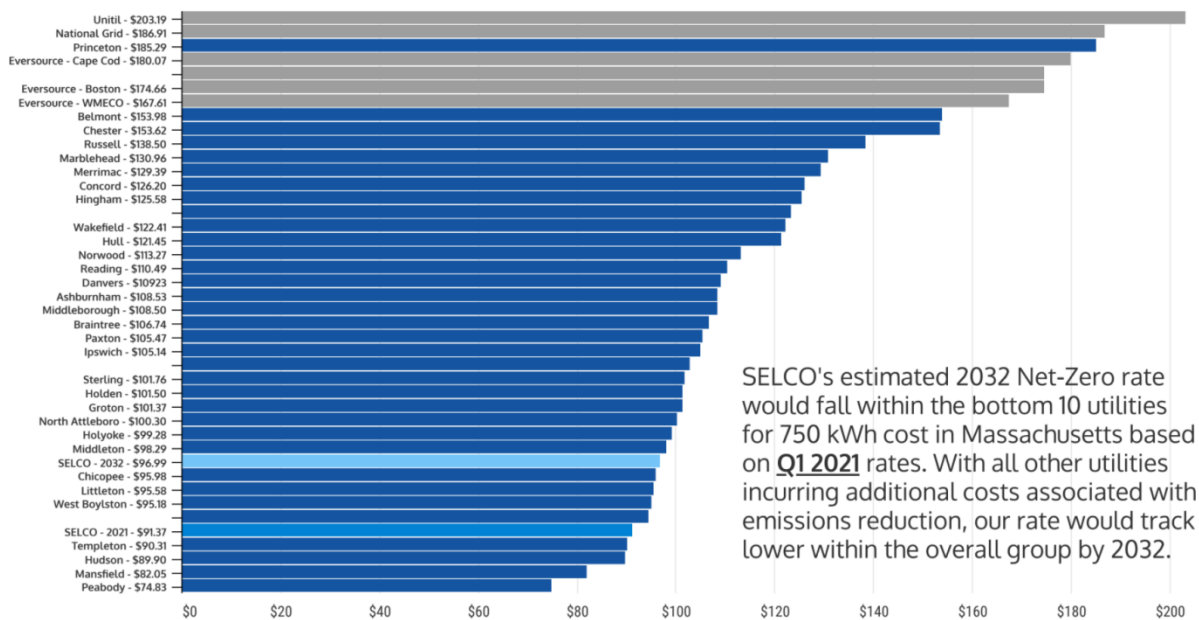


Figure 11. SELCO net-zero modelled costs, SELCO current costs, compared to other public and private utilities
 Source: Authors own calculations based on collected secondary data.

These expected bills are still around half of what investor owned utilities (IOUs) like National Grid and Eversource currently charge their customers, as seen in Figure 10 and Figure 11. Electric customers serviced by MLPs like SELCO are lucky in this regard to have such great service at a low cost, from both financial and environmental viewpoints. Cumulatively, from 2021 to 2032, this average customer would pay a total of about \$450 (Figure 8).

In the more delayed schedule, where 100% is reached in 2050, the last possible year to meet that requirement, a 65% non-carbon is reached in 2032. The total added cost of reaching 65% is \$7,047,194.15, or \$215.55 per “average 750 kWh customer” over this time period of 11 years (Figure 8). Comparing this to the more aggressive approach, the total cost of achieving the same 65% non-carbon level earlier in 2025 is less than half, at \$ 103.38 per average 750 kWh customer over those 5 years. The slight decrease in total annual cost in all scenarios from 2021 to 2022 is due to the slight increase in baseline non-carbon percentage from contracted MWhs increasing as well as the expected decrease in pricing for MA Class I RECs. Again, all of these modelled costs to achieve 100% non-carbon power supply align with historical actual costs that other MLPs have incurred, which is reassuring to the validity of this model.

5. Policy Recommendation and Conclusions

Rules-based and judgement-based fiscal policy should be adopted by SELCO to create a formal power supply policy and greenhouse gas emissions standard (GGES) based on the findings of this analysis. A diverse, layered and staggered approach to both energy and environmental attribute procurement should be taken, where reliance on one contract should not exceed 20% of the total portfolio. The complete policy document can be seen in the Attachment section. Considering the uncertainty of REC markets beyond ~2032, increased demand, the potentially limited supply of RECs, increasing prices, and the results of the financial analysis of the modelled costs to reach 100% non-carbon power supply, the best approach to reaching this emissions reduction goal is to participate proactively in this market and procure RECs well ahead of minimum schedule requirements, while still retaining low electric rates and excellent reliability. It is recommended that 100% is reached in 2032, increasing 5% annually from 45% in 2021. The target non-carbon level is rules based policy, where these levels must be met.

Because there is more price stability in bundled energy and REC contracts, and because it is easier for the general public to understand, it is recommended that SELCO take the REC treatment approach of purchasing and retiring RECs associated in all available power purchase contracts. The only exception to this would be SRECs from SELCO’s

solar facility where they should be sold for the expected revenue that was relied on for project feasibility, but some of this revenue should be used to purchase the equivalent MWhs in Class I RECs. This REC treatment approach is rules-based fiscal policy, where RECs must be treated in this way. Judgement based fiscal policy comes into play in the "Periodic Review" section of the policy document, where SELCO should revisit this policy given REC market conditions and re-run financial models to compare predicted costs versus actual costs. It is recommended that this periodic review be conducted at least annually, but not more than quarterly. It is also recommended that SELCO reconsider the format of their voluntary green pricing program, Green Light, as it may not be necessary as the portfolio increases in its non-carbon position. When at 100% non-carbon in 2032, all of the electricity in Shrewsbury can be claimed as clean energy and all customers will be paying slightly higher bills instead of a select few. The program could be modified so that customers can choose to pay extra for a higher REC class or a specific type of renewable (e.g., local solar).

This extensive and unique analysis of the financial options to reach 100% clean power for a public utility fills some of the holes that previous research has left open for research. Utilizing REC markets to achieve emissions reduction goals and requirements is possible, and is not that expensive in this case. Limitations of this analysis include the difficulty of predictive REC pricing, due to market volatility and dependence on state legislation and oversight, as well as the fact that new contracts are not considered. Further research is needed to develop a more robust predictive model of the future of the REC market. It is recommended that SELCO should also stay tuned to the public policy debates in this area, especially related to any potential updates, changes and restructuring of renewable energy monetary policy and mechanisms. REC markets have the strength of incentivizing the development and use of renewable, clean energy instead of fossil fuels, but have drawbacks such as difficulty in marketing these products, volatile prices, inconsistent definitions and processes between states. Uncertainty about the impact of public policy in the late years approaching 2035 and beyond makes long-term market predictions nearly impossible, but one could argue that is the case with many other markets. The current setup where states create markets for and assign value to environmental attributes produced by certified clean generating sources is proven to work effectively and likely to stick around for a while, perhaps in perpetuity, but there is always potential for new monetary systems to be created to incentivize renewable energy over fossil fuels.

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